NREL Spurred the Success of Multijunction Solar Cells

Many scientists once believed that high-quality gallium indium phosphide (GaInP) alloys could not be grown for use as semiconductors because the alloys would separate. However, researchers at the National Renewable Energy Laboratory (NREL) thought differently, and they employed GaInP in a material combination that allowed the multijunction cell to flourish. The multijunction cell is now the workhorse that powers satellites and the catalyst for renewed interest in concentrator photovoltaic products.

A multijunction cell is like a semi-transparent layer cake: the top cell produces electricity from the higher-energy portion of the solar spectrum, and the lower-energy sunlight passes through to the lower cells to be converted into electricity, resulting in a highly efficient production of power. To make it work, the stacked cells need to absorb complementary wavelengths of sunlight, and those absorption wavelengths are determined by the material’s bandgaps. A bandgap is the energy difference between certain energy bands that the material’s electrons can occupy.

While many researchers were focused on materials with ideal combinations of bandgaps, NREL researchers thought the focus should change to finding materials with chemical and structural compatibility—materials that had a bandgap combination that would give a high, but not necessarily the highest, theoretical efficiency. With that in mind, NREL researchers focused their efforts on GaInP and gallium arsenide (GaAs), which are well-matched chemically and have the same lattice constant, an indicator of how their crystals fit together at the atomic and molecular levels.

NREL applied for a patent for this “dual-junction” solar cell, and although the first cells were less than 10% efficient, NREL researchers thought the efficiency could be improved by purifying the indium. They eventually showed that a top cell of GaInP and a bottom cell of GaAs could capture and convert photons into electricity more efficiently than other materials.

Subsequently, all major research entities working on similar multijunction solar cells adopted some version of the GaInP/GaAs cell. True to the predictions of NREL researchers, as knowledge and processes advanced, efficiency surged. After a decade of research, NREL’s dual-junction solar cell surpassed 30% efficiency, and afterward, the NREL team and scientists worldwide started adding more semiconductor junctions, and the record steadily increased. More than a dozen companies are now capable of producing multijunction solar cells.