March 1995 • NREL/SP-410-7689

# U.S. Photovoltaic Patents: 1991—1993

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# Contents

# Introduction

This document contains U.S. patents on terrestrial photovoltaic (PV) power applications, including systems, components, and materials as well as manufacturing and support functions.

The patent entries in this document were issued from 1991 to 1993. The entries were located by searching USPA, the database of the U.S. Patent Office. The final search retrieved all patents under the class "Batteries, Thermoelectric and Photoelectric" and the subclasses "Photoelectric," "Testing," and "Applications." The search also located patents that contained the words "photovoltaic(s)" or "solar cell(s)" and their derivatives. After the initial list was compiled, most of the patents on the following subjects were excluded: space photovoltaic technology, use of the photovoltaic effect for detectors, and subjects only peripherally concerned with photovoltaics. Some patents on these three subjects were included when it appeared that those inventions might be of use in terrestrial PV power technologies.

## How to Use This Document

The PV patent entries are arranged according to the patent number in ascending order, from the earliest to the most recent, and divided according to the year in which they were issued. The entries for each patent include the inventor(s), the assignee, the title, the date of issue, and the abstract. Abstracts are reproduced in this document generally as they are found in the patents, except that statements referring to specific diagrams were modified or omitted because the document does not include illustrations.

The patents are indexed in this document by assignee, by inventor(s), and by subject. The three indexes follow the list of patent entries.

The subject index is divided according to 17 categories under three major divisions. Most patents are listed under two categories. The divisions and categories are as follows:

**Cells and Materials**

- Single-Crystal Silicon Cells
- Polycrystalline and Ribbon Silicon Cells
- Amorphous Silicon Cells
- Cells from III-V Materials (e.g., GaAs)
- Cells from I-III-$VI_2$ or II-VI Materials (e.g., $CuInSe_2$ or CdTe)
- Other PV Devices and Concepts
- Cell Components (metalization, substrates, conductive coatings, antireflective coatings)
- Cell Enhancement Techniques (surface and grain-boundary passivation, annealing)
- Materials Production and Processes (purification, deposition, doping)
- Characterization and Analysis

**Collectors**

- Flat-Plate Collectors (design, components, production)
- Concentrator Collectors (design, components, production)
- Optics and Trackers (lenses, reflectors, tracking devices, and related components)

**Systems**

- Utility-Interactive Systems and Interface Technologies (power conditioning)
- Utility-Independent Systems and Storage Technologies
- PV-Hybrid Systems (PV-thermal, photoelectrochemical)
- Systems Support (testing, maintenance, operation, and control)

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# Photovoltaic Patents
# 1991 - 1993

# 1991

**Des. 317,458**
Sawada, Masaji; Ikuzawa, Yoko, inventors; Sharp Corporation, assignee. *Electronic Calculator with Solar Cell*. June 11, 1991.

The ornamental design for an electronic calculator with solar cell.

**Des. 317,619**
Sawada, Masaji; Yoshimura, Youko, inventors; Sharp Corporation, assignee. *Electronic Calculator with Solar Cell*. June 18, 1991.

The ornamental design for an electronic calculator with solar cell.

**Des. 319,252**
Sawada, Masaji; Nishida, Kouji, inventors; Sharp Corporation, assignee. *Electronic Calculator with Solar Cell*. August 20, 1991.

The ornamental design for an electronic calculator with solar cell.

**314,523**
Omuro, Makoto, inventor; Hioki Denki Kabushiki Kaisha, assignee. *Multimeter*. February 12, 1991.

**4,009,456**
Eck, Berth, inventor; Lasinvast Svenska AB, assignee. *Door Lock Apparatus*. April 23, 1991.

A door lock apparatus includes a latch bolt which can be displaced from an operable position by actuating a door handle driver against the action of a biasing spring. A displaceable catch is provided for retaining the latch bolt in a retracted position. The catch is biased by a second spring into its catch position from which it can be displaced by an electromagnetic actuator, which in turn is connected to a wireless signal receiver. An alarm detector, remotely placed from the lock apparatus and connected to a wireless signal transmitter, is adapted to be activated when the detector detects a state of alarm, sending a signal which is detectable by the receiver at the lock apparatus for displacing the catch out of its catch position.

**4,981,525**
Kiyama, Seiichi; Hosokawa, Hiroshi; Hirono, Yutaka, inventors; Sanyo Electric Co., Ltd., assignee. *Photovoltaic Device*. January 1, 1991.

A metallic insulative substrate having its surface coated with an insulative layer, on which a large number of photoelectric converter elements are electrically connected to each other in series by connecting the first back electrode layer of one of photoelectric converter elements adjoining each other with the second back electrode layer of the other. Accordingly, electrical connection of these electrode layers in series does not affect the effective area used for photoelectric conversion. This consstitutionalso improves heat resistance of the insulative substrate. Electrical contact of the transparent light-receiving electrode layer and the second back electrode layer is achieved via contact holes each having a diameter identical to the diameter of those of the insulative and semiconductive layers. As a result, a sufficient insulative distance is provided between the transparent electrode layer and the first back electrode layer so that occurrence of accidental short circuit can be securely prevented.

**4,982,081**
Schmidt, Terrence C., inventor; Electrohome Limited, assignee. *Ambient Light Rejecting Quad Photodiode Sensor*. January 1, 1991.

An ambient light rejecting quad photodiode sensor having compensation diodes connected with reverse polarity to respective quadrant photodiodes within the sensor, the compensation diodes being located outside of the area of illumination. By direct connection of compensation diodes in reverse polarity to each quadrant of the quad photodiodes, a large boost in signal to noise ratio is achieved for eliminating the effects of ambient room light as well as sensor dark current.

**4,982,101**
Baker, Matt, inventor; Bently Nevada Corporation, assignee. *Fiberglass Collar for Data Transfer from Rotatable Shaft*. January 1, 1991.

Telemetry apparatus for a rotating machine shaft includes a fixed collar of lightweight composite material wrapped on the shaft and having embedded in it telemetry apparatus. Measured data such as torque from a strain gauge sensor is transmitted to a stationary sensor by pulses of infrared signals. An array of photovoltaic cells receives energy from a stationary source to power the rotating telemetry apparatus. All rotating electronics is embedded in the composite material which may be, for example, E-type fiberglass. Such composite material provides a resistance to centrifugal forces due to rotation of the shaft but has sufficient transparency to allow both the transmission of data and power to and from the rotating telemetry.

**4,982,176**
Schwarz, Frank, inventor. *Solar Powered Lighting and Alarm Systems Activated by Motion Detection*. January 1, 1991.

Solar powered outdoor lighting and/or alarm systems are provided and include a light source or alarm, a passive infrared (PIR) sensor in conjunction with a battery recharged via solar cells, and a control circuit coupled to the light source or alarm, the PIR sensor, and

the rechargeable battery. The control circuit guarantees that the light source or alarm is turned on by the battery only when the sensor senses the presence of a moving target. The systems may include a light detector which is utilized to prevent the system from activating in daylight. In the case of a lighting system, a timer is utilized to turn off a lamp after a desired period of time (e.g. 3 minutes). By limiting the "on-time" of the light source, a two to five watt bulb may be used. In the case of an alarm, the alarm may be hardwired to the control circuit; or, if desired, a transmitter powered by the rechargeable battery may be used to transmit an alarm signal to a remote receiver. The receiver is in turn coupled to its own power supply and to a control circuit which controls or switches desired components such as horns, bells, lights, etc.

**4,982,569**
Bronicki, Lucien Y., inventor; Ormat Turbines, Ltd., assignee. *Parallel Hybrid System for Generating Power*. January 8, 1991.

An intermittently operable non-fuel-consuming power generator, such as a photovoltaic array or a wind generator, is connected through a control circuit to a battery for charging the same and supplying current to a time-wise substantially constant electrical load. An electrical generator, connected to an intermittently operable prime mover, charges the battery and supplies current to the electrical load when the prime mover is operated. A sensor circuit senses at least one electrical parameter, such as a failure of the power generator to produce current, for controlling the operation of the prime mover (i.e. starting of the prime mover). The sensor circuit also senses a second electrical parameter, such as the charge level of the battery. The prime mover is made operational only if the battery capacity is less than a predetermined threshold level when the power generator fails to produce current.

**4,982,723**
Mori, Kei, inventor. *Accumulator Arrangement for the Sunlight Energy*. January 8, 1991.

A solar energy accumulator arrangement including a plurality of optical systems for focusing the sunlight and a fluid passage in a transparent body which is disposed such that it passes through, or in the vicinity of, the optical systems, the fluid passage receiving an induction substance which induces a photochemical reaction by light energy and accumulates the energy.

**4,986,169**
Chen, Ming-Hsiung, inventor. *Vehicular Internal Fan Ventilator*. January 22, 1991.

A vehicular internal fan ventilator, which includes a housing having set therein an internal ventilating chamber with a cross-flow air fan, a motor, a storage batteries and selector and a switch and a linkage to an oblique external portion of housing which is fixedly mounted a solar cell board to collect solar energy for the motor and/or to charge the storage batteries. The housing comprises a top retainer rib and a bottom window glass channel for convenient installation in with a separate, flexible and cuttable packing strip in a car between door frame upper trim and window glass of a vehicle.

**4,987,729**
Paytas, Anthony R., inventor. *Solar Powered Motor*. January 29, 1991.

A powered mower has a cordless electric power source defined by a rechargeable battery and a solar panel. The rechargeable battery is connected to a direct current motor for driving the mower blade and drive system for the powered mower. The solar panel supplies the rechargeable battery with additional voltage and current to assist the battery in maintaining its functional operating level.

**4,987,833**
Antosh, Mark J., inventor. *Solar Induction Monorail Apparatus and Method*. January 29, 1991.

A transportation system including a solar energy collecting monorail structure formed with a photovoltaic surface layer having a solar energy converting means for converting the collected solar energy to electrical energy. A power distribution means for distributing stored energy to transit vehicles being propelled along the monorail structure or distributing excess energy to a remote power utility source. The monorail structure includes means for propelling a transit vehicle according to magnetic principals associated with transverse flux motors. The system also includes a computer controlled, elevation compensating monorail structure extrusion machine comprising a fabrication chamber which continuously fabricates the monorail structure along a monorail construction right-of-way.

**4,988,642**
Yamazaki, Shunpei, inventor; Semiconductor Energy Laboratory Co., Ltd., assignee. *Semiconductor Device, Manufacturing Method, and System*. January 29, 1991.

An improved semiconductor device manufacturing system and method is shown. In the system, undesirable sputtering effect can be averted by virtue of a combination of an ECR system and a CVD system. Prior to the deposition according to the above combination, a sublayer can be pre-formed of a substrate in a reaction chamber and transported to another chamber in which deposition is made according to the combination without making contact with air, so that a junction thus formed has good characteristics.

**4,989,059**
Micheels, Ronald H.; Valdivia, Percy; Hanoka, Jack I., inventors; Mobil Solar Energy Corporation, assignee. *Solar Cell with Trench Through PN Junction*. January 29, 1991.

A solar cell fabrication procedure is described in which a trench is cut in the substrate so as to electrically isolate front and back regions of a flat solar cell. The trench is preferably cut around the perimeter of the rear side of the cell. The trench is preferably formed by an excimer laser which may be used to ablate a trench without diffusing conductive material deeper into the cell.

**4,989,124**
Shappell, Thomas E., inventor. *Solar Powered Sign*. January 29, 1991.

The present invention relates to an improved solar powered sign including one or more solar panels used to charge batteries which power various components of the sign. The sign may include a rotary display which is electrically powered and may also include a lamp. The sign may be mounted on a base facilitating easy transport.

**4,989,600**
Collier, Joseph M., inventor. *Tanning Pod*. February 5, 1991.

A tanning pod for use outdoors includes a body shell of curved configuration and provided with a transparent dome encompassing a majority of the extent of the pod and tapering to the front thereof. A bed within the pod is tiltable in a forward direction while a motive device is operable to rotate the pod relative an underlying support pedestal. A self-contained climate control system permits maintenance of desired temperature conditions within the pod regardless of the outside weather. Consoles adjacent the bed are provided with control panels allowing selective tilting of the bed and rotary displacement of the pod along with regulation of the climate control system as well as radiotape player devices. Current for operation of the pod and associated accessories may be supplied from a source of conventional AC power or alternatively, from attached or adjacent solar cells.

**4,990,286**
Gordon, Roy G., inventor; President and Fellows of Harvard College, assignee. *Zinc Oxyfluoride Transparent Conductor*. February 5, 1991.

Transparent, electrically conductive and infrared-reflective films of zinc oxyfluoride are produced by chemical vapor deposition from vapor mixtures of zinc, oxygen and fluorine-containing compounds. The substitution of fluorine for some of the oxygen in zinc oxide results in dramatic increases in the electrical conductivity. For example, diethyl zinc, ethyl alcohol and hexafluoropropene vapors are reacted over a glass surface at 400°C to form a visibly transparent, electrically conductive, infrared reflective and ultraviolet absorptive film of zinc oxyfluoride. Such films are useful in liquid crystal display devices, solar cells, electrochromic absorbers and reflectors, energy-conserving heat mirrors, and antistatic coatings.

**4,992,109**
Yoshikawa, Masao; Suzuki, Tetsuro; Kojima, Akio; Shoshi, Masayuki; Ohta, Masafumi, inventors; Ricoh Company, Ltd., assignee. *Photoelectric Conversion Element*. February 12, 1991.

A photoelectric conversion element has a front electrode, a rear electrode and a photo-activable layer sandwiched between these electrodes. The photoactivable layer contains a compound selected from a group consisting of a triphenylamine compound, a diaminocarbazole compound, an oxazole compound, a thiazole compound, and 1,3-dithiol compound. The compound contained in the photo-activatable layer improves photoelectric conversion efficiency.

**4,992,138**
Jensen, Millard J.; Hotchkiss, Gregory B., inventors; Texas Instruments Incorporated, assignee. *Method and Apparatus for Constructing a Foil Matrix for a Solar Cell*. February 12, 1991.

Solar spheres are formed of semi-conductor spheres of P-type interior having an N-type skin are pressed between a pair of aluminum foil members forming the electrical contacts to the P-type and N-type regions. The aluminum foils, which comprise 1.0% silicon by weight, are flexible and electrically insulated from one another. The spheres are patterned in a foil matrix forming a cell. Multiple cells can be interconnected to form a module of solar cell elements for converting sun light into electricity.

**4,993,348**
Wald, Leonard H., inventor. *Apparatus for Harvesting Energy and Other Necessities of Life at Sea*. February 19, 1991.

A vessel is provided, adapted for operating at the surface of the ocean, useful for a combination of functions, including providing food, fiber for clothing, living space, fresh water, transportation, and domestic energy for at least one person, as well as excess energy, good, fiber, and fresh / water for sale. The vessel comprises at least two hulls coupled with streamlined structs, the upper hull vertically aligned with the lower, the lower hull being fully submerged and the upper hull being fully unsubmerged and both hulls having substantially the same volume. The vessel is stabilized by a combination of passive lift and stabilization surfaces while the vessel is in motion, and laterally mounted stabilization reservoirs for use when the vessel is not moving. The vessel is controlled and stabilized

against wave-generated motion by a combination of actively controllable moveable surfaces, and is propelled by a sail and a water propellor. A combination of energy harvesting means is mounted on the vessel, including a sail augmented wind turbine, a water wave turbine, and a combination of concentrating and flat panel solar radiant energy collectors. Means is provided for converting the harvested energy into a storable form (hydrogen and oxygen) for later use or sale. Shelter is provided within the vessel for all daily living activities of an individual or a family. Means is provided for growing land food crops as well as sea food products for support of an individual or a family.

**4,993,868**
Eigenmann, Ludwig, inventor; Minnesota Mining and Manufacturing Co., assignee. February 19, 1991.

A continuous horizontal road-marking tape is described. The road-marking tape includes Light Emitting Diodes (LEDs) or high intensity microlamps, solar cells and retroreflecting elements. The LEDs may be double and focused for better visibility, their light is pulsing at a regular speed or at an emergency fast speed. The road-marking tape balances the solar energy captured by its solar cells with the emitted light employed to signal or warn motorists. Also described is the use of an emergency fast pulsing for signalling an emergency or the presence of ice, and the use of the tape for controlling situations where a single lane of roadway must alternatively pass traffic from two different directions. Activation of the light emitting sources is by sensing light from headlights of oncoming cars or by traffic lights.

**4,994,879**
Hayashi, Yutaka, inventor; Agency of Industrial Science & Technology, Ministry of International Trade & Industry, assignee. *Photoelectric Transducer with Light Path of Increased Length*. February 19, 1991.

A photoelectric transducer includes a planar transduction element portion which has a thickness and an upper and lower surface and in which incident light produces the photoelectric conversion. An optically transparent textured layer is formed on an optically transparent protective layer and provided on at least one of the surfaces of the planar transduction element portion.

**4,994,941**
Wen, Hung-Sheng, inventor. *Sign of Character and Figure*. February 19, 1991.

A sign of character and figure which, in addition to using the AC power supply, is particularly suitable for use with a solar energy means, comprising a solar cell for supplying the electrical energy converted from the solar energy; a battery means for receiving the electrical energy from the solar cell and supplying the stored electrical energy; a circuit means for automatically illuminating the character and figure display in the dark; a lighting means comprising a light bulb or light emitting diode as the light source; a very thin refracting plate wound within the body, the outer surface thereof having strips which are serrated at right angle and the inner surface being a smooth face through which the light from the light source is refracted into extremely uniform light rays to be emitted from the outer surface; the body comprising on the surface a figure display having a plurality of figures, each being composed of seven segments of " ", the desired figure being produced by means of strip shaped shades, and the body further comprising a character display with dots arranged in matrix, each dot comprising a large and a small holes with a " " shaped shade disposed therebetween for producing the desired character.

**4,997,491**
Hokuyo, Shigeru; Oda, Takao; Matsumoto, Hideo, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell and a Production Method Therefor*. March 5, 1991.

A solar cell includes a first conductivity type semiconductor substrate having two opposed surfaces, a second conductivity type first semiconductor layer disposed in the substrate at the first surface of the semiconductor substrate, a second conductivity type second semiconductor layer deposited on the first surface of the semiconductor substrate except for the first semiconductor layer production region, producing a pn junction with the semiconductor substrate having no reverse direction voltage blocking capability, a first conductivity type third semiconductor layer deposited on the second semiconductor layer, a first electrode covering the first semiconductor layer and connecting the third semiconductor layer with the first semiconductor layer, and a second electrode disposed at a second surface of the semiconductor substrate.

**4,999,059**
Bagno, Robert G., inventor. *Universal Solar Concentrator Panel*. March 12, 1991.

A solar concentrator device has a solar energy receiver and a solar energy reflector including a plurality of individual panels turnable about two mutually perpendicular axes so that the panels in one row are jointly turnable about a first axis, the panels in the same row are turnable also relative to two further axes.

**4,999,060**
Szekely, Klara; Felder, Bethanne; Wallace, Lloyd V., inventors; Siemens Solar Industries, L.P., assignee. *Solar Cell Packaging Assembly for Self-Contained Light*. March 12, 1991.

A self-contained photovoltaic powered light which is a stand alone unit. The solar cells which power the light are assembled and maintained within the top, or upper, portion of the self-contained unit. The solar cells are encapsulated within a resiliently deformable material to provide for contraction and expansion of the solar cells while at the same time providing protection from the elements for the assembly.

**4,999,308**
Nishiura, Masaharu; Yamada, Katsumi, inventors; Fuji Electric Co., Ltd., assignee. *Method of Making Thin Film Solar Cell Array.* March 12, 1991.

The present invention pertains to a thin film solar cell array that has an increased durability to high temperatures and high humidity. The thin film solar cell includes a transparent insulating substrate on which unit cells are placed in series. The rear electrodes of the unit cells are made of paste material containing conductive particles which may be applied by printing and baking at about 150°C. Further, the present invention achieves low contact resistance to the a-Si layer.

**4,999,560**
Morishima, Yoichi; Kobayashi, Kazuo; Suzuki, Isao, inventors; Kabushiki Kaisha Toshiba, assignee. *Electric Motor Running System Employing Photovoltaic Array.* March 12, 1991.

An electric motor running system consists of a photovoltaic array, an inverter for inverting output voltage of the photovoltaic array to AC voltage and automatically controlled so that the frequency is changed in accordance with the output voltage of the photovoltaic array, maintaining the ratio of the voltage to the frequency at a constant value, an induction motor operated by application of the AC voltage from the inverter, and a frequency increasing circuit for increasing the output frequency of the inverter instantaneously so that the motor produces the torque larger than the load starting torque when the motor is started and further decreasing the increased output frequency of the inverter to the normal running after the increased output frequency is maintained for a predetermined period of time. This construction allows the motor to be smoothly started even where a load connected to the motor is a positive displacement pump which has a large static friction torque.

**5,001,302**
Atsumi, Yoshinori, inventor; Casio Computer Co., Ltd., assignee. *Connecting Structure for an Electronic Part.* March 19, 1991.

A connecting structure for an electronic part employs an improved anisotropic electrically conductive layer. The layer includes a hot melt type insulative adhesive, heat resilient particles and carbon particles. Each of the heat resilient particles is made of thermoplastic resin and is plated with metal such as gold, nickel or the like. Each of the carbon particles is melted by a heat pressure and brings about an electric conductivity when it is dried and hardened. Thus, the anisotropically conductive layer disclosed in this invention does not include hard particles at all. Namely, an electronic part such as a solar battery cell or a semiconductor device is not damaged by particles of the conductive layer. In addition, the connecting structure employing the aforementioned layer improves the security of adherence and the reliability of the electric conductivity.

**5,001,415**
Watkinson, Stuart M., inventor. *Electrical Power Apparatus for Controlling the Supply of Electrical Power from an Array of Photovoltaic Cells to an Electrical Head.* March 19, 1991.

Electrical power transfer apparatus for controlling the supply of electrical power from an array of photovoltaic cells to an electrical load by means of a switching power converter. The switching power converter is controlled by a regulator to maintain the output voltage from the photovoltaic array at a fixed fraction of the open circuit voltage of the photovoltaic array, the fixed fraction suitably being between 0.75 and 0.8, whereby the power transfer from the photovoltaic array is maximized. The open circuit voltage of the photovoltaic array is sensed by inhibiting the operation of the switching power converter for short sampling periods at regular intervals, and allowing a capacitor to charge to the voltage of the open- circuited photovoltaic array during the sampling periods.

**5,002,617**
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro, inventors; Canon Kabushiki Kaisha, assignee. *PIN Heterojunction Photovoltaic Elements with Polycrystal AlAs(H,F) Semiconductor Film.* March 26, 1991.

A pin heterojunction photovoltaic element which generates photoelectromotive force by the junction of a p-type semiconductor layer, an i-type semiconductor layer, and an n-type semiconductor layer, characterized in that at least one of said p-type and n-type semiconductor layers comprises a polycrystal semiconductor film comprised of aluminum atoms (Al), arsenic atoms (As), hydrogen atoms (H), optionally fluorine atoms (F), and atoms (M) of a p-type or n-type dopant element, said polycrystal semiconductor film contains crystal grains of an average size in the range of 50 to 800 Å, and said polycrystal semiconductor film contains the hydrogen atoms (H) in an amount of 0.5 to 7 atomic %; said i-type comprises either (a) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F) or (b) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix, at least one kind of

atoms selected from the group consisting of carbon atoms (C) and germanium atoms (Ge), and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F).

**5,002,618**
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro, inventors; Canon Kabushiki Kaisha, assignee. *PIN Heterojunction Photovoltaic Elements with Polycrystal BaS(H,F) Semiconductor Film.* March 26, 1991.

A pin heterojunction photovoltaic element which generates photoelectromotive force by the junction of a p-type semiconductor layer, an i-type semiconductor layer and an n-type semiconductor layer, characterized in that at least one of said p-type and n-type semiconductor layers comprises a polycrystal semiconductor film comprised of boron atoms (B), arsenic atoms (As), hydrogen atoms (H), optionally fluorine atoms (F), and atoms (M) of a p-type or n-type dopant element, said polycrystal semiconductor film contains crystal grains of an average size in the range of 50 to 800 Å, and said polycrystal semiconductor film contains the hydrogen atoms (H) in an amount of 0.5 to 6 atomic %; said i-type comprises either (a) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F) or (b) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix, at least one kind of atoms selected from the group consisting of carbon atoms (C) and germanium atoms (Ge), and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F).

**5,002,796**
Nishida, Shoji, inventor; Canon Kabushiki Kaisha, assignee. *Process for Forming Functional Zinc Oxide Films Using Alkyl Zinc Compound and Oxygen-Containing Gas.* March 26, 1991.

A functional zinc oxide deposited thin film having high light permeability and low resistivity can be obtained at a low temperature of about 200°C, on an inexpensive substrate such as glass by a method of activating a starting material gas by means of activation energy, in a space different from a film-forming space thereby forming a precursor contributing to the formation of a deposited film, activating a starting material gas in a space different from the film-forming space and the space just mentioned above by means of activation energy thereby forming an active species wherein the starting material gas for forming the precursor is an alkyl zinc compound and the starting material for forming the active species is an oxygen gas or an ozone gas. This enables mass production of photovoltaic devices at high efficiency using a PN junction of PIN junction or high performance flat display device using liquid crystals, by which practical provision of power sources for domestic equipments or power sources for electric power appliance or large area display device can be obtained at a reduced cost.

**5,003,441**
Crowe, John R.; Cheatham, Gregory A., inventors. *Pop-Up Light Fixture.* March 26, 1991.

A terrain light fixture has a hollow body that is normally sunk within the ground, and a movable member disposed to telescope between a position retracted within the body and substantially flush with the ground surface and a position extended above the ground surface. The moveable member carries a light source, typically a 12 v.d.c. high intensity light bulb, that is energized in the extended position of the moveable member. The motive force to move the member is provided by an electrical lift mechanism, preferably either an electric motor or a shape-memory alloy. The motor- based lift mechanism operates equivalently to the power antenna of an automobile. The shape-memory alloy is typically configured as a spring. The application of electrical energization to both the light source and to the lift mechanism is preferably enabled by a switch that is responsive to sensed ambient light conditions. The energizing power may be external, or may be provided by an internal battery which is rechargeable from a solar array.

**5,003,866**
Ricci, Russell L., inventor. *Car Ventilator.* April 2, 1991.

A ventilator having a housing with first and second openings is mounted on structure of a vehicle and communicates directly with the vehicle cabin to move air between the vehicle cabin and the outside environment. The ventilator may be nonportably secured onto the vehicle structure on the windows, panels or the roof and provides a sleek low profile unit having a powered impeller to positively move air between the external environment and the vehicle cabin which impeller may be powered by a self-contained power supply connected with a charging source such as a photovoltaic panel and/or the vehicle's own electrical system. The ventilator may also be portably mounted on a ventilator insert placed within a partially rolled down window or a sunroof to temporarily utilize the circulating effects of the ventilator.

**5,006,082**
Hwang, Feng-Lin, inventor. *Actuating-Device for Small-Type Air-Feeded Water Floaters.* April 9, 1991.

An actuating device for small inflatable rafts or articles comprising a jaw clip for securing the device to the article, the clip having a top plate with solar cells mounted on the jaw clip upper rim, and a housing mounted to the jaw clip bottom.

The solar cell plate produces electric currents via sunshine, and a rechargeable battery in the housing is charged with electricity. The battery serves as a power source for an air pump in the housing to generate air pressure to inflate a raft or other article. The battery also serves as the power source for a motor in the housing which drives propellers on its output shaft thereby providing a means to propel the inflated raft or article in the water.

**5,006,179**
Gaddy, Edward M., inventor; Solarex Corporation, assignee. *Interconnect for Electrically Connecting Solar Cells*. April 9, 1991.

An interconnect for electrically connecting adjacent solar cells disposed in a solar cell array is disclosed. The interconnect is comprised of three parts: an elongated stress relief part disposed substantially parallel to adjacent side edges of the solar cells which are electrically connected by the interconnect; a first connecting part joined to a first end portion of the stress relief part and to the electrical contact of the first solar cells; and a second connecting part joined to the opposite end portion of the stress relief part and to the electrical contact of the adjacent solar cell. In this manner, stress induced in the interconnect as a result of thermal cycling of the solar cells electrically connected by the interconnect is significantly reduced as compared to prior art configurations to thereby increase the survivability and expected life of the interconnect. In addition, the removal and replacement of the connected solar cells is facilitated.

**5,006,180**
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro, inventors; Canon Kabushiki Kaisha, assignee. *PIN Heterojunction Photovoltaic Elements with Polycrystal Gap (H,F) Semiconductor Film*. April 9, 1991.

A pin heterojunction photovoltaic element which generates photoelectromotive force by the junction of a p-type semiconductor layer, an i-type semiconductor layer and an n-type semiconductor layer, characterized in that at least one of said p-type and n-type semiconductor layers comprises a polycrystal semiconductor film comprised of gallium atoms (Ga), phosphorus atoms (P), hydrogen atoms (H), optionally fluorine atoms (F), and atoms (M) of a p-type or n-type dopant element, said polycrystal semiconductor film contains crystal gains of an average size in the range of 50 to 1000 Å, and said polycrystal semiconductor film contains the hydrogen atoms (H) in an amount of 0.5 to 5 atomic %; and said i-type comprises either (a) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F) or (b) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix, at least one kind of atoms selected from the group consisting of carbon atoms (C) and germanium atoms (Ge), and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F).

**5,007,105**
Kudoh, Kazuhiro; Nishiyama, Toshirou; Anma, Sadayuki, inventors; NEC Corporation, assignee. *Watch Type Paging Receiver*. April 9, 1991.

A watch type paging receiver which may be put on person's wrist by a belt includes a body on which a display device such as a liquid crystal display device is provided. An inverted F-shaped main antenna is implemented by a part of the display device. A loop antenna is provided in addition to the main antenna and implemented by the belt. The main and loop antennas are selectively rendered active depending upon the level of a received signal. Even when the length of the belt is changed to suit person's wrist, accurate matching is established on the basis of the resulting length of the belt. A primary battery in the form of a solar battery and a secondary battery are associated with the receiver body and the belt, respectively. A vibration source which is adapted for tactual alerting forms a part of the belt.

**5,007,971**
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro, inventors; Canon Kabushiki Kaisha, assignee. *PIN Heterojunction Photovoltaic Elements with Polycrystal BP(H,F) Semiconductor Film*. April 16, 1991.

A pin heterojunction photovoltaic element which generates photoelectromotive force by the junction of a p-type semiconductor layer, an i-type semiconductor layer and an n-type semiconductor layer, characterized that at least one of said p-type and n-type semiconductor layers comprises a polycrystal semiconductor film comprised of boron atoms (B), phosphorus atoms (P), hydrogen atoms (H), optionally fluorine atoms (F), and atoms (M) of a p-type or n-type dopant element, said polycrystal semiconductor film contains crystal grains of an average size in the range of 50 to 800 Å, and said polycrystal semiconductor film contains the hydrogen atoms (H) in an amount of 0.5 to 7 atomic %; and i-type comprises either (a) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F), or (b) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix, at least one kind of atoms selected from the group consisting of carbon atoms (C) and germanium atoms (Ge), and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F).

**5,008,062**
Anderson, A. Jerome; Beze, Norman L., inventors; Siemens Solar Industries, assignee. *Method of Fabricating Photovoltaic Module.* April 16, 1991.

A photovoltaic panel is supported, sealed, and isolated from the environment by being encased in a reaction injection molded elastomer which encapsulates the back, sides, and a portion of the front side of the photovoltaic panel.

**5,008,579**
Conley, Jerry J.; Mortensen, Gary B., inventors; E.F. Johnson Company, assignee. *Light Emitting Polymer Electrical Energy Source.* April 16, 1991.

An electrical energy source is created by the combination of a light emitting polymer material having at least one light emitting surface emitting light energy of a specified frequency bandwidth and a photovoltaic cell having a light collecting surface and a pair of electrical contacts. The light collecting surface of the photovoltaic cell is optically coupled with the light emitting surface of the light emitting polymer material. An open-circuit voltage is generated between the pair of electrical contacts as a result of the absorption of emitted light energy from the light emitting polymer material by the photovoltaic cell. In the preferred embodiment, the light emitting polymer is a tritiated organic polymer to which at least one organic phosphor or scintillant is bonded. Maximum absorption of the emitted light energy is achieved by the intimate optical contact between the light emitting surface and the light collecting surface, by matching the maximum absorption frequency bandwidth of the photovoltaic cell with the specified frequency bandwidth of the emitted light energy from the light emitting polymer material, and by the structural arrangement of the light emitting polymer material itself.

**5,008,726**
Nakagawa, Katsumi; Ishihara, Shunichi; Kanai, Masahiro; Murakami, Tsutomu; Arao, Kozo; Fujioka, Yasushi; Sakai, Akira, inventors; Canon Kabushiki Kaisha, assignee. *PIN Junction Photovoltaic Element with P- or N-Type Semiconductor Layer Comprising Non-Single Crystal Material Containing Zn, Se, Te, H in Amount of 1 to 4 Atomic % and a Dopand and I-Type Semiconductor Layer Comprising Non-Single Crystal Si(H,F) Material.* April 16, 1991.

An improved pin junction photovoltaic element which causes photoelectromotive force by the junction of a p-type semiconductor layer, an i-type semiconductor layer and an n-type semiconductor layer, characterized in that at least one of said p-type semiconductor layer and said n-type semiconductor layer comprises a p-type or n-type $ZSnSe_{1-x}Te_x$:H:M film, where M is a dopant of p-type or n-type: the quantitative ratio of the Se to the Te is in the range of from 1:9 to 3:7 in terms of atomic ratio: the amount of the H is in the range of from 1 to 4 atomic %; and said film contains crystal grain domains in a proportion of 65 to 85 vol % per unit volume; and said i-type semiconductor layer comprises a non-single crystal Si(H,F) film or a non-single crystal Si(C,Ge)(H,F) film.

**5,009,243**
Barker, Owen P., inventor. *Solar Harness.* April 23, 1991.

The present invention is directed to a solar harness apparatus which includes a plurality of solar cells with each having an active surface, that is, a surface which absorbs photons to generate electrical power, and these are arranged in a substantially parallel fashion with the active surfaces all facing the same direction and with the solar cells being stacked in line behind one another. The solar harness includes a plurality of magnets with at least one magnet being located between each adjacent solar cell in the plurality of solar cells so as to hold the cells in the stacked arrangement without any further support and so as to create solderless contacts therewith. Means is connected to the stack for drawing electric current therefrom. Preferably, the magnets are at least partially wrapped or wound in electrically conductive material so that the conductivity in series is enhanced. Further, the solar harness apparatus may be employed in conjunction with a parabolic reflector so as to work with concentrated solar energy, it may be used in conjunction with means for converting electrical energy to transmittable wave energy and deployed extraterrestrially. Alternatively, the present invention solar harness apparatus may be reversed with power being put into it so as to create a wave energy transmission device.

**5,009,719**
Yoshida, Susumu, inventor; Mitsubishi Denki Kabushiki Kaisha, assignee. *Tandem Solar Cell.* April 23, 1991.

A tandem solar cell device includes an upper solar cell, a lower solar cell, and an intervening buffer layer. A short wavelength region of the incident light is absorbed by the upper solar cell while the light having passed through the upper solar cell is absorbed by the lower solar cell. The buffer layer is a semiconductor layer having a larger band gap energy than the upper solar cell, a crystalline lattice match with the upper solar cell, and a tunnel junction.

**5,009,720**
Hokuyo, Shigeru; Oda, Takao; Matsumoto, Hideo, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell.* April 23, 1991.

A solar cell for connection in series with a plurality of like cells to provide a solar generator which can produce a desired output voltage. The cell includes a photovoltaic section of compound semiconductor layers stacked on a semiconductor substrate to form a p-n

junction and a protective diode section electrically isolated from the photovoltaic section by a p-n junction. The photovoltaic and diode sections are connected in parallel and reverse polarity. The protective diode bypasses current in the solar generator when no light is incident on the photovoltaic section in parallel with the respective diode.

**5,009,721**
Matsumoto, Hideo; Hokuyo, Shigeru, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell.* April 23, 1991.

A solar cell device in which a plurality of solar cell elements are connected by interconnectors includes a metal film inserted between the electrode of the solar cell element and the interconnector, and the welded area between the metal film and the electrode is larger than the welded area between the metal film and the interconnector.

**5,010,040**
Vayman, Zinovy Y., inventor; Mobil Solar Energy Corporation, assignee. *Method of Fabricating Solar Cells.* April 23, 1991.

A method of forming a metallization pattern on a substrate used in the fabrication of a solar cell or other semiconductor device. The metallization pattern is formed by (1) hydrogen passivating a silicon substrate having a P/N junction formed therein adjacent one surface of the substrate, with a damaged surface layer being formed in conjunction with the hydrogen passivation process, and (2) laser annealing selected portions of said damaged layer whereby said selected portions form a metallization pattern to which selected metals will securely adhere when applied by immersion plating. The foregoing fabrication steps may be performed simultaneously.

A layer of material comprising $SiO_x$ may be redeposited on the one surface of the substrate as part of the hydrogen passivation procedure. In the laser annealing step, sections of the redeposited material scanned by the laser beam are ablated and the exposed underlying damaged surface layer is annealed.

**5,011,544**
Gaddy, Edward M.; Dominguez, Ramon, inventors; Solarex Corporation, assignee. *Solar Panel with Interconnects and Masking Structure and Method.* April 30, 1991.

A solar panel in which the bus-and-interconnect structures are visually masked, to improve not only aesthetics but also the operational characteristics of the panel. A transparent superstrate for the panel has on a surface juxtaposed to the radiation-receiving surfaces of the cells a pattern masking material just sufficient, with manufacturing tolerances, to mask the generally non-symmetrical interconnect structure in a substantially more uniform, symmetrical manner. The masking material may be matte-finish (paint) or highly reflective (a metallic deposit), and in either case may be applied by the same process (e.g., silk screen). The reflective mask structure inhibits heat build-up in the panel; and the matte-finish mask structure is generally unobtrusive and aesthetically pleasing, as required for example, in vehicular applications. A redundant bus structure yields surprisingly compact interconnects, with increased versatility in arrangement of grid patterns of collector electrodes, and is highly compatible with the masking structures and techniques.

**5,011,565**
Dube, Christopher E.; Gonsiorawski, Ronald C., inventors; Mobil Solar Energy Corporation, assignee. *Dotted Contact Solar Cell and Method of Making Same.* April 30, 1991.

A method of applying metallized contacts to a solar cell substrate, the front surface of which is covered with a dielectric layer. The method involves forming a plurality of apertures extending through the dielectric layer using a laser beam and defining a grid-shaped electrode. The apertures comprise a plurality of microscopically sized holes that are arranged in a series of rows, with the holes being spaced a relatively short distance from one another. Nickel is plated onto the portions of the substrate exposed through the apertures. The nickel plating is then overcoated with copper which is preferably applied by a contactless light-induced plating process. The copper plating process causes copper to be deposited so that it bridges over the dielectric layer between the holes so as to form an integrated grid electrode structure.

**5,011,567**
Gonsiorawski, Ronald C., inventor; Mobil Solar Energy Corporation, assignee. *Method of Fabricating Solar Cells.* April 30, 1991.

A method of forming a metallization pattern on a solar cell substrate having an outer layer of a selected dielectric such as silicon nitride, silicon dioxide, or glass, by removing selected portions of the dielectric layer with a laser beam. This laser exposure drives portions of the P/N junction positioned beneath the exposed regions of the substrate more deeply into the substrate. Removal of selected portions of the dielectric layer exposes regions of the silicon substrate on which conductors may be deposited by conventional immersion plating methods. This laser removal of the dielectric layer is effected in an environment substantially free of chemical etching substances. Following removal of the selected portions of the dielectric layer, the substrate is preferably immersed in a buffered oxide etch solution to remove residual silicon dioxide and is then preferably immersed in a high ratio (nitric acid to hydrofluoric acid) etch solution to remove residual silicon nitride. The method of forming a metallization pattern may be

incorporated into a comprehensive solar cell fabrication process.

**5,011,706**
Tarhay, Leo; Sharp, Kenneth G., inventors; Dow Corning Corporation, assignee. *Method of Forming Coatings Containing Amorphous Silicon Carbide*. April 30, 1991.

The invention is a method of forming a continuous coating of amorphous silicon carbide on the surface of articles by plasma enhanced chemical vapor deposition. In the method, the chemical vapor comprises a silicon-containing cyclobutane, such as a silacyclobutane or a 1,3-disilacyclobutane. The coatings formed by the invention are useful for application to solar cells, for preventing corrosion of electronic devices, for forming interlevel dielectric layers between metallization layers of electronic devices, and for providing abrasion resistance to surfaces.

**5,011,759**
Hitotsuyanagi, Hajime; Fujita, Nobuhiko; Itozaki, Hideo; Nakagama, Syoji; Tanaka, Saburo; Fukushima, Kazuhiko, inventors; Sumitomo Electric Industries, Ltd., assignee. *Semiconductor Element and Method of Forming Same and Article in Which Said Element is Used*. April 30, 1991.

The present invention relates to a semiconductor element and a method of forming the same and various kinds of articles in which said element is used.

Any material selected from the group consisting of $SiH_4$, $Si_2H_6$, and $SiF_4$, and $GeH_4$ or $GeF_4$, are used as raw material gases. $H_2$ is used as a diluent gas if necessary. A photochemical gas phase vapor deposition method is used, at a pressure of 0.1 to 20 Torr, an optical intensity of 10 to 1,000 $mW/cm^2$, and a substrate temperature of 50° to 250° C. A semiconductor element formed of a-SiGe:H film having superior photoelectric conductivity, a method of forming a semiconductor element film containing Ge added thereto and having high long wave length-sensitivity and superior film quality can be provided. In addition, various kinds of articles such as a solar cell having superior long wave length-sensitivity in which said element is used in a carrier-producing layer, an electrophotographic sensitive member containing said element in a carrier-producing layer, and an image sensor, in which said element is used in a carrier-producing layer, having superior long wave length-sensitivity can be provided.

**5,011,782**
Lamb, Walter R.; Griffin, Darrell, inventors; Electric Power Research Institute, assignee. *Method of Making Passivated Antireflective Coating for Photovoltaic Cell*. April 30, 1991.

The performance of a silicon photovoltaic cell is improved while process yield is maintained by first forming doped regions in a major surface of a silicon wafer and providing electrical interconnections to the doped regions prior to thinning the wafer by etching another major surface of the wafer. A passivating antireflection layer is applied to the etched surface after the surface is precleaned. The precleaning can be by ammonia plasma applied in situ as a precursor to depositing silicon nitride as the passivation layer.

**5,012,113**
Valentine, Kenneth H.; Falter, Diedre D.; Falter, Kelly G., inventors; Martin Marietta Energy Systems, Inc., assignee. *Infrared System for Monitoring Movement of Objects*. April 30, 1991.

A system for monitoring moving objects, such as the flight of honeybees and other insects, using a pulsed laser light source. This system has a self-powered micro-miniaturized transmitting unit powered, in the preferred embodiment, with an array solar cells. This transmitting unit is attached to the object to be monitored. These solar cells provide current to a storage energy capacitor to produce, for example, five volts for the operation of the transmittor. In the simplest embodiment, the voltage on the capacitor operates a pulse generator to provide a pulsed energizing signal to one or more very small laser diodes. The pulsed light is then received at a receiving base station using substantially standard means which converts the light to an electrical signal for processing in a microprocessor to create the information as to the movement of the object. In the case of a unit for monitoring honeybees and other insects, the transmitting unit weighs less than 50 mg, and has a size no larger than 1 x 3 x 5 millimeters. Also, the preferred embodiment provides for the coding of the light to uniquely identify the particular transmitting unit that is being monitored. A "wake-up" circuit is provided in the preferred embodiment whereby there is no transmission until the voltage on the capacitor has exceeded a pre-set threshold. Various other uses of the motion-detection system are described.

**5,012,160**
Thompson, Kathleen D. Dunn, inventor; Colorado Instruments, Inc., assignee. *Accordion Mount for Solar Cells Including Point-of-Purchase Display with LEDS*. April 30, 1991.

A display assembly particularly for the point-of-purchase field utilizes a light source to power the display. A solar cell is electrically connected, through a simple flashing circuit, to an array of light emitting diodes (LEDs). The diodes have a current usage of about 2 ma or less; e.g., they may be double heterojunction AlGaAs/GaAs material. The circuit has a current drain of about 0.1 ma or less. The solar cell may be mounted between an artificial light source (such as a fluorescent bulb) and a surrounding metal housing by sheet material having an undulating (e.g., accordion) configuration. Transparent UV-inhibited plastic film tape may attach the solar cell to a central undulation of the

sheet material while magnets strips attach side edges of the sheet material to a metal housing, so that the solar cell is in close proximity to (e.g., touches) the light source.

**5,012,220**
Miller, Moses, inventor. *Solar Powered Paging Device*. April 30, 1991.

A kit for providing solar power to a battery powered paging device. The kit includes a pair of mounting posts which are affixed to the pager and a module having strips of solar cells which is demountably attached to the mounting posts. The pair of strips of solar cells are attached in series to connecting terminal strips by biasing contact springs.

**5,012,457**
Mitchell, Thomas R.; Landesman, Robert E., inventors. *Aquatic Transducer System*. April 30, 1991.

An underwater transducer system reproduces high-fidelity audio signals underwater, and detects and monitors low levels of sound activity, both adjacent to a body of water such as a swimming pool, and in the water. The system includes an underwater housing for a diaphragm that directly contacts the water, a coil assembly movable within the housing and rigidly connected to the center of the diaphragm by a tubular member of the coil assembly engaging a cylindrical boss portion of the diaphragm. The housing can be suspended by an elongated cord member from a wall coping, or mounted within a wall fixture structure. The system can have a source of illumination, a conduit from the source terminating in the housing on the coil axis proximate the diaphragm, and an optical element sealingly protrudes the diaphragm for transmitting light-amplified illumination into the water. A head portion of the optical element that substantially fills the boss portion of the diaphragm incorporates a pair of mirrored surfaces for spreading the illumination and transmitting it into the water. A control unit located to one side of the water provides a speaker mode and a microphone mode of operating the transducer, the microphone mode having a monitor mode and an alarm mode for detecting an alarm condition based on discrimination of an alarm sound condition occurring in the pool. The control unit can also interface a closed circuit TV for visually monitoring the pool. Also disclosed is a method for making the underwater transducer.

**5,012,619**
Knepprath, Vernon E.; Levine, Jules D., inventors; Texas Instruments Incorporated, assignee. *Method and Apparatus for Forming Spheres*. May 7, 1991.

A method and apparatus for forming silicon spheres from irregular-shaped particles for use in solar cells are disclosed. The apparatus generally creates a gas vortex inside the chamber. This vortex induces the repeated collision of the particles against the abrasive lining to eventually form the silicon spheres and simultaneously sizing the silicon spheres.

**5,013,417**
Judd, Jr., Lawrence M., inventor. *Water Purifier*. May 7, 1991.

A water purifier including a floating body having two parallel disk shaped electrodes extending into the water. The polarity between the disks is alternated at predetermined intervals to avoid plating. The disks are preferably made of a copper/silver alloy. Preferably the device is powered by a photovoltaic panel attached to a skimmer cover. Alternatively, the device can be powered by a photovoltaic panel laminated to the top or the device can be configured for insertion into a pipe plug unit that can be used in connection with a pipe T.

**5,013,972**
Malkieli, Moshe; Apel, Israel, inventors; Samuel Kaner, assignee. *Dual-Powered Flickering Symbolic or Religious Light (Electronic Yahrzeit)*. May 7, 1991.

An eternal symbolic/religious memorial light having a flickering-candle appearance generated electronically by at least a pair of lamps and to the lamps in accordance with the background lighting conditions. Thus, the flickering appearance is made brighter during daylight when this is required in order to see the candle, and at nightfall, the brightness is diminished as the candle is more easily visible. In another alternative embodiment, the solar cells continuously run a user-programmed calendar/timer to turn on the lamp units only on specified memorial/anniversary days.

**5,015,086**
Okaue, Etsuo; Egawa, Masaru; Kasai, Yoshihiko; Horaguchi, Norio, inventors; Seiko Epson Corporation, assignee. *Electronic Sunglasses*. May 14, 1991.

Electronic sunglasses of the transmittance-varying type including liquid crystal panels employing the electro-optical effect and a solar cell using as a power source. The electronic sunglasses include a voltage detecting circuit having such a hysteresis characteristic so as to output a signal for changing transmittance of the liquid crystal panel from a high mode to a low mode at at least high predetermined voltage or illumination, and changing transmittance from a low mode to a high mode at at least a low voltage or illumination. The sunglasses also include a first switch which operates at at least two switch positions, one switch position having a first stage of illumination at less than 20,000 Lux and a second stage of illumination at 20,000 Lux or greater at which transmittance is changed from a high mode and another switch position disabling the voltage detecting circuit. Also included is a second switch which operates to change transmittance from a high mode to a low mode independently of the set voltage value in the voltage detecting circuit according to the hysteresis effect.

**5,017,243**
Otsubo, Mutsuyuki, inventor; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell and a Production Method Therefor.* May 21, 1991.

