# All-Inorganic Nanocrystal Solar Cells Fabricated

## *Absence of Organic Components Lead to Increased Robustness*

The research group of Faculty Senior Scientist Paul Alivisatos has developed the first ultra-thin solar cells comprised entirely of inorganic nanocrystals and spin-cast from solution. These nanocrystal solar cells are as cheap and easy to make as solar cells made from organic polymers and offer the added advantage of being stable in air because they contain no organic materials.

Most commercial solar cells today are made from silicon. Like many conventional semiconductors, silicon offers excellent, well-established electronic properties. However, the use of silicon or other conventional semiconductors in photovoltaic devices has to date been limited by the high cost of production—the fabrication of even the simplest semiconductor cell is a complex process that has to take place under tightly controlled conditions, such as high vacuum, and temperatures between 400 and 1,400 degrees Celsius.

All – organic nanocrystal solar cells are robust, 3% efficient

When it was discovered in 1977, that a certain group of "conjugated" organic polymers could be made to conduct electricity, there was immediate interest in using these materials in photovoltaic devices. Although it was shown that plastic solar cells could be made in bulk quantities for a few cents each, their power conversion efficiency continues to be been poor compared to cells made from semiconductors. Moreover, their efficiency deteriorates with exposure to air. In 2002, the Alivisatos group announced a breakthrough (MSD Highlight 02-1) in which they were able to fabricate hybrid solar cells with organic polymers and the semiconductor cadmium-selenide (CdSe). While these hybrids offer some of the best features of semiconductor and plastic solar cells (lower cost, higher efficiency), they remain sensitive to air because they contain organic components.

In this latest work, the researchers developed a technique in which rod-shaped, nanometer-sized crystals of two semiconductors, CdSe and cadmium-telluride (CdTe), are synthesized, dissolved in separate solutions, and then alternately spin-cast in layers onto a conductive glass substrate. The CdSe/CdTe films are electrical insulators in the dark but when exposed to sunlight, they undergo a dramatic increase in electrical conductivity—as much as three orders of magnitude. Unlike conventional semiconductor solar cells, in which an electrical current flows between layers of n-type and p-type semiconductor films, in these new inorganic nanocrystal solar cells, electrons and holes move among CdSe and CdTe crystals respectively, maintaining their separation and increasing the efficiency of the cell. The films, which are about 1,000 times thinner than a human hair, display efficiencies for converting sunlight to electricity of about 3 percent, comparable to the conversion efficiencies of the best organic solar cells. Unlike those organic cells, however, whose performance deteriorates over time, inorganic nanocrystal solar cells perform better over time.

The new materials share all of the primary advantages of organic solar cell materials—scalablity, controlled synthesis and the ability to be processed in solution—while retaining the broadband absorption and superior transport properties of traditional photovoltaic semiconductors. Current work is focusing on understanding the nature of the donor-acceptor heterojunction that is responsible for current generation in the cell and on increasing the power conversion efficiency. The group is also exploring cells fabricated by spin-casting a blend of CdSe and CdTe crystals. The overall goal is to develop a technology whereby the rooftops of residential homes and commercial buildings can be laminated with inexpensive, ultra-thin films of nano-sized semiconductors that will efficiently convert sunlight into electrical power and provide virtually all of our electricity needs.

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I. Gur, N. A. Fromer, M. L. Geier, A. P. Alivisatos, "Air-Stable All-Inorganic Nanocrystal Solar Cells Processed from Solution," Science 310, 462 (2005). I.G. acknowledges the National Science Foundation for support under a Graduate Research Fellowship.

