MORE EFFICIENT, LOW-COST SOLAR CELLS

Silicon solar cells have dominated industrial solar energy facilities, but they convert only about a quarter of the sunlight that reaches them to electric power. To explore alternative approaches, the U.S. Department of Energy's Office of Science funded an Energy Frontier Research Center (EFRC) that is now called Light Energy Activated Redox Processes.

Two of the Center's principal investigators, Mercouri Kanatzidis and Robert Chang, both at Northwestern University, collaborated on the project. Many research groups were investigating a type of thin-film solar cell that combines a photo-sensitized material that could efficiently absorb light and generate electrons with a liquid that could capture and conduct the electrons. When Chang investigated these solar cells more carefully, however, he concluded they were not a promising solution because the liquid was corrosive

About the image: As the costs of solar cells drop and their efficiency improves, solar power is set to play an ever-larger role in generating electricity and moving the U.S. toward a climate-friendly energy system. *(Matteo Fes / Shutterstock)*

The perovskite material in solar cells is manufactured in high-tech facilities, but perovskite crystals also occur in nature, such as the shiny pieces found in this sample collected in Arkansas.
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Commercial-sized perovskite-silicon solar cells that are nearing commercial production.
(Oxford PV)

and would eventually lead to cell failure. He suggested finding a different material to pair with the photo-sensitized thin-film layer. As it happened, Kanatzidis knew of a class of materials called perovskites that might work and proposed that Chang try it as the substitute material. Perovskites combine several different elements, have a unique structure, and are easy to make. A prototype cell combining a thin layer of perovskite and a photo-sensitized material not only worked, but the thin layer of perovskite also absorbed additional sunlight, boosting efficiency. Additional research improved performance to 10 percent efficiency.

Publication of that research generated enormous interest and a flurry of worldwide research that transformed the perovskite material into a full-fledged semiconductor and improved its ability to absorb sunlight, so that a separate photo-sensitized layer was no longer needed. Development of layered perovskite cells that used organic material to separate the layers helped to improve stability and cell lifetimes. Moreover, perovskite solar cells turned out to be easy and inexpensive to manufacture. Reported efficiencies for perovskite solar cells marched steadily higher, reaching 25 percent in less than a decade from their discovery.

Kanatzidis and Chang also discovered perovskites that could be combined with other solar cell materials, such as a thin layer of perovskite material on top of a standard silicon cell. This tandem structure allows each material to absorb a different part of the solar spectrum. These cells have reached 28 percent efficiency—above what standalone silicon cells can achieve—with the prospect of even higher efficiencies to come. Rapid advances in perovskite technology have led to strong interest in commercialization, with multiple startup companies leading the way.

In addition to solar cells, perovskites have other uses: the material makes better light-emitting diode (LED) lights, and commercialization of that application is taking off. Large single crystals of a perovskite material that includes bromine also turned out to be breakthrough detectors for gamma rays and are of great interest to astronomers, particle physicists, and—because nuclear weapons tests emit gamma rays—national security officials.

Reflecting on the bounty of applications and the EFRC process that triggered them, Kanatzidis says that the EFRC process and the collaboration among a dozen or so investigators enabled by the EFRC is "the best R&D system yet" because it fosters faster progress and unexpected breakthroughs.

Center for Light Energy Activated Redox Processes (LEAP)
(formerly the Argonne Northwestern Solar Energy Research Center [ANSER])
Winner — Scientific Ideas Award
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