A solar cell includes a first conductivity type semiconductor substrate, a second conductivity type semiconductor layer disposed at a first surface of the semiconductor substrate, a first electrode disposed on the semiconductor layer, a second electrode disposed on the first semiconductor substrate opposite the layer, a connection electrode disposed on the first surface of the semiconductor substrate insulated from the semiconductor layer, and an electrically conducting layer electrically connecting the second electrode and the connection electrode extending in the direction of the thickness of the semiconductor substrate. Since the first electrode and the connection electrode of the solar cell are both disposed on the first surface of the semiconductor substrate, the interconnection of a pair of adjacent solar cells is greatly simplified.

**5,017,308**
Iijima, Shigeru; Tanaka, Kazunobu; Matsuda, Akihisa; Matsumura, Mitsuo; Yamamoto, Hideo, inventors; Toa Nenryo Kogyo K.K., assignee. *Silicon Thin Film and Method of Producing the Same.* May 21, 1991.

A silicon thin film is composed of primarily silicon atoms, 0 to 8 atm % hydrogen, at least one element selected from the group including fluorine, chlorine, bromine and iodine and an impurity element, wherein about 80% to 100% of microcrystalline grains are interspersed in an amorphous phase. The thin film is produced by deposition on a substrate in a plasma atmosphere using as a raw material gas silane ($SiH_4$) or halogenated silane ($SiH_{0-3}X_{4-1}$) wherein X represents a halogen or a combination of two or more halogens, and a dopant gas mixed with the raw material gas. The method comprises the steps of: (1) diluting the mixed gas with hydrogen in a ratio of the diluting gas to the raw material gas of from 50:1 to 100:1, to control the film deposition rate to produce a layer including mixed crystalline and amorphous substances; and (2) applying an electric power to provide a plasma discharge power density of from 0.1 to about 0.5 $W/cm^2$, at a reaction pressure of 5 to 10 torr.

**5,017,521**
Yale, Brian; Fyles, Kenneth M., inventors; Pilkington plc, assignee. *Borosilicate Glass Compositions Incorporating Cerium Oxide.* May 21, 1991.

A low alkali borosilicate glass composition comprising 60% to 78% by weight of $SiO_2$, 10% to 25% by weight of $B_2O_3$, 3.5% to 6.0% by weight of $R_2O$, wherein $R_2$ represents $Na_2O$, $K_2O$ and/or $Li_2O$, 2.0% to 6.5% by weight of $CeO_2$, and 0.25% to 8.0% by weight of $Sb_2O_3$ and/or $As_2O_3$, the percentages being based on the total weight of the glass composition. The glass composition of the invention are suitable for use as protective covers for solar cells, especially solar cells which are used in satellites.

**5,019,176**
Brandhorst, Jr., Henry W.; Weinberg, Irving, inventors; The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, assignee. *Thin Solar Cell and Lightweight Array.* May 28, 1991.

A thin, lightweight solar cell utilizes front contact metallization. Both the front light receiving surface of the solar cell and the facing surface of the cover glass are recessed to accommodate this metallization. This enables the two surfaces to meet flush for an optimum seal.

**5,019,177**
Wanlass, Mark W., inventor; The United States of America as represented by the United States Department of Energy, assignee. *Monolithic Tandem Solar Cell.* May 28, 1991.

A single-crystal, monolithic, tandem photovoltaic solar cell is described which includes (a) an InP substrate having upper and lower surfaces, (b) a first photoactive subcell on the upper surface of the InP substrate, and (c) a second photoactive subcell on the first subcell. The first photoactive subcell is GaInAsP of defined composition. The second subcell is InP. The two subcells are lattice matched. The solar cell can be provided as a two-terminal device or a three-terminal device.

**5,020,150**
Shannon, John, inventor. *Combination Radio and Eyeglasses.* May 28, 1991.

A combination of a radio and eyeglasses includes an antenna that is wrapped around the lenses of the eyeglasses and extends across the nose bridge element to obtain improved reception. The radio includes a power source that has a battery and a solar energy converter so the radio can be played for great lengths of time. Earphones are mounted on the skull pieces of the eyeglass frames to be placed in a wearer's ear.

**5,020,232**
Whiteford, Carlton L., inventor. *Illuminated Level.* June 4, 1991.

The bubble vials of a carpenter's level are individually illuminated by a respective light emitting diode (LED) energized from a battery supported within the body of the level. Charge on the batteries is maintained by one or more solar cells mounted on an exterior surface of the body, and the LEDs are energized by a control

circuit including a normally open manually actuable switch and a pair of mercury switches supported within the body at different fixed orientations relative thereto such that one of them closes when the body is horizontally oriented to apply voltage to the LED for the horizontal bubble vial, and the other closes when the body of the level is vertically oriented and connects the battery to the LED for the bubble vials of the plumbing levels. Thus, the circuit automatically illuminates only the bubble vial, or vials, that need to be illuminated in order to observe the position of the bubble for the orientation selected by the user.

**5,020,919**
Suomi, Verner K., inventor; Wisconsin Alumni Research, assignee. *Heat Flow Sensing Apparatus and Method.* June 4, 1991.

An apparatus for determining heat flow at an interface between a water surface and the atmosphere comprising a floatable transparent panel member having a lower surface in contact with the water and an upper surface covered with a thin layer of water. A plurality of thermocouples are carried on both surfaces of the panel member for sensing the temperature of the water and the water layer in contact with the atmosphere. Electronic circuit means operatively associated with the thermocouple means records the temperature readings whereby the difference between the temperatures provides a measure of the heat flow at the interface.

**5,021,099**
Kim, Namsoo P.; Stanbery, Billy J., inventors; The Boeing Company, assignee. *Solar Cell Interconnection and Packaging Using Tape Carrier.* June 4, 1991.

Individual solar cells are electrically interconnected through an interconnect circuit supported on a flexible dielectric substrate. The solar cells are connected directly to the interconnect circuit by contact fingers that are an integral part of the interconnect circuit. The interconnection of the individual solar cells can be accomplished by manual or automated process.

**5,021,100**
Ishihara, Takashi; Sasaki, Hajime; Aiga, Masao, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Tandem Solar Cell.* June 4, 1991.

A multiple cell photovoltaic device includes first and second serially connected solar cells and a conductive or dielectric selective reflection film therebetween. The thickness of the selective reflection film is chosen to reflect short wavelength light which may be absorbed by the second solar cell and to transmit long wavelength light which is not absorbed by the second solar cell and may be absorbed by the first solar cell. When the selective reflection film comprises a dielectric material, apertures are provided in the selective reflection film for serial electrical connection of the two cells.

**5,021,103**
Hamakawa, Yoshihiro; Okamoto, Hiroaki; Hattori, Yutaka, inventors; Nippon Soken, Inc.; Nippondenso, Co., Ltd.;, assignee. *Method of Forming Microcrystalline Silicon-Containing Silicon Carbide Film.* June 4, 1991.

A microcrystalline silicon-containing silicon carbide semiconductor film has an optical energy gap of not less than 2.0 eV and a dark electric conductivity of less than $10^{-6}Scm^{-1}$. The Raman scattering light of the microcrystalline silicon-containing silicon carbide semiconductor film, which shows the presence of silicon crystal phase, has a peak in the vicinity of 530 $cm^{-1}$. This microcrystalline silicon-containing silicon carbide semiconductor film is formed on a substrate by preparing a mixture gas having a hydrogen dilution rate y, which is the ratio of the partial pressure of hydrogen gas to the sum of the partial pressure of a silicon-containing gas and the partial pressure of a carbon-containing gas, of 30, transmitting microwave of a frequency of not less than 100 MHz into the mixture gas near a substrate with an electric power density of not less than $4.4 \times 10^{-2}$, and generating plasma at a temperature of the substrate of not less than 200°C, and under a gas pressure of not less than $10^{-2}$ Torr.

**5,021,715**
Smith, Norman D.; Smith, Dresden G., inventors. *Lighting System for Roadside Signs.* June 4, 1991.

A system including a telescopic switch and method of operation is disclosed for intermittently illuminating a roadside sign in response to a vehicle passing along a selected portion of the road, the system including a lighting element for illuminating the sign and a telescopic switch including a circuit for transmitting the control signal to the lighting element, a photocell for initiating the control signal and a telescopic lens for focusing the photocell on the selected road portion whereby the photocell is capable of sensing lights on a vehicle passing along the selected road portion in order to initiate the control signal and cause the lighting element to illuminate the sign.

**5,022,381**
Allegro, Joseph, inventor. *Barrel-Shaped Solar Roofing Element and Method for Its Assembly.* June 11, 1991.

Shingles are formed of a top sheet and a bottom sheet of plastic confining solar energy conversion means therebetween. The sheets are sealed together about a perimeter to form flanges for fastening in overlapped order to a roof. The contour of the shingles is domed to provide for better solar energy conversion efficiencies. Insulation and support members disposed along an underside of the dome structure provide support to the assembly and insulate the roof. Decorative structure and

shingles of this nature permit a roof surface which does not belie its nature as a solar heating system. The plastic sheets may either form flow passageways for a solar heatable fluid or may encompass photovoltaic cells to form unitary shingle-solar conversion structure.

**5,022,929**
Gallois-Montbrun, Roger, inventor. *Solar Collector*. June 11, 1991.

The improved solar collector of the present invention is constituted by a roof-shaped structure serving as a support for a front and rear panel in the form of elongated rectangles having the same dimensions as the faces of the said structure, on which various solar energy collecting means are mounted, and whose top longitudinal edges are hinged to a common rotation axis coinciding with the ridge line of the structure.

Combined with a support, this roof-shaped structure forms an assembly which, by means of appropriate mechanisms, can move about a vertical rotation axis.

The solar collector is also provided with two different orientation systems: (1) the first system, operating in azimuth, enables the moving assembly to rotate about its vertical axis, with its plane solar collectors facing the sun; (2) the second system, operating in elevation, enables the front and back panels to rotate about their common horizontal axis and keep the same inclinations, normal to the sun's rays. This second orientation system constitutes the main improvement brought by the present invention to this solar collector device.

**5,022,930**
Ackerman, Bruce; Albright, Scot P.; Jordan, John F., inventors; Photon Energy, Inc., assignee. *Thin Film Photovoltaic Panel and Method*. June 11, 1991.

A thin film photovoltaic panel includes a backcap for protecting the active components of the photovoltaic cells from adverse environmental elements. A spacing between the backcap and a top electrode layer is preferably filled with a desiccant to further reduce water vapor contamination of the environment surrounding the photovoltaic cells. The contamination of the spacing between the backcap and the cells may be further reduced by passing a selected gas through the spacing subsequent to sealing the backcap to the base of the photovoltaic panels, and once purged this spacing may be filled with an inert gas. The techniques of the present invention are preferably applied to thin film photovoltaic panels each formed from a plurality of photovoltaic cells arranged on a vitreous substrate. The stability of photovoltaic conversion efficiency remains relatively high during the life of the photovoltaic panel, and the cost of manufacturing highly efficient panels with such improved stability is significantly reduced.

**5,023,144**
Yamamoto, Shigeru; Mori, Satoru; Hayashi, Akira, inventors; Mitsubishi Metal Corporation, assignee. *Silver Alloy Foil for Interconnector for Solar Cell*. June 11, 1991.

There is disclosed a silver alloy foil for an interconnector of a solar cell. The silver alloy contains 10 ppm to 1,000 ppm of calcium; 10 ppm to 750 ppm of at least one element selected from the group consisting of beryllium, lanthanum and indium; balance silver and unavoidable impurities. The alloy is less susceptible to softening even when the solar cell is exposed to temperature cycling. If calcium is further added, the hardness does not decrease even with the passage of time, to thereby exhibit superior characteristics for a prolonged period of time.

**5,023,595**
Bennett, Charles S., inventor. *Mail Arrival Signal System*. June 11, 1991.

A remote solar powered radio frequency transmitter assembly and radio receiving and signalling system to indicate delivery of mail. The means is powered by a rechargeable battery system which is normally recharged by solar cells located on the transmitter means housing. The transmitter comprises an FM radio transmitter operating in the 49 Mhz band, with a signal stretch sufficient for providing an alarm signal to receive at least 4200 feet distant over unbroken terrain. Upon opening of the mailbox door approximately 30 degrees, a switch initiates a 6-second operation of the transmitter means. A receiver is provided to detect the radiated signal, and to energize visual and audible signals in response thereto. Ten position DIP switches are provided at both transmitter means and receiver to vary the frequency of operation so as to minimize or eliminate interfering signals. The transmitter means is secured to the mailbox by a single attachment post. A jack plug and flexible cord are provided to connect the transmitter means and the switch. The switch is provided with a flat backing plate having a double sided adhesive for ease of installation. The audible alarm at the receiver comprises a digitally generated musical tune. The musical tune automatically stops after about 20 seconds, unless the receiver is reset sooner. Reset of the receiver turns off both the musical tune audible alarm and the flashing light visual alarm.

**5,024,706**
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro, inventors; Canon Kabushiki Kaisha, assignee. *PIN Heterojunction Photovoltaic Elements with Polycrystal ALP(H,F) Semiconductor Film*. June 18, 1991.

A pin heterojunction photovoltaic element which generates photoelectromotive force by the junction of a p-type semiconductor layer, an i-type semiconductor layer

and an n-type semiconductor layer, characterized in that at least one of said p-type and n-type semiconductor layers comprises a polycrystal semiconductor film comprised of aluminum atoms (Al), phosphorus atoms (P), hydrogen atoms (H), optionally fluorine atoms (F), and atoms (M) of a p-type or n-type dopant element, said polycrystal semiconductor film contains crystal grains of an average size in the range of 50 to 1000 Å, and said polycrystal semiconductor film contains the hydrogen atoms (H) in an amount of 0.5 to 5 atomic %; said i-type comprises a either (a) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F) or (b) a non-single crystal semiconductor film containing silicon atoms (Si) as a matrix, at least one kind of atoms selected from the group consisting of carbon atoms (C) and germanium atoms (Ge), and at least one kind of atoms selected from the group consisting of hydrogen atoms (H) and fluorine atoms (F).

**5,024,953**
Uematsu, Tsuyoshi; Saitoh, Tadashi, inventors; Hitachi, Ltd., assignee. *Method for Producing Opto-Electric Transducing Element*. June 18, 1991.

An opto-electric transducing element and a method for producing the same use a corrugated semiconductor substrate to produce an opto-electric transducing element. The element has a reduced effective thickness and an improved opto-electric conversion efficiency, while maintaining the mechanical strength.

**5,025,202**
Ishii, Akihiko; Honda, Yukihiro; Matsui, Toshio, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell Power System with a Solar Array Bus Lockup Cancelling Mechanism*. June 18, 1991.

A solar cell power system includes a device which determines the occurrence of solar array bus lockup by detecting the voltage of the power bus, the discharge current of the storage battery, and the solar array current (or the load current) and performing a calculation using these items of data in addition to the regulated bus voltage to emit a lockup signal, by which the magnitude of the load is reduced, thereby cancelling the lockup state. Alternatively, a solar cell system may include a lockup cancelling drive device, which accumulates in a coil cancelling drive, energy supplied from the storage battery and then discharges this energy to the power bus, thereby cancelling the lockup stage without reducing the magnitude of the load.

**5,027,051**
Lafferty, Donald L., inventor. *Photovoltaic Source Switching Regulator with Maximum Power Transfer Efficiency Without Voltage Change*. June 25, 1991.

For matching the electrical impedance of a photovoltaic power source and a load, a switching regulator circuit has properties especially suited to the conversion of photovoltaic power to electric power. The circuit regulates the source voltage for maximum power output and supplies a load voltage equal to the regulated source voltage. The circuit comprises two branches: one in which a switching transistor, a diode, and filter components provide a positive voltage; and the other in which similar components in a different configuration provide a negative voltage. The load voltage is the sum of these and is equal to the input voltage. Since the source voltage is substantially constant, the switching regulator in effect converts the photovoltaic power source to a constant-voltage source. The circuit provides improved performance and thus enhances the utility of photovoltaic power sources.

**5,028,274**
Basol, Bulent M.; Kapur, Vijay K., inventors; International Solar Electric Technology, Inc., assignee. *Group I-III-$VI_2$ Semiconductor Films for Solar Cell Application*. July 2, 1991.

This invention relates to an improved thin film solar cell with excellent electrical and mechanical integrity. The device comprises a substrate, a Group I-III-$VI_2$ semiconductor absorber layer and a transparent window layer. The mechanical bond between the substrate and the Group I-III-$VI_2$ semiconductor layer is enhanced by an intermediate layer between the substrate and the Group I-III-$VI_2$ semiconductor film being grown. The intermediate layer contains tellurium or substitutes therefor, such as Se, Sn, or Pb. The intermediate layer improves the morphology and electrical characteristics of the Group I-III-$VI_2$ semiconductor layer.

**5,028,488**
Nakagawa, Katsumi; Ishihara, Shunichi; Kanai, Masahiro; Murakami, Tsutomu; Arao, Kozo; Fujioka, Yasushi, inventors; Canon Kabushiki Kaisha, assignee. *Functional $ZnSe_{1-x}Te_x$:H Deposited Film*. July 2, 1991.

A functional $ZnSe_{1-x}Te_x$:H film having a high doping efficiency and with no substantial change in the characteristics upon light irradiation. Said film is characterized in that the Se/Te quantitative ratio is in the range from 3:7 to 1:9 by the atom number ratio, hydrogen atoms are contained in an amount of 1 to 4 atomic % and the ratio of the crystal grain domains per unit volume is in the range from 65% to 85% by volume. There are also provided improved p-type and n-type $ZnSe_{1-x}Te_x$:H:M films (M stands for a dopant) of high electroconductivity characterized in the foregoing way.

These deposited films may be efficiently deposited even on a non-single-crystal substrate made of metal, glass, or synthetic resin with a high deposition rate.

These films are suited for the preparation of a high functional device such as a photovoltaic element.

**5,028,546**
Hotchkiss, Gregory B., inventor; Texas Instruments Incorporated, assignee. *Method for Manufacture of Solar Cell with Foil Contact Point.* July 2, 1991.

Solar cells formed of semiconductor discrete spheres of p-type interior having an n-type skin are disclosed. The semiconductor spheres are pressed between a pair of aluminum foil members. A plurality of metal pads are formed to the p-type material of the discrete spheres to provide electrical contacts. The aluminum foils are flexible and electrically insulated from one another. One of the foils is electrically connected to the n-type skin of the discrete semiconductor sphere, and the other is electrically connected to the p-type interior of the sphere by means of the metal pads. The cells are patterned in a foil matrix forming an array. Multiple arrays can be interconnected to form a module of solar cell elements for converting sunlight into electricity.

**5,029,342**
Stein, Marc F.; O'Mara, Bradley, inventors. *Welder's Helmet and Photovoltaic Power Transmission Circuit Therefor.* July 9, 1991.

A welder's helmet including a panel of solar cells responsive to light generated by a welding operation to drive a fan incorporated in the helmet structure. The solar cells are mounted on the helmet above the viewing window and the fan is mounted in front of the mask below the viewing window. When a welding arc is struck, the light from the torch impinges on the solar panel and generates sufficient electricity to drive the fan. The fan forces air from the inside of the helmet outward through the front face in a velocity controlled stream carefully directed to prevent smoke and fumes from reaching the helmet, and to also blow the smoke away from the weld site in a particular manner so that visibility of the weld remains clear while not over-oxygenating the weld site. As air is exhausted from the inside of the helmet outward by the fan, fresh air is drawn in around the sides to replace that which is being exhausted to cool the welder and prevent ingestion of fumes and vapors. A photovoltaic power transmission circuit is provided to process electrical energy derived from light such as that produced by the arc of an arc welder during a welding operation.

**5,029,428**
Hiraki, Yoshiharu, inventor; Yoshida Kogyo K. K., assignee. *Solar Cell Panel Assembly for Driving Motor-Driven Screen Device.* July 9, 1991.

A solar cell panel assembly for supplying power to a motor-driven screen device incorporated in a double-glazed sliding door unit, comprises a strip-like solar cell panel provided in a lower portion of an inner surface of an outer windowpane of the door unit so as to abut on the inner surface of the outer windowpane in facing engagement therewith; and an elongated solar collector or Fresnel lens a rear surface of which abuts on a lower portion of an outer surface of the outer windowpane in front of the strip-like solar cell panel. The solar cell panel assembly further comprises: a strip-like sunlight reflector provided below the elongated solar collector, which reflector has a reflective surface facing upward.

**5,030,295**
Swanson, Richard M.; Gan, Jon-Yiew; Gruenbaum, Peter E., inventors; Electric Power Research Institute, assignee. *Radiation Resistant Passivation of Silicon Solar Cells.* July 9, 1991.

The interface of a silicon oxide passivation layer and a silicon substrate in a silicon solar cell is stabilized by covering the silicon oxide passivation layer with a layer of undoped or phosphorus doped polycrystalline silicon. A second layer of silicon oxide is formed by deposition on the surface of the phosphorus doped polycrystalline and enhances the anti-reflection characteristics of the composite structure.

**5,030,476**
Okamura, Ryuji; Otoshi, Hirokazu; Takei, Tatsuya, inventors; Canon Kabushiki Kaisha, assignee. *Process and Apparatus for the Formation of a Functional Deposited Film on a Cylindrical Substrate by Means of Microwave Plasma Chemical Vapor Deposition.* July 9, 1991.

A process for forming a functional deposited film which is adapted for use in an apparatus which comprises a substantially enclosed reaction chamber, a plurality of cylindrical substrates arranged to surround a discharge space and a microwave introduction means provided at least at one end of each cylindrical substrate and wherein microwave energy is introduced so that a glow discharge plasma containing reactant gases derived from starting gases is formed in the discharge space thereby forming a deposited film on each cylindrical substrate is described. The process is characterized in that a temperature control means is provided in the inside of each of said plurality of cylindrical substrates and simultaneous with the introduction of a thermally conductive gas, the thermally conductive gas is exhausted from the one end of each cylindrical substrate in the vicinity of the microwave introduction means. The process enables the deposited film of a good quality to be formed stably at high speed and the deposited film is useful as an element member for semiconductive devices, photosensitive devices for electrophotography, photovoltaic devices, other electronic elements and optical elements.

**5,030,743**
McDowell, Mathew E., inventor. *Organometallic Solar Voltaic Storage Cell.* July 9, 1991.

The present invention provides novel metal complexes and solutions containing the complexes which are useful for converting light energy into electrical energy. The complexes are formed by complexing certain metals, such as iron, with a carboxyl compound, chloride and ammonia to form a complex having carboxyl ligands, chloride ligands and ammonia ligands. The preferred carboxyl compound is citric acid, acetic acid or salts thereof. The invention also provides a solar cell which comprises a transparent container which contains a pair of electrodes immersed in the metal complex.

**5,032,472**
Michel, Christian G.; Schachter, Rozalie; Kuck, Mark A.; Baumann, John A.; Raccah, Paul M., inventors; Stauffer Chemical Company, assignee. *Films of Catenated Phosphorus Materials, Their Preparation and Use, and Semiconductor and Other Devices Employing Them.* July 16, 1991.

High phosphorus polyphosphides, namely $MP_x$, where M is an alkali metal (Li, Na, K, Rb, and Cs) or metals mimicking the bonding behavior of an alkali metal, and x = 7 to 15 or very much greater than 15 (new forms of phosphorus) are useful semiconductors in their crystalline, polycrystalline and amorphous forms (boules and films). $MP_{15}$ appears to have the best properties and $KP_{15}$ is the easier to synthesize. P may include other pnictides as well as other trivalent atomic species. Resistance lowering may be accomplished by doping with Ni, Fe, Cr, and other metals having occupied d or f outer electronic levels; or by incorporation of As and other pnictides. Top contacts forming junction devices doped with Ni and employing Ni as a back contact comprise Cu, Al, Mg, Ni, Au, Ag, and Ti. Photovoltaic, photoresistive, and photoluminescent devices are also disclosed. All semiconductor applications appear feasible.

These semiconductors belong to the class of polymer forming, trivalent atomic species forming homatomic, covalent bonds having a coordination number slightly less than 3. The predominant local order appears to be all parallel pentagonal tubes in all forms, including amorphous, except for the monoclinic and twisted fiber allotropes of phosphorus.

**5,032,527**
Maeba, Masayoshi; Kadonome, Nobuo; Takabatake, Yoshinobu, inventors; Sanyo Electric Co., Ltd., assignee. *Method of Forming Lead-Out Electrode Portion of Photovoltaic Device.* July 16, 1991.

A method of forming a lead-out electrode in an integrated-type photovoltaic device including photoelectric conversion cells connected to each other in series on a transparent substrate is to form a lead-out electrode portion or section by separating a laminate of a semiconductor photoactive layer and a back electrode layer into back electrode and lead-out portions by means of a scanned laser beam. The major part of the lead-out electrode portion is elongated and has, at the opposite end, enlarged sections for receiving external lead wires or conductors. Accordingly, the lead-out electrode portion occupies only a small area in the substrate and can be formed easily by scanning with a laser beam.

**5,032,717**
Roose, Lars D., inventor; The United States of America as represented by the United States Department of Energy, assignee. *Remote Control for Anode-Cathode Adjustment.* July 16, 1991.

An apparatus for remotely adjusting the anode-cathode gap in a pulse power machine has an electric motor located within a hollow cathode inside the vacuum chamber of the pulse power machine. Input information for controlling the motor for adjusting the anode-cathode gap is fed into the apparatus using optical wave guides. The motor, controlled by the input information, drives a worm gear that moves a cathode tip. When the motor drives in one rotational direction, the cathode is moved toward the anode and the size of the anode-cathode gap is diminished. When the motor drives in the other direction, the cathode is moved away from the anode and the size of the anode-cathode gap is increased. The motor is powered by batteries housed in the hollow cathode. The batteries may be rechargeable, and they may be recharged by a photovoltaic cell in combination with an optical waveguide that receives recharging energy from outside the hollow cathode. Alternatively, the anode-cathode gap can be remotely adjusted by a manually turned handle connected to mechanical linkage which is connected to a jack assembly. The jack assembly converts rotational motion of the handle and mechanical linkage to linear motion of the cathode moving toward or away from the anode.

**5,032,884**
Yamagishi, Hideo; Kondo, Masataka; Nishimura, Kunio; Hiroe, Akihiko; Asaoka, Keizou; Tsuge, Kazunori; Tawada, Yoshihisa; Yamaguchi, Minori, inventors; Kanegafuchi Kagaku Kogyo Kabushiki Kaisha, assignee. *Semiconductor PIN Device with Interlayer or Dopant Gradient.* July 16, 1991.

A semiconductor device comprising a pin-type or nip-type amorphous-containing semiconductor layers; characterized in that (1) at least one interlayer made of semiconductor or insulator having higher electrical resistivity than a semiconductor which adjoins the interlayer is/are interposed between semiconductor layers or between a semiconductor and an electrode, (2) an amount of dopant in a p-type or n-type layer is least at a junction interface of p/i or n/i and increases gradually toward a junction interface of p/electrode or n/electrode, or (3) a p-type semiconductor layer being

the same conductive type as the p-type semiconductor and having higher impurity density and/or an n-type semiconductor layer being the same conductive type as the n-type semiconductor layer and having higher impurity density is/are interposed between the p-type semiconductor layer and the electrode at the side of the p-type semiconductor layer and/or between the n-type semiconductor layer and the electrode at the side of the n-type semiconductor layer. According to the semiconductor device of the present invention (in the case of (1) or (2)), large $V_{oc}$ and electric current at a specific voltage can be obtained, further in the case of (3), photoelectric conversion efficiency can be improved.

**5,032,961**
Pouyanne, Marc; Mace, Roger; Blanc, Jean-Loup, inventors; Territoire de la Polynesie Francaise, a l'Energie Atomique Commissariat; Agence Francaise Pour la Maitrise de l'Energie, assignee. *Ground Light System for a Landing Strip*. July 16, 1991.

A ground light or beaconing system for a landing strip having at least one loop of lamps connected in series. Said loop is supplied by a solar cell, via a regulating circuit ensuring the preheating of the lamps while also maintaining a current flowing in the loop adapted to its operation.

**5,034,068**
Glenn, Gregory S.; Lillington, David R., inventors; Spectrolab, Inc., assignee. *Photovoltaic Cell Having Structurally Supporting Open Conductive Back Electrode Structure, and Method of Fabricating the Cell*. July 23, 1991.

A photoresponsive layer formed of a semiconductive material such as gallium arsenide has differently doped strata which define a junction therebetween, and generates a photovoltaic effect in response to light incident on a front surface thereof. A front electrode is formed on the front surface. A structurally supporting back electrode open conductive support or grid structure is formed on a back surface of the photoresponsive layer. The support structure is sufficiently thick, approximately 12 to 125 microns, to prevent breakage of the photoresponsive layer, which may be as thin as approximately 25 to 100 microns. The support structure has a pattern selected to prevent propagation of a crack through the photoresponsive layer thereof.

**5,034,110**
Gore, Rodney L.; Glore, Herbert F., inventors; Sal-Chlor Pty. Ltd., assignee. *Pool Chlorinators*. July 23, 1991.

A self-cleaning electrolytic chlorinator for swimming pools and water treatment plants comprises a low voltage D.C. power supply unit which cyclically reverses the polarity at the electrodes to shed accumulated deposits which plate out on the electrode surfaces. Damage to the delicate catalytic coating on the electrodes is prevented by stepping the applied potential from a maximum to a minimum value before changing polarity and then stepping the applied potential back to a maximum value.

**5,034,333**
Kim, Kangwon, inventor; Samsung Electron Devices Co., Ltd., assignee. *Method of Manufacturing an Amorphous Silicon Solar Cell*. July 23, 1991.

A method of manufacturing an amorphous silicon solar cell is disclosed in which the intrinsic body is formed as three laminated layers which are deposited by controlling the level of RF power for each lamina, thereby enhancing efficiency converting sunlight into electricity and promoting productivity.

**5,034,658**
Hiering, Roland; Ilberg, Vladimir, inventors. *Christmas-Tree, Decorative Artistic and Ornamental Object Illumination Apparatus*. July 23, 1991.

An illuminating system is provided for objects such as Christmas trees, decorations, works of art and ornaments. Electrically operated, light-emitting elements are hung on or fastened to or within these objects. The light-emitting elements include an electrical oscillatory circuit which can include, for example, inductive and capacitive elements. An energy source powers the elements with direct connection by way of electromagnetic waves or infrared light. The energy source can take the form of, for example, a high-frequency transmitter or an infrared radiation source.

**5,035,077**
Palmer, Sharon-Joy, inventor. *Apparatus and Method for Improved Plant Growth*. July 30, 1991.

A modular self-contained efficient horticulture growth chamber. Insulated panels form a sealed chamber having a grated subfloor. An algae tank grows algae below the subfloor. Trays are adjustably stacked and have mesh bottoms holding nutrient enriched gel. A broad spectrum light source is positioned on the south wall. A flow controlled irrigation misting system is timed in sequence with the light source. The chamber maintains a constant 68° to 78° Fahrenheit temperature with high humidity. Power is provided by a photovoltaic panel permitting installation in remote locations. The growth chamber and system provides high yields with little space and in locations not normally conducive to efficient growing.

**5,035,753**
Suzuki, Kunio; Abe, Masayoshi; Kinka, Mikio; Arai, Yasuyuki; Satake, Akemi; Nishi, Kazuo; Kugawa, Shuichi; Ishida, Noriya, inventors; Semiconductor Energy Laboratory Co., Ltd., assignee. *Photoelectric Conversion Device*. July 30, 1991.

A solar cell comprises a plurality of series connected photoelectric conversion structures formed on a substrate. The conversion structure consists of a first semiconductor film on a p-type, an intrinsic semiconductor film formed on the first semiconductor film such that one end thereof extends beyond an end of the first semiconductor film and a second semiconductor film of a second, opposite conductivity type formed on the intrinsic semiconductor film such that one end thereof extends beyond the extended end of the intrinsic semiconductor film and makes direct electrical contact with an end of the first semiconductor film of the adjacent structure.

**5,036,443**
Humble, Wayne; Spector, George, inventors. *Proximity Light*. July 30, 1991.

A proximity light is provided and consists of a housing adhesively mounted to a flat surface such as a wall or the underside of a toilet seat cover. An electrically operated light source is carried within the housing along with electronic circuitry for supplying electric current to energize the light source. A sensor switch is also carried within the housing and is connected between the electronic circuitry and the light source so as to close when it gets dark.

**5,037,043**
Roth, Martin; Kiendl, Helmut, inventors; Messerschmitt-Boelkow-Blohm, assignee. *Locking Arrangement for Unfolded Solar Generators*. August 6, 1991.

A locking arrangement for unfoldable solar generators which consist of several panels provides a lockable, partially unfolded, intermediate position and a lockable, completely unfolded final position. In the partially unfolded position, a panel is pivoted by 90° so that a lock pin which is acted upon by a radially inwardly directed spring force and which, at first, slides on an outer section of a curve of a guiding contour, locks into an opening of a curved slot in a guiding element having the guiding contour. During the transition into the fully unfolded position, a plate cam, which had stopped at first, is rotated so that its driving groove can accommodate the lock pin which can now continue to slide on an inner section of the curve into the final locking position.

**5,038,251**
Sugiyama, Yoshinobu; Sawada, Shohei; Hinooka, Takashi; Yoshida, Kaoru, inventors; Casio Computer Co., Ltd., assignee. *Electronic Apparatus and a Method for Manufacturing the Same*. August 6, 1991.

A thin electronic calculator having a circuit board unit in which an IC pellet is directly mounted on a film board and allowing easy mass-production is provided. Metal foil leads each having one end and the other end radially extending from the one end and having a larger width than the one end are formed on the film board. The IC pellet is bonded to one end portion of the metal foil leads through bump electrodes. The circuit board unit is fixed to a wiring board by an anisotropically electrical conductive adhesive. The other end of each metal foil lead is electrically connected to a corresponding connecting terminal formed on the wiring board. An electronic component assembly constituted by the circuit board unit and the wiring board is received in upper and lower covers, and is adhered by adhesive islands deposited on the covers.

**5,038,674**
Merges, Veit, inventor; Phototronics Solartechnik GmbH, assignee. *Solar Ventilation Arrangement for Passenger Compartments*. August 13, 1991.

An arrangement for ventilating the passenger compartment of a motor vehicle having a hinged roof cover, having one or several electric fans as well as a solar module integrated into the roof cover. The fans are constructed as axial-flow fans and are arranged in the area below the rear transverse edge of the roof cover. The axial-flow fans are coupled kinematically with the roof cover and its frame in such a manner that, when the roof cover is raised, they are swivelled in a forced manner into an effective position in the air gaps and, when the roof cover is closed, are swivelled into an ineffective position inside the roof recess without significantly reducing the headroom. The solar module which covers the roof cover for the most part is constructed in the semiconductor thin-film technique and, in a locally limited manner, has a transparency for the incident sunlight.

**5,039,352**
Mueller, Helmut F. O.; Gutjahr, Joerg, inventors. *External Wall Element for Buildings*. August 13, 1991.

The external wall element has an outer pane with lens-like holographic elements. On the inner pane, radiation receiving elements for generating energy are arranged in the focal plane of the holographic elements. The incident light may either be focused on the radiation receiving elements or on translucent portions of the inner pane. The external wall element optionally permits the generation of energy or reflection, transmission of diffuse light being effected in both cases.

**5,039,353**
Schmitt, Jacques, inventor; Societe Dite: Solems (Societe Anonyme), assignee. *Process for Improving the Spectral Response of a Photoconductive Structure, and Improved Solar Cell and Photoreceptive Structure*. August 13, 1991.

The invention is aimed at improving the spectral response of a photoconductive structure intended to receive a luminous radiation and comprising a substrate,

an electrically conductive transparent layer, a photoelectric conversion semiconductive layer in which is incorporated at least one complementary semiconductive sublayer which has an optical absorption threshold and an electrical charge diffusion length which are lower than those of the materials constituting the photoelectric conversion layer. According to the invention, the complementary sublayers are incorporated in the immediate neighborhood of several of the regions where the square of the optical electrical field of the stationary waves produced by the combination of the incident and reflected luminous radiations is at a maximum. The invention applies in particular to the manufacture of solar cells and other photoreceptive structures.

**5,039,354**
Nakagawa, Katsumi, inventor; Canon Kabushiki Kaisha, assignee. *Stacked Photovoltaic Device with Antireflection Layer*. August 13, 1991.

An improved stacked type photovoltaic device comprises a plurality of stacked photovoltaic elements wherein at least one element thereof comprises a semiconductor layer having a refractive index na and a semiconductor layer (b) having a refractive index nb and a semiconductor layer (c) is inserted therebetween as an antireflection layer; wherein said semiconductor layer (c) has constituent elements having a composition ratio different from the composition ratio of the constituent elements of both said semiconductor layer (a) and (b) and said semiconductor layer (c) has a refractive index $nc = (na,nb)^{\frac{1}{2}}$ and a thickness $d = (na, nb)^{\frac{1}{2}} lambda/4$ in which *lambda* represents a peak wavelength of the spectral sensitivity of an adjacent photovoltaic element positioned in the direction of light transmission.

The semiconductor layer (c) may also be constituted by a semiconductor film having an elemental composition comprising other elements in addition to the constituent elements of the semiconductor layer (b).

**5,039,928**
Nishi, Kazuo; Suzuki, Kunio; Kinka, Mikio; Satake, Akemi; Kugawa, Shuichi, inventors; Semiconductor Energy Laboratory Co., Ltd., assignee. *Accumulator for Portable Computers*. August 13, 1991.

A portable electric appliance is provided with a solar energy accumulator. The accumulator is integrally mounted on the electric appliance when the appliance is desired to operate or be transported. When the portable electric appliance is not used, the accumulator is removed from the appliance and moved to a bright place.

**5,040,455**
Doi, Shigetoshi; Kajimoto, Shinshi; Kuroiwa, Mutsutoshi, inventors; Mazda Motor Corporation, assignee. *Ventilation Device for Automobiles*. August 20, 1991.

A solar-powered ventilation device for a vehicle has a solar cell disposed on a car body and electrically connected to an electrically operated ventilation system, and a controller for detecting a predetermined temperature outside the car to electrically disconnect the ventilation system from the solar cell. The ventilation system is supplied with electric power from the solar cell, thereby ventilating or exhausting air from the vehicle interior only when the exterior temperature is higher than the predetermined temperature.

**5,040,585**
Hiraki, Yoshiharu, inventor; Yoshida Kogyo K. K., assignee. *Solar Cell Panel Assembly for Driving a Motor-Driven Screen Apparatus*. August 20, 1991.

A solar cell panel assembly for supplying power to a motor-driven screen apparatus mounted for movement between an inside glass plate and an outside glass plate spaced therefrom in a double-glazed sliding door unit includes a belt-like sheet of solar cell panels having its bottom edge portion disposed via a plurality of mount members so as to be held in contact with the lower inside portion of the outer glass plate, extending in the horizontal direction along the lower inside portion of the outer glass plate, and inclined in such manner that its top end portion extends toward the inner glass plate. Preferably, the solar cell panel is provided with a glass panel mounted in tight contact with an outer light receiving surface of the solar cell panel, and transparent resin having a refractive index equivalent to that of glass is filled by potting in a wedge-shaped space formed between the glass panel and the inner surface of the outer glass plate. Also, preferably a reflector plate of an inverse-L shape in cross section having its upper surface formed as a reflecting surface, is disposed so as to reflect toward the outside lower portion of the outer glass plate and extend along the outside lower portion of the same glass plate.

**5,041,762**
Hartai, Julius, inventor. *Luminous Panel*. August 20, 1991.

A luminous panel with light channels and wherein the light source preferably is based on gas discharge, comprises a gas tight, shockproof, impact resistant, transparent or translucent material, the light source being designed as a light channel in a matrix. The matrix is doped with at least one phosphor, the phosphor having a controlled distribution in the matrix. The light channel is designed integral with the luminous panel and made substantially of the same material as this. The matrix of the luminous panel may be surrounded by sheets or layers of hardened, shockproof, impact resistant, transparent or translucent material. The matrix is preferably of glass, polymer or ceramic material.

**5,041,952**
Janda, Rudolph W.; Douglas, Jerald L.; Condon, Jr., Edward F., inventors; Intermatic Incorporated, assignee. *Control Circuit for a Solar-Powered Rechargeable Power Source and Load*. August 20, 1991.

An inexpensive circuit for controlling the recharging of a rechargeable power source by a photovoltaic panel is used for powering a load such as the lamp of a walk light. Using a minimum number of components, the circuit can charge a rechargeable battery anytime sunlight is sufficient to place a potential across the battery that is greater than the present potential of the battery, can sense a decrease in voltage across the photovoltaic panel with diminishing ambient light and energize the load, can prevent the load from being energized when the ambient light level is sufficient to recharge the battery, can provide positive feedback at turn-on of the load, thereby hastening turn-on and providing hysteresis, can provide for adjusting the hysteresis bands, can shift the turn-on and turn-off thresholds, and can provide an adequate current to guarantee turn-on when using low leakage solar panels. A further embodiment can additionally exhibit hysteresis at load turn-off so that the load does not cycle on and off and can further raise the load turn-off threshold above the level where the battery is substantially discharged, thereby hastening recharging of the battery. A still further embodiment provides temperature compensation for improved performance.

**5,043,024**
Cammerer, Fritz; Bednorz, Klaus; Riermeier, Manfred, inventors; Siemens Aktiengesellschaft, assignee. *Solar Cell Device*. August 27, 1991.

Solar cell equipment is mounted using clamps of the present invention. The clamps enable a single mounting which may be employed in conjunction with a frame. The clamps provide electrical contact to the solar cell equipment for carrying the solar generated current. Clamps may also be completely insulated from the solar cell equipment. The clamps provide mechanical stabilization for the solar cell equipment.

**5,043,772**
Yamazaki, Shunpei, inventor; Semiconductor Energy Laboratory Co., Ltd., assignee. *Semiconductor Photoelectrically-Sensitive Device*. August 27, 1991.

A semiconductor photoelectrically sensitive device including a conductive substrate or a first conductive layer formed on the substrate, a non-single-crystal semiconductor layer member is disposed on the conductive substrate or the conductive layer, the non-single-crystal semiconductor layer member having at least one intrinsic, non-single-crystal semiconductor layer, and a second conductive layer is disposed on the non-single-crystal semiconductor layer member. The intrinsic non-single-crystal semiconductor layer contains sodium and oxygen in very low concentrations where each concentration is $5 \times 10^{18}$ atoms/cm$^3$ or less.

**5,044,939**
Dehlsen, James, G.P., inventor. *Reversing Linear Flow TPV Process and Apparatus*. September 3, 1991.

A linear combustion emitter regenerator process capable of operating at high temperatures for sustained periods of time, that includes flowing reactants including fuel and air to a combustion zone; adding regenerated heat to at least one of the reactants flowing to the zone; combusting the reactants at the zone to produce combustion products at high temperature, to heat radiant emitter; operating the emitter to radiate energy from the zone passing selective wavelengths of said radiated energy spectrum through an optical filter and converting the radiation from the emitter into photovoltaic-produced electricity; mounting optical filter on water-cooled window to act as a heat shield to protect photovoltaic cells from overheating; reflecting back to the emitter portions of the spectral emission not able to activate the photovoltaic cells; extracting heat absorbed by liquid-cooled window by means of a heat exchanger to transfer heat to incoming combustion air; extracting heat from the combustion products for return to the at least one of the reactants as the recuperated heat; removing the products of combustion at reduced temperature; and providing a porous bed at and to which the extracted heat is transferred; and periodically reversing the direction of flow of at least one of the reactants, and in heat transfer contact with the bed.

**5,045,409**
Eberspacher, Chris; Ermer, James H.; Mitchell, Kim W., inventors; Atlantic Richfield Company, assignee. *Process for Making Thin Film Solar Cell*. September 3, 1991.

A method of making group I-III-VI compound semiconductors such as copper indium diselenide for use in thin film heterojunction photovoltaic devices. A composite film of copper, indium, and possibly other group IIIA elements, is deposited upon a substrate. A separate film of selenium is deposited on the composite film. The substrate is then heated in a chamber in the presence of a gas containing hydrogen to form the compound semiconductor material.

**5,045,481**
Schilling, Roland; Tentscher, Karl-Heinz, inventors; TELEFUNKEN electronic GmbH, assignee. *Method of Manufacturing a Solar Cell*. September 3, 1991.

The invention relates to a solar cell which consists of a doped semiconductor base body and metallic connection contacts on the front and rear sides. For interconnection with further solar cells to form solar modules in series or parallel connection, at least one of the connection contacts comprises a connector contact which is homogeneously integrated with it, protrudes from the semiconductor base body and is deformable.

**5,047,090**
Hayashi, Yutaka; Tomonari, Shigeaki; Sakai, Jun; Kakite, Keizi, inventors; Agency of Industrial Science & Technology, assignee. *Semiconductor Device.* September 10, 1991.

A semiconductor device includes laminated photoelectric conversion elements each having a semiconductor thin film carrying out the photoelectric conversion, the respective semiconductor thin film having a relationship $L \leq 1/alpha(lambda)$ when incident light is of a wavelength *lambda*, the semiconductor thin film is of an absorption coefficient *alpha*(*lambda*) with respect to the light of the wavelength *lambda* and the carrier collecting length is L, whereby the optimum combination of the incident light wavelength and the sensitivity of the device can be obtained to realize a high photoelectric conversion efficiency.

**5,049,523**
Coleman, John H., inventor; Plasma Physics Corp., assignee. *Method of Forming Semiconducting Materials and Barriers.* September 17, 1991.

In a gaseous glow-discharge process for coating a substrate with semiconductor material, a variable electric field in the region of the substrate and the pressure of the gaseous material are controlled to produce a uniform coating having useful semiconducting properties. Electrodes having concave and cylindrical configurations are used to produce a spatially varying electric field. Twin electrodes are used to enable the use of an AC power supply and collect a substantial part of the coating on the substrate. Solid semiconductor material is evaporated and sputtered into the glow discharge to control the discharge and improve the coating. Schottky barrier and solar cell structures are fabricated from the semiconductor coating. Activated nitrogen species is used to increase the barrier height of Schottky barriers.

**5,053,083**
Sinton, Ronald A., inventor; The Board of Trustees of the Leland Stanford Junior University, assignee. *Bilevel Contact Solar Cells.* October 1, 1991.

A high efficiency back side contact solar cell is fabricated using a self-aligning process that reduces the number of masks and alignments as compared with prior processes. The back surface of the cell is patterned by etching into an array of bilevel, interdigitated mesas and trenches, separated by inclined surfaces. Doping of the back surface region produces laterally alternating and overlapping P and N regions associated with the mesas and trenches. A metalization layer is deposited over the entire back side of the cell. The portions of the metalization on the inclined surfaces are readily removed by etching. Removal of the metalization on the inclines surfaces separates the mesa conductors from the trench conductors, leaving a well-defined interdigitated array of positive electrodes and negative electrodes.

**5,053,355**
von Campe, Hilmar, inventor; Nukem GmbH, assignee. *Method and Means for Producing a Layered System of Semiconductors.* October 1, 1991.

A method and means for producing a layered semiconductor system are proposed wherein the required semiconductor layers are deposited on a carrier layer through interaction with a melt. The carrier layer itself may have a basic layer consisting of glass or quartz, which in turn may be formed from a melt by solidification on a metal melt.

**5,055,141**
Arya, Rajeewa R.; Catalano, Anthony W., inventors; Solarex Corporation, assignee. *Enhancement of Short-Circuit Current by Use of Wide Band Gap N-Layers in P-I-N Amorphous Silicon Photovoltaic Cells.* October 8, 1991.

A photovoltaic cell that includes a transparent substrate, a front conductive layer formed on the substrate, a p-type layer formed on the front conductive layer, an i-layer of amorphous silicon formed on the p-layer, a wide band gap n-type layer formed on the i-layer and a back contact layer formed on the n-type structure. The wide band gap n-type layer may be an n-type sandwich structure which includes first, second, and third n-layers successively formed on one another. The first n-layer is formed on the i-layer, the second n-layer is formed on the first n-layer, and the n-layer is formed on the second n-layer. The second n-layer has an optical band gap wider than the optical band gap of the first and second n-type layers.

**5,055,416**
Weber, Michael F., inventor; Minnesota Mining and Manufacturing Company, assignee. *Electrolytic Etch for Preventing Electrical Shorts in Solar Cells on Polymer Surfaces.* October 8, 1991.

A method for preventing shorts and shunts in solar cells having in order, an insulating substrate, a conductive metal layer on the substrate, an amorphous silicon layer and a transparent conductive layer. The method includes anodic etching of exposed portions of the metal layer after deposition of the amorphous silicon and prior to depositing the transparent conductive layer.

**5,056,447**
Labrador, Gaudencio A., inventor. *Rein-Deer Kite.* October 15, 1991.

What has been created is a new form of an equipment/kite that carry weight in mid-air regardless of fuel and/or wind, which converts the wind energy into mechanical energy by acting as a sail in a multi-level formation, which is in the form of a large flat air balloon 1/2 acre to more than 5 acres wide that floats in the air concave downward against the wind, which functions as a large kite in the presence of wind -- soaring upward instead of being blown down which may be constructed into a multi-level balloon kite from ground to the highest altitude of wind to carry several rotary blade windmills on each kite or top pull transportation on land or on water or on aerial cable railway; to carry electric wire conductors up into the clouds to collect electricity from the clouds; to carry lamps, advertisements, and observatory instruments to high altitudes; to serve as sail for large type of windmills in a configuration similar to the United Sail Windmill under U.S. Pat. No. 4,756,666 and as illustrated herewith showing multilevel kites pulling an elongate closed-loop Power Chain erected on land or on ocean. Created also is a new control system for said kite in the form of a Triple "T" Structure and an Elliptical Monorail Track.

