Polycrystalline Thin-Film Research: Copper Indium Gallium Diselenide

Scope. Copper indium gallium diselenide (CIGS) and a wide range of transparent conducting oxides (TCOs) is one of the research focuses of the Polycrystalline Thin-Film Research Group. The group develops processes and materials related to thin-film polycrystalline photovoltaics (PV) devices, and equipment required for routine analysis of these devices and materials. We work closely with the Measurements and Characterization activities to achieve a deeper understanding of thin-film materials and devices. The group also works with cadmium telluride (CdTe), but this sheet focuses only on the CIGS and related TCO work.

Core Competencies and Capabilities. Our CIGS thin-film PV effort is recognized worldwide. Key accomplishments include current (and past) world records for energy conversion efficiency (today at 20%), and the development of key processes, know-how, and intellectual property that has led to the highest efficiency for any thin-film technology. Our efforts aim at the ultimate goal of lowering the manufacturing cost of CIGS PV products. Thus, research projects currently under way tackle issues to improve CIGS processes and materials quality control, long-term stability and reliability of CIGS devices, and the search for new and alternative materials that can lead to a lower $/watt figure. We also collaborate with U.S. industry in specific topics of interest to the customer (e.g., substrates, comparative studies to optimize industrial processes, scale-up issues).

Specific capabilities in various areas are listed below:

- Substrates
  - Soda-lime glass
  - Na-free glass and ceramics
  - Metal foils
  - High-temperature plastics
- Cleaning
  - Various aqueous cleaning processes
  - High-speed spin rinse
- Mo Layer
  - Sputtering Mo
  - Various adhesion layers (e.g., Cr, Ni)
  - Mo patterning
- CIGS Layer
  - 4-source co-evaporation
  - Various processes (e.g., 3-step, 2-step, selenization)
- CdS and ZnOS Layers
  - CdS and ZnOS by chemical bath deposition, atomic layer deposition (ALD), sputtering
- Buffer Layer
  - Undoped ZnO by metal-organic chemical vapor deposition (MOCVD) or sputtering
  - ZnMgO by MOCVD or sputtering
- TCO Layer
  - ZnO:Al or ITO by sputtering
- Interconnects
  - Metallization for top-contact grids
  - Monolithic interconnection
- Antireflection Coating (ARC) Layer

Our capabilities in research and development of TCOs are directed at materials that may have significant advantages for improved thin-film PV performance, reduced use of scarce and/or expensive constituents, improved environmental stability, and/or demonstrate opportunities for advancing fundamental knowledge in this important technology area.

Contact

Rommel Noufi, Rommel.Noufi@nrel.gov, 303-384-6510
Web: www.nrel.gov/pv/thinfilm.html

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

NREL/FS-5200-48345 • Revised June 2013