**5,057,162**
Nelson, Robert E., inventor; TPV Energy Systems, Inc., assignee. *Thermophotovoltaic Technology*. October 15, 1991.

A high-output, narrow band thermally energized radiation source comprises a rare earth oxide radiator member that has a cross-sectional dimension in the range of 5 to 30 micrometers, the rare earth oxide radiator member, when heated to about 1700°C, having a concentrated radiated flux over the 400-2500 nanometer wavelength range such that at least 5% of the radiated flux is within a spectral band that is less than 400 nanometers wide.

**5,057,163**
Barnett, Allen M.; Hall, Robert B.; Rand, James A.; Ford, David H., inventors; AstroPower, Inc., assignee. *Deposited-Silicon Film Solar Cell*. October 15, 1991.

A thin-film photovoltaic solar cell features a thin polycrystalline silicon active semiconductor formed over a conductive ceramic substrate. Between the substrate and the adjacent active semiconductor layer is a barrier layer which provides for reflection of light, minimizes back surface recombination and prevents contamination of the active semiconductor.

**5,057,439**
Swanson, Richard M.; Gan, Jon-Yiew, inventors; Electric Power Research Institute, assignee. *Method of Fabricating Polysilicon Emitters for Solar Cells*. October 15, 1991.

Polysilicon contacts for silicon devices such as bipolar junction transistors and silicon solar cells are fabricated in a two-step anneal process to improve contact resistance and emitter saturation current density. After a silicon oxide layer is formed on a surface of a silicon substrate, a plurality of openings are formed there through to expose a plurality of contact surfaces on the surface of the silicon substrate. A thin thermally grown silicon oxide layer is then formed on the contact surfaces after which an undoped layer of polysilicon material is formed over the silicon oxide layers. The structure is then annealed at approximately 1050°C to break the thermally grown silicon oxide layer. Thereafter, a first layer of doped glass is formed over the silicon oxide surface and selectively etched to remove the first layer of glass from a first group of contact surfaces. A second layer of doped glass is then formed over the first group of contact surfaces and over the first layer of doped glass. Thereafter, the silicon substrate is annealed at a temperature of approximately 900°C, thereby driving in dopants from said first and second layers of glass into said polysilicon layer over said first and second groups of contact surfaces. Finally, the layers of glass are removed and the polysilicon layer is patterned to define first and second polysilicon contacts.

**5,059,254**
Yaba, Susumu; Takigawa, Tomoya; Osada, Koichi; Sato, Katsuhito; Omae, Masaru, inventors; Asahi Glass Company, Ltd., assignee. *Solar Cell Substrate and Solar Panel for Automobile*. October 22, 1991.

A glass substrate for a solar cell, comprising a glass sheet having a curved surface shape and a transparent electroconductive film formed on the concave surface side of said glass sheet.

**5,059,296**
Sherman, Mark, inventor; Floatron, Inc., assignee. *Portable Self-Contained Solar Powered Water Purifier*. October 22, 1991.

A portable self-contained solar powered water purifier for swimming pools, spas, and other bodies of water is disclosed. The purifier includes a buoyant housing for supporting a solar cell array above the surface of water to be treated and a purification cell below the surface of water to be treated. Suitable electrical connections, between the solar cell array and purification cell, are sealed to prevent the entry of water therebetween which could result in electrical shorts and corrosion. The purification cell includes a sacrifical anode, having a metal alloy essentially composed of copper and silver and a cathode which is preferably constructed of stainless steel so as to not react adversely with the sacrificial anode. Metallic copper and silver ions are released by the sacrificial anode to prevent algae and bacterial growth. The anode and cathode are structurally interrelated and secured to

each other and to the buoyant housing and the solar cell array to provide a practical, durable and long lasting unit.

**5,061,322**
Asano, Akihiko, inventor; Fuji Electric Corporation Research and Development Ltd., assignee. *Method of Producing P-Type Amorphous Silicon Carbide and Solar Cell Including Same.* October 29, 1991.

A method of producing a p-type hydrogenated amorphous silicon carbide thin film comprising the steps of preparing a raw material gas mixture consisting of a silicon compound, a hydrocarbon or a fluocarbon, and a boron compound, diluting the raw material gas mixture with hydrogen gas, and decomposing the raw material gas mixture by glow discharge to achieve a resultant film having a prescribed value of photoconductivity with a reduced optical absorption coefficient.

**5,061,511**
Saitoh, Keishi; Hashizume, Junichiro; Iida, Shigehira; Takei, Tetsuya; Arai, Takayoshi, inventors; Canon Kabushiki Kaisha, assignee. *Method for Forming Functional Deposited Films by Means of Microwave Plasma Chemical Vapor Deposition Method.* October 29, 1991.

An improved method for forming a functional deposited film by introducing a raw material gas into a substantially enclosed reaction chamber containing a substrate onto which the functional deposited film is to be deposited and coupling microwave energy from a source of microwave energy thereinto to thereby form a glow discharge plasma causing decomposition of the raw material gas whereby forming the functional deposited film on the substrate, the improvement comprising supplying microwave of a power equivalent of 1.1 times or more over that of microwave with which the deposition rate for the decomposed products from the raw material gas being deposited onto the substrate to be saturated to the raw material gas in the reaction chamber and regulating the inner pressure of the reaction chamber to a vacuum of 10 m Torr or less.

According to the method of this invention, there can be formed a desired functional deposited film having a wealth of many practically applicable characteristics and having an improved response speed against photocurrent at an improved deposition rate with a raw material gas utilization efficiency of hundred percent or nearly hundred percent. And the method of this invention makes it possible to mass-produce various functional elements comprising such deposited film usable in electrophotographic photosensitive member, photosensor, thin-film transistor, solar cell, etc. on an industrial scale thereby enabling low cost production.

**5,061,578**
Kozuma, Ichiro; Fujii, Toshinobu, inventors; Kabushiki Kaisha Meidensha, assignee. *Electrolyte Circulation Type Secondary Battery Operating Method.* October 29, 1991.

A method of operating a secondary battery including a stack of secondary cells operable, in the presence of electrolytes, in a charge mode charging electrical power from a source of electrical power and in a discharge mode discharging the charge electrical power from the secondary cell. A part of the electrical power from the electrical power source is used intermittently in the charge mode to provide intermittent circulation of the electrolytes through the secondary cell. The secondary cell continues to operate in the charge mode with the electrolytes residual in the secondary cell after each interruption of circulation of the electrolytes. A part of the electrical power charged in the secondary cell is used intermittently in the discharge mode to provide intermittent circulation of the electrolytes through the secondary cell. The secondary cell continues to operate in the discharge mode with the electrolytes residual in the secondary cell after each interruption of circulation of the electrolytes.

**5,062,028**
Frost, John S.; Wallace, Lloyd V.; Erickson, Mark R.; Felder, Bethanne, inventors; Atlantic Richfield Company, assignee. *Self-Contained Solar Powered Lamp.* October 29, 1991.

A self-contained photovoltaic powered light which is a stand alone unit. The solar cells which power the light are assembled and maintained within the top, or upper, portion of the self-contained unit. The solar cells are encapsulated within a resiliently deformable material to provide for contraction and expansion of the solar cells while at the same time providing protection from the elements for the assembly. A component tray assembly is rotationally secured to the upper portion of the lamp and a lens with decorative disks are rotationally secured to the component tray assembly.

**5,062,899**
Kruer, Mark A., inventor; The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, assignee. *Wide Acceptance Angle, High Concentration Ratio, Optical Collector.* November 5, 1991.

A cassegrain optical system provides improved collection of off-axis light yet is still characterized by a high concentration ratio. The optical system includes a primary mirror for collecting incoming light and reflecting the light to a secondary mirror which, in turn, reflects the light to a solar cell or other radiation collection device. The primary mirror reflects incoming on-axis light onto an annular section of the secondary mirror and results in the reflection of a

substantial amount of incoming off-axis light onto the remainder of the secondary mirror. Thus light which would otherwise be lost to the system will be captured by the collector. Furthermore, the off-axis sections of the secondary mirror may be of a different geometrical shape than the on-axis annular section so as to optimize the amount of off-axis light collected.

**5,064,477**
Delahoy, Alan E., inventor. *Radiant Energy Sensitive Device and Method*. November 12, 1991.

A radiant energy sensitive device formed by a radiant energy transmissive conductor of tin oxide with an overlying radiant energy transmissive layer of zinc oxide, that, in turn, underlies a radiant energy sensitive layer, with the result that the combination of the two radiant energy transmissive layers improves the performance of the radiant energy sensitive structure with respect to energy passing through the radiant energy transmissive layer.

**5,065,156**
Bernier, Denis, inventor. *Computer Controlled Parking Meter*. November 12, 1991.

A computer-controlled coin parking meter for managing the use of a parking lot having up to about ten parking spaces. It includes a first display device which singularly identifies the parking places and push button switches for operating it; a second display device indicating the parking time bought for the identified space; a rotary disk having, along its periphery, visible indicia indicating whether or not parking time has been paid for the parking places and a step-motor for rotating the disk so as to provide this latter information. The meter further includes a coin receiving and counting machine capable of allowing operation of the second display device so that it indicates the parking time bought and also capable of allowing rotation of the step motor and therefore of the indicia disk to display the information. Finally, the meter includes a computer assembly programmed to control sequential operation of the two devices and of the step motor from signals received from the push-button switch and from the coin receiving and counting machine, respectively.

**5,065,290**
Makar, Marko; Makar, Michael, inventors. *Illuminated Display*. November 12, 1991.

An illuminated display to be received on a perforate board to receive packages. There is a support of an electrically conducting material to be received in perforations in the board. The support can be connected to a source of electricity and an illuminator is attached to the support in electrical contact with the source of electricity. A package is carried by the support. Wares are attached to the package. An illuminated display having a base to be received on a pair of electrically conducting members is also disclosed. A pair of contacts, one to make electrical contact with each electrically conducting member are provided and a circuit is formed on the base. An illuminator on the base is in electrical contact with the circuit. Completion of the circuit by the pair of contacts lights the illuminator. A display having a support card to be received on a pair of electrical conductors is disclosed. Separate contacts on the card to make contact one with each conductor. A circuit on the card joins the separate contacts. An illuminator is in the circuit so that the separate contacts on the card can contact the conductors to complete the circuit to light the illuminator.

**5,065,291**
Frost, John S.; Erickson, Mark R.; Seegan, Kimberly E.; Boyer, Brent P., inventors; Atlantic Richfield Company, assignee. *Marking Light*. November 12, 1991.

A self-contained solar powered marking light. The marking light may be utilized to delineate certain predetermined boundaries without effectively illuminating the areas. The marking light automatically illuminates when output power from the photovoltaic cells contained therein fall below a predetermined level and automatically extinguishes when the voltage from the photovoltaic cells reaches a predetermined level. The marking light includes a lens which is closely coupled to a source of light and which includes a textured surface for diffusing the light to cause the lens to appear to glow when the source of light is illuminated. An electrical circuit is coupled between the photovoltaic cells and a battery and includes the source of light and switching means for automatically illuminating the light dependent upon the relative relationship between the voltage of the photovoltaic cells and the battery voltage.

**5,066,338**
Meyers, Roy D., inventor. *Solar Powered Navigation Buoy Generator*. November 19, 1991.

A solar electric generating system is provided which directly generates dc current from ambient light to charge a rechargeable battery through a blocking diode, and a wiring harness adaptable to connect to the existing internal circuitry of conventional existing navigation buoys. This invention is designed to be used as an add on to convert existing navigation buoys that now use throw-away batteries to more economical rechargeable batteries at a very low cost.

**5,066,339**
Dehlsen, James G.P., inventor. *Rotary Radiating Bed Thermophotovoltaic Process and Apparatus*. November 19, 1991.

A combustion/emitter/regeneration process capable of operating at high temperature for sustained periods of time, that includes flowing reactants including fuel and air to a combustion zone; adding recuperated heat to at

least two of the reactants flowing to the zone; combusting the reactants at the zone to produce combustion products at high temperature to heat a radiant emitter; extracting heat from the combustion products for return to the last least two of the reactants as the recuperated heat; removing the products of combustion at reduced temperature; and providing a porous bed which also functions as radiant emitter at and to which the extracted heat is transferred; rotating the bed about a rotation axis; and radiating light from the rotary bed and converting the radiated light into photovoltaic produced electricity.

**5,066,340**
Iwamoto, Masayuki; Minami, Kouji; Yamaoki, Toshihiko, inventors; Sanyo Electric Co., Ltd., assignee. *Photovoltaic Device*. November 19, 1991.

A photovoltaic device has a crystalline layer of a first conductivity type formed of crystalline silicon semiconductor material, an amorphous layer of an opposite conductivity type formed of amorphous silicon semiconductor material, and a microcrystalline layer formed of substantially intrinsic microcrystalline silicon semiconductor material provided between the crystalline layer and the amorphous layer.

**5,067,985**
Carver, Michael W.; Kolesar, Jr., Edward S., inventors; The United States of America as represented by the Secretary of the Air Force, assignee. *Back-Contact Vertical-Junction Solar Cell and Method*. November 26, 1991.

An interdigitated back-contact vertical-junction solar cell which utilizes an anisotropically etched 110-oriented silicon crystal wafer. The cell structure includes rounded corner top edges of the between cell channel walls in order to improve light capturing ability and also has pn-junctions disposed over all of the cavity internal surfaces. Additional pn-junctions are located on the rear surface of the cell array to assist in generated carrier collection into a rear mounted metallic conductor grid. The disclosed cell has desirable transducer efficiency, without the use of anti-reflection coatings, and previous improved physical robustness, and radiation hardening. Fabrication of the cell array includes an isotropic etch of the cell dividers and the anisotropic etching to form cell cavities.

**5,069,727**
Kouzuma, Shinichi; Inoue, Hiroshi; Murata, Kenji; Tanaka, Hiroyuki; Kishi, Yasuo, inventors; Sanyo Electric Co., Ltd., assignee. *Flexible Photovoltaic Device and Manufacturing Method Thereof*. December 3, 1991.

A flexible photovoltaic device comprises a first transparent, insulating, and flexible resin layer; a transparent electrode formed on the first resin layer; a flexible resin type locking member formed having satisfactory adherence along the inner periphery of the transparent electrode; a semiconductor layer formed to cover the transparent electrode and the locking member for photoelectric conversion; a back electrode formed on the semiconductor layer; and a second insulating and flexible resin layer formed on the back electrode.

**5,069,740**
Levine, Jules D.; Jensen, Millard J., inventors; Texas Instruments Incorporated, assignee. *Production of Semiconductor Grade Silicon Spheres from Metallurgical Grade Silicon Particles*. December 3, 1991.

A method of making single crystal semiconductor grade silicon spheres for solar cells and the like from metallurgical grade silicon. The process comprises sizing metallurgical grade silicon particles to a desired range and oxidizing the outer surfaces of the particles to form a silicon dioxide skin thereon. The particles are then heated to melt the silicon within the skin to cause impurities to travel into the skin. This is made possible because single crystals are formed. The skin and impurities therein are then etched off and the remaining particles are again treated to form a skin An intermediate shotting step can yield spheres of substantially uniform diameter for use as the feed for the repeat cycle.

**5,071,243**
Bronstein, Allen I., inventor. *Tensioned Cover for Parabolic Reflector*. December 10, 1991.

A generally rectangular tensioned cover comprises a pair of end forms having end portions. They are generally parallel along their lengths. A pair of side rails which are generally orthogonal to the end forms have first and second end portions. They are spaced substantially the lateral separation of the end forms with the end portions of each side rail positioned adjacent the end portions of an end form. A tensionable sheet spans from one side rail to the other and from one end form to the other. The sheet's first end portions are attached along the end forms. The lateral peripheral portions of the sheet are attached along the side rails. The end portion of the one end form is fastened to the first end portions of the side rails. The end portion of the other end form is fastened to selectable regions of the second end portions of the side rails. The sheet is tensioned longitudinally between the end forms.

**5,071,490**
Yokota, Akitoshi; Nakata, Yukihiko, inventors; Sharp Kabushiki Kaisha, assignee. *Tandem Stacked Amorphous Solar Cell Device*. December 10, 1991.

An amorphous solar cell is provided having a junction structure of a p-layer, an i-layer, and n-layer where an electromotive force is generated when the cell is irradiated by light. The amorphous solar cell includes an

upper cell and a lower cell which each have an i-layer. The upper and lower cells are stacked so that the upper cell is located on the light incident side. An output end of the upper cell and an output end of the lower cell are connected in parallel. The thickness of the i-layer of the lower cell is 300Å or less. Because the thickness of the i layer of the lower cell is 3000Å or less, the amorphous solar cell has a high initial photoelectric conversion efficiency and properties which are unlikely to be degraded by light.

**5,071,491**
Stein, Karl U.; Cammerer, Fritz, inventors; Siemens Aktiengesellschaft, assignee. *Frame for Solar Cell Devices.* December 10, 1991.

A frame for securing solar cell equipment in a solar generator and carrying solar generated current. The current carrying frame reduces the number of interconnections required in the overall device. As a result, the present invention is simpler and requires considerably less outlay than conventional solar generators

**5,072,209**
Hori, Toshio; Furuhashi, Kenji; Wakita, Makoto; Ueda, Kazuo, inventors; Kawajyuu Gifu Engineering Co., Ltd., assignee. *Data Display System for Vehicles.* December 10, 1991.

This data display system includes a wireless transmitter mounted on a vehicle. The wireless transmitter is used for transmitting a signal representative of data related to operation of the vehicle. A wireless receiver is mounted on a helmet worn by a driver of the vehicle. The receiver receives a transmitted data signal from the transmitter and generates an output signal. A power supply is mounted on the helmet, and comprises a solar cell and a secondary battery for supplying electric power to the receiver. Converter circuits are connected to an output stage of the wireless receiver for converting the output signal of the receiver into a light display signal of visible rays. A display and mirror are mounted on the helmet for projecting and displaying the display signal from the converter circuits in a forward visual field of the driver.

**5,073,054**
McDowell, W. Stuart, inventor. *Electronic Dictionary with Vertical Keyboard.* December 17, 1991.

An electronic dictionary or language translator is in the form of a thin electronic device, preferably at least 3" x 6" in size so that it may be placed in a book and used during reading. The electronic device has a relatively large display area and its keys are spread apart so that they may be readily operated by the fingers of either hand. The device utilizes a specially arranged keyboard with an alphabetical sequence of the letters, but with the vowels positioned so that they start and end each row. In addition, certain vowels are repeated both on the left and right sides of the keyboard.

**5,073,698**
Stultz, Timothy J., inventor; Peak Systems, Inc., assignee. *Method for Selectively Heating a Film on a Substrate.* December 17, 1991.

A method for selectively heating a film on a substrate. The film is provided with a different absorption characteristic for light than the absorption characteristic of the substrate. The specimen (combined film and substrate) is illuminated by light having a maximum intensity at a wavelength which will be substantially absorbed by the film and substantially not absorbed by the substrate.

**5,073,804**
Coleman, John H., inventor; Plasma Physics Corp., assignee. *Method of Forming Semiconductor Materials and Barriers.* December 17, 1991.

In a In a gaseous glow-discharge process for coating a substrate with semiconductor material, a variable electric field in the region of the substrate and the pressure of the gaseous material are controlled to produce a uniform coating having useful semiconducting properties. Electrodes having concave and cylindrical configurations are used to produce a spatially varying electric field. Twin electrodes are used to enable the use of an AC power supply and collect a substantial part of the coating of the substrate. Solid semiconductor material is evaporated and sputtered into the glow discharge to control the discharge and improve the coating. Schottky barrier and solar cell structures are fabricated from the semiconductor coating. Activated nitrogen species is used to increase the barrier height of Schottky barriers.

**5,074,489**
Gamzon, Eliyahu, inventor. *Method and System for Supporting an Airborne Vehicle in Space.* December 24, 1991.

A method and system for supporting an airborne vehicle in space over a predetermined location and for an extensive period, comprises coupling the airborne vehicle by cables to a plurality of unmanned aircraft each having its own propulsion system; controlling the unmanned aircraft to fly in circular orbits at equally-spaced angles around the airborne vehicle while coupled to the airborne vehicle, to tension the cables and thereby to support to airborne vehicle in space over the predetermined location; and supplying the unmanned aircraft with energy from an external source to maintain the unmanned aircraft in flight over an extended or indefinite period of time.

**5,074,706**
Paulos, Harry D., inventor; Olympic Machines, Inc., assignee. *Raised Depressible Pavement Marker*. December 24, 1991.

A depressible pavement marker is provided and includes a base receptacle, a piston assembly with a reflector and a resilient, compressible, water impervious mass. The base receptacle is mounted in the pavement with a portion of the piston assembly protruding above the pavement so that the reflector can be seen. The piston assembly and base are of a piston-in-cylinder arrangement with the piston assembly depressible into the base. The mass fills substantially the entire cavity formed between the inner surfaces of the piston assembly and the base. In another embodiment, a self-illuminating marker is provided and includes a solar cell, rechargeable battery, light source and sensor. The solar cell recharges the battery during daylight hours. The sensor energizes and de-energizes the light source in response to external indications. A further embodiment is also provided which includes a locational traffic marker having a transmitter in the piston assembly for sending a locational signal to a remote receiver such as for example a suitably equipped emergency vehicle.

**5,074,811**
Crisman, Dusty S., inventor. *Solar Powered Trolling Motor*. December 24, 1991.

An apparatus including a trolling motor housing, including a solar cell organization permitting selective use of solar cells or a battery to motivate the trolling motor drive. Modification of the invention includes manipulation apparatus for spacing and permitting rotation of the solar cells relative to the trolling motor housing in use.

**5,074,920**
Gonsiorawski, Ronald C.; Borenstein, Jeffrey T.; Kardauskas, Michael J., inventors; Mobil Solar Energy Corporation, assignee. *Photovoltaic Cells with Improved Thermal Stability*. December 24, 1991.

Photovoltaic cells with silver-rich thick film electrical contacts and superior thermal aging properties are disclosed. Electrical wires are bonded to the silver-rich thick film contacts using a tin and silver solder paste comprising between about 96% tin/4% silver and 98% tin/2% silver. Solar cells having soldered connections incorporating the present invention exhibit the capability of withstanding temperatures in the range of 150°C, with little or no deterioration of the solder bonds for periods far longer than conventionally prepared cells.

**5,075,763**
Spitzer, Mark B.; Dingle, Jason E., inventors; Kopin Corporation, assignee. *High Temperature Metallization System for Contacting Semiconductor Materials*. December 24, 1991.

A metallization system for contacting semiconductor materials employed in high temperature applications that is thermally stable. The system can be utilized in the fabrication of electronic devices such as diodes, lasers, transistors, solar cells, and integrated circuits comprised of such devices.

**5,075,857**
Maresca, Joseph S., inventor. *Unmanned Compliance Monitoring Device*. December 24, 1991.

Unmanned compliance monitoring device, data communication network and transaction processing apparatus for monitoring earth tremors, collecting and reporting seismic data profiles and calculating an earthquake epicenter incorporating a solar energy module, portable telephone, and satellite.

**5,076,634**
Müller, Hermann-Frank; Pflanz, Tassilo, inventors. *Sun Visor for Motor Vehicles*. December 31, 1991.

A sun visor for motor vehicles is provided that can be pivoted about its upper longitudinal rim. On that side that in a folded-down position faces toward the outside, the sun visor is provided with solar modules that are connected to at least one storage cell disposed in a recessed portion on the inner side of the sun visor. A pivot mounting of the sun visor can be snapped into and out of a catching device on the vehicle so that current stored from solar energy while driving can also be used outside of the vehicle. The sun visor can be supplemented with additional sun shields of appropriate construction.

**5,076,857**
Nowlan, Michael J., inventor; Spire Corporation, assignee. *Photovoltaic Cell and Process*. December 31, 1991.

An improved photovoltaic cell and a process of making it are disclosed. Essentially, the process merges the technology of ESB with the phenomenon of total internal reflection to provide a photovoltaic cell of improved conversion efficiency and comprising a solar cell formed of a semiconductor material and provided with a front contact, a cover plate formed of a glass having a thermal expansion coefficient matching that of the semiconductor material with the back surface of the cover plate provided with a plurality of V-grooves overlying the front contact and being electrostatically bonded to the solar cell. The V-grooves serve both as clearance slots for the front contact and its converging facets as reflecting surfaces to direct incident light onto the cell's surfaces in between the front contact grid lines.

**5,077,223**
Yamazaki, Shunpei, inventor; Semiconductor Energy Laboratory Co., Ltd., assignee. *Photoelectric Conversion Device and Method of Making the Same.* December 31, 1991.

A photoelectric conversion device has a non-single-crystal semiconductor laminate member formed on a substrate having a conductive surface, and a conductive layer formed on the non-single-crystal semiconductor laminate member. The non-single-crystal semiconductor laminate member has such a structure that a first non-single-crystal semiconductor layer having a P or N first conductivity type, an I-type second non-single-crystal semiconductor layer and a third non-single-crystal semiconductor layer having a second conductivity type opposite the first conductivity type are laminated in this order. The first (or third) non-single-crystal semiconductor layer is disposed on the side on which light is incident, and is P-type. The I-type non-single-crystal semiconductor layer has introduced thereinto a P-type impurity, such as boron which is distributed so that its concentration decreases towards the third (or first) non-single-crystal semiconductor layer in the thickwise direction of the I-type layer.

**5,077,796**
Bellaire, David L., inventor. *Cryptograph.* December 31, 1991.

An apertured device translatably receives a lottery ticket in juxtaposed relationship with the aperture to display a set of numbers appearing upon the lottery ticket. A panel adjacent the aperture accommodates entry of a predetermined set of numbers to permit visual correlation between the displayed set of numbers and the predetermined set of numbers.

## 1992

**5,078,151**
Laballery, Vincent, inventor. *Medical Auscultation Device.* January 7, 1992.

A medical auscultation device comprising an element intended to be applied to a patient's skin, which is characterized by the fact that it comprises on or in the vicinity of this element a heating resistance which is supplied by a contactor from an electric current source such as a battery.

**5,078,470**
Milman, Uri, inventor. *One-Way Peephole.* January 7, 1992.

A door-mounted security peephole providing an undistorted view over a relatively large area by use of a beam splitter optical system. The peephole comprises a door-mounted housing containing a beam splitter and light source arranged so that light is reflected from the beam splitter and toward the area exterior of the door. An observer behind the door may view the door exterior area including a visitor at the door entrance. The visitor, however, cannot see the observer through the beam splitter, because of the light reflected therefrom, thus increasing the overall security aspect. The design exploits the contrast sensitivity of the human eye as a function of field brightness.

**5,078,803**
Pier, David N.; Gay, Charles F.; Wieting, Robert D.; Langeberg, Heidi J., inventors; Siemens Solar Industries, assignee. *Solar Cells Incorporating Transparent Electrodes Comprising Hazy Zinc Oxide.* January 7, 1992.

Transparent conductors for use in a variety of different photovoltaic devices are disclosed, comprising at least one ZnO transparent conductor layer having a predetermined level of haziness achieved, e.g., through appropriate variation in the parameters employed in formation of the transparent conductor (for example, by chemical vapor deposition) and/or through treatment of the transparent conductor subsequent to its formation. The concentration and/or relative rate of introduction of dopant during the deposition of the transparent conductor may be adjusted to prepare films having the desired morphology and/or structure. Alternatively, the morphology, composition and/or structure of the transparent conductor may be modified by suitable post-formation treatments. A combination of at least two transparent layers may also be employed, comprising at least a first layer designed primarily to maximize the optical properties and at least a second layer designed to maximize the electrical properties.

**5,078,804**
Chen, Wen S.; Stewart, John M., inventors; The Boeing Company, assignee. *I-III-$VI_2$-Based Solar Cell Utilizing the Structure CuInGa$Se_2$CdZnS/ZnO.* January 7, 1992.

A thin-film I-III-$VI_2$-based solar cell having a first layer of copper indium gallium selenide, a second layer of cadmium zinc sulfide, a double layer of zinc oxide, and a metallization structure comprised of a layer of nickel covered by a layer of aluminum. An optional antireflective coating may be placed on said metallization structure. The cadmium zinc sulfide layer is deposited by means of an aqueous solution growth deposition process and may actually consist of two layers: a low zinc content layer and a high zinc content layer. Photovoltaic efficiencies of 12.5% at AM1.5 illumination conditions and 10.4% under AM0 illumination can be achieved.

**5,079,645**
Ritter, Carl A., inventor. *Solar Powered Diffractor*. January 7, 1992.

A solar powered ornamental light pattern producing device whih produces visually pleasing patterns of light, composed of a housing, a pair of photovoltaic devices connected with the housing, a shaft rotatably connected with the housing and rotated by the photovoltaic devices, a pedestal connected with a distal end of the shaft, a flat mirror located on the pedestal, and a multi-faceted crystal which is located upon the flat mirror. When sunlight strikes the solar cells of the photovoltaic devices a mechanical linkage with the photovoltaic devices causes the shaft to rotate. As the shaft rotates, the various facets of the crystal are rotated, causing sunlight reflected off the mirror and interacting with the crystal, and sunlight directly interacting with the crystal, to be refracted and reflected into a whole host of pleasing patterns and colors.

**5,079,726**
Keller, Lloyd E., inventor. *Response Speed and Accuracy Measurement Device*. January 7, 1992.

A response speed and accuracy measurement device includes a multidigit code generator for generating a multidigit code of numeric or alphabetic characters or other symbols. An operator controlled start switch causes a code to be generated and displayed for a limited fixed time duration. The operator then attempts to enter the last displayed code as quickly as possible using the data entry keys of a keyboard. A timer measures the operators response time. A comparator checks the entered code against the displayed code for detecting a match. An output is generated in the event of a match to indicate the operator's response time.

**5,080,724**
Chubb, Donald L., inventor; The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, assignee. *Selective Emitters*. January 14, 1992.

This invention relates to a small particle selective emitter for converting thermal energy into narrow band radiation with high efficiency. The small particle selective emitter is used in combination with a photovoltaic array to provide a thermal to electric energy conversion device. An energy conversion apparatus of this type is called a thermo-photovoltaic device.

In the first embodiment, small diameter particles of a rare earth oxide are suspended in an inert gas enclosed between concentric cylinders as shown in Figure 1. The rare earth oxides are used because they have the desired property of large emittance in a narrow wavelength band and small emittance outside the band. However, it should be emphasized that it is the smallness of the particles that enhances the radiation property. As shown in Figure 1, the small particle selective emitter is surrounded by a photovoltaic array.

In an alternate embodiment, the small particle gas mixture is circulated through a thermal energy source. This thermal energy source can be a nuclear reactor, solar receiver, or combustor of a fossil fuel.

**5,080,725**
Green, Martin A.; Wenham, Stuart R., inventors; Unisearch Limited, assignee. *Optical Properties of Solar Cells Using Tilted Geometrical Features*. January 14, 1992.

Solar cells are produced in which surface texturing of the substrate surface, in the form of geometric ridges and pyramids, are formed at an angle to the perpendicular such that the ridges and pyramids are not symmetrical about a perpendicular axis or plane. Such "tilted" texturing causes an increased number of passes of trapped light within the cell and also within the encapsulation covering the cell thereby increasing the chances of light being absorbed. A process for manufacture of cells with tilted texturing involves sawing a wafer from an ingot at an angle a to the 100 plane and then processing the wafer in a conventional fashion, including texturing the surface with ridges or pyramids.

**5,081,049**
Green, Martin A.; Wenham, Stuart R.; Srinivasamohan, Narayanan, inventors; Unisearch Limited, assignee. *Sculpted Solar Cell Surfaces*. January 14, 1992.

The present invention relates to the shaping of solar cell substrate surfaces in order to provide advantageous light-catching and interaction properties.

Previous solar cell substrates have suffered from a relatively high percentage loss of light due to reflection from the substrate surface, as well as the disadvantage that light passing into the substrate may not be absorbed in regions of high collection probability, close to the semiconductor junctions.

By specifically shaping the surface of the substrate to produce predetermined surface structures the above disadvantages can be minimized. Previous texturing of solar cell substrates has relied on the crystalline structure of the substrate to control the surface texture. The surface thus produced does not maximize the antireflection and absorption properties.

By using a laser scriber and following this with a chemical etch, we produce surface shapes which maximize the antireflection and absorption properties of the solar cell.

**5,081,069**
Parker, Sidney G.; Wood, Jerry; Turner, Robert T.; Fischer, Craig A., inventors; Texas Instruments Incorporated, assignee. *Method for Depositing a $TIO_2$ Layer Using a Periodic and Simultaneous Tilting and Rotating Platform Motion.* January 14, 1992.

Method and apparatus are disclosed for depositing a uniform layer of material, such as titanium dioxide, on the surface of an object, such as a silicon sphere of a solar array. Component gases are injected at predetermined rates into a heated reaction chamber where they react. Because of the reaction rate and injection velocities of the gases, the reaction is substantially completed at a calculated location inside the reaction chamber. The object which is to receive the layer, such as the solar array, is placed at the calculated location in the reaction chamber. The platform to which the solar array is attached is simultaneously tilted and rotated such that all areas of the surface of the array are uniformly exposed to the titanium dioxide reactant.

**5,082,505**
Cota, Albert O.; Reed, John J., inventors. *Self-Sustaining Power Module.* January 21, 1992.

A self-sustaining power module that combines the technologies of radioactivity with photovoltaic cells to produce an electrical power supply having a useful life of over ten years. The radioactive source is a tritium capsule that interfaces with the receptor surface of the photovoltaic cell. The capsule has inside surfaces that are coated with a phosphor and is filled with tritium gas. The tritium gas produces beta particles that bombard the phosphor causing the phosphor to luminesce and produce photons. The photons, in turn, strike and cause the photovoltaic cell to generate a current flow that is then applied, via a pair of electrodes, to an external load. Also disclosed is a power pack that houses a plurality of power modules. The power pack includes provisions that allow the power modules to be electrically interconnected to provide various series, parallel and series-parallel power output combinations.

**5,082,696**
Sharp, Kenneth G., inventor; Dow Corning Corporation, assignee. *Method of Forming Semiconducting Amorphous Silicon Films from the Thermal Decomposition of Dihalosilanes.* January 21, 1992.

The invention relates to the chemical vapor deposition of dihalogenated silanes to form stable, abrasion resistant, photoconductive, dopable semiconductor amorphous films on substrates. Additional hydrogen and plasma discharge conditions are not necessary to practice the invention.

**5,082,791**
Micheels, Ronald H.; Valdivia, Percy; Hanoka, Jack I., inventors; Mobil Solar Energy Corporation, assignee. *Method of Fabricating Solar Cells.* January 21, 1992.

A solar cell fabrication procedure is described in which an excimer laser is used to cut a trench in a flat solar cell substrate so as to electrically isolate front and back regions of the substrate. The trench is cut around the perimeter of the cell. The advantage of using an excimer laser is that it will ablate a trench without diffusing conductive material deeper into the cell.

**5,084,107**
Deguchi, Mikio; Itagaki, Takushi; Usui, Masaaki, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell and Solar Cell Array with Adhered Electrode.* January 28, 1992.

An electrode structure of a solar cell includes a metal wire fixed to the light incident surface of the solar cell with an electrically conductive adhesive. An electrode production method of a solar cell includes applying an electrically conductive adhesive to at least one of a portion of a metal wire and a portion of the light incident surface of the solar cell, pressing the metal wire into a predetermined position of the light incident surface of the solar cell, and solidifying the conductive adhesive to fix the metal wire.

**5,084,400**
Nath, Prem; Vogeli, Craig, inventors; Energy Conversion Devices, Inc., assignee. *Conversion Process for Passivating Short Circuit Current Paths in Electronic Devices Having a Metallic Electrode.* January 28, 1992.

An electronic device of the type including a thin film body having a superposed metallic electrode has short circuit defects therein passivated by a conversion process in which the electrical resistivity of the metallic electrode material is increased proximate the defect regions. Conversion is accomplished by exposing the metallic electrode material to a conversion reagent and activating the reagent proximate the defect regions. The process may be utilized for a variety of differently configured devices, and may be readily adapted for use in a roll-to-roll device fabrication process.

**5,084,664**
Gali, Carl E., inventor. *Solar Powered Lead Acid Battery Rejuvenator and Trickle Charger.* January 28, 1992.

A solar powered lead acid battery rejuvenator circuit is provided that generates fast time very short duration pulses on the order of five micro seconds or less with a five megavolt per second rise time to 1:1 to 1:3 times the theoretical cell voltage with pulses in the approximate range of from 2,000 to 10,000 times per second. The circuit is also a trickle charger for lead

acid batteries. A solar cell panel is connected to power a DC to AC inverter multivibrator having a center tap and opposite side end connections to a primary coil of a transformer. The secondary coil of the transformer, that is a fast rise time transformer in the order of two nano seconds per volt rise time transformer, has opposite end connections to two opposite side terminals of a four diode rectifier bridge. The other opposite connections of the AC to DC rectifier bridge are connected to like polarity terminals of a battery subject to rejuvenator pulse inputs and trickle charging. One of these battery circuit connections from the bridge includes a transistor connected through a voltage bias resistor to the transistor base, a resistor connected to the transistor emitter and to a terminal of the battery and also connected to a diode also connected to the transistor base.

**5,085,711**
Iwamoto, Masayuki; Minami, Koji; Watanabe, Kaneo, inventors; Sanyo Electric Co., Ltd., assignee. *Photovoltaic Device*. February 4, 1992.

A photovoltaic device capable of obtaining a high open circuit voltage, in which crystallization of a semiconductor is accelerated from the first stage of formation thereof such that a thin layer of the semiconductor is crystallized, by doping an electrode disposed between the semiconductor and a substrate with an element which reacts with an element in the semiconductor to accelerate crystallization of the semiconductor or by disposing a film made from a compound doped with said element between the semiconductor and the substrate.

**5,085,753**
Sherman, Mark, inventor; Floatron, Inc., assignee. *Water Purifier*. February 4, 1992.

A water purifier has a buoyant housing for supporting a purification cell below the water's surface and for supporting a solar cell array for providing power for the purification cell. The purification cell preferably has a solid cylindrical anode and a coiled wire cathode. The water purification cell operation includes electrolytic processes, electrocution and oxidation to destroy bacteria and algae in the water.

**5,085,885**
Foley, Henry C.; Varrin, Jr., Robert D.; Sengupta, Sourav K., inventors; University of Delaware, assignee. *Plasma-Induced, In-Situ Generation, Transport and Use or Collection of Reactive Precursors*. February 4, 1992.

A beam or flow of a reactive or metastable precursor such as a hydride or organometallic compound is created, and this beam or flow is used to treat (e.g., dope or coat or otherwise modify) a substrate, e.g., an advanced material such as a semiconductor layer, a photovoltaic cell, or a solar cell. The beam or flow can also be directed into a storage zone so that the precursor or precursors can be collected for future use. The beam or flow is created in an apparatus comprising at least three zones. Zone 1 is irradiated with microwave energy to generate a reactive gas rich in free radicals (e.g., rich in H, $CH_3$, etc.) zone 2 (downstream from zone 1) is substantially free of microwave energy and contains a target which is impinged upon by the free radicals and becomes a source of the precusor; zone 3 (downstream from zone 2) is where the precursors are either collected for storage or are used to treat the substrate. In a typical apparatus of this invention, a feed gas such as $H_2$ or $CH_4$ is introduced into an elongated tube which communicates with a microwave cavity containing a microwave plasma. A reactive gas containing free radicals (and perhaps some ions) flows from cavity to target, where the free radicals react with the target to form the precursor (e.g., a hydride such as silane). When the precursor enters zone 3 it can treat an advanced material, e.g. by decomposing into $Si + 2H_2$. The Si is deposited on the substrate and the liberated $H_2$ is pumped away. The pumping system also keeps the interior of the apparatus under subatmospheric pressure, e.g., 0.1 to 10 torr.

**5,085,939**
Wenz, Robert P.; Weber, Michael F.; Arudi, Ravindra L., inventors; Minnesota Mining and Manufacturing Company, assignee. *Thin Film-Coated Polymer Webs*. February 4, 1992.

The present invention relates to thin film-coated polymer webs, and more particularly to thin film electronic devices supported upon a polymer web, wherein the polymer web is treated with a purifying amount of electron beam radiation.

**5,086,003**
Hammerbacher, Milfred D., inventor; Texas Instruments Incorporated, assignee. *Method for Applying an Organic Insulator to a Solar Array*. February 4, 1992.

A method for applying a dielectric material to a solar array having an edge, a light gathering side and a back side, which includes the steps of sealing the array along the array edge, providing a gas pressure differential between the light gathering side and the back side which pressure is greater on the light gathering side than on the back side and applying the dielectric material to the back side of the array wherein the gas pressure differential is sufficient to substantially prevent the dielectric material from leaking from the back side to the light gathering side.

**5,086,267**
Janda, Rudolph W.; Douglas, Jerald L.; Condon, Jr., Edward F., inventors; Intermatic Incorporated, assignee. *Control Circuit for a Solar-Powered Rechargeable Power Source and Load*. February 4, 1992.

An inexpensive circuit for controlling the recharging of a rechargeable power source by a photovoltaic panel is used for powering a load such as the lamp of a walk light. Using a minimum number of components, the circuit can charge a rechargeable battery anytime sunlight is sufficient to place a potential across the battery that is greater than the present potential of the battery, can sense a decrease in voltage across the photovoltaic panel with diminishing ambient light and energize the load, can prevent the load from being energized when the ambient light level is sufficient to recharge the battery, can provide positive feedback at turn-on of the load, thereby hastening turn-on and providing hysteresis, can provide for adjusting the hysteresis bands, can shift the turn-on and turn-off thresholds, and can provide an adequate current to guarantee turn-on when using low leakage solar panels. A further embodiment can additionally exhibit hysteresis at load turn-off so that the load does not cycle on and off and can further raise the load turn-off threshold above the level where the battery is substantially discharged, thereby hastening recharging of the battery. A still further embodiment provides temperature compensation for improved performance.

**5,087,107**
Gumanelli, Giuseppe E., inventor; M.I.B. Elettronica S.R.L., assignee. *Device and Process for Protecting and Handling Bank Notes and Valuables*. February 11, 1992.

A device used for protecting and handling bank notes and valuables including, within a housing, a protection housing, mobile elements having a sliding direction and a plurality of safety compartments consecutive with one another along the sliding direction, locking elements defining as many stop positions of the mobile elements as there are safety compartments along the sliding direction, and a control device driving the locking elements. A process includes the insertion of bank notes and valuables in various safety compartments and making gradually accessible the content of compartments according to prefixed time sequences.

**5,087,296**
Kondo, Shigeki; Mizutani, Hidemasa, inventors; Canon Kabushiki Kaisha, assignee. *Solar Battery and Process for Preparing Same*. February 11, 1992.

A solar battery comprises a substrate, a first semiconductor layer of a first conduction type comprising a single crystal singly grown on a nucleation surface ($S_{NOL}$) formed on the surface of said substrate at the base for growing, said nucleation surface ($S_{NOL}$) being comprised of a material which is sufficiently greater in nucleation density (ND) than the material constituting the surface of said substrate and having a sufficiently fine area such that only a single nucleus grows, a second semiconductor layer of a second conduction type different than the conduction type of said first semiconductor layer and means for taking out the power.

**5,088,127**
Thornock, Del M., inventor. *Powered Rotating Display in a Hat*. February 18, 1992.

A hat having an electric motor driven rotatable display placard affixed to the top exterior of the hat. The driving motor of the placard is powered by a photovoltaic panel attached to the exposed surface of the hat. An electrically conductive circuit connects the photovoltaic panel to the motor. The placard is imprinted with written or graphic advertisements or symbols, and is rotated to attract greater attention.

**5,089,426**
Yamazaki, Shunpei; Suzuki, Kunio; Susukida, Masato; Kinka, Mikio; Fukada, Takeshi; Abe, Masayoshi; Kobayashi, Ippei; Shibata, Katsuhiko; Koyanagi, Kaoru; Nagayama, Susumu, inventors; Semiconductor Energy Laboratory Co., Ltd., assignee. *Method for Manufacturing a Semiconductor Device Free from Electrical Shortage Due to Pin-Hole Formation*. February 18, 1992.

An improved semiconductor device is disclosed which is free from current leakage due to pin-holes or other gaps. Also an improved method for processing a semiconductor device is shown. According to the invention, gaps produced in fabricating process of the semiconductor layer are filled with insulator in advance of deposition of electrodes. By virtue of this configuration, short current paths do not result even if transparent electrode is provided on the semiconductor layer.

**5,090,167**
Wassell, Stephen, inventor. *Solar Shed*. February 25, 1992.

A solar shed is disclosed comprising a secure shelter for battery-powered electric tools, such as lawnmowers, trimmers, and leaf blowers, and of the electric tools in the interior, so that the batteries are recharged for later use. The solar shed is marketed in prefabricated components, having a square floor so that the walls and the roof can be oriented in any of four directions with respect to each other, in particular, so that the slope of the roof can be oriented to face a generally southward direction, regardless of where the user wishes to locate the shed on the site. This will allow for adequate exposure of the photovoltaic cells to sunlight. The increase in height in the interior of the solar shed resulting from the sloped roof allows the walls to be shorter and therefore more manageable for easier assembly. Taller users can locate the door so that, upon entering the solar shed, the user has more headroom resulting from the sloped ceiling. In addition, the solar shed has its own battery-powered features, such as lighting, which are recharged by the same photovoltaic cells.

**5,090,689**
Petz, Peter, inventor. *Solar Carousel*. February 25, 1992.

A carousel powered by an arrangement of photoelectric solar panels is driven by an electric motor, which is connected through a battery to an arrangement of solar cells located on the roof of the carousel. Also connected to the battery, in parallel with the motor, are a number of decorative bulbs, to prevent overcharging of the battery. The solar panels are hinged and are placed on the roof of the carousel with one part of the panel horizontal to the ground, and the other part angled upwards, to maximize the capture of solar energy regardless of the location of the sun in the sky. Additionally, the carousel figures are removable and the roof and base of the carousel are hinged, so that the carousel can be folded into a transport position.

**5,090,770**
Heinrichs, Heinz-Josef; Enders, Stephan; Wagner, Udo; Dirksen, Alfred, inventors; Stabilus GmbH, assignee. *Electrical Seat Adjustment Device*. February 25, 1992.

In the case of an item of seating furniture, particularly an office chair, comprising at least one seat adjusting device, for example for adjusting the height of the seat, with a spring element engaging the two parts of the seat which are to be adjusted in respect of each other, particularly a pressurized fluid-filled spring, and with a locking device for the separable fixing of the two seat parts in whatever is the desired and selected adjusted position, the use of an electrical actuating element for the locking device is proposed, which is connected to a manually operable control means for the at least one seat adjustment, this allowing simplified operation with minimal structural expenditure.

**5,091,018**
Fraas, Lewis M.; Avery, James E.; Girard, Gerald R., inventors; The Boeing Company, assignee. *Tandem Photovoltaic Solar Cell with III-V Diffused Junction Booster Cell*. February 25, 1992.

A photovoltaic cell array involving rows and columns of tandem or stacked solar cell units composed of GaSa/GaSb associated with a radiation collector have produced measured energy conversion efficiencies of 31% AMO. The booster GaSb cell is manufactured by a process which produces a p-type diffusion region within a n-type substrate, has improved energy conversion efficiencies and can be mounted as part of a four terminal stacked solar cell unit.

**5,091,319**
Hotchkiss, Gregory B.; Jensen, Millard J., inventors. *Method of Affixing Silicon Spheres to a Foil Matrix*. February 25, 1992.

Solar cells are formed of semiconductor spheres of p-type interior having a n-type skin are pressed between a pair of aluminum foil members forming the electrical contacts to the p-type and n-type regions. The aluminum foils, which comprise 1.0% silicon by weight, are flexible and electrically insulated from one another. The spheres are patterned in a foil matrix forming a cell. Multiple cells can be interconnected to form a module of solar cell elements for converting sunlight into electricity.

**5,091,764**
Asaoka, Keizo; Tsuge, Kazunori; Tawada, Yoshihisa, inventors; Kanegafuchi Kagaku Kogyo Kabushiki Kaisha, assignee. *Semiconductor Device Having a Transparent Electrode and Amorphous Semiconductor Layers*. February 25, 1992.

A semiconductor device having a transparent electrode comprising $SnO_2$, at least one semiconductor layer and a back electrode on a glass substrate wherein the dopant density of the transparent electrode is not more than 0.5 weight %, so that light absorption in the transparent electrode is lowered.

**5,094,697**
Takabayashi, Akiharu; Yonehara, Takao, inventors; Canon Kabushiki Kaisha, assignee. *Photovoltaic Device and Method for Producing the Same*. March 10, 1992.

A photovoltaic device comprises a substrate having a plurality of conductive surfaces surrounded by an insulating surface, a plurality of first photovoltaic elements having single-crystal layer regions covering said conductive surfaces, and a second photovoltaic element covering said plurality of first photovoltaic elements. The single crystal layer regions are separated from each other.

**5,096,505**
Fraas, Lewis M.; Mansoori, Nurullah; Avery, James E.; Martin, John M.; Yerkes, John W., inventors; The Boeing Company, assignee. *Panel for Solar Concentrator and Tandem Cell Units*. March 17, 1992.

Solar cells, particularly GaAs/GaSb tandem solar cells, are mounted on a honeycomb light weight panel in optical alignment with solar energy concentrators mounted on a front panel side. The cells are mounted on metallized surfaces of the heat spreader that is attached to a panel wall rear panel side. A circuit carrier has conductors which are bonded to metallization islands that are on one side only of the heat spreader. The circuit carrier is adhered to the rear panel side.

**5,098,178**
Ortabasi, Ugur, inventor. *Superconducting Matrix*. March 24, 1992.

A superconductor has been disclosed which is formed of high temperature superconducting ceramic oxide particles distributed in a metal superconductor. In another embodiment, the superconducting particles are distributed in a dielectric matrix.

**5,098,482**
Warfield, Donald B., inventor; Solarex Corporation, assignee. *Vertical Junction Solar Cell.* March 24, 1992.

An improved vertical junction solar cell wherein the vertical junctions are formed by a plurality of grooves etched in the silicon wafer of the solar cell. The grooves define a plurality of walls having a top surface and side surfaces and a plurality of groove bottoms therebetween. In order to increase radiation resistance in such vertical junction solar cells, a focusing coverslide is provided which retracts or reflects incident light onto only the top surfaces of the walls and away from the grooved bottoms. It has been discovered that the majority of the radiation degradation in vertical junction solar cells occurs as a result of incident light impinging on the grooved bottoms, which are less resistant to radiation than are the top walls. Thus, the present invention provides a vertical junction solar cell with greatly increased radiation resistivity.

**5,098,850**
Nishida, Shoji; Yonehara, Takao, inventors; Canon Kabushiki Kaisha, assignee. *Process for Producing Substrate for Selective Crystal Growth, Selective Crystal Growth Process and Process for Producing Solar Battery by Use of Them.* March 24, 1992.

A process for producing a substrate for selective crystal growth, which comprises subjecting a substrate having a layer comprising a first material having higher nucleation density and a layer comprising a second material having lower nucleation density than the first material laminated thereon to application of an electrical field concentrated at a desired region of the layer comprising the second material, thereby removing the region whereby the layer comprising the first material is exposed.

**5,100,478**
Kawabata, Kiyoshi, inventor; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell.* March 31, 1992.

A solar cell includes a semiconductor substrate having a plurality of recesses at one surface leaving a plurality of mutually isolated areas of the substrate exposed at that surface, an electrically insulating material filling the recesses, a semiconductor film disposed on the substrate and the electrically insulating material forming a plurality of mutually isolated rectifying junctions with the substrate, one electrode in electrical contact with the semiconductor film at a light incident surface of the solar cell and another electrode in electrical contact with the substrate. The solar cell is made by forming the plurality of recesses, depositing an electrically insulating material on the substrate and in the recesses, removing a portion of the electrically insulating material to expose the substrate at a plurality of mutually isolated locations, depositing the semiconductor film on the electrically insulating material and the substrate, and depositing the electrodes.

**5,100,480**
Hayafuji, Norio, inventor; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell and Method for Manufacturing the Same.* March 31, 1992.

A solar cell includes an insulating or semi-insulating substrate having a pair of through holes, an n-type semiconductor layer disposed on the front surface of the substrate, and a p-type semiconductor layer disposed on the substrate in the first hole and on the n-type semiconductor layer. An n side electrode is formed on the surface of the n-type semiconductor layer in the second hole and also on a part of the back surface of the substrate. A p side electrode is formed on the surface of the p-type semiconductor layer in the first hold and also on the back surface of the substrate. In connecting a plurality of solar cells in a wafer in series, a trench reaching the substrate is formed between adjacent solar cells.

**5,100,808**
Glenn, Gregory S., inventor; Spectrolab, Inc., assignee. *Method of Fabricating Solar Cell with Integrated Interconnect.* March 31, 1992.

A pattern of current collection gridlines is formed on a surface of a photovoltaic wafer. An ohmic contact strip is formed adjacent to an edge of the wafer in electrical interconnection with the gridlines. Interconnect tabs are integrally formed with the gridlines and contact strip, extending away from the contact strip external of the edge for series or parallel interconnection with other solar cells. The interconnect tabs may have a stress relief configuration, including a non-planar bend or loop. The wafer initially has a first portion and a second portion. A barrier layer of photoresist or the like is formed on the second portion. The grid and contact strip are formed on the first portion simultaneously with forming the interconnect tabs over the barrier layer on the second portion using photolithography and metal deposition. The barrier layer is dissolved away, and the second portion is broken away from the first portion, leaving the interconnect tabs extending from the contact strip external of the remaining first portion of the wafer.

**5,101,260**
Nath, Prem; Call, John; Hoffman, Kevin; Laarman, Timothy; DiDio, Gary M., inventors; Energy Conversion Devices, Inc., assignee. *Multilayer Light Scattering*

*Photovoltaic Back Reflector and Method of Making Same.* March 31, 1992.

A multilayered, light-scattering back reflector for a photovoltaic device, said back reflector including a first relatively hard, textured layer atop a substrate and a second highly reflective layer conformally disposed atop the first layer. The back reflector may further include a third light scattering layer formed atop said second layer, said third layer adapted to further provide a barrier layer between the body of semiconductor material from which the photovoltaic device is formed and the multilayered back reflector.

**5,102,471**
Sasaki, Koji, inventor; Mitutoyo Corporation, assignee. *Portable Measuring Instrument with Solar Batteries.* April 7, 1992.

In a portable measuring instrument using as a power source a group of solar batteries in which a plurality of solar batteries are series- connected on the same plane, respective light receiving windows are made to be substantially equal in area to one another, and each of the light receiving windows surrounds the outer periphery of other light receiving windows adjacent thereto, whereby, even if part of the light which irradiates the light receiving windows of the solar batteries is screened by a hand or other holding means for operating and holding the portable measuring instrument, it is avoided that only a specific light receiving window is screened, so that a current of the group of solar batteries can be efficiently produced.

**5,103,268**
Yin, Ming-Jau; Tanner, David P., inventors; Siemens Solar Industries, L.P., assignee. *Semiconductor Device with Interfacial Electrode Layer.* April 7, 1992.

A semiconductor device having a thin film silicon-containing active layer and a metallic first electrode is provided with an interfacial metallic layer at an inner surface of a second electrode to increase electrical resistance and thereby reduce shunts adjacent pinhole-type defects of the active layer. The interfacial layer is preferably made of a metal selected from the group consisting of tin, gold, titanium, palladium and tantalum.

**5,103,851**
Nishida, Shoji; Yonehara, Takao, inventors; Canon Kabushiki Kaisha, assignee. *Solar Battery and Method of Manufacturing the Same.* April 14, 1992.

A solar battery characterized in the following respects of having at least one semiconductor multilayer structure having at least an electrode ($a_1$); a semiconductor crystal ($a_2$) of a first conductivity type formed on the electrode ($a_1$); and at least one set of laminate layers consisting of a high resistance semiconductor layer ($a_3$) and a semiconductor layer ($a_4$) of a second conductivity type and a semiconductor layer ($a_5$) of the first conductivity type which sequentially formed so as to cover the semiconductor crystal ($a_2$) of the first conductivity type and at least one semiconductor multilayer structure having at least: an electrode ($b_1$); a semiconductor crystal ($b_2$) of the second conductivity type formed on the electrode ($b_1$); and at least one set of laminate layers consisting of a high resistance semiconductor layer ($b_3$) and a semiconductor layer ($b_4$) of the first conductivity type and a semiconductor layer ($b_5$) of the second conductivity type which are alternately arranged on the same insulative substrate. The semiconductor multilayer structure sections are alternately electrically connected by high resistance semiconductor layers formed so as to cover the semiconductor multilayer structure sections. The surfaces of the high resistance semiconductor layers form light receiving surfaces.

**5,104,455**
Yokota, Akitoshi; Nakata, Yukihiko; Sannomiya, Hitoshi; Moriuchi, Sota; Inoue, Yasumi; Itoh, Manabu, inventors; Sharp Kabushiki Kaisha, assignee. *Amorphous Semiconductor Solar Cell.* April 14, 1992.

An amorphous semiconductor solar cell includes an i-type layer which is an at least partially alloyed, substantially intrinsic semiconductor, an n-type layer formed on one side of the i-type layer, and a p-type layer formed on the other side of the i-type layer, and the i-type layer has its energy band gap varied in a thickness direction to have a band gap larger than the band gap of the p-type layer in the vicinity of the interface with the p-type layer.

**5,104,633**
Sakaguchi, Yasuhiko; Aratani, Fukuo; Uchino, Kazuhiro; Yoshiyagawa, Mitsugi; Miyata, Kunio; Ishizaki, Masato; Kawahara, Tetsuro, inventors. *Method for Producing High-Purity Metallic Silicon and Apparatus Therefor.* April 14, 1992.

A method and apparatus for producing or manufacturing a high purity metallic silicon takes a process for generating silicon monoxide by causing reaction between a silicon dioxide containing material and molten state metallic silicon. The silicon monoxide thus generated is sucked for reduction by means of a reducing agent including a carbon containing material and a silicon containing material.

**5,106,492**
Distinti, John A.; Fonti, Robert G., inventors. *Solar Powered Swimming Pool Skimmer.* April 21, 1992.

A swimming pool skimmer includes a paddle wheel that directs fluid and debris into a debris catcher. The paddle wheel is turned by a motor that is powered from an array of solar cells. A solar concentrator focuses solar

energy onto the solar cells, and an alarm circuit includes a strain gauge on the debris catcher. The strain gauge forms one leg of a bridge circuit that is connected to a comparator having a feedback loop. The output of the comparator is connected to an alarm element either directly or remotely.

**5,106,495**
Hughes, Harold, inventor. *Portable Water Purification Device*. April 21, 1992.

A portable ozonization system having a tank mounted on a base housing a battery, pump and associated components. A photovoltaic battery charger is mounted on a surface of the tank. Water from the tank is periodically circulated from under the control of a low voltage DC timer by the pump through a venturi where it is subjected to DC generated ultraviolet radiation to treat virus, cysts, bacteria and organic material. Water is withdrawn from the tank for use through a filter to further enhance the water quality.

**5,106,763**
Bathey, Balakrishnan R.; Cretalla, Mary C.; Taylor, Aaron S., inventors; Mobil Solar Energy Corporation, assignee. *Method of Fabricating Solar Cells*. April 21, 1992.

A method and apparatus for producing crystalline substrates for use in fabricating solid state electronic devices. A hollow crystalline body is grown from a melt containing a dopant and a P-N junction is formed in said crystalline body as it is being grown. Then the hollow body is severed to provide individual solar cell substrates.

**5,107,637**
Robbins, Steven, inventor; B & E Energy Systems, Inc., assignee. *Transit Shelter with Self-Contained Illumination System*. April 28, 1992.

A shelter structure includes a photovoltaic illumination system. A pair of translucent, spaced-apart panels define an interior volume which houses and protects the lamps, batteries, and illumination circuitry of the system.

**5,109,989**
Kremmin, Klaus; Kremmin, Thomas R.F., inventors; K-2 Industries, Inc., assignee. *Rotary Display*. May 5, 1992.

A solar powered rotary display is assembled on a base having a stationary table mounted on a post fixed to the base, a rotary table mounted for rotation on the base about a main axis defined by the post, and a plurality of display disks mounted for rotation on the rotary table about respective planetary axes carried by the rotary table. A number of drive wheels are mounted on respective axles carried by the rotary table in positions about the main axis for supporting and balancing the rotary table on the base. Each of the drive wheels includes an annular friction surface in contact with both an upper surface of the base and a bottom surface of the display disks for rotating the disks in a fixed ratio with rotation of the rotary table.

**5,110,369**
Tornstrom, Eric; Norbedo, Anthony J., inventors; Mobil Solar Energy Corporation, assignee. *Cable Interconnections for Solar Cells Modules*. May 5, 1992.

A terminal connection for a solar cell device includes a conductive terminal strip protruding from the rear wall of the device and provided with a hole. An insulating convex/concave member is secured to the rear wall and is provided with an aperture which is positioned so that the hole in the strip extends across the aperture. The terminal strip extends between the insulating member and a nut received by the insulating member, with the nut being captured between the insulating member and the rear wall of the solar cell device. A connector member having a metal tube which is forged into electrical and mechanical connection with an exposed portion of a cable core is mechanically fastened to the terminal strip by a fastener which is screwed into the nut, whereby the terminal strip makes electrical contact between the cable and the solar device.

**5,110,370**
Vogeli, Craig; Nath, Prem, inventors; United Solar Systems Corporation, assignee. *Photovoltaic Device with Decreased Gridline Shading and Method for Its Manufacture*. May 5, 1992.

A photovoltaic cell includes a light-directing optical element integrally formed in an encapsulant layer thereof in the region of opaque current-collecting gridlines. The optical element redirects light which would be absorbed by the opaque structure to other regions of the photovoltaic device, thereby decreasing shading effects.

**5,110,531**
Nanis, Leonard, inventor; SRI International, assignee. *Process and Apparatus for Casting Multiple Silicon Wafer Articles*. May 5, 1992.

Method and apparatus of casting silicon produced by the reaction between $SiF_4$ and an alkaline earth metal into thin wafer-shaped articles suitable for solar cell fabrication.

**5,111,127**
Johnson, Woodward, inventor. *Portable Power Supply*. May 5, 1992.

A portable power supply having a rechargeable battery in a housing mounted on a portable frame. An inverter/converter unit, attached to the frame, is

hardwired to the battery for conversion of dc power to ac power and for recharging the battery from an external ac source. Power distribution means are provided for distributing dc and ac power. Photovoltaic panels are mounted to the frame for recharging the battery.

**5,116,427**
Fan, John C.C.; Zavracky, Paul M., inventors; Kopin Corporation, assignee. *High Temperature Photovoltaic Cell*. May 26, 1992.

A photovoltaic device utilizing compound semiconductor materials that are stable when operated at high temperatures. Hostile environments, and in particular, thermally stressful environments such as those generated by use of light concentrating systems, require encapsulation of the device. Sealing of the photoactive junction, the conductive grid, the exposed semiconductor surfaces, and the pads contacting the grid away from the junction area provide such thermal stability. A heterojunction structure can be used along with barrier materials providing a conductive grid in contact with the photoactive surface thereby reducing interdiffusion of that surface with the conductive grid.

**5,118,361**
Fraas, Lewis M.; Mansoori, Nurullah; Kim, Namsoo P.; Avery, James E., inventors; The Boeing Company, assignee. *Terrestrial Concentrator Solar Cell Module*. June 2, 1992.

Solar cells, particularly GaAs/GaSb tandem solar cells, are mechanically and electrically connected in the form of a string using a flexible circuit tape and mounted in optical alignment with solar energy concentrators in a module. A heat spreader body is attached to each cell unit as part of a heat sink and the cells are precisely positioned to provide optical alignment. The flexible circuit tape is formed by conductive strips sandwiched between layers of polymer dielectric tape and provided with tabs at predefined holes in the tape for bonding to current carrying surfaces of concentrated sunlight tandem solar cell units.

**5,118,945**
Winschuh, Erich; Petry, Harald, inventors; Siemens Aktiengesellschaft, assignee. *Photothermal Test Process, Apparatus for Performing the Process and Heat Microscope*. June 2, 1992.

A process, apparatus, and heat microscope for testing the properties of materials by the photothermal effect includes generating a laser beam with a laser light source integrated into a portable measuring head, emitting the laser beam toward a region of a surface of a material sample to be tested, and focusing the laser beam to a desired measurement point diameter at a target light spot with optics at an end toward the laser beam, for absorbing a proportion of the amount of light energy with irradiated volume elements of the material sample and emitting infrared light signals from the surface of the volume elements and volume elements adjacent thereto. The emitted IR light signals are conducted to an optical decoupling element for conducting the emitted IR light signals further and largely suppressing components of the laser beam reflected at the surface of the sample. Decoupled IR light signals are further conducted and focused onto receiving surface of at least one IR light detector inside the portable measuring head for converting received IR light signals into corresponding electrical signals for further signal processing. The laser beam is conducted from the laser light source to the optical element at the end of the laser beam with a first resulting degree of transmission and reflection of at least 60%, and the IR light signals emitted by the material sample are conducted to the at least one IR light detector with a second resulting degree of transmission and reflection of at least 60%.

**5,121,183**
Ogasawara, Nobuyoshi; Mitsui, Kotaro, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Light Responsive Heterojunction Semiconductor PN Element*. June 9, 1992.

A light responsive semiconductor includes a second conductivity type semiconductor substrate, a photoelectric conversion layer comprising semiconductor layers having a pn junction, which is disposed on the second conductivity type semiconductor substrate, a buffer layer comprising a second conductivity type semiconductor layer having a larger energy band gap than that of the photoelectric conversion layer. The element further includes a light reflection layer comprising a semiconductor layer which is disposed between the second conductivity type semiconductor substrate and the buffer layer. Alternatively, a light reflection layer which is a buffer layer is disposed between a photoelectric conversion layer and a semiconductor substrate.

**5,121,307**
Moore, Charles M., inventor. *Self Contained Solar Powered Strobe Light*. June 9, 1992.

A pole mounted self-contained solar-powered strobe light utilizing ultraviolet rays from the sun and moon for charging its batteries and employing a cylindrical housing open at one end for fitting over the top of a vertically mounted pole. Batteries are insertable in the other end of the housing which are covered by a cap for closing this end of the housing. The cap has mounted on it a strobe light connected to the batteries and covered by a transparent magnifying lens.

**5,121,818**
McComic, Richard D., inventor. *Solar Powered Cooling Apparatus for a Vehicle Brake System*. June 16, 1992.

A solar-powered cooling apparatus for a vehicle brake system utilizing a solar cell panel mounted within a vehicle front bumper to selectively actuate a blower motor located within an air duct housing. The air duct housing is connected to the front bumper of which has a plurality of forward openings with filtering screens so as to direct cool air flowing from the openings to the associated disk brake rotor. A plurality of openings are also formed on the top panel of the bumper of which the solar panel is operatively associated and where the openings can be adjusted via a slide plate operative through a push-pull cable located in a passenger compartment of the vehicle.

**5,123,968**
Fraas, Lewis M.; Avery, James E.; Girard, Gerald R., inventors; The Boeing Company, assignee. *Tandem Photovoltaic Solar Cell with III-V Diffused Junction Booster Cell.* June 23, 1992.

A photovoltaic cell array involving rows and columns of tandem or stacked solar cell units composed of GaSa/GaSb associated with a radiation collector have produced measured energy conversion efficiencies of 31% AMO. The booster GaSb cell is manufactured by a process which produces a p-type diffusion region within an n-type substrate, has improved energy conversion efficiencies and can be mounted as part of a four terminal stacked solar cell unit.

**5,124,269**
Kobayashi, Kenji; Tsuge, Kazunori; Tawada, Yoshihisa, inventors; Kanegafuchi Kagaku Kogyo, assignee. *Method of Producing a Semiconductor Device Using a Wire Mask Having a Specified Diameter.* June 23, 1992.

A semiconductor device producing method wherein a patterned transparent electrode, a patterned amorphous silicon semiconductor layer and a patterned backside electrode are formed on a substrate sequentially in this order, and the patterning of at least one of the amorphous silicon semiconductor layer and the backside electrode is carried out in a step of forming at least one of the amorphous silicon semiconductor layer and the backside electrode with a wire mask being brought into substantially close contact with a surface subjected to film forming and a step of removing a thin film formed at a region between the wire mask and the surface subjected to film forming in the forming step; and a film forming apparatus used in the producing method comprising a holder which holds a substrate having a surface subjected to film forming, a mechanism for fixing and positioning the substrate on the holder and a plurality of wires which are disposed on the film forming surface side of the substrate and are to be brought into substantially close contact with the film forming surface. The method and the apparatus enable the film forming operation and the patterning operation to be carried out simultaneously without lowering the characteristics of a solar cell.

**5,124,610**
Conley, Jerry J.; Mortensen, Gary B., inventors; E.F. Johnson Company, assignee. *Tritiated Light Emitting Polymer Electrical Energy Source.* June 23, 1992.

An electrical energy source is created by the combination of a light emitting polymer material having at least one light emitting surface emitting light energy of a specified frequency bandwidth and a photovoltaic cell having a light collecting surface and a pair of electrical contacts. The light collecting surface of the photovoltaic cell is optically coupled with the light emitting surface of the light emitting polymer material. An open-circuit voltage is generated between the pair of electrical contacts as a result of the absorption of emitted light energy from the light emitting polymer material by the photovoltaic cell. The light emitting polymer comprises a mixture of a polymer labelled with a tritium and an organic compound which emits light energy when subjected to radiation generated by the tritium. The organic compound is at least partly bonded to the polymer and the mixture is translucent at the specified frequency bandwidth of the light energy. Maximum absorption of the emitted light energy is achieved by the intimate optical contact between the light emitting surface and the light collecting surface, by matching the maximum absorption frequency bandwith of the photovoltaic cell with the specified frequency bandwith of the emitted light energy from the light emitting polymer material, and by the structural arrangement of the light emitting polymer material itself.

**5,125,608**
McMaster, Harold A.; Nicholson, Robert D.; Kaaka, Steven A. F., inventors; 700 Solar Club, Inc., assignee. *Photovoltaic Panel Support Assembly.* June 30, 1992.

Provided is a support assembly for mounting an array of photovoltaic panels to a support surface such as the ground. According to the invention there is provided a plurality of front and rear support posts, each post having an anchor portion to be driven into the support surface and a leg portion which is nested therein and longitudinally adjustable to raise or lower corresponding front and rear horizontal supports. Photovoltaic panels are mounted lengthwise across the horizontal supports in a predetermined position to minimize the stress thereon caused by wind load. The horizontal supports further comprise wiring raceways to support wiring harnesses originating from the photovoltaic panels and terminating at the end of each row of photovoltaic panels in the array.

**5,125,983**
Cummings, Richard D., inventor; Electric Power Research Institute, assignee. *Generating Electric Power from Solar Radiation.* June 30, 1992.

An extensive photovoltaic array for generating electric power from solar radiation as in a power plant includes an extensive unitary structural grid having substantial extent in both x and y directions and supported on a pedestal. The unitary structural grid is defined by a multiplicity of structural members connected to one another at angles and defining spaces therebetween. The structural grid has a depth sufficient to provide structural rigidity to the photovoltaic array. A large multiplicity of lens assemblies, each including at least one lens, is directly supported by and in spaces defined between structural members of the unitary structural grid. The lens assemblies close the upper side of the unitary structural grid. All other sides of the unitary structural grid are also closed. A plurality of solar cells are located within spaces defined between structural members of the structural grid and positioned to receive solar radiation that passes through respective lenses of the lens assemblies. The lens assemblies and the structural members of the structural grid have an integrated relationship.

**5,125,984**
Kruehler, Wolfgang; Grabmaier, Josef, inventors; Siemens Aktiengesellschaft, assignee. *Induced Junction Chalcopyrite Solar Cell*. June 30, 1992.

A new solar cell of a I-III-$VI_2$ semiconductor material that has an inversion layer is provided. The cell comprises a substrate having an electrically conductive, first electrode, a p-conductive, polycrystalline semiconductor layer of chalcopyrite material, a barrier layer composed of an electrically non-conductive material, a second electrode, and an antireflection layer. The antireflection layer has stationary, positve charges that induce a negatively charged inversion layer in the boundary surface region of the semiconductor layer relative to the barrier layer. The negatively charged inversion layer serves as an emitter for a space charge zone. In an embodiment the invention comprises a semiconductor layer of copper-indium- diselenide or copper-gallium-diselenide, a barrier layer of silicon dioxide, an antireflection layer of silicon nitride, and cesium chloride as the stationary charges.

**5,127,964**
Hamakawa, Yoshihiro; Tawada, Yoshihisa; Tsuge, Kazunori; Izumina, Masanobu, inventors; Kanegafuchi Kagaku Kogyo Kabushiki Kaisha, assignee. *Flexible Photovoltaic Device*. July 7, 1992.

A flexible photovoltaic device includes a flexible substrate and a photovoltaic device body. The flexible substrate is a metal foil or film provided with an electric insulating layer of a material having an electric conductivity of not more than $10^{-7}$ $(\Omega\text{-cm})^{-1}$ at the time of light impinging and selected from a heat resistant polymer, a metal oxide, a crystalline or amorphous silicon compound and an organometallic compound.

**5,130,103**
Yamagata, Kenji; Kumomi, Hideya; Tokunaga, Hiroyuki; Arao, Kozo, inventors; Canon Kabushiki Kaisha, assignee. *Method for Forming Semiconductor Crystal and Semiconductor Crystal Article Obtained by Said Method*. July 14, 1992.

Semiconductor crystals are formed by applying a semiconductor crystal forming treatment on a substrate having a free surface on which a deposition surface ($S_{NOS}$) with a small nucleation density and a deposition surface ($S_{NDL}$) with metal having a sufficiently small area for crystal growth only from a single nucleus and having a greater nucleation density ($ND_L$) than the nucleation density ($ND_S$) of the deposition surface ($S_{NOS}$) are arranged adjacent to each other, thereby growing a semiconductor single crystal from the single nucleus.

**5,131,341**
Newman, Edwin, inventor. *Solar Powered Electric Ship System*. July 21, 1992.

A system for producing and distributing electric power on a sailing ship, using arrays of photovoltaic cells covering the ships sails and rigging to generate electric power during daylight for the purpose of driving a ships screw. The solar array electric power output is processed by a voltage regulator which charges a large capacity storage battery and energizes an electric motor to drive the ships screw. An AC inverter is also provided to convert the DC power for the AC loads. To increase the area normally available on sailing ships for solar arrays, wing-booms which extend the lengths of the yards, and rolling booms above the yards are proposed for addition to the ships superstructure. The invention should make it possible for sailing ships to resume transportation of cargo without the need for auxiliary gas or oil-burning engines and a fuel supply.

**5,131,888**
Adkins II, Dwight O., inventor. *Solar Powered Exhaust Fan*. July 21, 1992.

A solar powered exhaust fan having a pipe adaptor for connection to the interior of portable buildings. The exhaust fan may be either DC or AC energized. Automatic and manual switches are provided.

**5,131,933**
Flödl, Helmut; Uebele, Paul, inventors; Telefunken Systemtechnik GmbH, assignee. *Solar Cell*. July 21, 1992.

A solar cell includes a silicon body with a first antireflection layer on its front side. The first antireflection layer has elongated window openings which extend parallel to one another. Parallel contact fingers

made of metal extend over the first antireflection layer at right angles to the window openings. The contact fingers make electrical contact with the silicon body through the window openings. A second antireflection layer is deposited on top of the contact fingers and the first antireflection layer. The second antireflection layer reduces reflection losses at the window openings, in addition to providing further reflection protection where it overlaps the first antireflection layer. Highly doped zones can be provided in the silicon body beneath the window openings.

**5,131,954**
Vogeli, Craig; Nath, Prem, inventors; United Solar Systems Corporation, assignee. *Monolithic Solar Cell Array and Method for Its Manufacturing*. July 21, 1992.

Large area, thin-film body of photovoltaic material is subdivided into a plurality of small area devices. Through a selective etching process, a portion of the bottom electrode of each small area device is exposed. A metallic contact member is deposited upon the exposed portion of the electrode and a series connection between adjoining cells is established by interconnecting the metallic contact member of a first cell with the top electrode of an adjoining cell, so as to provide a large-area photovoltaic device including a plurality of interconnected sub-cells.

**5,131,956**
Oohara, Takahiko; Usui, Masaaki; Ogasawara, Nobuyoshi; Mitsui, Kotaro, inventors; Mitsubishi Denki Kabushiki Kaisha; Nippon Telegraph and Telephone Corporation, assignee. *Photovoltaic Semiconductor Device*. July 21, 1992.

A photovoltaic semiconductor device includes a first conductivity type silicon substrate having a first main surface, a first conductivity type compound semiconductor layer disposed on a first, major portion of the first main surface of the silicon substrate, a second conductivity type compound semiconductor layer disposed on the first conductivity type compound semiconductor layer, a first electrode connected to the second conductivity type compound semiconductor layer, a portion of the first electrode being disposed on a second, minor portion of the first main surface of the silicon substrate with an intervening insulating film, and a second electrode disposed on a third, minor portion of the first main surface of the silicon substrate.

**5,133,809**
Sichanugrist, Porponth; Suzuki, Hirohisa; Nishi, Hirofumi, inventors; Showa Shell Sekiyu K.K., assignee. *Photovoltaic Device and Process for Manufacturing the Same*. July 28, 1992.

A photovoltaic device and a process for manufacturing a photovoltaic device which includes providing a plurality of spaced transparent electrode layer regions on an insulating transparent substrate plate, forming an amorphous semiconductor layer over the spaced transparent electrode layer regions, forming a patterned conductive printed electrode layer over the amorphous semiconductor layer to form a plurality of photovoltaic regions, and then irradiating the photovoltaic regions with a laser beam from the substrate plate side to heat and melt the transparent electrode, amorphous semiconductor, and conductive printed electrode in each photovoltaic region, thereby forming in each photovoltaic region a conductive path made of an alloy formed by the melting, thus electrically connecting the photovoltaic regions in series.

**5,133,810**
Morizane, Masashi; Okada, Koichi; Murata, Kenji; Inoue, Hiroshi; Kishi, Yasuo, inventors; Sanyo Electric Co., Ltd., assignee. *Flexible Photovoltaic Device and Manufacturing Method Thereof*. July 28, 1992.

A method of manufacturing a photovoltaic device includes the steps of: preparing a plurality of photovoltaic elements each including an insulator film, a first electrode, an amorphous semiconductor film for photoelectric conversion and a second electrode stacked in this order on a supporting substrate; electrically connecting the photovoltaic elements with each other; attaching a common protection film onto the second electrodes of the photovoltaic elements; and removing the supporting substrate from the photovoltaic elements, wherein the protection film mechanically couples the plurality of photovoltaic elements with each other.

**5,135,581**
Tran, Nang T.; Gilbert, James R., inventors; Minnesota Mining and Manufacturing Company, assignee. *Light Transmissive Electrically Conductive Oxide Electrode Formed in the Presence of a Stabilizing Gas*. August 4, 1992.

A light transmissive, electrically conductive oxide is doped with a stabilizing gas such as $H_2$ and $H_2O$. The oxide is formed by sputtering a light transmissive, electrically conductive oxide precursor onto a substrate at a temperature from 20°C to 300°C. Sputtering occurs in a gaseous mixture including a sputtering gas and the stabilizing gas.

**5,136,351**
Inoue, Yasumi; Nakata, Yukihiko; Itoh, Manabu; Yokota, Akitoshi; Sannomiya, Hitoshi; Moriuchi, Sota, inventors; Sharp Kabushiki Kaisha, assignee. *Photovoltaic Device with Porous Metal Layer*. August 4, 1992.

A photovoltaic device includes a semi-continuous metal layer having an uneven surface, which is not uniform, formed on a substrate, a reflective continuous metal layer having a substantially uniform thickness formed to cover the semi-continuous metal layer, a semiconductor film for photoelectric conversion formed on

the reflective continuous metal layer, and a transparent electrode formed on the semiconductor film.

**5,137,835**
Karg, Franz, inventor; Siemens Aktiengesellschaft, assignee. *Method for Manufacturing a Chalcopyrite Solar Cell*. August 11, 1992.

A method for producing a solar cell having a semiconductor layer of copper gallium diselenide covered with a window layer of copper aluminum diselenide by first producing a semiconductor material of one type of conductivity by forming either a copper gallium diselenide or a copper aluminum diselenide and then exchanging metal ions in the upper portion of the layer to provide an opposite type of conductivity by exchanging metal ions of the layer for another type. The exchange can include exchanging both the copper and gallium ions with the zinc ion to form a zinc diselenide window or replacing the gallium ions with aluminum ions to form a copper aluminum diselenide window or, if a copper aluminum diselenide layer had been provided, forming an absorbing layer by replacing the aluminum ions with the gallium ions to form the absorbing layer.

**5,138,403**
Spitzer, Mark B., inventor; Kopin Corporation, assignee. *High Temperature Schottky Barrier Bypass Diodes*. August 11, 1992.

A high temperature Schottky barrier diode utilizing a refractory metal with a p-type gallium arsenide wafer can be used as a bypass diode for solar cell arrays. The diode structure can be integrally formed with a solar cell having a high temperative metallized contact grid.

**5,139,578**
Valley, Charles R., inventor. *Liquid Crystal Coverslides for Solar Cells*. August 18, 1992.

A liquid crystal coverslide for both protecting and concealing solar cells and solar cell arrays is disclosed. A conventional construction of an emulsion of encapsulated liquid crystal droplets is sandwiched between two pieces of polyester or silica to form a coverslide which is in turn mounted over a solar cell or solar cell arrays. The liquid crystal coverslide is electrically switched between transparent and opaque operating modes in order to achieve full light transmission, full power output or protection concealment.

**5,141,564**
Chen, Wen S.; Stewart, John M., inventors; The Boeing Company, assignee. *Mixed Ternary Heterojunction Solar Cell*. August 25, 1992.

A thin film heterojunction solar cell and a method of making it has a p-type layer of mixed ternary I-III-$VI_2$ semiconductor material in contact with an n-type layer of mixed binary II-VI semiconductor material. The p-type semiconductor material includes a low resistivity copper-rich region adjacent the back metal contact of the cell and a composition gradient providing a minority carrier mirror that improves the photovoltaic performance of the cell. The p-type semiconductor material preferably is $CuInGaSe_2$ or $CuIn(SSe)_2$.

**5,142,331**
Yoshida, Susumu, inventor; Mitsubishi Denki Kabushiki Kaisha, assignee. *Photoelectric Conversion Semiconductor Device*. August 25, 1992.

A first conductivity type first semiconductor layer is formed on an insulation substrate and a second conductivity type second semiconductor layer is formed on the first semiconductor layer in order to provide a semiconductor device having a highly reliable electrode structure. In order to accomplish this electrode structure, a first electrode which is insulated from the first semiconductor layer with an insulation film, is formed on an area extending from a part of the second semiconductor layer to an exposed surface of the insulation substrate which is not covered with the first semiconductor layer. A second electrode, which is separate from the second semiconductor layer, is formed on a part of the first semiconductor layer which is not covered with the second semiconductor layer. Using this construction, a solar battery cell can be realized. Additionally, the first electrode has a connection region on the exposed surface of the insulation substrate in order to provide connection with an external terminal. This enables welding or bonding with an external terminal on this particular connection region.

**5,143,556**
Matlin, Ronald W., inventor. *Support for Photovoltaic Arrays*. September 1, 1992.

A supported photovoltaic array and method in which support elements are in rows spaced from one another and are bi-directionally spanned by members which mount photovoltaic modules that are separated from one another and are slidably clipped to the spanning members by cushioned load-spreading fasteners.

**5,145,442**
Zan, Ja D., inventor. *Multi-Purpose Solar Energy Operated Toy Vehicle*. September 8, 1992.

A multi-purpose solar energy operated toy vehicle generally has a plate resembling a ship to be placed on a ship body, while a pair of paddles are connected to the ship body with a motor. A solar cell panel is installed to provide electrical energy by way of photoelectric effect, so that a battery disposed in a housing on the place can be electrically charged and the motor can be driven to move the vehicle. A pair of front wheels can be rotatably attached on the front portion of the ship body and a pair of rear wheels can replace the paddles to allow the vehicle to run on the ground.

**5,145,793**
Oohara, Takahiko; Ohmachi, Yoshiro; Kadota, Yosihaki; Mitsui, Kotaro; Ogasawara, Nobuyoshi; Nishimura, Takashi, inventors; Mitsubishi Denki Kabushiki Kaisha; Nippon Telegraph and Telephone Corporation, assignee. *Manufacturing a Gallium Arsenide Solar Cell on a Silicon Substrate*. September 8, 1992.

A method for manufacturing a solar cell which includes at least a first GaAs layer of a first conductivity type and a second GaAs layer of a second conductivity type sequentially formed on a first main surface of an Si substrate of the first conductivity type, a first electrode formed on a second main surface opposite to the first main surface of the Si substrate and a second electrode formed on the second GaAs layer. The method includes a first step of forming a layer comprising a material having a thermal expansion coefficient smaller than that of Si on the second main surface of the Si substrate at a temperature close to room temperature and a second step of sequentially forming the first and second GaAs layers on the first main surface of the Si substrate.

**5,147,468**
Deguchi, Mikio, inventor; Mitsubishi Denki Kabushiki Kaisha, assignee. *Photovoltaic Semiconductor Device and Method for Manufacturing the Same*. September 15, 1992.

A semiconductor device has a plurality of unit photovoltaic elements arranged on a substrate and connected to each other in series. The photovoltaic device includes first semiconductor layers with low resistivity formed on a high-temperature-resistant insulating substrate and spaced apart at a predetermined interval and second semiconductor layers selectively formed on corresponding first semiconductor layers so that a part of the respective first semiconductor layer is exposed. The second semiconductor layer is not in contact with the first semiconductor layer of an adjacent photovoltaic element. As a result, there is provided a photovoltaic semiconductor device comprising a plurality of unit photovoltaic elements connected to each other in series with high conversion efficiency and which is not easily degraded by light irradiation.

**5,149,188**
Robbins, Steven, inventor; Solar Outdoor Lighting, Inc., assignee. *Solar Powered Exterior Lighting System*. September 22, 1992.

A self-contained solar powered light having a battery system where the battery container is mounted between two cantilevered arms on an upright vertical support. The light element is mounted at the distal end of one of the cantilevered arms. The photovoltaic panels are mounted on the upper cantilevered arm and point upward toward the sun. A computer is operably connected between the battery and the photovoltaic panels and the light element to determine when the light element should be actuated and deactuated based upon amperage produced by the photovoltaic panels. The vertical support has a U-shaped cross member which can engage poles with circular cross section or poles with external side flats. Threaded fasteners fix the vertical support onto the pole member.

**5,150,043**
Flesner, Larry D., inventor; The United States of America as represented by the Secretary of the Navy, assignee. *Apparatus and Method for Non-Contact Surface Voltage Probing by Scanning Photoelectron Emission*. September 22, 1992.

An apparatus and method for non-contact sensing electrical potentials of selected regions on the surface of a sample are provided. A typical sample is an integrated circuit, electronic device, or semiconductor material. The sample is positioned within a vacuum chamber and irradiated with an ultraviolet light beam so that the material emits electrons by the photoelectric effect. The electrons have kinetic energies which are variable according to the electrical potential of the surface of the material. Emitted electrons having kinetic energies within a predetermined range are selected by an electron energy analyzer. An electron detector receives the selected electrons and produces electrical signals corresponding to the energies of said selected electrons. In another embodiment of the invention, a modulated light beam other than the ultraviolet light probe beam irradiates the material in order to produce time varying modulation of the photoelectron energy spectrum.

**5,151,255**
Fukuda, Nobuhiro; Kobayashi, Sadao; Miyachi, Kenji; Takenouchi, Hidemi; Kawahara, Yoji; Teramoto, Takayuki, inventors; Mitsui Toatsu Chemicals, Inc., assignee. *Method for Forming Window Material for Solar Cells and Method for Producing Amorphous Silicon Solar Cell*. September 29, 1992.

A method for forming a dihydride rich amorphous silicon semiconductor film suitable for use as a window material of solar cells only from a silicon material, which comprises decomposing a gaseous mixture composed of disilane, a dopant capable of imparting p-type electrical conductivity and a diluent gas by applying a glow discharge energy, and thereby forming a semiconductor film having an optical band gap of at least 1.8 eV, preferably more than 1.9 eV, on a substrate.

**5,151,373**
Deguchi, Mikio; Itagaki, Takushi; Usui, Masaaki, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Method of Making a Solar Cell Electrode*. September 29, 1992.

An electrode structure of a solar cell includes a metal wire fixed to the light incident surface of the solar cell with an electrically conductive adhesive. An electrode production method of a solar cell includes applying an electrically conductive adhesive to at least one of a portion of a metal wire and a portion of the light incident surface of the solar cell, pressing the metal wire into a predetermined position of the light incident surface of the solar cell, and solidifying the conductive adhesive to fix the metal wire.

**5,151,377**
Hanoka, Jack I.; Danielson, Scott E., inventors; Mobil Solar Energy Corporation, assignee. *Method for Forming Contacts.* September 29, 1992.

A method and apparatus are provided for forming grid electrodes for solar cells, the method and apparatus essentially involving dispensing a viscous ink through a hollow pen tip onto a selected horizontally oriented solar cell blank, so that the discharged ink forms a ribbon or line on the blank, with the pen tip being spaced far enough above the solar cell blank so that it does not ride on the deposited ribbon or line, whereby the width and height of the written ribbon or line are not determined by the o.d. of the pen tip or any pressure exerted by the pen tip.

**5,151,385**
Yamamoto, Hideaki; Seki, Koichi; Tanaka, Toshihiro; Sasano, Akira; Tsukada, Toshihisa; Shimomoto, Yasuharu; Nakano, Toshio; Kanamori, Hideto, inventors; Hitachi, Ltd., assignee. *Method of Manufacturing a Metallic Silicide Transparent Electrode.* September 29, 1992.

A semiconductor device such as a solar cell, photodiode and solid state imaging device comprises a semiconductor layer made of amorphous silicon formed on a given substrate, and a transparent conductive layer formed by an interfacial reaction between the amorphous silicon and a metallic film directly formed on the amorphous silicon. This transparent conductive layer is used as a transparent electrode of the device and if necessary the remainder after having partially removed the metallic film for the transparent conductive layer is used as a conductive layer and light shielding film.

**5,151,386**
Bottari, Frank J.; Hanoka, Jack I.; Sylva, Frank W., inventors; Mobil Solar Energy Corporation, assignee. *Method of Applying Metallized Contacts to a Solar Cell.* September 29, 1992.

A method of applying metallized contacts to the surfaces of semiconductor substrates using a conventional pad printing device. Standard screen printing inks diluted 2-30 weight percent with an appropriate solvent have been satisfactorily used to accomplish the method. For certain contact configurations, portions of the surface of the substrate are covered with a Mylar mask during the pad printing process. The method makes it possible to form a metallized contact having a uniform thickness on an uneven substrate surface, e.g., the surface of a silicon substrate produced by the EFG method.

**5,152,601**
Ferng, Shing-Lai, inventor. *Solar Power-Operated Construction Work Warning Lamp.* October 6, 1992.

A solar power-operated construction work warning lamp comprising a base covered by a bottom cover to hold a power supply control circuit and a column, the power supply control circuit consisted of a storage battery, a power switch and an IC board, the column having a plurality of LEDs thereon respectively connected to the power supply control circuit, a lamp guard mounted on the base at the top and covered with a transparent convex cover, a solar cell assembly supported on the column inside the lamp guard and electrically connected to the power supply control circuit, and a plurality of reflectors mounted on a plurality of openings around the lamp guard, wherein the radiant energy of sunlight collected by the solar cell assembly is converted into electric power for charging the storage battery and for driving the light emitting elements to flash signals by means of the control of the IC board and the power switch.

**5,153,497**
Eiden, Glenn E., inventor. *Circuit for Regulating Charging of a Storage Battery by a Photovoltaic Array.* October 6, 1992.

A circuit for regulating the charging of a storage battery by a photovoltaic array includes a relay switch connected between the storage battery and photovoltaic array. An operational amplifier connected as a differential amplifier with a low-pass filter has one input terminal connected to a voltage reference. The output of the operational amplifier is connected to the input of a transistor amplifier having an output connected to the control coil of the relay switch. When the battery voltage exceeds a predetermined setpoint, as presented to the input terminal of the operational amplifier through the resistive divider, relative to the voltage reference, the operational amplifier and transistor amplifier de-energize the control coil of the relay switch, thereby opening the relay switch and disconnecting the photovoltaic array from the storage battery. As the voltage of the storage battery falls below the setpoint, the state of the relay switch is reversed and charging resumes. The low pass filter prevents the relay switch from changing state at a frequency greater than a preselected frequency.

**5,153,780**
Jorgensen, Gary J.; Carasso, Meir; Wendelin, Timothy J.; Lewandowski, Allan A., inventors; The United States of America as represented by the United States Department of Energy, assignee. *Method and Apparatus for Uniformly Concentrating Solar Flux for Photovoltaic Applications.* October 6, 1992.

A dish reflector and method for concentrating moderate solar flux uniformly on a target plane on a solar cell array, the dish having a stepped reflective surface that is characterized by a plurality of ring-like segments arranged about a common axis, and each segment having a concave spherical configuration.

**5,154,810**
Kamerling, Marc.A.; Beauchamp, William T.; Klinger, Robert E.; Lehan, John P., inventors; Optical Coating Laboratory, Inc., assignee. *Thin Film Coating and Method*. October 13, 1992.

A system and process for forming optical quality, protective, relatively thick, thin film coatings on workpieces such as detectors or solar cells. The apparatus includes a rotary cylindrical sputtering system which incorporates separate deposition devices and at least one chemical reaction device for simultaneously (1) depositing materials which form tensile and compressive oxides and (2) oxidizing the deposited materials. The system also includes a stressometer system, preferably a cantilevered beam stressometer system which monitors the stress of the depositing film in-situ. The monitored stress levels are used to control the relative amounts of compressive and tensile materials which are deposited and, thus, control stress in the thin film coatings. In a preferred embodiment for forming protective covers on solar cells, the deposition devices are linear magnetron sputter cathode devices having silicon and aluminum targets, and the reaction device is a linear magnetron ion source oxidizer device. Film stress in the thin film coating is controlled by controlling power to the silicon and aluminum targets.

**5,155,051**
Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi, inventors; Sanyo Electric Co., Ltd., assignee. *Method of Manufacturing Photovoltaic Device*. October 13, 1992.

A method of manufacturing a photovoltaic device, wherein an amorphous semiconductor layer of one conductivity type doped with impurities which determine the conductivity type is formed on a substrate having a conductive surface, an insulating film is formed on this amorphous semiconductor layer, the insulating film is patterned to partially form aperture regions where the surface of said amorphous semiconductor layer is exposed, an intrinsic amorphous semiconductor layer on said insulating film and the aperture regions formed over the substrate, the amorphous semiconductor layer of one conductivity type and the intrinsic amorphous semiconductor layer are thermally treated, crystallization is advanced using the amorphous semiconductor layer of one conductivity type located beneath said aperture region as a core to form a polycrystal semiconductor layer of one conductivity type, a semiconductor layer of the other conductivity type is formed on this polycrystal semiconductor layer, and an electrode is formed in contact with the semiconductor layer region of the other conductivity type located over said aperture regions.

**5,155,565**
Wenz, Robert P.; Tran, Nang T., inventors; Minnesota Mining and Manufacturing Company, assignee. *Method for Manufacturing an Amorphous Silicon Thin Film Solar Cell and Schottky Barrier Diode on a Common Substrate*. October 13, 1992.

A thin-film p-i-n solar cell and Schottky barrier diode are fabricated adjacent one another on a common flexible polyimide substrate. A titanium nitride diffusion barrier prevents contaminants of an aluminum contact layer on the substrate from reacting with the semiconductor body of the solar cell and diode during subsequent fabrication. An $n^+$-type hydrogenated amorphous silicon layer overlies the layer of titanium nitride and forms an ohmic contact with the solar cell and diode. The diode includes a n-type layer of silicon doped with phosphorus to a concentration of $10^{18}$ to $10^{20}$ atoms per cubic centimeter to increase its forward current density. The solar cell and diode are separated from one another by an epoxy strip. A top conducting oxide layer forms a Schottky barrier with the semiconductor body of the diode.

**5,155,668**
Tanner, David P.; Erickson, Mark R.; Frost, John S., inventors; Siemens Solar Industries, L.P., assignee. *Solar Powered Lamp Utilizing Cold Cathode Fluorescent Illumination and Method of Facilitating Same*. October 13, 1992.

A solar powered lamp utilizing cold cathode fluorescent illumination and means for facilitating same. The solar powered lamp is powered through the utilization of photovoltaic cells which charge a battery for providing power to a cold cathode fluorescent bulb in the absence of sunlight. The cold cathode fluorescent bulb provides increased illumination and a longer lamp life. The solar powered lamp comprises circuitry for converting the low power provided by the battery into an alternating current voltage sufficient to operate the cold cathode fluorescent bulb in order to facilitate a longer lamp life and provide increased illumination. In a preferred embodiment, a lens configured with vertically disposed ribs about its inner surface is disposed about the cold cathode fluorescent lamp, which is vertically disposed within the lamp, to further enhance illumination.

**5,156,568**
Ricci, Russell L., inventor. *Car Ventilator*. October 20, 1992.

A ventilator insert to be received within the generally wedge-shaped confine provided by a hinged sunroof glass. The ventilator insert may have a powered

impeller to positively move air between the external environment and the vehicle cabin which impeller may be powered by a self- contained power supply connected with a charging source such as a photovoltaic panel and/or the vehicle's own electrical system.

**5,156,978**
Bathey, Balakrishnan R.; Cretalla, Mary C.; Taylor, Aaron S., inventors; Mobil Solar Energy Corporation, assignee. *Method of Fabricating Solar Cells.* October 20, 1992.

A method and apparatus for producing crystalline substrate for use in fabricating solid state electronic devices. A hollow crystalline body is grown from a melt containing a dopant and a P-N junction is formed in said crystalline body as it is being grown. Then the hollow body is severed to provide individual solar cell substrates.

**5,158,618**
Rubin, Leoind B.; Osipov, Alexandr S.; Sizganov, Jury G.; Untila, Gennady G.; Kharitonov, Andrei L.; Rakhimov, Alexandr T., inventors; BioPhotonics, Inc., assignee. *Photovoltaic Cells for Converting Light Energy to Electric Energy and Photoelectric Battery.* October 27, 1992.

A solar photovoltaic cells with a conductive current collecting contacts embedded in a block of optical transparent polymer material between the semiconductor wafer and protective cover in such a manner that at least the section thereof which are in contact with the surface of the semiconductor wafer protrude from the polymer block. This provides for a reliable ohmic contact between the current collecting contacts and the semiconductor wafer. The disclosed geometry of the solar cell reduces the shadowing area of the semiconductor wafer by up to 90%.

**5,159,191**
Mankovitz, Roy J., inventor. *Apparatus and Method for Using Ambient Light to Control Electronic Apparatus.* October 27, 1992.

A broadcast receiver is disclosed which is powered by a solar cell in combination with a rechargeable battery mounted within a waterproof housing which is adapted for attachment to a lounge chair used for suntanning. The control of power, tuning, and volume functions is accomplished using photodetectors mounted within and adjacent transparent areas of the housing. User operated shutters mounted external to the housing shield selective photodetectors from ambient light. A separate data entry shutter is used to enable memory circuits which store control signals corresponding to the shielded photodetectors. The stored control signals are used to control the operating functions of the receiver. Audio signals are inductively coupled through the housing to external headphones.

**5,160,214**
Sakurai, Mikio; Sakurai, Chikako, inventors. *Irrigation System and Irrigation Method.* November 3, 1992.

An irrigation system comprises a pump facility for pumping up seawater from the sea, an artificial seawater lake formed in an inland area, a freshwater producing plant for producing freshwater from seawater, an artificial freshwater lake, and an irrigation canal for supplying the freshwater to a projected irrigation area. A solar-cell power generation plant is constructed for supplying electric power to operate the irrigation system. The irrigation including the artificial seawater lake is formed in an inland area in a comparatively short time, and freshwater is produced from the seawater stored in the artificial seawater lake. Therefore, freshwater can be supplied to a projected irrigation area at an early stage of the construction of the irrigation system.

**5,160,920**
Harris, Richard H., inventor; International Business Machines Corporation, assignee. *Fail Safe Display for Shelf Labels.* November 3, 1992.

Described is an electronic shelf label LCD device having a segmented liquid crystal (LC) film disposed on a plurality of segmented and non- segmented photovoltaic cells which provide power for driving the LCD device and electrical signals which are used to indicate malfunctioning LCD segments.

**5,162,239**
Winer, Kris A.; Thornton, Robert L., inventors; Xerox Corporation, assignee. *Laser Crystallized Cladding Layers for Improved Amorphous Silicon Light-Emitting Diodes and Radiation Sensors.* November 10, 1992.

Scanning laser crystallization of p- and n-type hydrogenated amorphous silicon alloy cladding layers enhances the doping efficiency of such layers without changing the luminescence or other important properties of the middle i-layer in a p-i-n device. The dc dark conductivity of the doped layers increases by a factor of about 100 to about 10,000 above a sharp laser energy density threshold whose magnitude increases with decreasing impurity concentration. In one method, a doped amorphous silicon alloy layer is deposited on an amorphous glass substrate, scanned with laser irradiation, and then an intermediate i-layer is formed over this layer. Another doped amorphous silicon alloy layer is deposited on this layer, doped oppositely from the first doped layer. The second doped layer is then crystallized by scanning laser irradiation, leaving the underlying i-layer virtually unchanged in optical and electronic properties.

**5,164,019**
Sinton, Ronald A., inventor; SunPower Corporation, assignee. *Monolithic Series-Connected Solar Cells Having Improved Cell Isolation and Method of Making Same*. November 17, 1992.

Series connected cells of a solar array formed in a monolithic semiconductor substrate are electrically isolated by forming grooves in a first major surface partially through the substrate between cells and then fracturing the substrate from the bottom of the grooves to an opposing major surface. Metallization interconnecting to cells provides physical integrity of the cell array after the fracturing of the substrate. The grooves can be formed prior to completion of fabrication of the cells or after fabrication of the cells. In an array embodiment where each cell extends from one major surface to the opposing major surface, the grooves can be formed in both major surfaces.

**5,164,020**
Wagner, Erich; Twesme, Edward N.; Hidalgo, Craig, inventors; Solarex Corporation, assignee. *Solar Panel*. November 17, 1992.

A solar panel for use in a roof-mounted array of solar panels, each panel having ridges protruding outwardly and adjacent to the side edges for receiving a standing seam cap between side-adjacent panels. Each solar panel is formed as an integral structure having a photovoltaic module, an edge of which is sealed by a base substrate. The base substrate is configured to have lipped top and bottom edges which interlock to form a watertight seal between top-adjacent and bottom-adjacent solar panels. The solar panel array can be mounted on a roof, in place of shingles or the like, to provide environmental protection for the interior of a building.

**5,164,654**
Bertram, Leo; Schemmann, Hugo; Husgen, Theodor, inventors; U.S. Philips Corporation, assignee. *Solar Energy Operated Automatic Charge Device for Electric Appliances*. November 17, 1992.

A charging device for accumulator-operated small electrical appliances, for example, electric dry-shavers, which are energized by rechargeable accumulators which can be charged by means of a charging device including solar cells. The charging device includes an energy buffer which is connected parallel to the solar cells for buffering the solar energy when the charge capacity of the solar cells is below the charge current threshold of the accumulator. The buffered solar energy is supplied to the accumulator when a discharge current of the energy buffer exceeds the charge current threshold of the accumulator and flows until the discharge current falls below the charge current threshold.

**5,167,724**
Chiang, Clement J., inventor; The United States of America as represented by the United States Department of Energy, assignee. *Planar Photovoltaic Solar Concentrator Module*. December 1, 1992.

A planar photovoltaic concentrator module for producing an electrical signal from incident solar radiation includes an electrically insulating housing having a front wall, an opposing back wall and a hollow interior. A solar cell having electrical terminals is positioned within the interior of the housing. A planar conductor is connected with a terminal of the solar cell of the same polarity. A lens forming the front wall of the housing is operable to direct solar radiation incident to the lens into the interior of the housing. A refractive optical element in contact with the solar cell and facing the lens receives the solar radiation directed into the interior of the housing by the lens and directs the solar radiation to the solar cell to cause the solar cell to generate an electrical signal. An electrically conductive planar member is positioned in the housing to rest on the housing back wall in supporting relation with the solar cell terminal of opposite polarity. The planar member is operable to dissipate heat radiated by the solar cell as the solar cell generates an electrical signal and further forms a solar cell conductor connected with the solar cell terminal to permit the electrical signal generated by the solar cell to be measured between the planar member and the conductor.

**5,169,456**
Johnson, Kenneth C., inventor. *Two-Axis Tracking Solar Collector Mechanism*. December 8, 1992.

This invention is a novel solar tracking mechanism incorporating a number of practical features that give it superior environmental resilience and exceptional tracking accuracy. The mechanism comprises a lightweight space frame assembly supporting an array of point-focus Fresnel lenses in a two-axis tracking structure. The system is enclosed under a glass cover which isolates it from environmental exposure and enhances tracking accuracy by eliminating wind loading. Tracking accuracy is also enhanced by the system's broadbased tracking support. The system's primary intended application would be to focus highly concentrated sunlight into optical fibers for transmission to core building illumination zones, and the system may also have potential for photovoltaic or photothermal solar energy conversion.

**5,169,791**
Muenzer, Adolf, inventor; Siemens Aktiengesellschaft, assignee. *Method for the Passivation of Crystal Defects in Polycrystalline Silicon Material*. December 8, 1992.

A method for the passivation of crystal defects in polycrystalline or amorphous silicon material using a temperature treatment step in a hydrogen-containing

atmosphere. The method results in favorable diode properties and favorable passivation properties in amorphous or, respectively,polycrystalline silicon material in a simple manner. Hydrogen-oxygen compounds are reduced at the surface of the silicon material, creating atomic hydrogen that diffuses into the silicon material.

**5,171,373**
Hebard, Arthur F.; Miller, Barry; Rosamilia, Joseph M.; Wilson, William L., inventors; AT&T Bell Laboratories, assignee. *Devices Involving the Photo Behavior of Fullerenes*. December 15, 1992.

It has been found that fullerenes exhibit photoelectronic behavior such as photoconductivity or photovoltaic properties. Such behavior allows the fabrication of a variety of devices, such as solar cells and the use of various light-induced processes, such as the generation of a current by illumination of appropriate fullerene interfaces.

**5,173,270**
Kida, Michio; Sahira, Kensho; Nozoe, Akikuni, inventors; Mitsubishi Materials Corporation, assignee. *Monocrystal Rod Pulled from a Melt*. December 22, 1992.

A monocrystal rod utilized for producing the semiconductor device or solar cell includes a neck section, a main rod section and a shoulder section. The next section is smaller in diameter than a seed crystal. The main rod section is formed integrally with the neck section and is larger in diameter than the neck section. The shoulder section is tapered for linking the neck section to the main rod section. The main rod section has a stopper section at the top portion of the main rod section, and the stopper section is larger than the main rod section.

Also, an apparatus for preparing the monocrystal rod has a safety member for supporting upwards the stopper section of the falling monocrystal rod.

Further, a method of preparing the monocrystal rod includes the steps as follows. The seed crystal is pulled out from a melt in a crucible while rotating it. The speed of pulling the seed crystal is at first increased to grow the neck section whose diameter is smaller than the seed crystal, and then is gradually decreased to grow the shoulder section. Subsequently, the pulling speed is increased again so as to prevent further increase in diameter to grow the stopper section at the lower end of the shoulder section or at the top portion of the main rod section, and then is decreased again to grow the main rod section whose diameter is equal to a required diameter.

**5,273,593**
Marquardt, Reinhold; Böhmer, Walter; Harzheim, Horst; Jäger, Wolfgang; Chehab, Oussama; Rosendahl, Reiner, inventors; Flachglas-Solartechnik GmbH, assignee. *Structural Element, in Particular a Facade Element*. December 28, 1992.

In a structural element, in particular a facade element with an outside plate sandwich, in which solar cells are arranged between an outer plate and an inner plate, and with another internal plate, which is provided at a distance from the plate sandwich by means of a spacing frame defining the interior, the solar cells are embedded in a layer of casting resin; furthermore, the inner plate recedes in its dimensions in the region of at least one edge at least partially with respect to the corresponding edge of the outer plate and forms thus a recess that also reaches over the layer of casting resin and through which the necessary electrical lines are guided, whereby the recess in the direction of the interior of the structural element is covered by the spacing frame. As an alternative, the outer plate can recede with respect to the inner plate.

## 1993

**5,176,758**
Nath, Prem; Vogeli, Craig, inventors; United Solar Systems Corporation, assignee. *Translucent Photovoltaic Sheet Material and Panels*. January 5, 1993.

A light transmissive power generating photovoltaic device includes a power generating film having a substrate, a plurality of semiconductor layers, and a transparent conductive oxide layer with a grid adhered on the top surface thereof. Apertures pass through the opaque semiconductive layers to let light pass through. The power generating film is laminated onto a transparent glass sheet on each side to form the photovoltaic device.

**5,177,628**
Moddel, Garret R., inventor; The University of Colorado Foundation, Inc., assignee. *Self-Powered Optically Addressed Spatial Light Modulator*. January 5, 1993.

A self-powered liquid crystal spatial light modulator is disclosed having a pair of spaced transparent glass plates, on each plate of which a transparent electrically conductive film is coated so as to be in confronting relation. A voltage/current generating, photovoltaic/photodiode, light sensitive layer is coated onto one of the conductive films. A liquid crystal layer is confined between the other conductive film and the light sensitive layer. A shorting circuit element connects the two conductive films. This shorting circuit element may be internal or external to the spatial light modulator. A pixel area of the spatial light modulator is

addressed by a beam of light that illuminates the pixel area and operates to activate a corresponding areas of the light sensitive layer. The voltage/current that is generated in this area of the light sensitive film causes a current to flow through the shorting circuit element, to thereby activate, switch or charge the corresponding area of the liquid crystal layer. Transmission mode and reflection mode spatial light modulators are described.

**5,178,685**
Borenstein, Jeffrey T.; Gonsiorawski, Ronald C., inventors; Mobil Solar Energy Corporation, assignee. *Method for Forming Solar Cell Contacts and Interconnecting Solar Cells.* January 12, 1993.

Photovoltaic cells with silver-rich thick film electrical contacts having superior thermal aging properties are disclosed. The silver-rich contacts are formed by firing a silver ink or paste wherein substantially all of the silver in the ink or paste before firing is in the form of spherical particles. Preferably inter-cell connections to the contacts are accomplished using a tin and silver solder paste comprising between about 96% tin/4% silver and 98% tin/2% silver. Solar cells having contacts incorporating the present invention exhibit the capability of withstanding temperatures in the range of 150°C, with little or no thermal degradation of contact peel strength in the region of the solder bonds.

**5,180,434**
DiDio, Gary M.; Jones, Kermit; Hoffman, Kevin; Laarman, Timothy; Call, John; Nath, Prem, inventors; United Solar Systems Corporation, assignee. *Interfacial Plasma Bars for Photovoltaic Deposition Apparatus.* January 19, 1993.

In continuous apparatus for the glow discharge deposition of amorphous silicon alloy solar cells of p-i-n type configuration in a plurality of interconnected, dedicated deposition chambers, a plasma bar operatively disposed between at least the plasma regions in which the layer pairs of amorphous silicon alloy material defining the major semiconductor junction of the solar cell are deposited. The plasma bar is adapted to initiate a plasma so as to prevent chemically adsorbed contaminants from deleteriously affecting the surface of the first deposited of the layer pair, thereby improving the open circuit voltage of the solar cell. In a similar manner, the plasma bar may also be provided between the layer pairs of amorphous silicon alloy material which combine to define the minor semiconductor junction of the solar cell. Finally, a plasma bar may be disposed between the oxide-based layer of a back reflector for reducing oxygen contamination of the silicon alloy material deposited thereupon.

**5,180,441**
Cornwall, Mickey; Peterson, David M.; Stern, Theodore G., inventors; General Dynamics Corporation/Space Systems Division, assignee. *Solar Concentrator Array.* January 19, 1993.

A solar concentrator panel having an array of off-axis cylindrical parabolic mirrors with an optical design of relatively short focal length solar cells arranged in line that converts sunlight to electricity. The back surface of the mirrors are used as the solar cell mount and the heat sink for the adjacent mirror. By appropriate positioning of the adjacent mirror so that the focal line of the parabola falls within the boundary or rim of the mirror reflected solar light can be directed to the solar cell mounted on the back of the adjacent mirror and converted to electricity.

**5,180,442**
Elias, Eric, inventor. *Integration System for Solar Modules.* January 19, 1993.

Photovoltaic solar modules are efficiently assembled into an array by the use of a lattice and mounting-conducting electrodes. The lattice consists of parallel conducting strips spaced apart by a distance equal to the width of a module, secured to a supporting frame. The electrodes are attached to busbars fabricated on the modules which are environmentally sealed with the ends of the electrodes protruding. The protruding ends fit into slots punched into the conducting strips, both securing the modules and electrically connecting them to the lattice. A large array of series and parallel connected modules can thus be formed.

**5,180,686**
Banerjee, Arindam; Guha, Subhendu, inventors; Energy Conversion Devices, Inc., assignee. *Method for Continuously Depositing a Transparent Oxide Material by Chemical Pyrolysis.* January 19, 1993.

A method of depositing a layer of doped or undoped wide band gap oxide material by chemical spray pyrolysis, upon a continuously advancing, elongated web of substrate material in a continuous, roll-to-roll process.

**5,181,968**
Nath, Prem; Vogeli, Craig, inventors; United Solar Systems Corporation, assignee. *Photovoltaic Device Having an Improved Collector Grid.* January 26, 1993.

An improved photovoltaic device in which an electrically conductive adhesive is employed to affix the grid structure to the upper electrode thereof. By appropriately selecting the resistivity of the conductive adhesive, normal photogenerated current flow is readily accommodated, while shunted current flow, through patent or latent defects is substantially eliminated.

**5,182,091**
Yuge, Noriyoshi; Baba, Hiroyuki; Aratani, Fukuo, inventors; Kawasaki Steel Corporation, assignee. *Method and Apparatus for Purifying Silicon.* January 26, 1993.

Disclosed herein are a method and apparatus for purifying silicon, which are suitable for economical and mass production of high-purity silicon for solar cells from regular-grade silicon containing boron and carbon in large quantities. The method comprises directing a plasma jet stream of an inert gas toward the surface of molten silicon held in a container lined with silica or a silica-based refractory. For improved purification, the inert gas as the plasma gas is mixed with 0.1-10 vol% steam and/or less than 1 g of silica powder per liter of the inert gas at normal state. Alternatively, the container may have a bottom opening and is provided with an electrode having a cooling means underneath the bottom of the container, with the electrode and the cathode of the plasma torch connected to a power source for plasma generation, so that the plasma jet and electron beam are directed toward the surface of molten silicon.

**5,184,502**
Adams, George W.; McGoey, Michael J., inventors; Remote Power, Inc., assignee. *Helicopter Installable, Self-Powered, Modular, Remote, Telemetry Package.* February 9, 1993.

The instrumentation package is transportable to remote sites solely by a light helicopter. Accordingly, three skids are provided, each of which weighs less than 1,200 pounds. An instrument skid comprises a generally horizontally disposed frame having jacks mounted on it for leveling. Instruments and control elements are also mounted to the frame, preconnected at the factory, and protected from weather. A separate battery skid is provided which is mounted on the instrument skid at the site. A solar array skid, the sloping roof of which comprises solar cells is separately transportable by helicopter to the site and is lowered onto and fastened to the instrument skid. The instrument skid preferably has a self-contained generator mounted thereon when it is transported to the site. An instrument and antenna mounting tower for telemetry, if desired, is broken down and carried within the solar array skid to the site and then mounted on the rear of the instrument skid and tied to the solar array skid. The solar array faces the equator. The battery skid is located such that predetermined relative wind velocities from the north or the south produce a zero force at any one jack. The solar array extends over the instruments and control elements and the generator mounted on the instrument skid. The package is particularly useful for monitoring air quality, in which case a gas analyzer is mounted on the instrument skid in a refrigerator.

**5,185,042**
Ferguson, David L., inventor; TRW, Inc., assignee. *Generic Solar Cell Array Using a Printed Circuit Substrate.* February 9, 1993.

There is disclosed a generic solar array panel which utilizes a printed circuit substrate. A series of electrically conductive paths for interconnecting the solar cells and other electronic components to form a solar electric power supply network is formed on or encapsulated into the substrate. An integral bus line conducts the collected power to a load. Stress relief loops routed in the substrate compensate for differences in characteristics of thermal expansion between the solar cell and the substrate while maintaining the integrity of the network's electrical connections.

**5,187,115**
Coleman, John H., inventor; Plasma Physics Corp., assignee. *Method of Forming Semiconducting Materials and Barriers Using a Dual Enclosure Apparatus.* February 16, 1993.

In a gaseous glow-discharge process for coating a substrate with semiconductor material, a variable electric field in the region of the substrate and the pressure of the gaseous material are controlled to produce a uniform coating having useful semiconducting properties. Electrodes having concave and cylindrical configurations are used to produce a spacially varying electric field. Twin electrodes are used to enable the use of an AC power supply and collect a substantial part of the coating on the substrate. Solid semiconductor material is evaporated and sputtered into the glow-discharge to control the discharge and improve the coating. Schottky barrier and solar cell structures are fabricated from the semiconductor coating. Activated nitrogen species is used to increase the barrier height of Schottky barriers.

**5,191,876**
Atchley, Curtis L., inventor. *Rotatable Solar Collection System.* March 9, 1993.

Applicant's invention is a lightweight solar collection system, supported overhead, having a parabolic reflecting trough which continuously rotates about a fluid-filled collection conduit located at the trough's focal point. The system is supported overhead preventing bending of the collection conduit, ensuring that solar rays reflected off the trough will continuously focus on the conduit. A tracking system, cooperating with the reflection assembly, monitors the location of the sun, cuing the motor when rotation of the trough is required for maximum heat collection. The efficiency acquired through a reflection assembly supported and braced overhead used in cooperation with a system monitoring movement of the sun, allows solar heat collection for operation of a cooling and heating unit simply and economically.

**5,192,400**
Parker, Sidney G.; Hammerbacher, Milfred D.; Levine, Jules D.; Hotchkiss, Gregory B., inventors; Texas Instruments Incorporated, assignee. *Method of Isolating Shorted Silicon Spheres*. March 9, 1993.

Solar cells are formed of semiconductor spheres of P-type interior having an N-type skin are pressed between a pair of aluminum foil members forming the electrical contacts to the P-type and N-type regions. The aluminum foils, which comprise 1.0% silicon by weight, are flexible and electrically insulated from one another. The spheres are patterned in a foil matrix forming a cell. Multiple cells can be interconnected to form a module of solar elements for converting sun light into electricity.

**5,192,991**
Hosokawa, Makoto, inventor; Semiconductor Energy Laboratory Co., Ltd., assignee. *Crystallized Polycrystalline Semiconductor Device*. March 9, 1993.

A polycrystalline semiconductor device and a method of manufacturing the device are disclosed. An amorphous semiconductor film is deposited on a glass with substrate and given thermal treatment at a crystallization temperature of 600°C, or lower, to form a polycrystalline photoconductive structure. The substrate is made from a material having the property of contracting at a percentage different than the semiconductor film by 10% or less, the contraction being caused by the thermal treatment.

**5,194,398**
Miyachi, Kenji; Fukuda, Nobuhiro; Ashida, Yoshinori; Koyama, Masato, inventors; Mitsui Toatsu Chemicals, Inc., assignee. *Semiconductor Film and Process for Its Production*. March 16, 1993.

A method for forming an amorphous semiconductor film, which comprises (a) a film-forming step of forming a semiconductor film having not more than 20 atomic percent of bound hydrogen to a thickness of 3 to 1000Å, and (b) a modifying step of modifying the formed film, the steps being repeated multiple times.

**5,196,086**
Kida, Michio; Sahira, Kensho; Nozoe, Akikuni, inventors; Mitsubishi Materials Corporation, assignee. *Monocrystal Rod Pulled from a Melt*. March 23, 1993.

A monocrystal rod utilized for producing the semiconductor device or solar cell includes a neck section, a main rod section and a shoulder section. The neck section is smaller in diameter than a seed crystal. The main rod section is formed integrally with the neck section and is larger in diameter than the neck section. The shoulder section is tapered for linking the neck section to the main rod section. The main rod section has a stopper section at the top portion of the main rod section, and the stopper section is larger than the main rod section.

Also, an apparatus for preparing the monocrystal rod has a safety member for supporting upward the stopper section of the falling monocrystal rod.

Further, a method of preparing the monocrystal rod includes the steps as follows. The seed crystal is pulled out from a melt in a crucible while rotating it. The speed of pulling the seed crystal is at first increased to grow the neck section whose diameter is smaller than the seed crystal, and then is gradually decreased to grow the shoulder section. Subsequently, the pulling speed is increased again so as to prevent further increase in diameter to grow the stopper section at the lower end of the shoulder section or at the top portion of the main rod section, and then is decreased again to grow the main rod section whose diameter is equal to a required diameter.

**5,196,144**
Smith, Paul; Heeger, Alan J.; Cao, Yong; Chiang, Jin-Chih; Andreatta, Alejandro, inventors; Regents of the University of California, assignee. *Electrically Conductive Polyaniline*. March 23, 1993.

Polyanilines are provided that are soluble and that form crystalline solids upon precipitation. The solid polyanilines are electrically conductive, soluble, and can be fabricated into various shaped articles for use in, for example, batteries, electrodes, photovoltaic cells, semiconductor devices and the like.

**5,196,690**
Flesner, Larry D.; Miller, Stephen A.; Dubbelday, Wadad B., inventors; The United States of America as represented by the Secretary of the Navy, assignee. *Optically Powered Photomultiplier Tube*. March 23, 1993.

An optically powered photomultiplier tube is provided, comprising a vacuum chamber having a window for incident optical radiation which is to be detected; a photocathode to receive the optical radiation; an electron multiplier system within the chamber to amplify the electron current from the photocathode; an anode to receive the amplified electron current; a high voltage photocell array positioned within the chamber for generating high voltage electrical power that is provided to the electron multiplier system; a system for delivering optical power to the photocell array; a first electrical contact penetrating the container in a vacuum tight manner and operably coupled to the anode; and a second electrical contact penetrating the container in a vacuum tight manner and operably coupled to the photocell array.

**5,197,291**
Levinson, Lionel M., inventor; General Electric Company, assignee. *Solar Powered Thermoelectric Cooling Apparatus*. March 30, 1993.

A thermoelectric module powered by a solar cell is used to cool a battery which serves as a backup power supply in a time-of-use power meter. Solar irradiation incident on the power meter containing the battery, of sufficient intensity to result in heating of the battery, concurrently causes the solar cell to generate an electric current. If the battery temperature rises above a predetermined level, the thermoelectric module cools the battery in dependence on the power generated by the solar cell.

**5,197,801**
Swisher, Max B., inventor. *Tumbler*. March 30, 1993.

A tumbler includes a support frame assembly rotatably mounting a drum assembly for driving by a drive assembly comprising an electric motor drivingly connected to the drum assembly, a battery coupled to the electric motor, and a photovoltaic panel connected to the battery for charging it.

**5,199,429**
Kroll, Mark W.; Adams, Theodore P., inventors; AngeMed, Inc.; assignee. *Implantable Defibrillator System Employing Capacitor Switching Networks*. April 6, 1993.

The present invention uses switching networks for the predetermined combination of capacitor-discharge waveforms in order to approximate a particular waveform for application to the heart muscle in a defibrillation procedure. These are usually biphasic waveforms, or waveforms exhibiting a positive pulse followed immediately by a negative pulse. Examples of the discharge-process possibilities are those of two capacitors in parallel, two in series, two in sequence, or a capacitor or capacitors with polarity inverted. Adding capacitors and switches expands the range of possibilities and provides waveforms "tailoring" under the guidance of a switching network that can be digitally programmed from an external programming console, much as in the digital programming of a pacemaker system. Digital signals are transmitted to the implanted system using infrared, visible, RF electromagnetic radition, or ultrasound radiation. The use of multiple capacitors rather than just a single capacitor makes it possible to pack the components more densely, and in the case of some waveforms, to use less total capacitance than in the prior art, both factors contributing to very desirable size reduction for the implantable defibrillator. One or more implanted batteries are used to meet the heavy energy requirements of defibrillation and these are recharged, one at a time, and after full discharge, by means of implanted series-array photovoltaic devices, preferably monolithic.

**5,201,961**
Yoshikawa, Masao; Suzuki, Tetsurou, inventors; Ricoh Company, Ltd., assignee. *Photovoltaic Device Containing Organic Material Layers and Having High Conversion Efficiency*. April 13, 1993.

The present invention discloses a photovoltaic device comprising a portion containing three layers disposed between two electrodes, at least one of which is light transmittable; wherein said three layers consist of a first layer of organic electron acceptor material, a second layer of organic electron donor material and a third layer of organic electron donor material different from the material of the second layer; or a first layer of organic electron donor material, a second layer of organic electron acceptor material and a third layer of organic electron acceptor material different from the acceptor material of the second layer, the sequence of the three layers being counted from a light incident side, and the device having a high photoelectric conversion efficiency.

**5,202,271**
Kouzuma, Shinichi; Inoue, Hiroshi; Murata, Kenji; Tanaka, Hiroyuki; Kishi, Yasuo, inventors; Sanyo Electric Co., Ltd., assignee. *Manufacturing Method of Photovoltaic Device*. April 13, 1993.

A manufacturing method of a photovoltaic device, whereby a photovoltaic device of a large area in the laminated structure of a first resin layer with light transmitting property, a photo-electric converting element consisting of a transparent electrode layer, a thin-film semiconductor layer and a back electrode layer, and a second resin layer in this order is mechanically cut into an optional size, which is followed by a step wherein the first and second resin layers of the cut photovoltaic device of a smaller area are thermally treated or at least one of the transparent electrode layer and back electrode layer at the section is etched and removed. Because of the above treatment for the cut photovoltaic device of a smaller area, an electric short circuit between the transparent electrode layer and back electrode layer at the section is prevented.

**5,202,790**
Uchino, Kenji; Hikita, Kazuyasu; Tanaka, Yoshiaki; Ono, Mikiya, inventors; Mitsubishi Mining and Cement Company, assignee. *Photo-Driven Light Beam Deflecting Apparatus*. April 13, 1993.

A photo-driven optical deflecting apparatus in which a light beam is deflected by using only light beam(s), comprising (a) a dielectric substate having "photovoltaic effect"; (b) one or more first couples of electrodes formed in or on at least a portion of the surface(s) of said substrate so as to polarize the portion(s) positioned between said couple(s) of the electrodes formed thereby; (c) one or more photo-driving or photo-receiving elements provided at least in the

polarized portions of the surface of said dielectric substrate, having a polarization direction oriented in one direction, and having photovoltaic effect so as to generate a voltage between said electrodes; (d) a dielectric and transparent prism having "electro-optic effect" through which a light beam to be deflected is passed and deflected, provided on the surface of said substrate, having a second couple of electrodes provided on a couple of the surfaces of the prism, which surfaces are parallel to the optic axis; and a polarizer provided on the surface through which said beam enters; (e) leads electrically connecting said first electrodes to said second electrodes; the light beam to be deflected enters through said polarizer into said prism through which the light beam passes to be deflected; and said prism being operated directly by the photovoltage generated by said photo-driving element(s).

**5,204,272**
Guha, Subhendu; Banerjee, Arindam; Yang, Chi C., inventors; United Solar Systems Corporation, assignee. *Semiconductor Device and Microwave Process for Its Manufacture.* April 20, 1993.

Open circuit voltage of photovoltaic devices manufactured by a microwave deposition process is increased by disposing a bias wire in the microwave energized plasma and applying a positive voltage of approximately 100 volts to the wire during only a portion of the time in which the intrinsic semiconductor layer is being deposited.

**5,204,586**
Moore, Fred A., inventor; Siemens Solar Industries, assignee. *Solar Powered Lamp Having a Circuit for Providing Positive Turn-On at Low Light Levels.* April 20, 1993.

A solar powered lamp having a circuit for providing positive turn-on at low light levels causes a light source thereof to undergo a discrete transition to an "on" condition and prevents unnecessary drain on a battery thereof. The circuit comprises a positive feedback loop which amplifies current flow rapidly to a predetermined level at which the light source is illuminated. In doing so, it causes a plurality of solar powered lamps to illuminate at substantially the same time.

**5,204,667**
Inoue, Tai, inventor; Yazaki Corporation, assignee. *Indication Display Unit for Vehicles.* April 20, 1993.

An indication display unit for a vehicle has a reflecting member having an electric unit, a supporting member having a connecting portion electrically connectable with and disconnectable from the electric unit. The support member removably holds the reflecting member at a position of reflecting surface so as to project various operational information indicated on the indicating surface to the reflecting surface. Since the reflecting member of the present invention is provided with an electric unit and a removable connecting portion, it can be easily replaced by another type of reflecting member. Furthermore, by providing a solar cell at the rear surface of the reflecting member, the lowered electromotive force caused by self-discharge of batteries loaded on the vehicle can be somehow compensated.

**5,205,782**
Ohba, Shunji, inventor. *Car Ventilating System.* April 27, 1993.

An exhaust path penetrating through a portion of a vehicle's body to exhaust air in a cabin of a vehicle with an air-flow activating means and a valve which opens only when the fresh-air activating means works, a fresh-air conducting path penetrating through a portion of said vehicle's body to conduct fresh air into the cabin with an air-flow activating means and a valve which opens only when the air-flow activating means works, and an electric circuit which drives each of said air-flow activating means and each of said values with electricity supplied from solar cells mounted on an external face of said vehicle's body to receive sunlight and generate electricity.

**5,206,180**
Yoshida, Takashi, inventor; Fuji Electric Corporation Research and Development, Ltd., assignee. *Process for Producing an Amorphous Photoelectric Transducer.* April 27, 1993.

An amorphous photoelectric transducer of the type that converts light energy to electric energy using a p-n or p-i-n junction in an amorphous semiconductor having a p-type film on the light entrance side is disclosed. The p-type amorphous semiconductor film is formed with gaseous boron trifluoride ($BF_3$) as a dopant, the film containing boron atoms at a concentration in the range of $1 \times 10^{20}$ - $2 \times 10^{21}$ atoms/$cm^3$, and the concentration of fluorine atoms in the film being no more than one half of the concentration of boron atoms. A process for producing an amorphous photo-electric transducer is also disclosed, wherein the p-type amorphous semiconductor film is formed by a pulse discharge-assisted chemical vapor deposition (CVD) technique which decomposes a feed gas including gaseous boron trifluoride ($BF_3$) as a dopant.

**5,206,523**
Goesele, Ulrich M.; Lehmann, Volker E., inventors. *Microporous Crystalline Silicon of Increased Band Gap for Semiconductor Applications.* April 27, 1993.

A process is disclosed for producing microporous crystalline silicon which has a band gap substantially increased relative to that of normal crystalline silicon. This process involves the preparation of quantum wires of silicon by means of a chemical attack method carried out

on silicon that has been doped such that it conducts electricity substantially via the effective transport of electric charge by means of so-called holes. The microporous crystalline silicon thus produced is in the form of a discrete mass having a bulk-like, interconnected crystalline silicon structure of quantum wires whose band gap is greater than normal crystalline silicon. Because of this increased band gap this microporous crystalline silicon may be used as an active element in applications such as tandem solar cells.

**5,208,578**
Tury, Jon M.; Tury, Edward L., inventors. *Light Powered Chime*. May 4, 1993.

A light powered chime for indoor use specifically designed to be random, approximating a windchime. In one embodiment a solar cell provides current to a timing circuit and to a storage capacitor. The timing circuit intermittently fires a silicon controlled rectifier causing current to flow from the capacitor through a motor. A striker is connected to the motor shaft by way of a string and clip. Rotation of the motor causes the striker to contact one or more suspended chimes. Randomness is achieved by virtue of sunlight variability and by the mechanical and electrical design.

**5,209,012**
Palmer, Sharon-Joy, inventor. *Method for Improved Plant Growth*. May 11, 1993.

A method of attaining horticulture growth in a modular self-contained growth chamber formed of insulated panels having a grated subfloor. The method includes growing algae in an algae tank below the subfloor; and providing stacked trays having mesh bottoms to hold a nutrient enriched gel. Providing a broad spectrum of light on the south wall; irrigating mist in a timed sequence with the provision of light and maintaining the chamber at a constant 68° to 78° F temperature with high humidity. Power is provided by a photovoltaic panel permitting installation in remote locations. The growth chamber and system provides high yields with little space and in locations not normally conducive to efficient growing.

**5,210,804**
Schmid, Guenther W., inventor. *Solar Powered Hearing Aid and Reenergizer Case*. May 11, 1993.

In-the-ear type hearing aid has a rechargeable storage cell permanently connected and permanently situated within its shell, and a solar cell carried on its back plate and facing outward. The solar cell provides power to energize the hearing aid amplifier while the device is worn and also reenergizes the storage cell under average ambient conditions. The solar cell serves as a noise filter to reduce the background noise apparent to the wearer. A semitransparent cover or door cosmetically conceals the solar cell while the aid is being worn, but permits some ambient light to penetrate to the solar cell. For recharging, the door can be opened for full exposure onto the solar cell. A combination storage and reenergizing case is provided by the hearing aids.

**5,211,470**
Frost, John S.; Erickson, Mark R.; Seegan, Kimberly E.; Boyer, Brent P., inventors; Siemens Solar Industries, assignee. *Self-Contained Solar Powered Light*. May 18, 1993.

A self-contained solar powered marking light. The marking light may be utilized to delineate certain predetermined boundaries without effectively illuminating the areas. The marking light automatically illuminates when output power from the photovoltaic cells contained therein fall below a predetermined level and automatically extinguishes when the voltage from the photovoltaic cells reaches a predetermined level. The marking light includes a lens which is closely coupled to a source of light and which includes a textured surface for diffusing the light to cause the lens to appear to glow when the source of light is illuminated. An electrical circuit is coupled between the photovoltaic cells and a battery and includes the source of light and switching means for automatically illuminating the light dependent upon the relative relationship between the voltage of the photovoltaic cells and the battery voltage.

**5,211,761**
Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi, inventors; Sanyo Electric Co., Ltd., assignee. *Photovoltaic Device and Manufacturing Method Thereof*. May 18, 1993.

A photovoltaic device according to the present invention has a buffer layer on a heat-resistant substrate for enhancing the adhesion characteristic of the substrate, a first semiconductor thin film including polycrystalline silicon of one conductivity type formed by a liquid phase growth method, and a second semiconductor thin film of opposite conductivity type, formed in this order.

**5,211,762**
Isoda, Satoru; Ueyama, Satoshi; Kawakubo, Hiroaki; Maeda, Mitsuo, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Photoresponsive Element Utilizing a Molecular Heterojunction*. May 18, 1993.

A photoresponsive element utilizing a molecular heterojunction includes a first redox material film, a second redox material film having a different redox potential from that of the first redox material film and disposed in contact with the first redox material film, a first electrode connected to the first redox material film, and a second electrode connected to the second redox material film. The photoresponsive element is photoconductive and photovoltaic.

**5,212,385**
Jones, Barbara L., inventor. *Diamond alpha Particle Detector*. May 18, 1993.

A radiation detector element which is optimized for the detection of *alpha* particles comprises a layer of diamond or diamond-like carbon with first and second electrical contacts applied to the surface of the layer. The layer is formed on a silicon substrate, together with an electronic circuit. Each of the contacts defines a rectifying junction with the layer, thus defining a back-to-back diodic structure, having junction characteristics which are responsive to the intensity of radiation incident on the detector element. The electronic circuit is powered by a battery or a solar cell, and activates an LCD indicator if the intensity of the incident radiation exceeds a predetermined level. The radiation detector element and the electronic circuit are housed on a card which is sized similarly to a conventional identification card.

**5,212,395**
Berger, Paul R.; Cho, Alfred Y.; Dutta, Niloy K.; Lopata, John; O'Bryan, Henry M.; Sivco, Deborah L.; Zydzik, George J., inventors; AT&T Bell Laboratories, assignee. *P-I-N Photodiodes with Transparent Conductive Contacts*. May 18, 1993.

This invention pertains to a p-i-n $In_{0.53}Ga_{0.47}As$ photodiode having an optically transparent composite top electrode consisting of a thin semitransparent metal layer from 10 to 40 nm thick and a transparent cadmium tin oxide (CTO) layer from 90 to 600 nm thick. The metal layer makes a non-alloyed ohmic contact to the semiconductor surface, acts as a barrier between the semiconductor and the CTO preventing oxidation of the semiconductor from the $O_2$ in the plasma during reactive magnetron sputtering of the CTO layer, and prevents formation of a p-n junction between the semiconductor and CTO. The CTO functions as the n or p contact, an optical window and an anti-reflection coating. The top electrode also avoids shadowing of the active layer by the top electrode, thus allowing greater collection of incident light. Since the top electrode is non-alloyed, interdiffusion into the i-region is not relevant, which avoids an increased dark current.

**5,212,916**
Dippel, Hans-Jurgen; Raupach, Peter, inventors; Peter Raupach, assignee. *Device for Shading Spaces*. May 25, 1993.

In an arrangement having a surface for accommodating photovoltaic cells which are adapted to be connected to a current collector or the like, in particular in the case of a roof skin which is stretched over frame members, the arrangement is formed in the manner of a net from cables and the photovoltaic cells are disposed at or between the junctions of the cables. The invention also includes the photovoltaic cells which are arranged floatingly at the flexible surface of the arrangement.

**5,213,626**
Paetz, Werner, inventor; Webasto-Schade GmbH, assignee. *Transparent Pane for Vehicles*. May 25, 1993.

Transparent pane for vehicles, in particular, a transparent cover for sliding roofs, lifting roofs, and the like, with a transparent outer layer and a solar laminate lying flat against the inside of this outer layer. The active part of the solar laminate is formed of a first subsection lying in the outer edge area of the pane which is made of crystalline semiconductor material, and a second subsection that is made of an amorphous semiconductor material.

**5,213,627**
Marquardt, Reinhold; Böhmer, Walter; Harzheim, Horst; Jäger, Wolfgang; Chehab, Oussama; Rosendahl, Reiner, inventors; Flachglas-Solartechnik GmbH, assignee. *Structural Element, in Particular Facade Element*. May 25, 1993.

In a structural element, in particular a facade element with an outside plate sandwich, in which solar cells are arranged between an outer plate and an inner plate, and with another internal plate, which is provided at a distance from the plate sandwich by means of a spacing frame defining the interior, the solar cells are embedded in a layer of casting resin; furthermore, the inner plate recedes in its dimensions in the region of at least one edge at least partially with respect to the corresponding edge of the outer plate and forms thus a recess that also reaches over the layer of casting resin and through which the necessary electrical lines are guided, whereby the recess in the direction of the interior of the structural element is covered by the spacing frame. As an alternative, the outer plate can recede with respect to the inner plate.

**5,213,628**
Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi, inventors; Sanyo Electric Co., Ltd., assignee. *Photovoltaic Device*. May 25, 1993.

A photovoltaic device includes a monocrystalline or polycrystalline semiconductor layer of one conductivity type, a substantially intrinsic substantially amorphous semiconductor layer having a predetermined thickness small enough to avoid producing carriers therein. The substantially intrinsic, substantially amorphous layer is formed on the one conductivity type semiconductor layer, and a substantially amorphous semiconductor layer of the opposite conductivity type is formed on the intrinsic, semiconductor layer.

**5,214,002**
Hayashi, Yutaka; Yamanaka, Mitsuyuki, inventors; Agency of Industrial Science and Technology, assignee. *Process for Depositing a Thermal CVD Film of Si or Ge Using a Hydrogen Post-Treatment Step and an Optional Hydrogen Pre-Treatment Step.* May 25, 1993.

A process for depositing a thin semiconductor film includes the steps of depositing a thin film on a substrate by feeding onto the surface of the substrate being heated a gaseous starting material containing a constituent element of the thin film, and feeding excited hydrogen to the thin film without exposing the thin film to the ambient air. Disilane was fed together with hydrogen carrier gas onto a quartz substrate to deposit thereon a thin amorphous silicon film, to which excited hydrogen from a hydrogen plasma was then fed to modify the deposited thin silicon film. As a result, the photoconductivity of the thin silicon film was improved.

**5,215,598**
Kouzuma, Shinichi; Inoue, Hiroshi; Murata, Kenji; Tanaka, Hiroyuki; Kishi, Yasuo, inventors; Sanyo Electric Co., Ltd., assignee. *Flexible Photovoltaic Device and Manufacturing Method Thereof.* June 1, 1993.

A flexible photovoltaic device comprises a first, insulating and flexible resin layer; a first electrode formed on the first resin layer; a flexbile resin type locking member formed having satisfactory adherence and formed along the inner periphery of the transparent electrode; a semiconductor layer formed to cover the first electrode and the locking member for photoelectric conversion; a second electrode formed on the semiconductor layer; and a second insulating and flexible resin layer formed on the second electrode.

**5,215,599**
Hingorani, Narain G.; Mehta, Harshad, inventors; Electric Power Research Institute, assignee. *Advanced Solar Cell.* June 1, 1993.

An advanced solar cell having an improved efficiency over known conventional solar cells uses an external electric field to enhance the conversion of solar energy into electrical energy. The advanced solar cell has a layered extrinsic semiconductor with a lightly doped base layer sandwiched between two oppositely and heavily doped layers to form a p-n junction within the semiconductor. The base layer has opposing incident and collection surfaces, at least one of which has recessed contact regions interspersed between biasing regions. At least one of the heavily doped layers is substantially confined within the recessed contact regions. Overlaying the biasing region is an enhancement layer, such as a layered MOS structure. Biasing the enhancement layer provides an externally generated electric field to the semiconductor which enhances a depletion region formed around the p-n junction when photon radiation impinges on the semiconductor. A transparent layer of a conductive material may overlay one of the heavily doped layers or comprise a portion of the MOS structure. A method is also provided of converting solar energy into electrical energy.

**5,216,543**
Calhoun, Clyde D., inventor; Minnesota Mining and Manufacturing Company, assignee. *Apparatus and Method for Patterning a Film.* June 1, 1993.

The present invention relates to an apparatus and method for patterning areas of a radiation absorbent film material. In the preferred embodiment, the film material is at least partially electrically conductive. The radiation is focused onto the film by a lenticular lens having a plurality of optically active elements to provide a radiation pattern on the film and remove or displace portions of the film to form a corresponding pattern, preferably a conductive pattern. The film may have one or more layers or regions, but at least one region must be radiation absorbent in order to allow the formation of patterns in the film in accordance with the present invention. The areas of the film affected by the phenomenon of radiation absorption are non-conductive voids which may separate the film into a plurality of conductive grid lines whereby the film is useful with a conductive lens film to increase the apparent efficiency of a photovoltaic cell.

**5,216,972**
Dufrene, John K.; Deed, John, inventors. *Lighted Cleat.* June 8, 1993.

A device which is a translucent boat or ship cleat constructed of polyurethane. The cleat is molded as one piece and can be either clear or have color added such as international orange. The cleat has a recess in its base in which a light source can be placed. Lighting such as incandescent, neon or LED may be used. The cleat can be powered from an external source either AC or DC. The cleat can also have solar cells placed in its horns which can store energy in storage cells mounted with the cleat at its base for powering LED during non-sunlight hours. The illuminated cleat makes it easy to locate the mooring for a boat in the dark. It also makes the cleat visible for the safety of persons walking on the mooring structure. The polyurethane construction provides for a lighter, more durable, and less abrasive device for boat moorings.

**5,217,000**
Pierce-Bjorklund, Patricia, inventor. *Compound Solar Collector Building Construction.* June 8, 1993.

A compound construction matrix harvests energy incident on all peripheries of a building by providing compound components having anterior and posterior portions with respect to radiation, the anterior portions being generally transparent and the posterior portions being selectively translucent,transparent or opaque, the

compound components being arranged in communicating relation to form walls and roofs having multiple internal cavities and passages between cavities which permit light and air to flow freely within the matrix, allowing light incident from any angle to be reflected from cavity sidewalls toward posterior portions to form overlapping incidence on translucent conversion surfaces and to pass through tinted conversion means for direct gain, and allowing air in each cavity to expand freely in any direction from sunlit to shaded portions and through apertures toward shaded portions of adjacent cavities, to thereby form a dynamic airstream passing over translucent conversion surfaces and non-transparent conversion surfaces, seeking equilibrium surface temperatures throughout the matrix and removing energy developed in each cavity, the temperature of the air stream being modified by the thermal properties of the material of fabrication of the matrix and coatings and devices placed in matrix cavities, all cavities forming a single vessel, chambered manifold extending about the periphery of a building and performing all functions of a solar collector, e.g., retention, conversion, and distribution of incident energy while also providing the structural walls and light transmissive skin of the building.

**5,217,285**
Sopori, Bhushan L., inventor; The United States of America as represented by the United States Department of Energy, assignee. *Apparatus for Synthesis of a Solar Spectrum*. June 8, 1993.

A xenon arc lamp and a tungsten filament lamp provide light beams that together contain all the wavelengths required to accurately simulate a solar spectrum. Suitable filter apparatus selectively direct visible and ultraviolet light from the xenon arc lamp into two legs of a trifurcated randomized fiber optic cable. Infrared light selectively filtered from the tungsten filament lamp is directed into the third leg of the fiber optic cable. The individual optic fibers from the three legs are brought together in a random fashion into a single output leg. The output beam emanating from the output leg of the trifurcated randomized fiber optic cable is extremely uniform and contains wavelengths from each of the individual filtered light beams. This uniform output beam passes through suitable collimation apparatus before striking the surface of the solar cell being tested. Adjustable aperture apparatus located between the lamps and the input legs of the trifurcated fiber optic cable can be selectively adjusted to limit the amount of light entering each leg, thereby providing a means of "fine tuning" or precisely adjusting the spectral content of the output beam. Finally, an adjustable aperture apparatus may also be placed in the output beam to adjust the intensity of the output beam without changing the spectral content and distribution of the output beam.

**5,217,296**
Tanner, David P.; Frost, John S.; Erickson, Mark R.; Moore, Fred A., inventors; Siemens Solar Industries, assignee. *Solar Powered Light*. June 8, 1993.

A solar powered light adapted to be mounted under the eaves of a building, a wall or the like for use in security applications. In a preferred embodiment of the present invention, the solar powered light comprises an adjustable configuration having a lamp with an infrared detector or sensor rotatably mounted thereto and a photovoltaic or solar cell array rotatably disposed at a remote end of an extension arm movably attached to the lamp. Such a flexible arrangement allows the photovoltaic array to be positioned to receive direct sunlight. The sensor activates the solar powered light upon sensing infrared to illuminate the surrounding areas when a presence is sensed and turn it off when a presence is no longer sensed. In accordance with a second embodiment, the solar powered light does not include an infrared detector and provides continuous illumination for a given period of time. In accordance with a third embodiment, the solar powered light does not include an infrared detector, but includes a battery having a higher capacity configured to provide illumination for extended periods of time. In accordance with a fourth embodiment, the solar powered light is configured to be used directly with a user's battery. The solar powered light utilizes a compact fluorescent bulb and circuitry for providing longer lamp life, instantaneous illumination and eliminating flickering during start up.

**5,217,539**
Fraas, Lewis M.; Sundaram, Veeravana S.; Avery, James A.; Gruenbaum, Peter E.; Malocsay, Eric, inventors; The Boeing Company, assignee. *III-V Solar Cells and Doping Processes*. June 8, 1993.

Zinc diffusion procedures applicable for large scale manufacture of GaAs and GaSb cells used in tandem solar cells having a high energy conversion efficiency. The zinc doping and carrier concentration are restricted to be less than about $10^{19}/cm^3$ to obtain good light generated carrier collection and hence good short circuit currents. The amount of zinc that is available for diffusion during a drive-in heating step is restricted. Confinement of zinc and arsenic vapors during the heating step may be effected by use of a proximity source wafer or by an encapsulant layer. The zinc diffusion of GaSb is obtained by a homogeneous light diffusion that is followed by a patterned heavy diffusion to give low ohmic contact with the grid lines. Texture etching of the GaSb solar cell is also compatible with this diffusion process.

**5,217,540**
Ogura, Hiroshi, inventor; Sharp Kabushiki Kaisha, assignee. *Solar Battery Module*. June 8, 1993.

A solar battery module to be mounted on a mounting face of a mounting body, comprising a solar battery module body, solar cells for converting sunlight into electric energy inside the solar battery module body, a connection lead wire connected with the solar cells and which passes through a hole in the mounting surface, fasteners passing through the holes in the mounting surface for mounting the solar battery module body to the mounting face, and spacers provided in the vicinity of the fasteners and the connection lead wire for contacting the mounting face and preventing water from flowing into the mounting body and the solar battery module body, wherein the spacers include a soft resin which can conform to the shape of the mounting face, and a sealing resin, which is adherent and waterproof, provided on both faces of the soft resin for covering a gap defined around the connection lead wire and the fastener so as to prevent water from flowing into the mounting body.

**5,217,921**
Kaido, Yoshinori; Masatoshi, Otsuki, inventors; Sanyo Electric Co., Ltd., assignee. *Method of Photovoltaic Device Manufacture.* June 8, 1993.

This method of photovoltaic device manufacture has process steps to form a transparent electrode layer comprising at least a tin oxide layer on a transparent substrate, to divide the transparent electrode layer into a plurality of unit areas by laser scribing, and to subsequently heat treat (anneal) the device. The laser for scribing the transparent electrode layer into a plurality of unit areas has an energy density greater than or equal to 21 $J/cm^2$. Further, when the diameter of the laser beam spot on the transparent electrode layer is D and the distance between pulses is X, the laser satisfies the condition $0.5\ D \leq X \leq 0.85\ D$.

**5,218,213**
Gaul, Stephen J.; Rouse, George V., inventors; Harris Corporation, assignee. *SOI Wafer with SiGe.* June 8, 1993.

An SOI wafer is formed having a silicon-germanium layer between the epitaxial layer of the device and the insulative layer. The process includes bonding a second substrate to a silicon-germanium layer on a first substrate by an intermediate insulative layer. The first substrate is removed down to the silicon-germanium layer and the silicon layer is epitaxially formed on the silicon-germanium layer.

**5,220,181**
Kanai, Masahiro; Tanaka, Hisami; Sakou, Harumi, inventors; Canon Kabushiki Kaisha, assignee. *Photovoltaic Element of Junction Type with an Organic Semiconductor Layer Formed of a Polysilane Compound.* June 15, 1993.

An improved junction type photovoltaic element, characterized by having an organic semiconductor layer formed of a polysilane compound of 6000 carbon atoms, $R_2$ stands for an alkyl group, cycloalkyl group, aryl group or aralkyl group of 3 to 8 carbon atoms, $R_3$ stands for an alkyl group of 1 to 4 carbon atoms, $R_4$ stands for an alkyl group of 1 to 4 carbonatoms, A and A' respectively stands for an alkyl group, cycloalkyl group, aryl group or aralkyl group of 4 to 12 carbon atoms wherein the two substitutes may be the same of different one from the other, and each of n and m is a mole ratio showing the proportion of the number of respective monomers versus the total of the monomers in the polymers wherein $n + m = 1$, $0 < n \leq 1$ and $0 \leq m < 1$.

**5,221,363**
Gillard, Calvin W., inventor; Lockheed Missiles & Space Company, assignee. *Solar Cell Window Fitting.* June 22, 1993.

An array of solar cells for supplying electrical energy to a building (e.g., for operating air-conditioning equipment) is mounted in a window fitting, which comprises a pair of transparent glass panes between which a window blind (e.g., of the venetian blind type) is mounted. Solar cells are secured to slats of the window blind so as to be exposed to sunlight incident thereon.

**5,221,364**
Hotaling, Steven P., inventor; The United States of America as represented by the Secretary of the Air Force, assignee. *Lightweight Solar Cell.* June 22, 1993.

A method for fabricating a lightweight solar cell is provided wherein (a) an LD silica aerogel substrate at densities between 10 - 1,000 mg/cc is prepared, (b) the surface of such aerogel substrate is polished to an optical quality surface, (c) a dielectric planarization layer of $SiO_2$ is applied to so-polished substrate surface, and (d) one or more photovoltaic thin film layers are deposited on the planarization layer to form such lightweight solar cell, which includes an LD aerogel substrate that was not available before the invention hereof. Such substrates as well as the PV thin film layers are sufficiently transparent to admit energizing light not only through the PV layers of the cell but also, if desired, through the substrate side of such cell, to energize such PV layers from one or both sides as desired. The solar cells of the invention, with their LD aerogel substrates are much lighter than prior art solar cells. This is advantageous in satellite applications since the solar array weight is substantial. Such lightweight solar cells of the invention also find further advantage on the ground, e.g., for solar-powered vehicles in which weight is a primary concern.

**5,221,365**
Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi, inventors; Sanyo Electric Co., Ltd., assignee. *Photovoltaic Cell and Method of Manufacturing Polycrystalline Semiconductor Film.* June 22, 1993.

A thin film transistor and a photovoltaic cell wherein a polycrystalline semiconductive film, having a large grain size and high carrier mobility obtained by heat treatment of a polycrystalline semiconductive film, an amorphous semiconductive film, a microcrystalline semiconductive film or the like on a substrate with a textured surface, is used as a channel layer or a photoactivation layer, the textured surface being formed by etching one surface of the substrate or forming a textured thin film on the substrate.

A method of manufacturing a polycrystalline semiconductive film, wherein a surface of a substrate is etched or a textured thin film is formed on the substrate to form a textured surface, and a polycrystalline semiconductive film, an amorphous semiconductive film, a microcrystalline semiconductive film or the like is formed on the textured surface, and the semiconductive film is polycrystallized by heat treatment.

**5,221,854**
Banerjee, Arindam; Guha, Subhendu; Yang, Chi C., inventors; United Solar Systems Corporation, assignee. *Protective Layer for the Back Reflector of a Photovoltaic Device.* June 22, 1993.

A protective layer is disposed between a silver reflective electrode and a layer of transparent conductive oxide in a photovoltaic device so as to prevent oxidation of the silver. The protective layer may be continuous or discontinuous and may be fabricated from $MgF_2$, $Si_xN_y$ or $T_{ix}N_y$ where x and y are positive numbers.

**5,221,891**
Janda, Rudolph W.; Douglas, Jerald L.; Condon, Jr., Edward F., inventors; Intermatic Incorporated, assignee. *Control Circuit for a Solar-Powered Rechargeable Power Source and Load.* June 22, 1993.

An inexpensive circuit for controlling the recharging of a rechargeable power source by a photovoltaic panel is used for powering a load such as the lamp of a walk light. Using a minimum number of components, the circuit can charge a rechargeable battery anytime sunlight is sufficient to place a potential across the battery that is greater than the present potential of the battery, can sense a decrease in voltage across the photovoltaic panel with diminishing ambient light and energize the load, can prevent the load from being energized when the ambient light level is sufficient to recharge the battery, can provide positive feedback at turn-on of the load, thereby hastening turn-on and providing hysteresis, can provide for adjusting the hysteresis bands, can shift the turn-on and turn-off thresholds, and can provide an adequate current to guarantee turn-on when using low leakage solar panels. A further embodiment can additionally exhibit hysteresis at load turn-off so that the load does not cycle on and off and can further raise the load turn-off threshold above the level where the battery is substantially discharged, thereby hastening recharge of the battery. A still further embodiment provides temperature compensation for improved performance.

**5,223,043**
Olson, Jerry M.; Kurtz, Sarah R., inventors; The United States of America as represented by the United States Department of Energy, assignee. *Current-Matched High-Efficiency, Multijunction Monolithic Solar Cells.* June 29, 1993.

The efficiency of a two-junction (cascade) tandem photovoltaic device is improved by adjusting (decreasing) the top cell thickness to achieve current matching. An example of the invention was fabricated out of $Ga_{0.52}In_{0.48}P$ and GaAs. Additional lattice-matched systems to which the invention pertains include $Al_xGa_{1-x}/GaAs$ ($x = 0.3$-$0.4$), GaAs/Ge and $Ga_yIn_{1-y}P/Ga_{y+0.5}In_{0.5-y}As (0<y<5)$.

**5,223,044**
Asai, Masahito, inventor; Sharp Kabushiki Kaisha, assignee. *Solar Cell Having a Bypass Diode.* June 29, 1993.

A solar cell having a bypass diode includes a second conductivity type layer and a second conductivity type well formed on the front surface of a first conductivity type semiconductor substrate, and a first conductivity type layer formed in a second conductivity type well. A comb-shaped front electrode is formed over the front surface of the substrate and includes a plurality of narrow grid fingers and a bus portion to which the grid fingers are connected. At least a part of the bus portion of the electrode covers the entire first conductivity type layer. A back electrode is formed on the back surface of the substrate. The first conductivity type substrate and the second conductivity type layer constitute the solar cell, and the second conductivity type well and the first conductivity type layer constitute the bypass diode. The solar cell and the bypass diode are electrically connected in parallel between the front electrode and the back electrode with their polarities being opposite to each other.

**5,225,712**
Erdman, William L., inventor; U.S. Windpower, Inc., assignee. *Variable Speed Wind Turbine with Reduced Power Fluctuation and a Static VAR Mode of Operation.* July 6, 1993.

A wind turbine power converter is disclosed herein that smooths the output power from a variable speed wind turbine, to reduce or eliminate substantial power

fluctuations on the output line. The power converter has an AC-to-DC converter connected to a variable speed generator that converts wind energy to electric energy, a DC-to-AC inverter connected to a utility grid, and DC voltage link connected to an electrical energy storage device such as a battery or a fuel cell, or a photovoltaic or solar cell. Also, an apparatus and method is disclosed herein for controlling the instantaneous current flowing through the active switches at the line side inverter to supply reactive power to the utility grid. The inverter can control reactive power output as a power factor angle, or directly as a number of VARs independent of the real power. Reactive power can be controlled in an operating mode when the wind turbine is generating power, or in a static VAR mode when the wind turbine is not operating to produce real power. To control the reactive power, a voltage waveform is used as a reference to form a current control waveform for each output phase. The current control waveform for each phase is applied to a current regulator which regulates the drive circuit that controls the currents for each phase of the inverter. Means for controlling the charge/discharge ratio and regulating the voltage on the DC voltage link is also disclosed.

**5,228,772**
Mitchell, Kim W.; Stizema, Jr., Ronald L., inventors; Siemens Solar Industries, assignee. *Solar Powered Lamp Having a Cover Containing a Fresnel Lens Structure.* July 20, 1993.

A solar powered light comprises a cover containing a fresnel lens structure (also referred to as a fresnel lens cover) which is disposed directly above and adjacent to a photovoltaic cell thereof. The fresnel lens cover comprises a continuous and smooth outer surface and a prismatic inner surface having a plurality of prismatic means arranged in concentric circles to bend incoming radiation, especially at high angles of incidence, such as during winter months or at the beginning or end of a day, toward an optical axis thereof. The prisms have different thicknesses and are arranged in different angular configurations to accomplish the desired bending at each point of the cover. In a preferred embodiment, additional prismatic means are formed on a peripheral portion of the outer surface to cover a photodetector used for sensing the absence of light and triggering circuitry to turn on the solar powered lights.

**5,228,924**
Barker, James M.; Underwood, John C.; Shingleton, Jefferson, inventors; Mobil Solar Energy Corporation, assignee. *Photovoltaic Panel Support Assembly.* July 20, 1993.

A solar energy power source is provided comprising at least two flat photovoltaic panels disposed in co-planar side-by-side relation and an improved support structure for supporting the panels for pivotal movement on a pivot axis that extends transversely of the panels, the improved structure including a single selectively operable drive means for pivoting all of the panels simultaneously and by the same amount of angular displacement.

**5,228,925**
Nath, Prem; Singh, Avtar, inventors; United Solar Systems Corporation, assignee. *Photovoltaic Window Assembly.* July 20, 1993.

A photovoltaic window assembly suitable for use in building and vehiclular applications. The window assembly includes an optically transmissive substrate having one or more photovoltaic devices disposed thereon. A decorative template having cut-outs coextensive with each of the photovoltaic devices is disposed on the substrate such that the photovoltaic devices extend through the cut-outs. A window opening is also formed in the decorative template for transmission of light. An encapsulating layer is formed on the substrate, solar cells and decorative template to protect the solar cells and assembly from environmental damage and deterioration.

**5,228,926**
Glatfelter, Troy; Vogeli, Craig; Call, Jon; Hammond, Ginger, inventors; United Solar Systems Corporation, assignee. *Photovoltaic Device with Increased Light Absorption and Method for Its Manufacture.* July 20, 1993.

A photovoltaic cell having a light-directing optical element integrally formed in an encapsulant layer thereof. The optical element redirects light to increase the internal absorption of light incident on the photovoltaic device.

**5,228,964**
Middleby, Samuel R., inventor. *Chlorinating Apparatus.* July 20, 1993.

Chlorinators are provided for use with saltwater swimming pools. The chlorinators do not require mains electric power and can be fitted to the pool without requiring any significant modification of the pool piping. One form of chlorinator comprises a set of electrodes which are connected to the output of an electric generator which, in turn, is driven by the flow of water produced by the pool pump during filtration. The generator has a shaft on which is mounted an impeller which may be driven by the water flow through the pool return pipe outlet or the water flow in the leaf basket cavity. In another form, a generator is mechanically coupled to the pump motor. In yet another form of the invention, the electrodes of a chlorinator are mounted on the underside of a floating housing and are powered from solar cells located on the topside of the housing.

**5,229,624**
Marks, Alvin M., inventor. *Light-Polarizing Electrically Conducting Film.* July 20, 1993.

A new composition of matter is described comprising a stretch oriented electrically conducting light-polarizing film. An improved light-electric power converting film uses molecular diodes (diads) in this film composition aligned head-to-tail by light and an electric field. The area of the film is utilized more efficiently by reversing the head-to-tail directions of the diads in adjacent areas. This film is laminated to an electrode structure connected to busbars on a substrate sheet. Current flow through the film is unidirectional between pairs of adjacent electrodes, and is summed on busbars connected to an external load. Two such films arranged orthogonally convert about 72% of the incident light power to electric power. A manufacturing device is disclosed. Critical ranges of parameters are derived and experimental data presented.

**5,229,649**
Nielsen, Wyn Y.; Luck, Jonathan M., inventors; Solatrol, Inc., assignee. *Light-Energized Electronics Energy Management System.* July 20, 1993.

An irrigation controller is powered for all normal operations by light incident upon an 18 square inch photovoltaic module. Electrical power from the photovoltaic module is stored in high performance "super" capacitors. A transportable battery power source is connected to the controller to power its communication, such as for manual exercise and/or the loading of irrigation control programs. The external battery power source leaves the capacitor power storage recharged at the conclusion of each communication episode. The irrigation controller electronics, save for a real time clock that is updated, are not provided with a timing signal, and thereby consume almost no energy, save for brief millisecond sporadic time intervals of scheduled irrigation control. Capacitor power storage is approximately 6.5 mWH. Worse case photovoltaic energy production is 7.5 mWH daily. The sporadically operative irrigation controller uses less than 6.4 mWH per day, with remaining energy expended on up to 128 ultra-low-power valve actuations per day.

**5,230,746**
Wiedeman, Scott; Jackson, Frederick R., inventors; Amoco Corporation, assignee. *Photovoltaic Device Having Enhanced Rear Reflecting Contact.* July 27, 1993.

A photovoltaic device includes a rear reflecting conductive contact layer adjacent an active semiconductor layer. The rear layer is composed of a light transmissive conductive layer formed on the active layer, an intermediate layer formed on the light transmissive conductive layer, and a layer of light reflecting conductive material formed on the intermediate layer. The intermediate layer includes a dielectric material and portions through which the adjacent light transmissive and light reflecting conductive layers are conductively connected. For example, the intermediate layer can be provided as a thin layer of substantially only a dielectric material or as a cermet.

**5,230,753**
Wagner, Sigurd, inventor; Princeton University, assignee. *Photostable Amorphous Silicon-Germanium Alloys.* July 27, 1993.

Alloys of hydrogenated amorphous silicon and germanium are disclosed that exhibit unexpectedly low saturated defect densities, particularly relative to the initial defect densities of the alloys, so as to render them substantially resistant to Staebler-Wronski degradation. The alloys are producible using conventional equipment, but glow-discharge methods are preferred. The preferred amount of germanium in the alloy is about 15 at.% to about 50 at. %. The alloys are particularly useful for making photovoltaic cells. The alloys can be used as intrinsic semiconductors and doped for use as "n" or "p" materials. Methods for making the alloys are also disclosed.

**5,230,837**
Babasade, Wolfgang W., inventor. *Fragrance Dispenser and Method for Fragrance Dispensing.* July 27, 1993.

A fragrance dispenser utilizing a fragrance dispensing wheel is described. The fragrance wheel is directly mounted onto a rotatable motor shaft, the motor being powered by either conventional AC or DC current, or by a photovoltaic cell. Absorbent panels on the wheel direct ambient air in response to motor rotation. When powered by photovoltaic cell fragrance is dispensed in an economic and safe manner in proportion to room lighting.

**5,231,781**
Dunbar, Bret A., inventor; Bret Allen Dunbar, assignee. *Illuminated Float.* August 3, 1993.

An illuminated float comprises a plurality of solar generators, a storage battery for storing therein the electrical energy generated by the solar generator, a light-emitting element which emits the light by the energy supplied from the storage battery, a homing device which emits a high-frequency beacon displayed on the ships display screen, and an energy control means which permits the supply of electrical energy from the storage battery to the light-emitting element and the homing device only when ambient illumination drops below a predetermined level.

**5,232,105**
Gregg, Stephen R., inventor. *Solar Powered Crystal Display Rack.* August 3, 1993.

A solar powered crystal display is disclosed. The device is used to display various crystal forms in a window. A series of friction drive wheels and a solar powered electric motor are used to rotate the crystals, which are suspended under a plate. The plate is formed into any design desired. For example the plate can be shaped like a cloud, the sun, a star, animals, rainbows, etc. The purpose of the plate is to conceal the drive mechanism from view. The plate is hung from a flange attached to the drive mechanism. The device can also be operated without the plate. An auxiliary drive unit is also disclosed that permits additional crystals to be suspended from the original device. The device can be placed against a window using suction cups or can be suspended from hooks placed into the window casing. As the crystals are rotated, the sunlight will refract through the crystals, producing aesthetical pleasing, colorful patterns in a room.

**5,232,518**
Nath, Prem; Laarman, Timothy; Singh, Avtar, inventors; United Solar Systems Corporation, assignee. *Photovoltaic Roof System*. August 3, 1993.

A photovoltaic roofing system includes a plurality of roofing panels each having a photovoltaic device thereupon and each including an electrical connector engageable with a connector on another panel. The panels include upstanding flanges and a batten and seam roof construction may be readily configured by interconnecting the panels, fastening them to the roof and covering adjoining flanges with the battens.

**5,232,519**
Glatfelter, Troy; Vogeli, Craig; Nath, Prem, inventors; United Solar Systems Corporation, assignee. *Wireless Monolithic Photovoltaic Module*. August 3, 1993.

A wireless, monolithic photovoltaic module. The module includes top and bottom, rectangular electrodes with a photovoltaic body and an adjacent insulating strip sandwiched in between the electrodes, the insulating strip being disposed proximate the edge of the bottom electrode. A bus bar overlies the insulating strip, but not the photovoltaic body, and is connected to a net of current carrying grid lines which overlie the photovoltaic body to form a current collector. A top encapsulating layer has diffractive grooves formed therein which overlie the grid lines to minimize shading effects otherwise caused by shadows from the grid lines.

**5,232,860**
Kawanishi, Yasuyoshi; Takahashi, Osamu; Otsuki, Masatoshi; Sawada, Kenzi, inventors; Sanyo Electric Co., Ltd., assignee. *Method of Flexible Photovoltaic Device Manufacture*. August 3, 1993.

A method of flexible photovoltaic device manufacture in which an inorganic separation layer and inorganic first protective film layer are formed on a supporting substrate. On the inorganic first protective film, a first electrode, an amorphous silicon photovoltaic layer, a second electrode, and a second protective film are formed in that order. Then the supporting substrate and the inorganic separation layer are separated. The inorganic separation layer is a material that bonds weakly with both the supporting substrate and the inorganic first protective film.

**5,235,232**
Conley, Jerry J.; Mortensen, Gary B., inventors; E.F. Johnson Company, assignee. *Adjustable-Output Electrical Energy Source Using Light-Emitting Polymer*. August 10, 1993.

A long-life, electrical energy source having an adjustable output is comprised of a light emitting phosphor activated by a radioisotope and coupled to a plurality of photovoltaic cells that have their outputs electrically connected together. The output power of the electrical energy source is effectively regulated by selectively changing the connections of the outputs of the photovoltaic cells in response to the progression of time.

**5,235,266**
Schaffrin, Christian, inventor; Schottel-Werft Josef Becker GmbH & Co. KG, assignee. *Energy-Generating Plant, Particularly Propeller-Type Ship's Propulsion Plant, Including a Solar Generator*. August 10, 1993.

An energy-generating plant including a solar generator, having solar cells, for producing electrical energy. The electrical energy is supplied to a direct current converter, the output power of which may be used to charge an energy storage system, such as batteries. The input resistance of the direct current converter is adapted, such as by a microcomputer, to the maximum power point (MPP) of the solar generator, the MPP being dependent upon the solar insolation and the temperature of the solar cells. At start up of the plant, or when there is a change of power at the output of the direct current converter, a search process is carried out to attain the MPP of the solar generator. The energy storage system may be used to energize an electric motor for driving the propeller of a ship.

**5,236,378**
Newman, Edwin, inventor. *Storage of Photovoltaic Arrays on a Ship*. August 17, 1993.

A system for storing and installing horizontally placed photovoltaic arrays on a ship. The prior art is improved by holding the arrays steady in a four-sided frame. The arrays are placed parallel to the keel, strung between two succeeding yards and rolled up by rotating guides placed near two succeeding masts, and lowered to the deck to reduce windage. The procedure may be reversed.

**5,236,516**
Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi, inventors; Sanyo Electric Co., Ltd., assignee. *Photovoltaic Apparatus.* August 17, 1993.

A photovoltaic apparatus for directly converting light energy into electric energy, comprising a light shielding substrate, at least one surface of the light shielding substrate being a metal; a light transmitting insulating layer on the above surface; and a photovoltaic body on a surface of the insulating layer, the photovoltaic body including a light transmitting first electrode, an amorphous or microcrystal semiconductive layer, and a light transmitting second electrode laminated in this order, with the first electrode being in contact with the insulating layer.

**5,237,490**
Ferng, Shing-Lai, inventor. *Solar Power Operated, Construction Work Warning Lamp with Focusing Device for Intensifying the Intensity of Light.* August 17, 1993.

A solar power operated, construction work warning lamp which is consisted of a base secured inside a lamp guard and covered by a top cover and a bottom cover to hold a solar cell assembly and a light emitting assembly, wherein a light intensifier is fastened to the base on the top and secured in place by a framed seal and an enclosing wall, to intensify the intensity of light given by the solar cell assembly. The light intensifier is consisted of two symmetrical condenser lens assemblies connected into a cylindrical shape covered around the light emitting assembly to hold a plurality of condenser lens for intensifying the intensity of light given by the light emitting elements on the light emitting assembly.

**5,237,764**
Gray, Jay C., inventor. *Solar Driven Novelty Device.* August 24, 1993.

The present invention comprises a solar driven novelty device including a frame having a first side and a second side; a solar panel attached to the frame and in an adjustable relationship thereto; a rotatable disk disposed on the frame; a motor in operative connection with the solar panel and also in operative connection with the disk, wherein the motor causes the disk to rotate in response to electricity generated by the solar panel and transmitted to the motor; and suction cups for attaching the frame to the surface, the suction cups being adjustable to permit either the first side of the frame or the second side of the frame to be adjacent to the surface.

**5,238,519**
Nath, Prem; Whelan, Kenneth J., inventors; United Solar Systems Corporation, assignee. *Solar Cell Lamination Apparatus.* August 24, 1993.

Apparatus for simultaneously laminating thin polymeric sheets onto at least one surface of a plurality of spacedly disposed substrates, such as photovoltaic modules. By simultaneously accommodating the lamination of a plurality of modules, the cost of the back-end fabrication of those modules is substantially reduced. The apparatus includes a plurality of diaphragms adapted to forcibly and simultaneously urge the polymeric sheets against at least one surface of each of the respective modules to be laminated. The force is preferably generated by a pump which creates a vacuum between the diaphragm and the substrate surface.

**5,238,879**
Plaettner, Rolf, inventor; Siemens Aktiengesellschaft, assignee. *Method for the Production of Polycrystalline Layers Having Granular Crystalline Structure for Thin-Film Semiconductor Components Such as Solar Cells.* August 24, 1993.

A method for producing polycrystalline layers having granular crystalline structure is provided. Pursuant to the method, a thin intermediate layer of amorphous is deposited before the deposition of the polycrystalline layer in order to avoid crystal structure influence proceeding from the structure of the substrate is prevented by the amorphous intermediate layer. Pursuant to the present invention, the thin-film technology can also be utilized for polycrystalline silicon layers, this being especially desirable in the manufacture of solar cells.

**5,240,510**
Goldade, Victor A.; Markov, Evgeny M.; Pinchuk, Lenoid S.; Kestelman, Vladimir N.; Girin, Andrey M., inventors; Development Products, Inc., assignee. *Photovoltaic Cell.* August 31, 1993.

A solar cell having an active zone made of a polar polymeric film material is disclosed. The electric contacts on the surfaces of the active zone are made of metals differing in electrochemical potentials. At least one of the electric contacts has a coating that absorbs solar radiation. The absorbent coating is preferably applied to the electric contact in the form of a polymeric material whose shape approximates a hemisphere. The active zone surface and the electric contact surface free of hemispherical portions are provided with an absorbent coating made of a material whose absorbing capability is different from that of the material of the hemispherical portions.

**5,240,647**
Ashley, Carol S.; Brinker, C. Jeffrey; Reed, Scott; Walko, Robert J., inventors. *Process for Making Solid-State Radiation-Emitting Composition.* August 31, 1993.

The invention provides a process for loading an aerogel substrate with tritium and the resultant compositions. According to the process, an aerogel substrate is hydrolyzed so that surface OH groups are formed. The hydrolyzed aerogel is then subjected to tritium exchange employing, for example, a tritium-containing gas, whereby tritium atoms replace H atoms of surface OH groups. OH and/or CH groups of residual alcohol present in the aerogel may also undergo tritium exchange.

**5,242,504**
Iwamoto, Masayuki; Minami, Kouji; Yamaoki, Toshihiko, inventors; Sanyo Electric Co., Ltd., assignee. *Photovoltaic Device and Manufacturing Method Therefor*. September 7, 1993.

A photovoltaic device, wherein a non-crystalline semiconductor layer of one conductivity type formed on a single crystal or a polycrystalline semiconductor substrate of the opposite conductivity type is annealed thereby to change the non-crystalline semiconductor to a polycrystalline semiconductor, with a pn junction plane formed therebetween. The depth of the junction plane is 500 Å or less from the light incident surface of the polycrystallized semiconductor. Moreover, the light incidence surface can be made uneven by increasing the growth rate of the non-crystalline semiconductor.

**5,242,505**
Lin, Guang H.; He, Mu Z.; Kapur, Mridula; Bockris, John O'M., inventors; Electric Power Research Institute, assignee. *Amorphous Silicon-Based Photovoltaic Semiconductor Materials Free From Staebler-Wronski Effects*. September 7, 1993.

Alloys of amorphous silicon with Group VIa elements are disclosed that form high-quality materials for photovoltaic cells that are resistant to Staebler-Wronski photodegradation. Also disclosed are methods for manufacturing the alloys. The alloys can be formed as films on solid-state substrates by reacting silane gas and at least one alloying gas ($H_2M$, wherein M is an element from Group VIa of the periodic table), preferably with hydrogen dilution, by a glow-discharge method such as plasma-enhanced chemical vapor deposition. The alloys can have an optical band gap energy from about 1.0 eV to about 2.3 eV, as determined by selecting one or more different Group VIa elements for alloying or by changing the concentration(s) of the alloying element(s) in the alloy. The alloys exhibit excellent light-to-dark conductivity ratios, excellent structural quality, and resistance to Staebler-Wronski degradation. They can be used as "i" type or doped for use as "p" or "n" type materials.

**5,242,507**
Iverson, Ralph B., inventor; Boston University, assignee. *Impurity-Induced Seeding of Polycrystalline Semiconductors*. September 7, 1993.

A semiconductor fabrication process improves the crystal structure of a polycrystalline semiconductor. Adding impurities in large quantities causes an acceleration of the crystallization without noticeably increasing the number of spontaneous nucleations in the material. The result is a region of relatively larger crystalline grains within the doped region which extend approximately 1 μm into the undoped region by the time the entire material has crystallized. Junction devices can be created with better electrical characteristics than ordinary polycrystalline semiconductor devices due to fewer grain boundaries at the electrical junctions. One fabrication technique can result in single crystal devices. Another implementation shows a method for fabricating improved polycrystalline vertical diodes such as solar cells.

**5,243,578**
Mathez, Bernard E., inventor; Lemrich and Cie S. A., assignee. *Electronic Timepiece*. September 7, 1993.

It comprises a standard electronic movement held in the case by means of an encasing ring made of synthetic material and also containing a large-sized accumulator gripped between two conductive plates. The upper plate is covered with an insulating film pierced with a hole, through which the blade of the battery receptacle of the movement comes in contact with the plate. The other pole of the accumulator is connected to the movement by means of the base, the case, and the dial. The encasing ring carries photovoltaic cells illuminated through indentations of the dial. The timepiece can advantageously be produced in small series, and its power reserve is very high.

**5,244,508**
Colozza, Anthony J., inventor; The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, assignee. *Self-Deploying Photovoltaic Power System*. September 14, 1993.

A lightweight flexible photovoltaic (PV) blanket is attached to a support structure of initially stowed telescoping members. The deployment mechanism comprises a series of extendable and rotatable columns. As these columns are extended the PV blanket is deployed to its proper configuration.

**5,244,509**
Arao, Kozo; Fujioka, Yasushi; Niwa, Mitsuyuki; Takeuchi, Eiji, inventors; Canon Kabushiki Kaisha, assignee. *Substrate Having an Uneven Surface for Solar Cell and a Solar Cell Provided with Said Substrate*. September 14, 1993.

A reflective solar cell substrate comprising a base member composed of a metallic material provided with irregularities at the surface thereof and a buffer layer

disposed on said base member so as to cover the entire of said irregularities at the surface of said base member, said buffer layer being composed of a substantially transparent or translucent and conductive material, said buffer layer being provided with irregularities at the surface thereof, and said irregularities at the surface of said buffer layer comprising a plurality of thickened convex portions and a plurality of thinned concave portions, said portions being alternately arranged. The reflective solar cell substrate reflects light reaching the substrate without being absorbed by the optically active layer at an effective angle, whereby the solar cell exhibits improved photovoltaic characteristics.

**5,246,350**
Lackstrom, David; Raghunathan, Kidambi, inventors; International Product and Technology Exchange, Inc., assignee. *High Efficiency Solar Powered Pumping System*. September 21, 1993.

A high efficiency solar powered water pumping system includes a solar collector for heating and vaporizing a working fluid. The vaporized working fluid is passed to a motor and valve assembly that alternatively delivers the working fluid to a power unit and exhausts the working fluid from the power unit to a condenser. The power unit has a driving member that moves up and down driving a sucker rod of a sucker rod assembly which raises water from a well in the earth. The water pumped from the ground passes through a tube in the condenser. The working fluid which has been exhausted from the power unit into the condenser, condenses to a liquid. The liquid working fluid is then pumped from the condenser by a positive displacement pump and is returned to the solar collector to repeat the cycle.

**5,246,506**
Arya, Rajeewa R.; Catalano, Anthony W., inventors; Solarex Corporation, assignee. *Multijunction Photovoltaic Device and Fabrication Method*. September 21, 1993.

A multijunction photovoltaic device includes first and second amorphous silicon PIN photovoltaic cells in a stacked arrangement. An interface layer, composed of a doped silicon compound, is disposed between the two cells and has a lower band gap than the respective n- and p-type adjacent layers of the first and second cells. The interface layer forms an ohmic contact with the one or the adjacent cell layers of the same conductivity type, and a tunnel junction with the other of the adjacent cell layers. The disclosed device is fabricated by a glow discharge process.

**5,246,782**
Kennedy, Alvin P.; Bratton, Larry D.; Jezie, Zdravko; Lane, Eckel R.; Perettie, Donald J.; Richey, W. Frank; Babb, David A.; Clement, Katherine S., inventors; The Dow Chemical Company, assignee. *Laminates of Polymers Having Perfluorocyclobutane Rings and Polymers Containing Perfluorocyclobutane Rings*. September 21, 1993.

A laminate has at least two layers, at least one of which comprises a polymer having more than one perfluorocyclobutane group. Such polymers impart qualities of environmental or protection, chemical and solvent resistance, hydrolytic stability, lubricity, low dielectric, hydrostatic stability, weatherability, flame resistance, chemical resistance, hydrolytic stability, lubricity, environmental protection, scratch resistance, solvent resistance, surface passivation, water repellancy, lower surface refractive index, lower surface coefficient of friction, fluid barrier properties, oil repellancy, thermal stability, and/or reduced moisture pick-up. Additionally , the coatings are optically clear, easy to apply either neat, in a solvent or otherwise, have relatively low cure temperatures for their temperature resistance, and exhibit insulating and planarizing capabilities.

**5,247,349**
Olego, Diego J.; Baumann, John A.; Schachter, Rozalie; Serreze, Harvey B.; Spicer, William E.; Raccah, Paul M., inventors; Stauffer Chemical Company, assignee. *Passivation and Insulation of III-V Devices with Pnictides, Particularly Amorphous Pnictides Having a Layer-Like Structure*. September 21, 1993.

Pnictide thin films, particularly phosphorus, grown on III-V semiconductors, particularly InP, GaP, and GaAs, are amorphous and have a novel layer-like, puckered sheet-like local order. The thin films are typically 400 Å thick and grown preferably by molecular beam deposition, although other processes such as vacuum evaporation, sputtering, chemical vapor deposition, and deposition from a liquid melt may be used. The layers are grown on the <100> <110> and <111> surfaces of the III-V crystals. The pnictide layer reduces the density of surface states, and allows the depletion layer to be modulated, the surface barrier reduced, the electron concentration at the surface increased, and there is a decrease in the surface recombination velocity and an increase in the photoluminescence intensity. The layers may be utilized in MIS and metal-semiconductor (Schottky) devices for example to insulate and passivate MISFETS, to passivate MESFETS, to reduce the surface current component of the reverse bias dark current in P-I-N and avalanche diodes, and to improve performance of opto-electronic devices such as light emitting diodes, lasers, solar cells, photo cathodes and photo detectors. The pnictide layer may be applied to intermetallic and compound semiconductors having a pnictide component. The pnictides may be phosphorus, arsenic, antimony, or bismuth, or combinations thereof.

**5,248,278**
Fuerst, Arpad; Schreiter, Thomas; Reinsch, Burkhard; Paetz, Werner, inventors; Webasto AG Fahrzeugtechnik, assignee. *Ventilator Roof for Vehicles*. September 28, 1993.

Ventilator roof for use in motor vehicles with a roof opening in a fixed roof surface which can be closed by a cover. The cover can be swung by pivoting around a pivoting axis at, or near its rear edge, into a ventilation position in which the cover front edge is below the roof surface, while the cover rear edge is kept at the height of the roof surface, and a ventilation gap is formed between the cover front edge and the front edge of the roof opening. At least one electrically powered blower is built into a ventilation channel leading from the ventilation gap into the vehicle interior. The blower can be powered by solar cells or the on-board vehicle power unit (battery) with safeguards to prevent use when the vehicle power unit lacks sufficient charge. In some embodiments, arrangements are also provided to enable the blower to provide ventilation of the interior space of the vehicle even when the cover is closed.

**5,248,345**
Sichanugrist, Porponth; Tanaka, Norimitsu, inventors; Showa Shell Sekiyu K.K., assignee. *Integrated Photovoltaic Device*. September 28, 1993.

An integrated photovoltaic device which comprises a plurality of amorphous silicon based solar cells each comprising on the light-receiving side of a common transparent substrate, a transparent electrode, a metal electrode on the transparent electrode, and an amorphous semiconductor layer interposed between the metal electrode and the transparent electrode, said plurality of solar cells being interconnected in a series or series-parallel fashion by means of said transparent electrode and said metal electrode, said metal electrode being formed of a metal film comprising, in superposition in order from the amorphous semiconductor layer side, layers of aluminum, an additive metal for aluminum bronze, and copper.

**5,248,347**
Ochi, Seiji, inventor; Mitsubishi Denki Kabushiki Kaisha, assignee. *Solar Cell*. September 28, 1993.

In a semiconductor device having a metal electrode on a crystalline semiconductor surface, the metal electrode includes first portions electrically and mechanically connected to the surface and second portions mechanically separated from the surface and having configurations that easily deform. These first and second portions are alternatingly arranged on the surface. Accordingly, stress applied to the semiconductor beneath the electrode is reduced and deformation of the semiconductor element due to thermal stress is prevented, thereby preventing deterioration of element characteristics.

**5,248,348**
Miyachi, Kenji; Koyama, Masato; Ashida, Yoshinori; Fukuda, Nobuhiro, inventors; Mitsui Toatsu Chemicals, Inc., assignee. *Amorphous Silicon Solar Cell and Method for Manufacturing the Same*. September 28, 1993.

A method for preparing an amorphous silicon solar cell is disclosed which comprises forming on a substrate, in the following order, a first electrode, a first conductive film, a thin first substantially intrinsic film, a thicker second substantially intrinsic film, a second conductive film, and a second electrode.

The method being characterized in that at least the thicker second substantially intrinsic film is formed by the sequential steps of: (a) depositing a semiconductor film containing 20 atom. % or less of bound hydrogen and/or bound deuterium to a thickness of from 5 to 1000 Å, and then (b) modifying the deposited film, the sequence of steps being repeated multiple times.

The solar cell formed by the above-mentioned method is particularly excellent in long-term stability.

**5,248,349**
Foote, James B.; Kaaka, Steven A. F.; Meyers, Peter V.; Nolan, James F., inventors; Solar Cells, Inc., assignee. *Process for Making Photovoltaic Devices and Resultant Product*. September 28, 1993.

A process and apparatus for making a large-area photovoltaic device that is capable of generating low-cost electrical power. The apparatus for stations provide heated vapors of semiconductor material within the oven for continuous elevated temperature deposition of semiconductor material whose main layer is cadmium telluride is deposited on an upwardly facing surface of the substrate by each deposition station from a location within the oven above the roller conveyor. A cooling station rapidly cools the substrate after deposition of the semiconductor material thereon to strengthen the glass sheet of the substrate.

**5,248,519**
Stoakley, Diane M.; St. Clair, Anne K., inventors; The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, assignee. *Process for Preparing an Assembly of an Article and a Soluble Polyimide Which Resists Dimensional Change, Delamination, and Debonding When Exposed to Changes in Temperature*. September 28, 1993.

An assembly of an article and a polyimide is prepared. The assembly resists dimensional change, delamination, or debonding when exposed to changes in temperature. An article is provided. A soluble polyimide resin solution having a low coefficient of thermal expansion (CTE) was prepared by dissolving the polyimide in solvent and adding a metal ion-containing additive to the solution. Examples of this additive are: $Ho(OOCCH_3)_3$, $Er(NPPA)_3$, $TmCl_3$, and $Er(C_5H_7O_2)_3$. The soluble polyimide resin is combined with the article to form the assembly.

**5,248,621**
Sano, Masafumi, inventor; Canon Kabushiki Kaisha, assignee. *Method for Producing Solar Cell Devices of Crystalline Material*. September 28, 1993.

A solar cell device is produced by forming at least one semiconductor layer of single crystalline material having an uneven surface on a substrate. A photovoltaic element utilizing the semiconductor layer is formed and bonded to another substrate. The produced solar cell device has a large area, high conversion efficiency and may be mass produced at low cost.

**5,248,931**
Flesner, Larry D.; Dubbelday, Wadad B., inventors; The United States of America as represented by the Secretary of the Navy, assignee. *Laser Energized High Voltage Direct Current Power Supply*. September 28, 1993.

A light energized high voltage direct current power supply comprises a light source including solid-state laser diodes powered by electrical current at a voltage level $V_1$ for generating light; a photocell array positioned to receive the light and fabricated with silicon-on-sapphire for providing electrical power having an output voltage $V_2$, where $V_2 > V_1$, where the photocell array includes serially connected photovoltaic cells; and a voltage regulator operably coupled to the light source and the photocells array for controlling the output of the power supply to a predetermined voltage level.

**5,250,120**
Takada, Jun; Nakajima, Akihiko; Hayashi, Katsuhiko; Asaoka, Keizo; Tawada, Yoshihisa, inventors; Kanegafuchi Chemical Industry Co., Ltd., assignee. *Photovoltaic Device*. October 5, 1993.

This invention relates to a photovoltaic device, such as a solar cell or a photosensor, which comprises an amorphous silicon semiconductor photosensitive layer and, as disposed on respective sides thereof, a transparent electrode and a rear electrode. The rear electrode is a multi-layer structure constructed by alternately successive depositions, each in a thickness of 0.3 to 50 nm, of two or more metals selected from the group consisting of Cu, Ag, and Au. In using such a Cu/Ag multi-layer structure or an Au/Ag multi-layer structure as the rear electrode, the thickness of each Cu or Au layer is controlled at 0.3 to 20 nm and that of each Ag layer at 1 to 50 nm. The total thickness of the rear electrode is 20 nm to 1 μm. This construction insures improved photoelectric conversion efficiency and improved reliability of the device.

**5,250,265**
Kawaguchi, Kiyoshi; Itoh, Norihisa; Yamashita, Kouji; Matsui, Kazuma, inventors; Nippondenso Co., Ltd., assignee. *Automotive Solar-Operated Deodorizer with Solar Cell Cooling and Automated Operational Control*. October 5, 1993.

A deodorizer which comprises a deodorant member, an electric motor, a fan fixed to the electric motor, a receptacle having these members accommodated therein, and a solar cell provided in the receptacle and adapted to supply a driving electric power to the electric motor, whereby, owing to the blowing action of the fan, air is caused to enter the interior the receptacle from an air suction port and pass therethrough and is blown out from an air blowout port to outside the receptacle, and the air is caused to flow around a portion of the receptacle where the solar cell is intalled.

**5,252,139**
Schmitt, Jacques; Ricaud, Alain; Siefert, Jean-Marie, inventors; Solems S.A., assignee. *Photovoltaic Thin Layers Panel Structure*. October 12, 1993.

Panel structure suitable for forming a photovoltaic device, comprising an electrically insulating transparent support substrate; photosensitive elements constituted by thin layers stacked on a first face of the said substrate and comprising an opaque electrically conducting layer, openings being formed through this opaque layer in order to allow a portion of the light received by the structure to traverse the said photosensitive elements; an electrically insulating transparent potting layer covering the same photoactive conversion elements; and, over the top, a protecting plate. This plate may be curved. In this case, the potting layer will be constituted by an adhesive sheet.

**5,252,140**
Kobayashi, Shigeyoshi; Yaba, Susumu; Kikugawa, Shinya; Muhl, Stephen; Madan, Arun, inventors. *Solar Cell Substrate and Process for Its Production*. October 12, 1993.

A solar cell substrate comprising a glass plate, and a transparent electrically conductive layer formed thereon, wherein said glass plate is tempered.

**5,252,141**
Inoue, Yuji; Yamamoto, Hiroshi, inventors; Canon Kabushiki Kaisha, assignee. *Modular Solar Cell with Protective Member*. October 12, 1993.

A solar cell module including at least one photovoltaic device, covering material for covering the at least one photovoltaic device, and a frame for covering the end portions of the covering materials. The covering materials are provided, in the end portions thereof, with a recess or a penetrating hole. The frame is provided with a projection adapted to engage with the recess or penetrating hole.

**5,252,142**
Matsuyama, Jinsho; Murakami, Tsutomu; Matsuda, Koichi; Yamamoto, Hiroshi; Yamashita, Toshihiro, inventors; Canon Kabushiki Kaisha, assignee. *PIN Junction Photovoltaic Element Having an I-Type Semiconductor Layer with a Plurality of Regions Having Different Graded Band Gaps*. October 12, 1993.

A pin junction photovoltaic element having an i-type semiconductor layer formed of a variable band gap semiconductor material, said i-type semiconductor layer being positioned between a p-type semiconductor layer having a band gap wider than that of said i-type semiconductor layer and an n-type semiconductor layer having a band gap wider than that of said i-type semiconductor layer, characterized in that said i-type semiconductor layer contains a first region (a) which is positioned on the side of said p-type semiconductor layer and also has a graded band gap, a second region (b) which is adjacent to said first region (a) and has a graded band gap, and a third region (c) which is positioned on the side of said n-type semiconductor layer and also has a graded band gap; said i-type semiconductor layer having a minimum band gap at the boundary between said first greater than that of the band gap of said second region (b).

**5,253,150**
Vanni, Robert R., inventor. *Warning Light*. October 12, 1993.

A warning light is provided that includes a base member having at least one electroluminescent panel mounted thereon that is enclosed by an upper housing secured to base member and of which at least a portion comprises a lens member preferably in the form of at least one panel section that includes fluorescent material operative to fluoresce upon exposure to light incident thereupon emitted by electroluminescent panel. The warning light is preferably powered by a rechargeable battery that is charged by at least one solar cell mounted on upper housing in a manner operative to enable solar energy to be incident thereupon.

**5,253,300**
Knapp, Herbert C., inventor; H.C. Knapp Sound Technology, Inc., assignee. *Solar Powered Hearing Aid*. October 12, 1993.

Hearing aids include rechargeable batteries and contacts accessible from outside of the hearing aid casing for the battery. A charging case includes solar cells mounted on the charging case for outputting energy for charging the batteries in the hearing aids. The charging case may include silos for supporting an over-the-ear hearing aid or a recess for receiving a volume control on the hearing aid.

**5,254,179**
Ricaud, Alain; Schmitt, Jacques; Siefert, Jean-Marie; Emeraud, Thierry, inventors; Solems S.A., assignee. *Photovoltaic Device and Solar Module Having a Partial Transparency*. October 19, 1993.

The specification discloses a photovoltaic device comprising a transparent, electrically insulating substrate, a plurality of photoelectric conversion elements, using thin-layer technology, disposed as a stack on the substrate, these photoelectric conversion elements comprising a layer of material forming an opaque electrode traversed by cuts or openings, the latter advantageously exhibiting a groove shape which is elongate in a transverse direction of the cell and forming between them bands of material which are favorably oriented in the direction of the photogenerated current lines. A reinforced insulation of the cuts by a protective shoulder between the layers may be provided. The invention permits partial- transparency solar cells or modules to be obtained.

**5,254,300**
Priewasser, Georg; Huber, Lothar; Spatzier, Gerhard, inventors; Wacker-Chemitronic Gesellschaft fur Elektronik-Grundstoffe mbH, assignee. *Process for Casting Silicon Blocks of Columnar Structure*. October 19, 1993.

By means of the process and by means of the apparatus, fused silicon is produced continuously, or in phases, and zonally cast into a mold in which it is caused to solidify zonally. The temperature conditions in the solidification zone are controlled with the aid of a movable heating zone, by means of which the crystallization front is adjusted to the rising level that fills up the mold, this level being in turn controlled by the fusion rate of the silicon. Polycrystalline silicon blocks can be obtained in which, because of the flat shape of the crystallization front, the columnar single-crystal domains within the blocks extend almost vertically and which represent an excellent solar cell base material having high diffusion lengths and lifetimes of the minority charge carriers, from which solar cells of correspondingly high efficiencies can be produced.

**5,254,481**
Nishida, Shoji, inventor; Canon Kabushiki Kaisha, assignee. *Polycrystalline Solar Cell Manufacturing Method*. October 19, 1993.

A solar cell has a polycrystalline layer formed on a metal substrate. The crystal orientation of the crystal grains of the silicon layer is regulated in the film thickness direction.

**5,255,666**
Curchod, Donald B., inventor. *Solar Electric Conversion Unit and System*. October 26, 1993.

A solar electric conversion unit and system includes substantially increased efficiency with reduced losses and increased acceptance angles. The system employs a short focal length fresnel lens extruded to further include depending side walls. The free edges of the sides carry a heat sink supporting a photovoltaic cell. The extruded side walls function as light pipes for carrying light directly to the photovoltaic cell. The walls are reflective inwardly of the unit to further avoid loss of stray light.

**5,256,576**
Guha, Subhendu; Yang, Chi C.; Banerjee, Arindam, inventors; United Solar Systems Corporation, assignee. *Method of Making PIN Junction Semiconductor Device with RF Deposited Intrinsic Buffer Layer*. October 26, 1993.

A method for manufacturing thin film, photovoltaic devices of the type having an intrinsic semiconductor layer disposed between two oppositely charged doped semiconductor layers. A buffer layer of intrinsic semiconductor material is RF deposited at the junction between a microwave deposited, base intrinsic layer and a layer of doped material. The cell produced by the method of the present invention has enhanced performance characteristics over cells having microwave deposited intrinsic layers with no barrier layers.

**5,256,887**
Yang, Liyou, inventor; Solarex Corporation, assignee. *Photovoltaic Device Including a Boron Doping Profile in an I-Type Layer*. October 26, 1993.

A photovoltaic cell for use in a single junction or multijunction photovoltaic device, which includes a p-type layer of a semiconductor compound including silicon, an i-type layer of an amorphous semiconductor compound including silicon, and an n-type layer of a semiconductor compound including silicon formed on the i-type layer. The i-type layer including an undoped first sublayer formed on the p-type layer, and a boron-doped second sublayer formed on the first sublayer.

**5,258,076**
Wecker, Reinhard, inventor; MWB Messwandler-Bau AG, assignee. *Arrangement for Covering Doors, Windows or Like Type Room Closure*. November 2, 1993.

An arrangement for covering doors, windows or like type room closure devices having translucent regions, in particular a curtain or a roller blind, is provided, at the side thereof which faces towards the room closure device, with photovoltaic cells or a photovoltaic layer and the same is connected to a current storage means.

**5,258,077**
Shahryar, Ishaq, inventor; Solec International, Inc., assignee. *High Efficiency Silicon Solar Cells and Method of Fabrication*. November 2, 1993.

A very inexpensive, uncomplicated, and high throughput manufacturing process for fabrication of high efficiency silicon solar cells is disclosed. The manufacturing process begins with a low resistivity Czochralski wafer. Then the wafer's front surface is texturized and a lightly doped N type junction is formed in the front surface. Next, silicon dioxide is thermally grown on the wafer's front and back surfaces. Then a computer driven laser beam cuts the front surface oxide to form the grooves needed for the fabrication of the topside electrical contacts. The next step is to diffuse phosphorus deeply in the silicon under the groove areas, where the oxide has been eliminated by the laser beam. Thereafter, electroless plating of gold, nickel, and copper in the groove areas is performed to form the topside ohmic contacts. Subsequently, junction edges at the wafer edges are plasma etched to remove any electrical shunts. Finally, rear ohmic contacts are screen printed and sintered.

**5,261,968**
Jordan, John F., inventor; Photon Energy, Inc., assignee. *Photovoltaic Cell and Method*. November 16, 1993.

An improved photovoltaic panel and method of forming a photovoltaic panel are disclosed for producing a high efficiency CdS/CdTe photovoltaic cell. The photovoltaic panel of the present invention is initially formed with a substantially thick CdS layer, and the effective thickness of the CdS layer is substantially reduced during regrowth to both form large diameter CdTe crystals and substantially reduce the effective thickness of the CdS layer by diffusion into the CdTe layer such that a majority of sunlight having a wavelength less than 520 nm passes through the CdS layer to the photovoltaic junction. Shorting of individual cells is substantially minimized by providing a conductive layer which is formed from two tin oxide layers, each having substantially dissimilar electrical conductivity, such that an electrically conductive tin oxide layer interconnects the plurality of photovoltaic cells, while the comparatively high resistivity tin oxide layer prevents shorting of a cell. The electron density of the high resistivity tin oxide layer may be adjusted to be within a magnitude of approximately three orders of the presumed electron density of the CdTe layer, such that a energy-producing junction is formed in any area of flaws in the CdS layer by the CdTe layer and tin oxide layer. The photovoltaic panel of the present invention has a low material and manufacturing cost, yet produces a surprisingly high efficiency to produce a low cost per output watt photovoltaic panel.

**5,261,969**
Stanbery, Billy J., inventor; The Boeing Company, assignee. *Monolithic Voltage-Matched Tandem Photovoltaic Cell and Method for Making Same*. November 16, 1993.

A monolithic photovoltaic cell that includes at least one upper cell and two or more lower cells is disclosed. The upper cell is separated from the lower cells by an intrinsic isolation layer to which both the upper and lower cells are bonded. A conductive backplane formed integrally with the upper cell serves as a member of that cell and is actually bonded to the intrinsic isolation layer. Each lower cell is provided with a conductive backplane that functions as the interface between the cell and the intrinsic isolation layer. A selectively applied metallization layer series connects the lower tandem cells together and connects the lower cells in parallel across the upper cell. Dielectric material is applied between the individual photovoltaic cells and the metallization layer to prevent the metallization layer from shorting out the photovoltaic cells. In one embodiment of the invention, the upper photovoltaic cell may be an AlGaAs homojunction photovoltaic cell, the lower cells may be $CuInSe_2$/CdZnS heterojunction photovoltaic cells, and a layer of ZnSe may serve as the isolation layer between the cells. In one version of this embodiment of the invention, the n-regions of the upper and lower cells are located closest to the isolation layer. In one method of manufacture, the upper cell structure is initially epitaxially grown on a wafer, the isolation layer is grown over the upper cell structure, the lower cells are formed over the isolation layer, the entire structure is separated from the wafer and inverted, the upper cell is formed from the upper cell structure, and the upper cell is metallized to connect it to the lower cells.

**5,261,970**
Landis, Geoffrey A.; Jenkins, Phillip P., inventors; Sverdrup Technology, Inc., assignee. *Optoelectronic and Photovoltaic Devices with Low-Reflectance Surfaces*. November 16, 1993.

Low-angle V-grooves are provided in the target surfaces of optoelectronic or photovoltaic devices such as solar cells and photodetectors. The low angle V-grooves increase the efficiency of the devices by promoting total internal reflection of light reflected from the target surface at the interface of the coverglass and the external environment.

**5,262,756**
Chien, Tseng L., inventor. *Solar Powered Warning Light*. November 16, 1993.

A solar-powered warning light apparatus including a solar module that charges a single rechargeable Ni-Cad battery is operable for intermittently flashing a xenon flash tube. A recharging network of the apparatus allows the solar cell module to recharge the battery when sunlight is impinging upon the solar module for providing virtually maintenance-free and long-term operation of the warning light by the battery during the dark or twilight hours when warning lights are needed to warn vehicle drivers of road hazards or environment hazards.

**5,264,285**
Dougherty, Thomas K., inventor; Hughes Aircraft Company, assignee. *Method of Bonding Using Polycarborane Siloxane Polymers*. November 23, 1993.

A surface of one substrate is bonded to a surface of another substrate employing a low temperature vulcanizing carborane siloxane adhesive composition. The bonding method comprises (a) forming a solution comprising (1) a polycarborane siloxane polymer having vinyl groups attached to the backbone thereof, the concentration of vinyl groups per carborane group ranging from about 3 to 30%, (2) a difunctional silane curing agent, (3) a catalyst comprising a transition metal complex, and (4) a chosen solvent; (b) applying the solution to at least one of the surfaces; (c) allowing the solvent to evaporate, forming a thin film of the adhesive on the surface; (d) bringing the surfaces of the substrates into contacts; and (e) bonding the surfaces of the substrates together by application of heat and, optionally, pressure. Optionally, the coated part(s) may be stored at a low temperature for a long period of time prior to the bonding process. This invention is particularly useful for bonding a solar cell cover to a solar cell or for bonding solar cells to an underlying substrate.

**5,264,376**
Abbott, Donald C.; Mohendra, Bawa S.; Frechette, Raymond A., inventors; Texas Instruments Incorporated, assignee. *Method of Making a Thin Film Solar Cell*. November 23, 1993.

A method is provided of making a thin film solar cell comprising depositing solar cell material on a substrate using an ionized gas stream for transporting and applying solar cell material to the substrate.

**5,264,710**
Yamagishi, Hideo; Hiroe, Akihiko; Nishio, Hitoshi; Miki, Keiko; Tsuge, Kazunori; Tawada, Yoshihisa, inventors; Kanegafuchi Kagaku Kogyo Kabushiki Kaisha, assignee. *Amorphous Semiconductor, Amorphous Semiconductor Device Using Hydrogen Radicals*. November 23, 1993.

Amorphous semiconductor thin film is exposed to an atmosphere of hydrogen radical during or after the formation of thin film, or is subject to light irradiation having a density of not less than 10 $W/cm^2$ at a wavelength of 300 to 700 nm during the formation of the thin film. The obtained thin film has improved, i.e., small photo deterioration. The semiconductor device using the above thin film is

preferably applied to solar cells or thin film transistors.

**5,266,125**
Rand, James A.; Barnett, Allen M.; Hall, Robert B., inventors; AstroPower, Inc., assignee. *Interconnected Silicon Film Solar Cell Array*. November 30, 1993.

A plurality of thin polycrystalline silicon solar cells formed on a ceramic substrate and which are electrically series connected to form a monolithically interconnected submodule. Adjacent solar cells are electrically separated by a vertical trench and electrically connected by interconnects located below the light receiving surface of each solar cell. The submodules are provided with external electrical contacts for electrically connecting into a photovoltaic module assembly.

**5,266,126**
Deguchi, Mikio, inventor; Mitsubishi Denki Kabushiki Kaisha, assignee. *Semiconductor Device and Method for Manufacturing the Same*. November 30, 1993.

A semiconductor device includes a porous, electrically insulating substrate, a semiconductor film disposed on the substrate, and a metal filling the pores of the substrate, the metal contacting the semiconductor film at the interface of the substrate and the semiconductor film.

**5,268,037**
Glatfelter, Troy, inventor; United Solar Systems Corporation, assignee. *Monolithic, Parallel Connected Photovoltaic Array and Method for Its Manufacture*. December 7, 1993.

A monolithic array of photovoltaic devices includes a plurality of subcells electrically interconnected in a parallel relationship. The subcells are disposed upon a common, electrically conductive substrate and each includes an insulating region disposed upon the substrate and an electrode body disposed upon the insulating region. The subcells each include a photovoltaic semiconductor body disposed upon the electrode body and the array includes a continuous body of top electrode material disposed so as to cover each of the semiconductor bodies and to fill the space therebetween and establish electrical communication between the substrate and the semiconductor bodies. The substrate forms one terminal of the array and the conductive bodies are in electrical communication with a bus bar which forms the other terminal of the array. Also disclosed herein is a method for the fabrication of the array.

**5,268,038**
Riermeier, Manfred; Zinke, Gerhard; Muenzer, Adolf, inventors; Siemens Solar GmbH, assignee. *Electrical Terminal Element for Solar Modules*. December 7, 1993.

A simple connection for a solar cell module is composed of a soldered-on, stud-shaped terminal element that is fixed with a retainer element plugged thereover and glued to the back side of the solar module. The projection of the end of the terminal element comprises a connection for a cable.

**5,268,039**
Vogeli, Craig; Nath, Prem, inventors; United Solar Systems Corporation, assignee. *Photovoltaic Device Including Shunt Preventing Layer and Method for the Deposition Thereof*. December 7, 1993.

A photovoltaic device which is resistant to shunt and short circuit defects developing between the opposed electrodes thereof. The photovoltaic device comprises an electrically conductive substrate, a semiconductor body including a photogenerative region, a layer of transparent conductive material, and means for collecting photogenerated current. In particular, a layer of low-conductivity material is operatively positioned between the layer of transparent conductive material and the collecting means, thereby resistively restricting the flow of electric current through short circuit portions. A method of fabricating such a shunt-resistant photovoltaic device is also disclosed.

**5,268,832**
Kandatsu, Yukio, inventor; Kabushiki Kaisha Toshiba, assignee. *DC/AC Inverter Controller for Solar Cell, Including Maximum Power Point Tracking Function*. December 7, 1993.

A DC/AC inverter controlling system controls a DC/AC inverter so as to continuously output maximum AC power thereof, taking account of solar energy generated from a solar cell. The DC/AC inverter controlling system comprises: a DC/AC inverter unit for inverting DC (direct current) power derived from the solar cell power source into AC (alternating current) power to be supplied to an AC power line; a power variation judging unit for judging whether or not a variation measured during a predetermined time period and occurring in the AC power outputted from the DC/AC inverter unit, exceeds a predetermined value, thereby producing a power variation judging signal; and a power controlling unit for controlling the DC/AC inverter unit so as to reduce the power variation to substantially zero in response to the power variation judging signal, while the power variation does not exceed the predetermined value. As a result, the AC power outputted from the DC/AC inverter unit becomes a maximum value thereof.

**5,269,851**
Horne, William E., inventor; United Solar Technologies, Inc., assignee. *Solar Energy System*. December 14, 1993.

A solar energy system that includes a primary concentrator, a receiver having a plurality of photovoltaic cells, and a prefilter surrounding the receiver. The prefilter absorbs some of the radiation that is out of band with respect to the photovoltaic cells, and may include a conduit for a cooling fluid. The cells on the receiver are positioned such that each cell receives the same solar energy flux. The receiver may include a phase change material to protect the photovoltaic cells from excessive temperatures.

**5,269,852**
Nishida, Shoji, inventor; Canon Kabushiki Kaisha, assignee. *Crystalline Solar Cell and Method for Producing the Same*. December 14, 1993.

A crystalline solar cell is formed by growing single crystals on respective plural nucleation areas provided on a non-nucleation surface in such a manner that the neighboring single crystals do not have a crystal grain boundary therebetween. The solar cell comprises an insulation layer having an aperture formed on each of said single crystals. A semiconductor junction is formed at each single crystal at the respective aperture.

**5,270,248**
Rosenblum, Mark D.; Hanoka, Jack I., inventors; Mobil Solar Energy Corporation, assignee. *Method for Forming Diffusion Junctions in Solar Cell Substrates*. December 14, 1993.

Silicon solar cells are made by subjecting semiconductor substrates to a diffusion junction forming process wherein a liquid source material containing a selected dopant is sprayed onto one side of the substrates, and thereafter the substrates are fired in an oxygen-containing environment under conditions calculated to cause the dopant to diffuse into the substrates so as to form a shallow p-n junction in each substrate.

**5,270,263**
Kim, Sung C.; Yu, Chris C.; Doan, Trung T., inventors; Micron Technology, Inc., assignee. *Process for Depositing Aluminum Nitride (AlN) Using Nitrogen Plasma Sputtering*. December 14, 1993.

A process for depositing a thin film of aluminum nitride (AlN) includes sputtering an aluminum target with energetic nitrogen ions generated in a nitrogen plasma. A single gas (i.e., nitrogen) is used as both the reactive gas and as the sputtering gas. The process is especially adapted for forming an etchstop layer for use in forming contact vias through a dielectric layer in semiconductor manufacture. The process is also useful in semiconductor manufacture for forming an aluminum nitride (AlN) film that may be used as a passivation layer, as a ceramic packaging material, as a mask for ion implantation, as a substrate material in hybrid circuits, and as a high band gap window for GaAs solar cells.

**5,270,636**
Lafferty, Donald L., inventor. *Regulating Control Circuit for Photovoltaic Source Employing Switches, Energy Storage, and Pulse Width Modulation Controller*. December 14, 1993.

A regulating circuit controls current flow from a photovoltaic power source to a storage battery to improve the conversion of solar energy to electric energy. Two transistors are switched on and off at high frequency to regulate the average current flow to the battery. A pulse-width-modulator control chip varies the on-time of each transistor independently to provide separate control of source voltage and circuit output voltage. The source is regulated to produce maximum power and the output voltage is regulated to provide an optimum battery charging voltage. The maximum available energy is transferred from the source to the battery, thereby improving the conversion efficiency of the system.

**5,271,225**
Adamides, Alexander, inventor. *Multiple Mode Operated Motor with Various Sized Orifice Ports*. December 21, 1993.

An apparatus powered by solar cell photon energy having a motor for rotating a drive shaft by the use of compressed air. The motor comprising: a housing having a circular cross section with a drive shaft extending therethrough; a rotor having concave cups on its exterior surface mounted on the drive shaft within the housing; ports extending through the housing to cause rotation of the rotor; a plurality of sources of compressed air positioned adjacent to the housing. The apparatus further includes an alternator and/or a system for converting solar energy into mechanical energy comprising a battery chargeable through solar panels to generate power for reciprocating pistons to thereby generate the compressed air. Finally, the apparatus includes a compressor for generating electrical current and compressed air comprising: a cylindrical housing and magnet having a circular cross section and opposed parallel planar faces; resilient members coupled at their external ends to the faces of the housing and at their internal ends to the faces of the magnet; a primary wire adapted to initiate reciprocation of the magnet, the primary wire being coupled to a source of potential and wound with opposite ends adjacent to the faces of the housing for being intersected by the ends of the magnet when reciprocating; and a secondary wire wound oppositely from the primary wire with opposite ends adjacent to the faces of the housing for being intersected by the ends of the magnet when reciprocating for thereby generating current for use.

**5,272,119**
Falster, Robert, inventor; MEMC Electronic Materials, SpA., assignee. *Process for Contamination Removal and Minority Carrier Lifetime Improvement in Silicon*. December 21, 1993.

A process for increasing the minority carrier recombination lifetime in a silicon body contaminated with transition metals, especially iron. The silicon body is stored at a temperature and for a period sufficient to cause metal to diffuse from the bulk of the silicon body to the surface of the silicon body to measurably increase the minority carrier recombination lifetime.

**5,273,608**
Nath, Prem, inventor; United Solar Systems Corporation, assignee. *Method of Encapsulating a Photovoltaic Device*. December 28, 1993.

A flexible encapsulated photovoltaic device is prepared by disposing photovoltaic devices on a sheet of thermoplastic material, disposing a front encapsulant material atop the devices, and disposing a bottom encapsulant layer so as to provide a multi-layered structure. The multi-layered structure is rolled under tension so as to compress the layers and the roll is heated to activate the thermoplastic material and bond the layers together. Additional layers may be interposed prior to rolling.

**5,273,911**
Sasaki, Hajime; Morikawa, Hiroaki; Satoh, Kazuhiko; Deguchi, Mikio, inventors; Mitsubishi Denki Kabushiki Kaisha, assignee. *Method of Producing a Thin-Film Solar Cell*. December 28, 1993.

A method for producing a thin-film solar cell having a thin-film active layer on a graphite sheet substrate includes the steps of adhering two sheets of graphite together, forming semiconductor thin films serving as active layers on second main surfaces of the two sheets of graphite, and separating the two sheets of graphite from each other. In this structure, stress caused by a difference in expansion coefficients between the upper sheet and the semiconductor thin film is cancelled by stress caused by a difference in expansion coefficients between the lower sheet and the semiconductor thin film Therefore, curvature of the substrates is prevented whereby subsequent process steps are easily carried out. In addition, the number of products per unit time is doubled, thereby increasing productivity.

**5,274,584**
Henderson, Watson R.; Kelly, Michael S.; Leonhardt, Michael L.; Paurus, Floyd G.; Smith, Archibald W.; Szerlip, Stanley R., inventors; Storage Technology Corporation, assignee. *Solid State Memory Device Having Optical Data Connections*. December 28, 1993.

The solid state memory device consists of a circuit board based system which is mounted in a 3480 type magnetic tape cartridge form factor housing to make this media physically compatible with the 3480 type magnetic tape cartridges. The interconnection of the solid state memory device with the read/write device is by an optical connection which transfers data between the solid state memory device and the associated read/write device. A plurality of batteries in the solid state memory device provide power for the memory retention capability required of the volatile solid state memory devices. The batteries are recharged by the use of a pair of power rails that are incorporated into the exterior housing of the 3480 form factor cartridge. Thus, the associated read/write device applies power to the solid state memory via these power rails when the 3480 form factor cartridge is placed in the associated read/write device. Likewise, an associated manual or automated cartridge storage system supplies power when the cartridge is offline, in storage.

# Indexes

# ASSIGNEE

Agency of Industrial Science & Technology, Ministry of International Trade & Industry
1991: 4,994,879

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1993: 5,214,002

Amoco Corporation
1993: 5,230,746

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President and Fellows of Harvard College
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The United States of America as represented by the Secretary of the Air Force
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1993: 5,221,364

The United States of America as represented by the Secretary of the Navy
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1993: 5,217,285
5,223,043

The University of Colorado Foundation, Inc.
1993: 5,177,628

Toa Nenryo Kogyo K.K.
1991: 5,017,308

TPV Energy Systems, Inc.
1991: 5,057,162

TRW, Inc.
1993: 5,185,042

U.S. Philips Corporation
1992: 5,164,654

# INVENTOR

# SUBJECT

## CELLS AND MATERIALS

### Single-Crystal Silicon Cells

#### 1991

**5,053,083**
*Bilevel Contact Solar Cells.*
Sinton, Ronald A.
The Board of Trustees of the Leland Stanford Junior University

**5,067,985**
*Back-Contact Vertical-Junction Solar Cell and Method.*
Carver, Michael W.; Kolesar, Jr., Edward S.
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*Optical Properties of Solar Cells Using Tilted Geometrical Features.*
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Unisearch Limited

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Warfield, Donald B.
Solarex Corporation

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Telefunken Systemtechnik GmbH

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Hingorani, Narain G.; Mehta, Harshad
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**5,223,044**
*Solar Cell Having a Bypass Diode.*
Asai, Masahito
Sharp Kabushiki Kaisha

**5,258,077**
*High Efficiency Silicon Solar Cells and Method of Fabrication.*
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Solec International, Inc.

### Polycrystalline and Ribbon Silicon Cells

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*Solar Cell with Trench Through PN Junction.*
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**4,992,138**
*Method and Apparatus for Constructing a Foil Matrix for a Solar Cell.*
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Mobil Solar Energy Corporation

#### 1993

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*Method for Forming Solar Cell Contacts and Interconnecting Solar Cells.*

Borenstein, Jeffrey T.; Gonsiorawski, Ronald C.
Mobil Solar Energy Corporation

**5,192,991**
*Crystallized Polycrystalline Semiconductor Device.*
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Semiconductor Energy Laboratory Co., Ltd.

**5,211,761**
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Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi
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**5,221,365**
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**5,242,507**
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Iverson, Ralph B.
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Deguchi, Mikio
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*Crystalline Solar Cell and Method for Producing the Same.*
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## Amorphous Silicon Cells

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Kiyama, Seiichi; Hosokawa, Hiroshi; Hirono, Yutaka
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*Semiconductor Device, Manufacturing Method, and System.*
Yamazaki, Shunpei
Semiconductor Energy Laboratory Co., Ltd.

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Fuji Electric Co., Ltd.

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Sumitomo Electric Industries, Ltd.

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Nippon Soken, Inc.; Nippondenso, Co., Ltd.;

**5,032,884**
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Kanegafuchi Kagaku Kogyo Kabushiki Kaisha

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*Method of Manufacturing an Amorphous Silicon Solar Cell.*
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Samsung Electron Devices Co., Ltd.

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Schmitt, Jacques
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Semiconductor Energy Laboratory Co., Ltd.

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Arya, Rajeewa R.; Catalano, Anthony W.
Solarex Corporation

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Fuji Electric Corporation Research and Development Ltd.

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Yokota, Akitoshi; Nakata, Yukihiko
Sharp Kabushiki Kaisha

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*Method of Forming Semiconductor Materials and Barriers.*
Coleman, John H.
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Yamazaki, Shunpei
Semiconductor Energy Laboratory Co., Ltd.

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*Photovoltaic Device.*
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Sanyo Electric Co., Ltd.

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*Thin Film-Coated Polymer Webs.*
Wenz, Robert P.; Weber, Michael F.; Arudi, Ravindra L.
Minnesota Mining and Manufacturing Company

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*Semiconductor Device Having a Transparent Electrode and Amorphous Semiconductor Layers.*
Asaoka, Keizo; Tsuge, Kazunori; Tawada, Yoshihisa
Kanegafuchi Kagaku Kogyo Kabushiki Kaisha

**5,104,455**
*Amorphous Semiconductor Solar Cell.*
Yokota, Akitoshi; Nakata, Yukihiko; Sannomiya, Hitoshi; Moriuchi, Sota; Inoue, Yasumi; Itoh, Manabu
Sharp Kabushiki Kaisha

**5,110,370**
*Photovoltaic Device with Decreased Gridline Shading and Method for Its Manufacture.*
Vogeli, Craig; Nath, Prem
United Solar Systems Corporation

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Kobayashi, Kenji; Tsuge, Kazunori; Tawada, Yoshihisa
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*Flexible Photovoltaic Device.*
Hamakawa, Yoshihiro; Tawada, Yoshihisa; Tsuge, Kazunori; Izumina, Masanobu
Kanegafuchi Kagaku Kogyo Kabushiki Kaisha

**5,136,351**
*Photovoltaic Device with Porous Metal Layer.*
Inoue, Yasumi; Nakata, Yukihiko; Itoh, Manabu; Yokota, Akitoshi; Sannomiya, Hitoshi; Moriuchi, Sota
Sharp Kabushiki Kaisha

**5,151,255**
*Method for Forming Window Material for Solar Cells and Method for Producing Amorphous Silicon Solar Cell.*
Fukuda, Nobuhiro; Kobayashi, Sadao; Miyachi, Kenji; Takenouchi, Hidemi; Kawahara, Yoji; Teramoto, Takayuki
Mitsui Toatsu Chemicals, Inc.

## 1993

**5,180,434**
*Interfacial Plasma Bars for Photovoltaic Deposition Apparatus.*

**5,246,506**
*Multijunction Photovoltaic Device and Fabrication Method.*
Arya, Rajeewa R.; Catalano, Anthony W.
Solarex Corporation

**5,248,345**
*Integrated Photovoltaic Device.*
Sichanugrist, Porponth; Tanaka, Norimitsu
Showa Shell Sekiyu K.K.

**5,248,348**
*Amorphous Silicon Solar Cell and Method for Manufacturing the Same.*
Miyachi, Kenji; Koyama, Masato; Ashida, Yoshinori; Fukuda, Nobuhiro
Mitsui Toatsu Chemicals, Inc.

**5,248,349**
*Process for Making Photovoltaic Devices and Resultant Product.*
Foote, James B.; Kaaka, Steven A. F.; Meyers, Peter V.; Nolan, James F.
Solar Cells, Inc.

**5,250,120**
*Photovoltaic Device.*
Takada, Jun; Nakajima, Akihiko; Hayashi, Katsuhiko; Asaoka, Keizo; Tawada, Yoshihisa
Kanegafuchi Chemical Industry Co., Ltd.

**5,252,142**
*PIN Junction Photovoltaic Element Having an I-Type Semiconductor Layer with a Plurality of Regions Having Different Graded Band Gaps.*
Matsuyama, Jinsho; Murakami, Tsutomu; Matsuda, Koichi; Yamamoto, Hiroshi; Yamashita, Toshihiro
Canon Kabushiki Kaisha

**5,256,576**
*Method of Making PIN Junction Semiconductor Device with RF Deposited Intrinsic Buffer Layer.*
Guha, Subhendu; Yang, Chi C.; Banerjee, Arindam
United Solar Systems Corporation

**5,256,887**
*Photovoltaic Device Including a Boron Doping Profile in an I-Type Layer.*
Yang, Liyou
Solarex Corporation

**5,264,710**
*Amorphous Semiconductor, Amorphous Semiconductor Device Using Hydrogen Radicals.*
Yamagishi, Hideo; Hiroe, Akihiko; Nishio, Hitoshi; Miki, Keiko; Tsuge, Kazunori; Tawada, Yoshihisa
Kanegafuchi Kagaku Kogyo Kabushiki Kaisha

**5,268,037**
*Monolithic, Parallel Connected Photovoltaic Array and Method for Its Manufacture.*
Glatfelter, Troy
United Solar Systems Corporation

**5,268,039**
*Photovoltaic Device Including Shunt Preventing Layer and Method for the Deposition Thereof.*
Vogeli, Craig; Nath, Prem
United Solar Systems Corporation

**5,273,608**
*Method of Encapsulating a Photovoltaic Device.*
Nath, Prem
United Solar Systems Corporation

## Cells from III-V Materials (e.g., GaAs)

### 1991

**4,997,491**
*Solar Cell and a Production Method Therefor.*
Hokuyo, Shigeru; Oda, Takao; Matsumoto, Hideo
Mitsubishi Denki Kabushiki Kaisha

**5,019,177**
*Monolithic Tandem Solar Cell.*
Wanlass, Mark W.
The United States of America as represented by the United States Department of Energy

### 1992

**5,091,018**
*Tandem Photovoltaic Solar Cell with III-V Diffused Junction Booster Cell.*
Fraas, Lewis M.; Avery, James E.; Girard, Gerald R.
The Boeing Company

**5,100,480**
*Solar Cell and Method for Manufacturing the Same.*

Hayafuji, Norio
Mitsubishi Denki Kabushiki Kaisha

**5,116,427**
*High Temperature Photovoltaic Cell.*
Fan, John C.C.; Zavracky, Paul M.
Kopin Corporation

**5,121,183**
*Light Responsive Heterojunction Semiconductor PN Element.*
Ogasawara, Nobuyoshi; Mitsui, Kotaro
Mitsubishi Denki Kabushiki Kaisha

**5,131,956**
*Photovoltaic Semiconductor Device.*
Oohara, Takahiko; Usui, Masaaki; Ogasawara, Nobuyoshi; Mitsui, Kotaro
Mitsubishi Denki Kabushiki Kaisha; Nippon Telegraph and Telephone Corporation

**5,142,331**
*Photoelectric Conversion Semiconductor Device.*
Yoshida, Susumu
Mitsubishi Denki Kabushiki Kaisha

**5,145,793**
*Manufacturing a Gallium Arsenide Solar Cell on a Silicon Substrate.*
Oohara, Takahiko; Ohmachi, Yoshiro; Kadota, Yosihaki; Mitsui, Kotaro; Ogasawara, Nobuyoshi; Nishimura, Takashi
Mitsubishi Denki Kabushiki Kaisha; Nippon Telegraph and Telephone Corporation

### 1993

**5,212,395**
*P-I-N Photodiodes with Transparent Conductive Contacts.*
Berger, Paul R.; Cho, Alfred Y.; Dutta, Niloy K.; Lopata, John; O'Bryan, Henry M.; Sivco, Deborah L.; Zydzik, George J.
AT&T Bell Laboratories

**5,217,539**
*III-V Solar Cells and Doping Processes.*
Fraas, Lewis M.; Sundaram, Veeravana S.; Avery, James A.; Gruenbaum, Peter E.; Malocsay, Eric
The Boeing Company

**5,223,043**
*Current-Matched Multijunction Monolithic Solar*
Olson, Jerry M.; Kurtz, Sarah R.
The United States of America as represented by the United States Department of Energy

**5,247,349**
*Passivation and Insulation of III-V Devices with Pnictides, Particularly Amorphous Pnictides Having a Layer-Like Structure.*
Olego, Diego J.; Baumann, John A.; Schachter, Rozalie; Serreze, Harvey B.; Spicer, William E.; Raccah, Paul M.
Stauffer Chemical Company

**5,248,347**
*Solar Cell.*
Ochi, Seiji
Mitsubishi Denki Kabushiki Kaisha

**5,270,263**
*Process for Depositing Aluminum Nitride (AlN) Using Nitrogen Plasma Sputtering.*
Kim, Sung C.; Yu, Chris C.; Doan, Trung T.
Micron Technology, Inc.

## Cells from I-III-$VI_2$ or II-VI Materials (e.g., $CuInSe_2$ or CdTe)

### 1991

**5,028,274**
*Group I-III-$VI_2$ Semiconductor Films for Solar Cell Application.*
Basol, Bulent M.; Kapur, Vijay K.
International Solar Electric Technology, Inc.

**5,045,409**
*Process for Making Thin Film Solar Cell.*
Eberspacher, Chris; Ermer, James H.; Mitchell, Kim W.
Atlantic Richfield Company

### 1992

**5,078,804**
*I-III-$VI_2$-Based Solar Cell Utilizing the Structure $CuInGaSe_2CdZnS/ZnO$.*
Chen, Wen S.; Stewart, John M.
The Boeing Company

**5,125,984**
*Induced Junction Chalcopyrite Solar Cell.*
Kruehler, Wolfgang; Grabmaier, Josef
Siemens Aktiengesellschaft

**5,137,835**
*Method for Manufacturing a Chalcopyrite Solar Cell.*
Karg, Franz
Siemens Aktiengesellschaft

**5,141,564**
*Mixed Ternary Heterojunction Solar Cell.*
Chen, Wen S.; Stewart, John M.
The Boeing Company

## 1993

**5,261,968**
*Photovoltaic Cell and Method.*
Jordan, John F.
Photon Energy, Inc.

## Other PV Devices and Concepts

## 1991

**4,992,109**
*Photoelectric Conversion Element.*
Yoshikawa, Masao; Suzuki, Tetsuro; Kojima, Akio; Shoshi, Masayuki; Ohta, Masafumi
Ricoh Company, Ltd.

**4,997,491**
*Solar Cell and a Production Method Therefor.*
Hokuyo, Shigeru; Oda, Takao; Matsumoto, Hideo
Mitsubishi Denki Kabushiki Kaisha

**5,002,617**
*PIN Heterojunction Photovoltaic Elements with Polycrystal AlAs(H,F) Semiconductor Film.*
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro
Canon Kabushiki Kaisha

**5,002,618**
*PIN Heterojunction Photovoltaic Elements with Polycrystal BaS(H,F) Semiconductor Film.*
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro
Canon Kabushiki Kaisha

**5,006,180**
*PIN Heterojunction Photovoltaic Elements with Polycrystal Gap (H,F) Semiconductor Film.*
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro
Canon Kabushiki Kaisha

**5,007,971**
*PIN Heterojunction Photovoltaic Elements with Polycrystal BP(H,F) Semiconductor Film.*
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro
Canon Kabushiki Kaisha

**5,008,579**
*Light Emitting Polymer Electrical Energy Source.*
Conley, Jerry J.; Mortensen, Gary B.
E.F. Johnson Company

**5,008,726**
*PIN Junction Photovoltaic Element with P- or N-Type Semiconductor Layer Comprising Non-Single Crystal Material Containing Zn, Se, Te, H in Amount of 1 to 4 Atomic % and a Dopand and I-Type Semiconductor Layer Comprising Non-Single Crystal Si(H,F) Material.*
Nakagawa, Katsumi; Ishihara, Shunichi; Kanai, Masahiro; Murakami, Tsutomu; Arao, Kozo; Fujioka, Yasushi; Sakai, Akira
Canon Kabushiki Kaisha

**5,009,719**
*Tandem Solar Cell.*
Yoshida, Susumu
Mitsubishi Denki Kabushiki Kaisha

**5,021,100**
*Tandem Solar Cell.*
Ishihara, Takashi; Sasaki, Hajime; Aiga, Masao
Mitsubishi Denki Kabushiki Kaisha

**5,024,706**
*PIN Heterojunction Photovoltaic Elements with Polycrystal ALP(H,F) Semiconductor Film.*
Kanai, Masahiro; Aoike, Tatsuyuki; Matsuda, Koichi; Kawakami, Soichiro
Canon Kabushiki Kaisha

**5,030,743**
*Organometallic Solar Voltaic Storage Cell.*
McDowell, Mathew E.

**5,032,472**
*Films of Catenated Phosphorus Materials, Their Preparation and Use, and Semiconductor and Other Devices Employing Them.*
Michel, Christian G.; Schachter, Rozalie; Kuck, Mark A.; Baumann, John A.; Raccah, Paul M.
Stauffer Chemical Company

**5,039,354**
*Stacked Photovoltaic Device with Antireflection Layer.*
Nakagawa, Katsumi
Canon Kabushiki Kaisha

**5,044,939**
*Reversing Linear Flow TPV Process and Apparatus.*
Dehlsen, James, G.P.

**5,047,090**
*Semiconductor Device.*
Hayashi, Yutaka; Tomonari, Shigeaki; Sakai, Jun; Kakite, Keizi
Agency of Industrial Science & Technology

**5,057,162**
*Thermophotovoltaic Technology.*
Nelson, Robert E.
TPV Energy Systems, Inc.

**5,061,578**
*Electrolyte Circulation Type Secondary Battery Operating Method.*
Kozuma, Ichiro; Fujii, Toshinobu
Kabushiki Kaisha Meidensha

**5,066,339**
*Rotary Radiating Bed Thermophotovoltaic Process and Apparatus.*
Dehlsen, James G.P.

**5,066,340**
*Photovoltaic Device.*
Iwamoto, Masayuki; Minami, Kouji; Yamaoki, Toshihiko
Sanyo Electric Co., Ltd.

**5,076,857**
*Photovoltaic Cell and Process.*
Nowlan, Michael J.
Spire Corporation

## 1992

**5,080,724**
*Selective Emitters.*
Chubb, Donald L.
The United States of America as represented by the Administrator of the National Aeronautics and Space Administration

**5,082,505**
*Self-Sustaining Power Module.*
Cota, Albert O.; Reed, John J.

**5,094,697**
*Photovoltaic Device and Method for Producing the Same.*
Takabayashi, Akiharu; Yonehara, Takao
Canon Kabushiki Kaisha

**5,098,178**
*Superconducting Matrix.*
Ortabasi, Ugur

**5,100,478**
*Solar Cell.*
Kawabata, Kiyoshi
Mitsubishi Denki Kabushiki Kaisha

**5,103,851**
*Solar Battery and Method of Manufacturing the Same.*
Nishida, Shoji; Yonehara, Takao
Canon Kabushiki Kaisha

**5,124,610**
*Tritiated Light Emitting Polymer Electrical Energy Source.*
Conley, Jerry J.; Mortensen, Gary B.
E.F. Johnson Company

**5,130,103**
*Method for Forming Semiconductor Crystal and Semiconductor Crystal Article Obtained by Said Method.*
Yamagata, Kenji; Kumomi, Hideya; Tokunaga, Hiroyuki; Arao, Kozo
Canon Kabushiki Kaisha

**5,147,468**
*Photovoltaic Semiconductor Device and Method for Manufacturing the Same.*
Deguchi, Mikio
Mitsubishi Denki Kabushiki Kaisha

**5,171,373**
*Devices Involving the Photo Behavior of Fullerenes.*
Hebard, Arthur F.; Miller, Barry; Rosamilia, Joseph M.; Wilson, William L.
AT&T Bell Laboratories

## 1993

**5,192,400**
*Method of Isolating Shorted Silicon Spheres.*
Parker, Sidney G.; Hammerbacher, Milfred D.; Levine, Jules D.; Hotchkiss, Gregory B.
Texas Instruments Incorporated

**5,196,690**
*Optically Powered Photomultiplier Tube.*

Flesner, Larry D.; Miller, Stephen A.; Dubbelday, Wadad B.
The United States of America as represented by the Secretary of the Navy

**5,201,961**
*Photovoltaic Device Containing Organic Material Layers and Having High Conversion Efficiency.*
Yoshikawa, Masao; Suzuki, Tetsurou
Ricoh Company, Ltd.

**5,206,523**
*Microporous Crystalline Silicon of Increased Band Gap for Semiconductor Applications.*
Goesele, Ulrich M.; Lehmann, Volker E.

**5,211,762**
*Photoresponsive Element Utilizing a Molecular Heterojunction.*
Isoda, Satoru; Ueyama, Satoshi; Kawakubo, Hiroaki; Maeda, Mitsuo
Mitsubishi Denki Kabushiki Kaisha

**5,213,628**
*Photovoltaic Device.*
Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi
Sanyo Electric Co., Ltd.

**5,215,599**
*Advanced Solar Cell.*
Hingorani, Narain G.; Mehta, Harshad
Electric Power Research Institute

**5,218,213**
*SOI Wafer with SiGe.*
Gaul, Stephen J.; Rouse, George V.
Harris Corporation

**5,220,181**
*Photovoltaic Element of Junction Type with an Organic Semiconductor Layer Formed of a Polysilane Compound.*
Kanai, Masahiro; Tanaka, Hisami; Sakou, Harumi
Canon Kabushiki Kaisha

**5,221,364**
*Lightweight Solar Cell.*
Hotaling, Steven P.
The United States of America as represented by the Secretary of the Air Force

**5,229,624**
*Light-Polarizing Electrically Conducting Film.*
Marks, Alvin M.

**5,235,232**
*Adjustable-Output Electrical Energy Source Using Light-Emitting Polymer.*
Conley, Jerry J.; Mortensen, Gary B.
E.F. Johnson Company

**5,240,510**
*Photovoltaic Cell.*
Goldade, Victor A.; Markov, Evgeny M.; Pinchuk, Lenoid S.; Kestelman, Vladimir N.; Girin, Andrey M.
Development Products, Inc.

**5,240,647**
*Process for Making Solid-State Radiation-Emitting Composition.*
Ashley, Carol S.; Brinker, C. Jeffrey; Reed, Scott; Walko, Robert J.

**5,242,504**
*Photovoltaic Device and Manufacturing Method Therefor.*
Iwamoto, Masayuki; Minami, Kouji; Yamaoki, Toshihiko
Sanyo Electric Co., Ltd.

**5,248,621**
*Method for Producing Solar Cell Devices of Crystalline Material.*
Sano, Masafumi
Canon Kabushiki Kaisha

**5,248,931**
*Laser Energized High Voltage Direct Current Power Supply.*
Flesner, Larry D.; Dubbelday, Wadad B.
The United States of America as represented by the Secretary of the Navy

**5,261,969**
*Monolithic Voltage-Matched Tandem Photovoltaic Cell and Method for Making Same.*
Stanbery, Billy J.
The Boeing Company

**5,261,970**
*Optoelectronic and Photovoltaic Devices with Low-Reflectance Surfaces.*
Landis, Geoffrey A.; Jenkins, Phillip P.
Sverdrup Technology, Inc.

**5,270,248**
*Method for Forming Diffusion Junctions in Solar Cell Substrates.*
Rosenblum, Mark D.; Hanoka, Jack I.
Mobil Solar Energy Corporation

**5,273,911**
*Method of Producing a Thin-Film Solar Cell.*
Sasaki, Hajime; Morikawa, Hiroaki; Satoh, Kazuhiko; Deguchi, Mikio
Mitsubishi Denki Kabushiki Kaisha

## Cell Components (metallization, substrates, conductive coatings, antireflective coatings)

### 1991

**4,990,286**
*Zinc Oxyfluoride Transparent Conductor.*
Gordon, Roy G.
President and Fellows of Harvard College

**4,994,879**
*Photoelectric Transducer with Light Path of Increased Length.*
Hayashi, Yutaka
Agency of Industrial Science & Technology, Ministry of International Trade & Industry

**5,001,302**
*Connecting Structure for an Electronic Part.*
Atsumi, Yoshinori
Casio Computer Co., Ltd.

**5,002,796**
*Process for Forming Functional Zinc Oxide Films Using Alkyl Zinc Compound and Oxygen-Containing Gas.*
Nishida, Shoji
Canon Kabushiki Kaisha

**5,006,179**
*Interconnect for Electrically Connecting Solar Cells.*
Gaddy, Edward M.
Solarex Corporation

**5,009,721**
*Solar Cell.*
Matsumoto, Hideo; Hokuyo, Shigeru
Mitsubishi Denki Kabushiki Kaisha

**5,011,706**
*Method of Forming Coatings Containing Amorphous Silicon Carbide.*
Leo; Sharp, Kenneth G.
Dow Corporation

**5,011,782**
*Method of Making Passivated Antireflective Coating for Photovoltaic Cell.*
Lamb, Walter R.; Griffin, Darrell
Electric Power Research Institute

**5,017,521**
*Borosilicate Glass Compositions Incorporating Cerium Oxide.*
Yale, Brian; Fyles, Kenneth M.
Pilkington plc

**5,023,144**
*Silver Alloy Foil for Interconnector for Solar Cell.*
Yamamoto, Shigeru; Mori, Satoru; Hayashi, Akira
Mitsubishi Metal Corporation

**5,024,953**
*Method for Producing Opto-Electric Transducing Element.*
Uematsu, Tsuyoshi; Saitoh, Tadashi
Hitachi, Ltd.

**5,028,488**
*Functional $ZnSe_{1-x}Te_x$:H Deposited Film.*
Nakagawa, Katsumi; Ishihara, Shunichi; Kanai, Masahiro; Murakami, Tsutomu; Arao, Kozo; Fujioka, Yasushi
Canon Kabushiki Kaisha

**5,030,295**
*Radiation Resistant Passivation of Silicon Solar Cells.*
Swanson, Richard M.; Gan, Jon-Yiew; Gruenbaum, Peter E.
Electric Power Research Institute

**5,057,439**
*Method of Fabricating Polysilicon Emitters for Solar Cells.*
Swanson, Richard M.; Gan, Jon-Yiew
Electric Power Research Institute

**5,074,920**
*Photovoltaic Cells with Improved Thermal Stability.*
Gonsiorawski, Ronald C.; Borenstein, Jeffrey T.; Kardauskas, Michael J.
Mobil Solar Energy Corporation

**5,075,763**
*High Temperature Metallization System for Contacting Semiconductor Materials.*
Spitzer, Mark B.; Dingle, Jason E.
Kopin Corporation

## 1992

**5,078,803**
*Solar Cells Incorporating Transparent Electrodes Comprising Hazy Zinc Oxide.*
Pier, David N.; Gay, Charles F.; Wieting, Robert D.; Langeberg, Heidi J.
Siemens Solar Industries

**5,081,049**
*Sculpted Solar Cell Surfaces.*
Green, Martin A.; Wenham, Stuart R.; Srinivasamohan, Narayanan
Unisearch Limited

**5,081,069**
*Method for Depositing a $TIO_2$ Layer Using a Periodic and Simultaneous Tilting and Rotating Platform Motion.*
Parker, Sidney G.; Wood, Jerry; Turner, Robert T.; Fischer, Craig A.
Texas Instruments Incorporated

**5,084,107**
*Solar Cell and Solar Cell Array with Adhered Electrode.*
Deguchi, Mikio; Itagaki, Takushi; Usui, Masaaki
Mitsubishi Denki Kabushiki Kaisha

**5,098,850**
*Process for Producing Substrate for Selective Crystal Growth, Selective Crystal Growth Process and Process for Producing Solar Battery by Use of Them.*
Nishida, Shoji; Yonehara, Takao
Canon Kabushiki Kaisha

**5,100,808**
*Method of Fabricating Solar Cell with Integrated Interconnect.*
Glenn, Gregory S.
Spectrolab, Inc.

**5,101,260**
*Multilayer Light Scattering Photovoltaic Back Reflector and Method of Making Same.*
Nath, Prem; Call, John; Hoffman, Kevin; Laarman, Timothy; DiDio, Gary M.
Energy Conversion Devices, Inc.

**5,135,581**
*Light Transmissive Electrically Conductive Oxide Electrode Formed in the Presence of a Stabilizing Gas.*
Tran, Nang T.; Gilbert, James R.
Minnesota Mining and Manufacturing Company

**5,138,403**
*High Temperature Schottky Barrier Bypass Diodes.*
Spitzer, Mark B.
Kopin Corporation

**5,151,373**
*Method of Making a Solar Cell Electrode.*
Deguchi, Mikio; Itagaki, Takushi; Usui, Masaaki
Mitsubishi Denki Kabushiki Kaisha

**5,151,377**
*Method for Forming Contacts.*
Hanoka, Jack I.; Danielson, Scott E.
Mobil Solar Energy Corporation

**5,151,385**
*Method of Manufacturing a Metallic Silicide Transparent Electrode.*
Yamamoto, Hideaki; Seki, Koichi; Tanaka, Toshihiro; Sasano, Akira; Tsukada, Toshihisa; Shimomoto, Yasuharu; Nakano, Toshio; Kanamori, Hideto
Hitachi, Ltd.

**5,151,386**
*Method of Applying Metallized Contacts to a Solar Cell.*
Bottari, Frank J.; Hanoka, Jack I.; Sylva, Frank W.
Mobil Solar Energy Corporation

**5,158,618**
*Photovoltaic Cells for Converting Light Energy to Electric Energy and Photoelectric Battery.*
Rubin, Leoind B.; Osipov, Alexandr S.; Sizganov, Jury G.; Untila, Gennady G.; Kharitonov, Andrei L.; Rakhimov, Alexandr T.
BioPhotonics, Inc.

## 1993

**5,178,685**
*Method for Forming Solar Cell Contacts and Interconnecting Solar Cells.*
Borenstein, Jeffrey T.; Gonsiorawski, Ronald C.
Mobil Solar Energy Corporation

**5,180,686**
*Method for Continuously Depositing a Transparent Oxide Material by Chemical Pyrolysis.*
Banerjee, Arindam; Guha, Subhendu
Energy Conversion Devices, Inc.

**5,181,968**
*Photovoltaic Device Having an Improved Collector Grid.*
Nath, Prem; Vogeli, Craig
United Solar Systems Corporation

**5,196,144**
*Electrically Conductive Polyaniline.*
Smith, Paul; Heeger, Alan J.; Cao, Yong; Chiang, Jin-Chih; Andreatta, Alejandro
Regents of the University of California

**5,216,543**
*Apparatus and Method for Patterning a Film.*
Calhoun, Clyde D.
Minnesota Mining and Manufacturing Company

**5,221,854**
*Protective Layer for the Back Reflector of a Photovoltaic Device.*
Banerjee, Arindam; Guha, Subhendu; Yang, Chi C.
United Solar Systems Corporation

**5,223,044**
*Solar Cell Having a Bypass Diode.*
Asai, Masahito
Sharp Kabushiki Kaisha

**5,228,924**
*Photovoltaic Panel Support Assembly.*
Barker, James M.; Underwood, John C.; Shingleton, Jefferson
Mobil Solar Energy Corporation

**5,228,926**
*Photovoltaic Device with Increased Light Absorption and Method for Its Manufacture.*
Glatfelter, Troy; Vogeli, Craig; Call, Jon; Hammond, Ginger
United Solar Systems Corporation

**5,230,746**
*Photovoltaic Device Having Enhanced Rear Reflecting Contact.*
Wiedeman, Scott; Jackson, Frederick R.
Amoco Corporation

**5,244,509**
*Substrate Having an Uneven Surface for Solar Cell and a Solar Cell Provided with Said Substrate.*
Arao, Kozo; Fujioka, Yasushi; Niwa, Mitsuyuki; Takeuchi, Eiji
Canon Kabushiki Kaisha

**5,246,782**
*Laminates of Polymers Having Perfluorocyclobutane Rings and Polymers Containing Perfluorocyclobutane Rings.*
Kennedy, Alvin P.; Bratton, Larry D.; Jezie, Zdravko; Lane, Eckel R.; Perettie, Donald J.; Richey, W. Frank; Babb, David A.; Clement, Katherine S.
The Dow Chemical Company

**5,248,519**
*Process for Preparing an Assembly of an Article and a Soluble Polyimide Which Resists Dimensional Change, Delamination, and Debonding When Exposed to Changes in Temperature.*
Stoakley, Diane M.; St. Clair, Anne K.
The United States of America as represented by the Administrator of the National Aeronautics and Space Administration

**5,250,120**
*Photovoltaic Device.*
Takada, Jun; Nakajima, Akihiko; Hayashi, Katsuhiko; Asaoka, Keizo; Tawada, Yoshihisa
Kanegafuchi Chemical Industry Co., Ltd.

**5,252,140**
*Solar Cell Substrate and Process for Its Production.*
Kobayashi, Shigeyoshi; Yaba, Susumu; Kikugawa, Shinya; Muhl, Stephen; Madan, Arun

**5,261,970**
*Optoelectronic and Photovoltaic Devices with Low-Reflectance Surfaces.*
Landis, Geoffrey A.; Jenkins, Phillip P.
Sverdrup Technology, Inc.

**5,264,285**
*Method of Bonding Using Polycarborane Siloxane*
Dougherty, K.
Hughes Aircraft Company

**5,270,263**
*Process for Depositing Aluminum Nitride (AlN) Using Nitrogen Plasma Sputtering.*
Kim, Sung C.; Yu, Chris C.; Doan, Trung T.
Micron Technology, Inc.

## Cell Enhancement Techniques (surface and grain-boundary passivation, annealing)

### 1991

**5,055,416**
*Electrolytic Etch for Preventing Electrical Shorts in Solar Cells on Polymer Surfaces.*

Weber, Michael F.
Minnesota Mining and Manufacturing Company

## 1992

**5,084,400**
*Conversion Process for Passivating Short Circuit Current Paths in Electronic Devices Having a Metallic Electrode.*
Nath, Prem; Vogeli, Craig
Energy Conversion Devices, Inc.

**5,162,239**
*Laser Crystallized Cladding Layers for Improved Amorphous Silicon Light-Emitting Diodes and Radiation Sensors.*
Winer, Kris A.; Thornton, Robert L.
Xerox Corporation

**5,169,791**
*Method for the Passivation of Crystal Defects in Polycrystalline Silicon Material.*
Muenzer, Adolf
Siemens Aktiengesellschaft

## 1993

**5,192,400**
*Method of Isolating Shorted Silicon Spheres.*
Parker, Sidney G.; Hammerbacher, Milfred D.; Levine, Jules D.; Hotchkiss, Gregory B.
Texas Instruments Incorporated

**5,242,507**
*Impurity-Induced Seeding of Polycrystalline Semiconductors.*
Iverson, Ralph B.
Boston University

**5,247,349**
*Passivation and Insulation of III-V Devices with Pnictides, Particularly Amorphous Pnictides Having a Layer-Like Structure.*
Olego, Diego J.; Baumann, John A.; Schachter, Rozalie; Serreze, Harvey B.; Spicer, William E.; Raccah, Paul M.
Stauffer Chemical Company

**5,272,119**
*Process for Contamination Removal and Minority Carrier Lifetime Improvement in Silicon.*
Falster, Robert
MEMC Electronic Materials, SpA.

# Materials Production and Processes (purification, deposition, doping)

## 1991

**5,012,619**
*Method and Apparatus for Forming*
Knepprath, Vernon E.; Levine, Jules
Texas Instruments Incorporated

**5,030,476**
*Process and Apparatus for the Formation of a Functional Deposited Film on a Cylindrical Substrate by Means of Microwave Plasma Chemical Vapor Deposition.*
Okamura, Ryuji; Otoshi, Hirokazu; Takei, Tatsuya
Canon Kabushiki Kaisha

**5,049,523**
*Method of Forming Semiconducting Materials and Barriers.*
Coleman, John H.
Plasma Physics Corp.

**5,053,355**
*Method and Means for Producing a Layered System of Semiconductors.*
von Campe, Hilmar
Nukem GmbH

**5,061,511**
*Method for Forming Functional Deposited Films by Means of Microwave Plasma Chemical Vapor Deposition Method.*
Saitoh, Keishi; Hashizume, Junichiro; Iida, Shigehira; Takei, Tetsuya; Arai, Takayoshi
Canon Kabushiki Kaisha

**5,069,740**
*Production of Semiconductor Grade Silicon Spheres from Metallurgical Grade Silicon Particles.*
Levine, Jules D.; Jensen, Millard J.
Texas Instruments Incorporated

**5,073,698**
*Method for Selectively Heating a Film on a Substrate.*
Stultz, Timothy J.
Peak Systems, Inc.

## 1992

**5,082,696**
*Method of Forming Semiconducting Amorphous Silicon Films from the Thermal Decomposition of Dihalosilanes.*

Sharp, Kenneth G.
Dow Corning Corporation

**5,085,885**
*Plasma-Induced, In-Situ Generation, Transport and Use or Collection of Reactive Precursors.*
Foley, Henry C.; Varrin, Jr., Robert D.; Sengupta, Sourav K.
University of Delaware

**5,104,633**
*Method for Producing High-Purity Metallic Silicon and Apparatus Therefor.*
Sakaguchi, Yasuhiko; Aratani, Fukuo; Uchino, Kazuhiro; Yoshiyagawa, Mitsugi; Miyata, Kunio; Ishizaki, Masato; Kawahara, Tetsuro

**5,110,531**
*Process and Apparatus for Casting Multiple Silicon Wafer Articles.*
Nanis, Leonard
SRI International

**5,154,810**
*Thin Film Coating and Method.*
Kamerling, Marc.A.; Beauchamp, William T.; Klinger, Robert E.; Lehan, John P.
Optical Coating Laboratory, Inc.

**5,156,978**
*Method of Fabricating Solar Cells.*
Bathey, Balakrishnan R.; Cretalla, Mary C.; Taylor, Aaron S.
Mobil Solar Energy Corporation

**5,173,270**
*Monocrystal Rod Pulled from a Melt.*
Kida, Michio; Sahira, Kensho; Nozoe, Akikuni
Mitsubishi Materials Corporation

## 1993

**5,182,091**
*Method and Apparatus for Purifying Silicon.*
Yuge, Noriyoshi; Baba, Hiroyuki; Aratani, Fukuo
Kawasaki Steel Corporation

**5,187,115**
*Method of Forming Semiconducting Materials and Barriers Using a Dual Enclosure Apparatus.*
Coleman, John H.
Plasma Physics Corp.

**5,192,991**
*Crystallized Polycrystalline Semiconductor Device.*
Hosokawa, Makoto
Semiconductor Energy Laboratory Co., Ltd.

**5,196,086**
*Monocrystal Rod Pulled from a Melt.*
Kida, Michio; Sahira, Kensho; Nozoe, Akikuni
Mitsubishi Materials Corporation

**5,206,180**
*Process for Producing an Amorphous Photoelectric Transducer.*
Yoshida, Takashi
Fuji Electric Corporation Research and Development, Ltd.

**5,214,002**
*Process for Depositing a Thermal CVD Film of Si or Ge Using a Hydrogen Post-Treatment Step and an Optional Hydrogen Pre-Treatment Step.*
Hayashi, Yutaka; Yamanaka, Mitsuyuki
Agency of Industrial Science and Technology

**5,230,753**
*Photostable Amorphous Silicon-Germanium Alloys.*
Wagner, Sigurd
Princeton University

**5,238,879**
*Method for the Production of Polycrystalline Layers Having Granular Crystalline Structure for Thin-Film Semiconductor Components Such as Solar Cells.*
Plaettner, Rolf
Siemens Aktiengesellschaft

**5,242,505**
*Amorphous Silicon-Based Photovoltaic Semiconductor Materials Free From Staebler-Wronski Effects.*
Lin, Guang H.; He, Mu Z.; Kapur, Mridula; Bockris, John O'M.
Electric Power Research Institute

**5,254,300**
*Process for Casting Silicon Blocks of Columnar Structure.*
Priewasser, Georg; Huber, Lothar; Spatzier, Gerhard
Wacker-Chemitronic Gesellschaft fur Elektronik-Grundstoffe mbH

**5,270,248**
*Method for Forming Diffusion Junctions in Solar Cell Substrates.*
Rosenblum, Mark D.; Hanoka, Jack I.
Mobil Solar Energy Corporation

## COLLECTORS

### Flat-Plate Collectors (design, components, production)

### 1991

**4,981,525**
*Photovoltaic Device.*
Kiyama, Seiichi; Hosokawa, Hiroshi; Hirono, Yutaka
Sanyo Electric Co., Ltd.

**4,988,642**
*Semiconductor Device, Manufacturing Method, and System.*
Yamazaki, Shunpei
Semiconductor Energy Laboratory Co., Ltd.

**4,989,059**
*Solar Cell with Trench Through PN Junction.*
Micheels, Ronald H.; Valdivia, Percy; Hanoka, Jack I.
Mobil Solar Energy Corporation

**4,992,138**
*Method and Apparatus for Constructing a Foil Matrix for a Solar Cell.*
Jensen, Millard J.; Hotchkiss, Gregory B.
Texas Instruments Incorporated

**4,999,308**
*Method of Making Thin Film Solar Cell Array.*
Nishiura, Masaharu; Yamada, Katsumi
Fuji Electric Co., Ltd.

**5,008,062**
*Method of Fabricating Photovoltaic Module.*
Anderson, A. Jerome; Beze, Norman L.
Siemens Solar Industries

**5,009,720**
*Solar Cell.*
Hokuyo, Shigeru; Oda, Takao; Matsumoto, Hideo
Mitsubishi Denki Kabushiki Kaisha

**5,010,040**
*Method of Fabricating Solar Cells.*
Vayman, Zinovy Y.
Mobil Solar Energy Corporation

**5,011,544**
*Solar Panel with Interconnects and Masking Structure and Method.*
Gaddy, Edward M.; Dominguez, Ramon
Solarex Corporation

**5,011,565**
*Dotted Contact Solar Cell and Method of Making Same.*
Dube, Christopher E.; Gonsiorawski, Ronald C.
Mobil Solar Energy Corporation

**5,011,567**
*Method of Fabricating Solar Cells.*
Gonsiorawski, Ronald C.
Mobil Solar Energy Corporation

**5,017,243**
*Solar Cell and a Production Method Therefor.*
Otsubo, Mutsuyuki
Mitsubishi Denki Kabushiki Kaisha

**5,017,308**
*Silicon Thin Film and Method of Producing the Same.*
Iijima, Shigeru; Tanaka, Kazunobu; Matsuda, Akihisa; Matsumura, Mitsuo; Yamamoto, Hideo
Toa Nenryo Kogyo K.K.

**5,019,176**
*Thin Solar Cell and Lightweight Array.*
Brandhorst, Jr., Henry W.; Weinberg, Irving
The United States of America as represented by the Administrator of the National Aeronautics and Space Administration

**5,021,099**
*Solar Cell Interconnection and Packaging Using Tape Carrier.*
Kim, Namsoo P.; Stanbery, Billy J.
The Boeing Company

**5,022,381**
*Barrel-Shaped Solar Roofing Element and Method for Its Assembly.*
Allegro, Joseph

**5,022,930**
*Thin Film Photovoltaic Panel and Method.*
Ackerman, Bruce; Albright, Scot P.; Jordan, John F.
Photon Energy, Inc.

**5,028,546**
*Method for Manufacture of Solar Cell with Foil Contact Point.*
Hotchkiss, Gregory B.
Texas Instruments Incorporated

**5,032,527**
*Method of Forming Lead-Out Electrode Portion of Photovoltaic Device.*
Maeba, Masayoshi; Kadonome, Nobuo; Takabatake, Yoshinobu
Sanyo Electric Co., Ltd.

**5,034,068**
*Photovoltaic Cell Having Structurally Supporting Open Conductive Back Electrode Structure, and Method of Fabricating the Cell.*
Glenn, Gregory S.; Lillington, David R.
Spectrolab, Inc.

**5,035,753**
*Photoelectric Conversion Device.*
Suzuki, Kunio; Abe, Masayoshi; Kinka, Mikio; Arai, Yasuyuki; Satake, Akemi; Nishi, Kazuo; Kugawa, Shuichi; Ishida, Noriya
Semiconductor Energy Laboratory Co., Ltd.

**5,045,481**
*Method of Manufacturing a Solar Cell.*
Schilling, Roland; Tentscher, Karl-Heinz
TELEFUNKEN electronic GmbH

**5,069,727**
*Flexible Photovoltaic Device and Manufacturing Method Thereof.*
Kouzuma, Shinichi; Inoue, Hiroshi; Murata, Kenji; Tanaka, Hiroyuki; Kishi, Yasuo
Sanyo Electric Co., Ltd.

**5,071,491**
*Frame for Solar Cell Devices.*
Stein, Karl U.; Cammerer, Fritz
Siemens Aktiengesellschaft

## 1992

**5,086,003**
*Method for Applying an Organic Insulator to a Solar Array.*
Hammerbacher, Milfred D.
Texas Instruments Incorporated

**5,089,426**
*Method for Manufacturing a Semiconductor Device Free from Electrical Shortage Due to Pin-Hole Formation.*
Yamazaki, Shunpei; Suzuki, Kunio; Susukida, Masato; Kinka, Mikio; Fukada, Takeshi; Abe, Masayoshi; Kobayashi, Ippei; Shibata, Katsuhiko; Koyanagi, Kaoru; Nagayama, Susumu
Semiconductor Energy Laboratory Co., Ltd.

**5,091,319**
*Method of Affixing Silicon Spheres to a Foil Matrix.*
Hotchkiss, Gregory B.; Jensen, Millard J.

**5,103,268**
*Semiconductor Device with Interfacial Electrode Layer.*
Yin, Ming-Jau; Tanner, David P.
Siemens Solar Industries, L.P.

**5,110,369**
*Cable Interconnections for Solar Cells Modules.*
Tornstrom, Eric; Norbedo, Anthony J.
Mobil Solar Energy Corporation

**5,125,608**
*Photovoltaic Panel Support Assembly.*
McMaster, Harold A.; Nicholson, Robert D.; Kaaka, Steven A. F.
700 Solar Club, Inc.

**5,131,954**
*Monolithic Solar Cell Array and Method for Its Manufacturing.*
Vogeli, Craig; Nath, Prem
United Solar Systems Corporation

**5,133,809**
*Photovoltaic Device and Process for Manufacturing the Same.*
Sichanugrist, Porponth; Suzuki, Hirohisa; Nishi, Hirofumi
Showa Shell Sekiyu K.K.

**5,133,810**
*Flexible Photovoltaic Device and Manufacturing Method Thereof.*
Morizane, Masashi; Okada, Koichi; Murata, Kenji; Inoue, Hiroshi; Kishi, Yasuo
Sanyo Electric Co., Ltd.

**5,143,556**
*Support for Photovoltaic Arrays.*
Matlin, Ronald W.

**5,155,051**
*Method of Manufacturing Photovoltaic Device.*
Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi
Sanyo Electric Co., Ltd.

**5,155,565**
*Method for Manufacturing an Amorphous Silicon Thin Film Solar Cell and Schottky Barrier Diode on a Common Substrate.*
Wenz, Robert P.; Tran, Nang T.
Minnesota Mining and Manufacturing Company

**5,164,019**
*Monolithic Series-Connected Solar Cells Having Improved Cell Isolation and Method of Making Same.*
Sinton, Ronald A.
SunPower Corporation

**5,164,020**
*Solar Panel.*
Wagner, Erich; Twesme, Edward N.; Hidalgo, Craig
Solarex Corporation

**5,273,593**
*Structural Element, in Particular a Facade Element.*
Marquardt, Reinhold; Böhmer, Walter; Harzheim, Horst; Jäger, Wolfgang; Chehab, Oussama; Rosendahl, Reiner
Flachglas-Solartechnik GmbH

## 1993

**5,176,758**
*Translucent Photovoltaic Sheet Material and Panels.*
Nath, Prem; Vogeli, Craig
United Solar Systems Corporation

**5,180,434**
*Interfacial Plasma Bars for Photovoltaic Deposition Apparatus.*
DiDio, Gary M.; Jones, Kermit; Hoffman, Kevin; Laarman, Timothy; Call, John; Nath, Prem
United Solar Systems Corporation

**5,180,442**
*Integration System for Solar Modules.*
Elias, Eric

**5,185,042**
*Generic Solar Cell Array Using a Printed Circuit Substrate.*
Ferguson, David L.
TRW, Inc.

**5,202,271**
*Manufacturing Method of Photovoltaic Device.*
Kouzuma, Shinichi; Inoue, Hiroshi; Murata, Kenji; Tanaka, Hiroyuki; Kishi, Yasuo
Sanyo Electric Co., Ltd.

**5,213,627**
*Structural Element, in Particular Facade Element.*
Marquardt, Reinhold; Böhmer, Walter; Harzheim, Horst; Jäger, Wolfgang; Chehab, Oussama; Rosendahl, Reiner
Flachglas-Solartechnik GmbH

**5,215,598**
*Flexible Photovoltaic Device and Manufacturing Method Thereof.*
Kouzuma, Shinichi; Inoue, Hiroshi; Murata, Kenji; Tanaka, Hiroyuki; Kishi, Yasuo
Sanyo Electric Co., Ltd.

**5,217,540**
*Solar Battery Module.*
Ogura, Hiroshi
Sharp Kabushiki Kaisha

**5,217,921**
*Method of Photovoltaic Device Manufacture.*
Kaido, Yoshinori; Masatoshi, Otsuki
Sanyo Electric Co., Ltd.

**5,228,926**
*Photovoltaic Device with Increased Light Absorption and Method for Its Manufacture.*
Glatfelter, Troy; Vogeli, Craig; Call, Jon; Hammond, Ginger
United Solar Systems Corporation

**5,232,519**
*Wireless Monolithic Photovoltaic Module.*
Glatfelter, Troy; Vogeli, Craig; Nath, Prem
United Solar Systems Corporation

**5,232,860**
*Method of Flexible Photovoltaic Device Manufacture.*
Kawanishi, Yasuyoshi; Takahashi, Osamu; Otsuki, Masatoshi; Sawada, Kenzi
Sanyo Electric Co., Ltd.

**5,236,378**
*Storage of Photovoltaic Arrays on a Ship.*
Newman, Edwin

**5,236,516**
*Photovoltaic Apparatus.*
Noguchi, Shigeru; Iwata, Hiroshi; Sano, Keiichi
Sanyo Electric Co., Ltd.

**5,238,519**
*Solar Cell Lamination Apparatus.*
Nath, Prem; Whelan, Kenneth J.
United Solar Systems Corporation

**5,242,504**
*Photovoltaic Device and Manufacturing Method Therefor.*
Iwamoto, Masayuki; Minami, Kouji; Yamaoki, Toshihiko
Sanyo Electric Co., Ltd.

**5,244,508**
*Self-Deploying Photovoltaic Power System.*
Colozza, Anthony J.
The United States of America as represented by the Administrator of the National Aeronautics and Space Administration

**5,248,345**
*Integrated Photovoltaic Device.*
Sichanugrist, Porponth; Tanaka, Norimitsu
Showa Shell Sekiyu K.K.

**5,248,348**
*Amorphous Silicon Solar Cell and Method for Manufacturing the Same.*
Miyachi, Kenji; Koyama, Masato; Ashida, Yoshinori; Fukuda, Nobuhiro
Mitsui Toatsu Chemicals, Inc.

**5,248,349**
*Process for Making Photovoltaic Devices and Resultant Product.*
Foote, James B.; Kaaka, Steven A. F.; Meyers, Peter V.; Nolan, James F.
Solar Cells, Inc.

**5,252,139**
*Photovoltaic Thin Layers Panel Structure.*
Schmitt, Jacques; Ricaud, Alain; Siefert, Jean-Marie
Solems S.A.

**5,252,140**
*Solar Cell Substrate and Process for Its Production.*
Kobayashi, Shigeyoshi; Yaba, Susumu; Kikugawa, Shinya; Muhl, Stephen; Madan, Arun

**5,252,141**
*Modular Solar Cell with Protective Member.*
Inoue, Yuji; Yamamoto, Hiroshi
Canon Kabushiki Kaisha

**5,254,179**
*Photovoltaic Device and Solar Module Having a Partial Transparency.*
Ricaud, Alain; Schmitt, Jacques; Siefert, Jean-Marie; Emeraud, Thierry
Solems S.A.

**5,254,481**
*Polycrystalline Solar Cell Manufacturing Method.*
Nishida, Shoji
Canon Kabushiki Kaisha

**5,256,576**
*Method of Making PIN Junction Semiconductor Device with RF Deposited Intrinsic Buffer Layer.*
Guha, Subhendu; Yang, Chi C.; Banerjee, Arindam
United Solar Systems Corporation

**5,258,077**
*High Efficiency Silicon Solar Cells and Method of Fabrication.*
Shahryar, Ishaq
Solec International, Inc.

**5,264,376**
*Method of Making a Thin Film Solar Cell.*
Abbott, Donald C.; Mohendra, Bawa S.; Frechette, Raymond A.
Texas Instruments Incorporated

**5,266,125**
*Interconnected Silicon Film Solar Cell Array.*
Rand, James A.; Barnett, Allen M.; Hall, Robert B.
AstroPower, Inc.

**5,268,037**
*Monolithic, Parallel Connected Photovoltaic Array and Method for Its Manufacture.*
Glatfelter, Troy
United Solar Systems Corporation

**5,268,038**
*Electrical Terminal Element for Solar Modules.*
Riermeier, Manfred; Zinke, Gerhard; Muenzer, Adolf
Siemens Solar GmbH

**5,268,039**
*Photovoltaic Device Including Shunt Preventing Layer and Method for the Deposition Thereof.*
Vogeli, Craig; Nath, Prem
United Solar Systems Corporation

**5,273,608**
*Method of Encapsulating a Photovoltaic Device.*
Nath, Prem
United Solar Systems Corporation

**5,273,911**
*Method of Producing a Thin-Film Solar Cell.*
Sasaki, Hajime; Morikawa, Hiroaki; Satoh, Kazuhiko; Deguchi, Mikio
Mitsubishi Denki Kabushiki Kaisha

## Concentrator Collectors (design, components, production)

### 1991

**4,982,723**
*Accumulator Arrangement for the Sunlight Energy.*
Mori, Kei

**5,009,243**
*Solar Harness.*
Barker, Owen P.

### 1992

**5,118,361**
*Terrestrial Concentrator Solar Cell Module.*
Fraas, Lewis M.; Mansoori, Nurullah; Kim, Namsoo P.; Avery, James E.
The Boeing Company

**5,123,968**
*Tandem Photovoltaic Solar Cell with III-V Diffused Junction Booster Cell.*
Fraas, Lewis M.; Avery, James E.; Girard, Gerald R.
The Boeing Company

**5,125,983**
*Generating Electric Power from Solar Radiation.*
Cummings, Richard D.
Electric Power Research Institute

**5,167,724**
*Planar Photovoltaic Solar Concentrator Module.*
Chiang, Clement J.
The United States of America as represented by the United States Department of Energy

### 1993

**5,180,441**
*Solar Concentrator Array.*
Cornwall, Mickey; Peterson, David M.; Stern, Theodore G.
General Dynamics Corporation/Space Systems Division

**5,255,666**
*Solar Electric Conversion Unit and System.*
Curchod, Donald B.

## Optics and Trackers (lenses, reflectors, trackingdevices, and related components)

### 1991

**4,999,059**
*Universal Solar Concentrator Panel.*
Bagno, Robert G.

**5,022,929**
*Solar Collector.*
Gallois-Montbrun, Roger

**5,039,352**
*External Wall Element for Buildings.*
Mueller, Helmut F. O.; Gutjahr, Joerg

**5,062,899**
*Wide Acceptance Angle, High Concentration Ratio, Optical Collector.*
Kruer, Mark A.
The United States of America as represented by the Administrator of the National Aeronautics and Space Administration

**5,071,243**
*Tensioned Cover for Parabolic Reflector.*
Bronstein, Allen I.

### 1992

**5,096,505**
*Panel for Solar Concentrator and Tandem Cell Units.*
Fraas, Lewis M.; Mansoori, Nurullah; Avery, James E.; Martin, John M.; Yerkes, John W.
The Boeing Company

**5,139,578**
*Liquid Crystal Coverslides for Solar Cells.*
Valley, Charles R.

**5,153,780**
*Method and for Uniformly Concentrating Flux for Photovoltaic Applications.*
Jorgensen, Gary J.; Carasso, Meir; Wendelin, Timothy J.; Lewandowski, Allan A.
The United States of America as represented by the United States Department of Energy

**5,169,456**
*Two-Axis Tracking Solar Collector Mechanism.*
Johnson, Kenneth C.

## 1993

**5,191,876**
*Rotatable Solar Collection System.*
Atchley, Curtis L.

**5,228,924**
*Photovoltaic Panel Support Assembly.*
Barker, James M.; Underwood, John C.; Shingleton, Jefferson
Mobil Solar Energy Corporation

**5,248,519**
*Process for Preparing an Assembly of an Article and a Soluble Polyimide Which Resists Dimensional Change, Delamination, and Debonding When Exposed to Changes in Temperature.*
Stoakley, Diane M.; St. Clair, Anne K.
The United States of America as represented by the Administrator of the National Aeronautics and Space Administration

**5,252,139**
*Photovoltaic Thin Layers Panel Structure.*
Schmitt, Jacques; Ricaud, Alain; Siefert, Jean-Marie
Solems S.A.

# SYSTEMS

## Systems and Technologies (power conditioning)

## 1991

**4,989,600**
*Tanning Pod.*
Collier, Joseph M.

**4,994,941**
*Sign of Character and Figure.*
Wen, Hung-Sheng

## 1993

**5,230,837**
*Fragrance Dispenser and Method for Fragrance Dispensing.*
Babasade, Wolfgang W.

**5,232,518**
*Photovoltaic Roof System.*
Nath, Prem; Laarman, Timothy; Singh, Avtar
United Solar Systems Corporation

## Utility-Independent Systems and Storage Technologies

## 1991

**Des. 317,458**
*Electronic Calculator with Solar Cell.*
Sawada, Masaji; Ikuzawa, Yoko
Sharp Corporation

**Des. 317,619**
*Electronic Calculator with Solar Cell.*
Sawada, Masaji; Yoshimura, Youko
Sharp Corporation

**Des. 319,252**
*Electronic Calculator with Solar Cell.*
Sawada, Masaji; Nishida, Kouji
Sharp Corporation

**314,523**
*Multimeter.*
Omuro, Makoto
Hioki Denki Kabushiki Kaisha

**4,009,456**
*Door Lock Apparatus.*
Eck, Berth
Lasinvast Svenska AB

**4,982,081**
*Ambient Light Rejecting Quad Photodiode Sensor.*
Schmidt, Terrence C.
Electrohome Limited

**4,982,101**
*Fiberglass Collar for Data Transfer from Rotatable Shaft.*
Baker, Matt
Bently Nevada Corporation

**4,982,176**
*Solar Powered Lighting and Alarm Systems Activated by Motion Detection.*
Schwarz, Frank

**4,986,169**
*Vehicular Internal Fan Ventilator.*
Chen, Ming-Hsiung

**4,987,729**
*Solar Powered Motor.*
Paytas, Anthony R.

**4,987,833**
*Solar Induction Monorail Apparatus and Method.*
Antosh, Mark J.

**4,989,124**
*Solar Powered Sign.*
Shappell, Thomas E.

**4,993,868**

Eigenmann, Ludwig
Minnesota Mining and Manufacturing Co.

**4,999,060**
*Solar Cell Packaging Assembly for Self-Contained Light.*
Szekely, Klara; Felder, Bethanne; Wallace, Lloyd V.
Siemens Solar Industries, L.P.

**4,999,560**
*Electric Motor Running System Employing Photovoltaic Array.*
Morishima, Yoichi; Kobayashi, Kazuo; Suzuki, Isao
Kabushiki Kaisha Toshiba

**5,003,441**
*Pop-Up Light Fixture.*
Crowe, John R.; Cheatham, Gregory A.

**5,003,866**
*Car Ventilator.*
Ricci, Russell L.

**5,006,082**
*Actuating-Device for Small-Type Air-Feeded Water Floaters.*
Hwang, Feng-Lin

**5,007,105**
*Watch Type Paging Receiver.*
Kudoh, Kazuhiro; Nishiyama, Toshirou; Anma, Sadayuki
NEC Corporation

**5,012,113**
*Infrared System for Monitoring Movement of Objects.*
Valentine, Kenneth H.; Falter, Diedre D.; Falter, Kelly G.
Martin Marietta Energy Systems, Inc.

**5,012,160**
*Accordion Mount for Solar Cells Including Point-of-Purchase Display with LEDS.*
Thompson, Kathleen D. Dunn
Colorado Instruments, Inc.

**5,012,220**
*Solar Powered Paging Device.*
Miller, Moses

**5,012,457**
*Aquatic Transducer System.*
Mitchell, Thomas R.; Landesman, Robert E.

**5,013,417**
*Water Purifier.*
Judd, Jr., Lawrence M.

**5,013,972**
*Dual-Powered Flickering Symbolic or Religious Light (Electronic Yahrzeit).*
Malkieli, Moshe; Apel, Israel
Samuel Kaner

**5,015,086**
*Electronic Sunglasses.*
Okaue, Etsuo; Egawa, Masaru; Kasai, Yoshihiko; Horaguchi, Norio
Seiko Epson Corporation

**5,020,150**
*Combination Radio and Eyeglasses.*
Shannon, John

**5,020,232**
*Illuminated Level.*
Whiteford, Carlton L.

**5,020,919**
*Heat Flow Sensing Apparatus and Method.*
Suomi, Verner K.
Wisconsin Alumni Research

**5,021,715**
*Lighting System for Roadside Signs.*
Smith, Norman D.; Smith, Dresden G.

**5,023,595**
*Mail Arrival Signal System.*
Bennett, Charles S.

**5,029,342**
*Welder's Helmet and Photovoltaic Power Transmission Circuit Therefor.*
Stein, Marc F.; O'Mara, Bradley

**5,029,428**
*Solar Cell Panel Assembly for Driving Motor-Driven Screen Device.*
Hiraki, Yoshiharu
Yoshida Kogyo K. K.

**5,032,717**
*Remote Control for Anode-Cathode Adjustment.*
Roose, Lars D.
The United States of America as represented by the United States Department of Energy

**5,032,961**
*Ground Light System for a Landing Strip.*
Pouyanne, Marc; Mace, Roger; Blanc, Jean-Loup
Territoire de la Polynesie Francaise, a l'Energie Atomique Commissariat; Agence Francaise Pour la Maitrise de l'Energie

**5,034,110**
*Pool Chlorinators.*
Gore, Rodney L.; Glore, Herbert F.
Sal-Chlor Pty. Ltd.

**5,034,658**
*Christmas-Tree, Decorative Artistic and Ornamental Object Illumination Apparatus.*
Hiering, Roland; Ilberg, Vladimir

**5,035,077**
*Apparatus and Method for Improved Plant Growth.*
Palmer, Sharon-Joy

**5,036,443**
*Proximity Light.*
Humble, Wayne; Spector, George

**5,038,251**
*Electronic Apparatus and a Method for Manufacturing the Same.*
Sugiyama, Yoshinobu; Sawada, Shohei; Hinooka, Takashi; Yoshida, Kaoru
Casio Computer Co., Ltd.

**5,038,674**
*Solar Ventilation Arrangement for Passenger Compartments.*
Merges, Veit
Phototronics Solartechnik GmbH

**5,039,928**
*Accumulator for Portable Computers.*
Nishi, Kazuo; Suzuki, Kunio; Kinka, Mikio; Satake, Akemi; Kugawa, Shuichi
Semiconductor Energy Laboratory Co., Ltd.

**5,040,455**
*Ventilation Device for Automobiles.*
Doi, Shigetoshi; Kajimoto, Shinshi; Kuroiwa, Mutsutoshi
Mazda Motor Corporation

**5,040,585**
*Solar Cell Panel Assembly for Driving a Motor-Driven Screen Apparatus.*
Hiraki, Yoshiharu
Yoshida Kogyo K. K.

**5,041,762**
*Luminous Panel.*
Hartai, Julius

**5,056,447**
*Rein-Deer Kite.*
Labrador, Gaudencio A.

**5,059,254**
*Solar Cell Substrate and Solar Panel for Automobile.*
Yaba, Susumu; Takigawa, Tomoya; Osada, Koichi; Sato, Katsuhito; Omae, Masaru
Asahi Glass Company, Ltd.

**5,059,296**
*Portable Self-Contained Solar Powered Water Purifier.*
Sherman, Mark
Floatron, Inc.

**5,062,028**
*Self-Contained Solar Powered Lamp.*
Frost, John S.; Wallace, Lloyd V.; Erickson, Mark R.; Felder, Bethanne
Atlantic Richfield Company

**5,065,156**
*Computer Controlled Parking Meter.*
Bernier, Denis

**5,065,290**
*Illuminated Display.*
Makar, Marko; Makar, Michael

**5,065,291**
*Marking Light.*
Frost, John S.; Erickson, Mark R.; Seegan, Kimberly E.; Boyer, Brent P.
Atlantic Richfield Company

**5,066,338**
*Solar Powered Navigation Buoy Generator.*
Meyers, Roy D.

**5,072,209**
*Data Display System for Vehicles.*
Hori, Toshio; Furuhashi, Kenji; Wakita, Makoto; Ueda, Kazuo
Kawajyuu Gifu Engineering Co., Ltd.

**5,073,054**
*Electronic Dictionary with Vertical Keyboard.*
McDowell, W. Stuart

**5,074,489**
*Method and System for Supporting an Airborne Vehicle in Space.*
Gamzon, Eliyahu

**5,074,706**
*Raised Depressible Pavement Marker.*
Paulos, Harry D.
Olympic Machines, Inc.

**5,074,811**
*Solar Powered Trolling Motor.*
Crisman, Dusty S.

**5,075,857**
*Unmanned Compliance Monitoring Device.*
Maresca, Joseph S.

**5,076,634**
*Sun Visor for Motor Vehicles.*
Müller, Hermann-Frank; Pflanz, Tassilo

**5,077,796**
*Cryptograph.*
Bellaire, David L.

## 1992

**5,078,151**
*Medical Auscultation Device.*
Laballery, Vincent

**5,078,470**
*One-Way Peephole.*
Milman, Uri

**5,079,645**
*Solar Powered Diffractor.*
Ritter, Carl A.

**5,079,726**
*Response Speed and Accuracy Measurement Device.*
Keller, Lloyd E.

**5,084,664**
*Solar Powered Lead Acid Battery Rejuvenator and Trickle Charger.*
Gali, Carl E.

**5,085,753**
*Water Purifier.*
Sherman, Mark
Floatron, Inc.

**5,087,107**
*Device and Process for Protecting and Handling Bank Notes and Valuables.*
Gumanelli, Giuseppe E.
M.I.B. Elettronica S.R.L.

**5,088,127**
*Powered Rotating Display in a Hat.*
Thornock, Del M.

**5,090,167**
*Solar Shed.*
Wassell, Stephen

**5,090,689**
*Solar Carousel.*
Petz, Peter

**5,090,770**
*Electrical Seat Adjustment Device.*
Heinrichs, Heinz-Josef; Enders, Stephan; Wagner, Udo; Dirksen, Alfred
Stabilus GmbH

**5,102,471**
*Portable Measuring Instrument with Solar Batteries.*
Sasaki, Koji
Mitutoyo Corporation

**5,106,492**
*Solar Powered Swimming Pool Skimmer.*
Distinti, John A.; Fonti, Robert G.

**5,106,495**
*Portable Water Purification Device.*
Hughes, Harold

**5,107,637**
*Transit Shelter with Self-Contained Illumination System.*
Robbins, Steven
B & E Energy Systems, Inc.

**5,109,989**
*Rotary Display.*
Kremmin, Klaus; Kremmin, Thomas R.F.
K-2 Industries, Inc.

**5,111,127**
*Portable Power Supply.*
Johnson, Woodward

**5,121,307**
*Self Contained Solar Powered Strobe Light.*
Moore, Charles M.

**5,121,818**
*Solar Powered Cooling Apparatus for a Vehicle Brake System.*
McComic, Richard D.

**5,131,341**
*Solar Powered Electric Ship System.*
Newman, Edwin

**5,131,888**
*Solar Powered Exhaust Fan.*
Adkins II, Dwight O.

**5,145,442**
*Multi-Purpose Solar Energy Operated Toy Vehicle.*
Zan, Ja D.

**5,149,188**
*Solar Powered Exterior Lighting System.*
Robbins, Steven
Solar Outdoor Lighting, Inc.

**5,152,601**
*Solar Power-Operated Construction Work Warning Lamp.*
Ferng, Shing-Lai

**5,155,668**
*Solar Powered Lamp Utilizing Cold Cathode Fluorescent Illumination and Method of Facilitating Same.*
Tanner, David P.; Erickson, Mark R.; Frost, John S.
Siemens Solar Industries, L.P.

**5,156,568**
*Car Ventilator.*
Ricci, Russell L.

**5,159,191**
*Apparatus and Method for Using Ambient Light to Control Electronic Apparatus.*
Mankovitz, Roy J.

**5,160,214**
*Irrigation System and Irrigation Method.*
Sakurai, Mikio; Sakurai, Chikako

**5,160,920**
*Fail Safe Display for Shelf Labels.*
Harris, Richard H.
International Business Machines Corporation

**5,164,654**
*Solar Energy Operated Automatic Charge Device for Electric Appliances.*
Bertram, Leo; Schemmann, Hugo; Husgen, Theodor
U.S. Philips Corporation

## 1993

**5,177,628**
*Self-Powered Optically Addressed Spatial Light Modulator.*
Moddel, Garret R.
The University of Colorado Foundation, Inc.

**5,184,502**
*Helicopter Installable, Self-Powered, Modular, Remote, Telemetry Package.*
Adams, George W.; McGoey, Michael J.
Remote Power, Inc.

**5,196,690**
*Optically Powered Photomultiplier Tube.*
Flesner, Larry D.; Miller, Stephen A.; Dubbelday, Wadad B.
The United States of America as represented by the Secretary of the Navy

**5,197,291**
*Solar Powered Thermoelectric Cooling Apparatus.*
Levinson, Lionel M.
General Electric Company

**5,197,801**
*Tumbler.*
Swisher, Max B.

**5,199,429**
*Implantable Defibrillator System Employing Capacitor Switching Networks.*
Kroll, Mark W.; Adams, Theodore P.
AngeMed, Inc.

**5,202,790**
*Photo-Driven Light Beam Deflecting Apparatus.*

Uchino, Kenji; Hikita, Kazuyasu; Tanaka, Yoshiaki; Ono, Mikiya
Mitsubishi Mining and Cement Company

**5,204,586**
*Solar Powered Lamp Having a Circuit for Providing Positive Turn-On at Low Light Levels.*
Moore, Fred A.
Siemens Solar Industries

**5,204,667**
*Indication Display Unit for Vehicles.*
Inoue, Tai
Yazaki Corporation

**5,205,782**
*Car Ventilating System.*
Ohba, Shunji

**5,208,578**
*Light Powered Chime.*
Tury, Jon M.; Tury, Edward L.

**5,209,012**
*Method for Improved Plant Growth.*
Palmer, Sharon-Joy

**5,210,804**
*Solar Powered Hearing Aid and Reenergizer Case.*
Schmid, Guenther W.

**5,211,470**
*Self-Contained Solar Powered Light.*
Frost, John S.; Erickson, Mark R.; Seegan, Kimberly E.; Boyer, Brent P.
Siemens Solar Industries

**5,212,385**
*Diamond alpha Particle Detector.*
Jones, Barbara L.

**5,212,916**
*Device for Shading Spaces.*
Dippel, Hans-Jurgen; Raupach, Peter
Peter Raupach

**5,213,626**
*Transparent Pane for Vehicles.*
Paetz, Werner
Webasto-Schade GmbH

**5,216,972**
*Lighted Cleat.*
Dufrene, John K.; Deed, John

**5,217,000**
*Compound Solar Collector Building Construction.*
Pierce-Bjorklund, Patricia

**5,217,296**
*Solar Powered Light.*
Tanner, David P.; Frost, John S.; Erickson, Mark R.; Moore, Fred A.
Siemens Solar Industries

**5,217,540**
*Solar Battery Module.*
Ogura, Hiroshi
Sharp Kabushiki Kaisha

**5,221,363**
*Solar Cell Window Fitting.*
Gillard, Calvin W.
Lockheed Missiles & Space Company

**5,228,772**
*Solar Powered Lamp Having a Cover Containing a Fresnel Lens Structure.*
Mitchell, Kim W.; Stizema, Jr., Ronald L.
Siemens Solar Industries

**5,228,925**
*Photovoltaic Window Assembly.*
Nath, Prem; Singh, Avtar
United Solar Systems Corporation

**5,228,964**
*Chlorinating Apparatus.*
Middleby, Samuel R.

**5,229,649**
*Light-Energized Electronics Energy Management System.*
Nielsen, Wyn Y.; Luck, Jonathan M.
Solatrol, Inc.

**5,230,837**
*Fragrance Dispenser and Method for Fragrance Dispensing.*
Babasade, Wolfgang W.

**5,231,781**
*Illuminated Float.*
Dunbar, Bret A.
Bret Allen Dunbar

**5,232,105**
*Solar Powered Crystal Display Rack.*
Gregg, Stephen R.

**5,232,518**
*Photovoltaic Roof System.*
Nath, Prem; Laarman, Timothy; Singh, Avtar
United Solar Systems Corporation

**5,237,490**
*Solar Power Operated, Construction Work Warning Lamp with Focusing Device for Intensifying the Intensity of Light.*
Ferng, Shing-Lai

**5,237,764**
*Solar Driven Novelty Device.*
Gray, Jay C.

**5,243,578**
*Electronic Timepiece.*
Mathez, Bernard E.
Lemrich and Cie S. A.

**5,244,508**
*Self-Deploying Photovoltaic Power System.*
Colozza, Anthony J.
The United States of America as represented by the Administrator of the National Aeronautics and Space Administration

**5,248,278**
*Ventilator Roof for Vehicles.*
Fuerst, Arpad; Schreiter, Thomas; Reinsch, Burkhard; Paetz, Werner
Webasto AG Fahrzeugtechnik

**5,250,265**
*Automotive Solar-Operated Deodorizer with Solar Cell Cooling and Automated Operational Control.*
Kawaguchi, Kiyoshi; Itoh, Norihisa; Yamashita, Kouji; Matsui, Kazuma
Nippondenso Co., Ltd.

**5,253,150**
*Warning Light.*
Vanni, Robert R.

**5,253,300**
*Solar Powered Hearing Aid.*
Knapp, Herbert C.
H.C. Knapp Sound Technology, Inc.

**5,258,076**
*Arrangement for Covering Doors, Windows or Like Type Room Closure.*
Wecker, Reinhard
MWB Messwandler-Bau AG

**5,262,756**
*Solar Powered Warning Light.*
Chien, Tseng L.

**5,271,225**
*Multiple Mode Operated Motor with Various Sized Orifice Ports.*
Adamides, Alexander

**5,274,584**
*Solid State Memory Device Having Optical Data Connections.*
Henderson, Watson R.; Kelly, Michael S.; Leonhardt, Michael L.; Paurus, Floyd G.; Smith, Archibald W.; Szerlip, Stanley R.
Storage Technology Corporation

## PV-Hybrid Systems (PV-thermal, photoelectrochemical)

### 1991

**4,982,569**
*Parallel Hybrid System for Generating Power.*
Bronicki, Lucien Y.
Ormat Turbines, Ltd.

**4,982,723**
*Accumulator Arrangement for the Sunlight Energy.*
Mori, Kei

**4,993,348**
*Apparatus for Harvesting Energy and Other Necessities of Life at Sea.*
Wald, Leonard H.

### 1993

**5,217,000**
*Compound Solar Collector Building Construction.*
Pierce-Bjorklund, Patricia

**5,225,712**
*Variable Speed Wind Turbine with Reduced Power Fluctuation and a Static VAR Mode of Operation.*
Erdman, William L.
U.S. Windpower, Inc.

**5,235,266**
*Energy-Generating Plant, Particularly Propeller-Type Ship's Propulsion Plant, Including a Solar Generator.*
Schaffrin, Christian
Schottel-Werft Josef Becker GmbH & Co. KG

**5,246,350**
*High Efficiency Solar Powered Pumping System.*
Lackstrom, David; Raghunathan, Kidambi
International Product and Technology Exchange, Inc.

**5,269,851**
*Solar Energy System.*
Horne, William E.
United Solar Technologies, Inc.

## Systems Support (testing, maintenance operation, and control)

### 1991

**4,982,569**
*Parallel Hybrid System for Generating Power.*
Bronicki, Lucien Y.
Ormat Turbines, Ltd.

**5,001,415**
*Electrical Power Apparatus for Controlling the Supply of Electrical Power from an Array of Photovoltaic Cells to an Electrical Head.*
Watkinson, Stuart M.

**5,025,202**
*Solar Cell Power System with a Solar Array Bus Lockup Cancelling Mechanism.*
Ishii, Akihiko; Honda, Yukihiro; Matsui, Toshio
Mitsubishi Denki Kabushiki Kaisha

**5,027,051**
*Photovoltaic Source Switching Regulator with Maximum Power Transfer Efficiency Without Voltage Change.*
Lafferty, Donald L.

**5,037,043**
*Locking Arrangement for Unfolded Solar Generators.*
Roth, Martin; Kiendl, Helmut
Messerschmitt-Boelkow-Blohm

**5,041,952**
*Control Circuit for a Solar-Powered Rechargeable Power Source and Load.*
Janda, Rudolph W.; Douglas, Jerald L.; Condon, Jr., Edward F.
Intermatic Incorporated

**5,043,024**
*Solar Cell Device.*
Cammerer, Fritz; Bednorz, Klaus; Riermeier, Manfred
Siemens Aktiengesellschaft

### 1992

**5,086,267**
*Control Circuit for a Solar-Powered Rechargeable Power Source and Load.*
Janda, Rudolph W.; Douglas, Jerald L.; Condon, Jr., Edward F.
Intermatic Incorporated

**5,118,945**
*Photothermal Test Process, Apparatus for Performing the Process and Heat Microscope.*
Winschuh, Erich; Petry, Harald
Siemens Aktiengesellschaft

**5,150,043**
*Apparatus and Method for Non-Contact Surface Voltage Probing by Scanning Photoelectron Emission.*
Flesner, Larry D.
The United States of America as represented by the Secretary of the Navy

**5,153,497**
*Circuit for Regulating Charging of a Storage Battery by a Photovoltaic Array.*
Eiden, Glenn E.

### 1993

**5,217,285**
*Apparatus for Synthesis of a Solar Spectrum.*
Sopori, Bhushan L.
The United States of America as represented by the United States Department of Energy

**5,221,891**
*Control Circuit for a Solar-Powered Rechargeable Power Source and Load.*
Janda, Rudolph W.; Douglas, Jerald L.; Condon, Jr., Edward F.
Intermatic Incorporated

**5,268,832**
*DC/AC Inverter Controller for Solar Cell, Including Maximum Power Point Tracking Function.*
Kandatsu, Yukio
Kabushiki Kaisha Toshiba

**5,270,636**
*Regulating Control Circuit for Photovoltaic Source Employing Switches, Energy Storage, and Pulse Width Modulation Controller.*
Lafferty, Donald L.