*Dedicated in loving memory to Benjamin Boussert, Giulia Adesso, and Jason Choy.*

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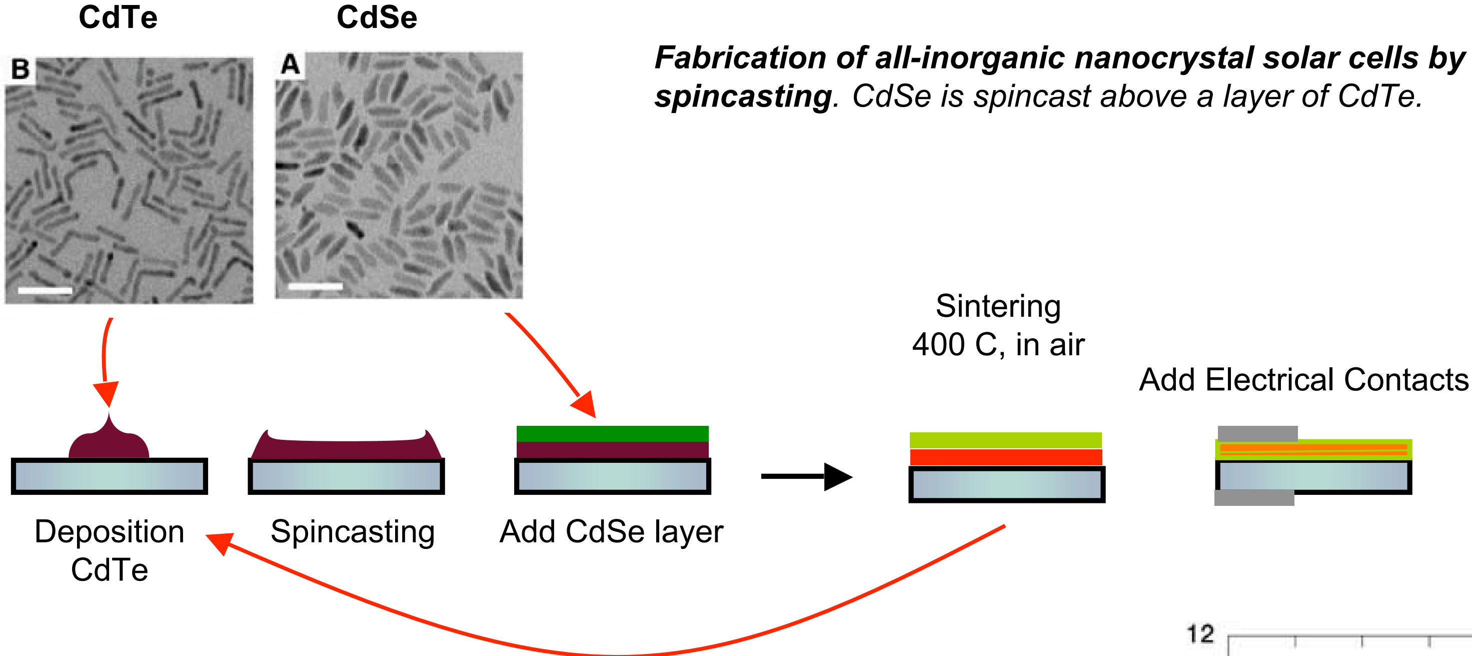
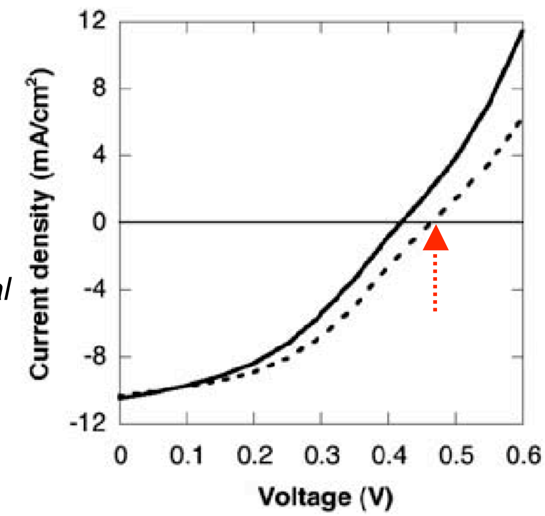



***Fabrication of all-inorganic nanocrystal solar cells by spincasting**. CdSe is spincast above a layer of CdTe.*




***Solar cell performance** under simulated sunlight conditions. The solid line is data obtained upon first exposure to air. After 13,000 hours of exposure to ambient atmosphere (dotted line) both the absolute current density and open circuit voltage (arrow) are increased, demonstrating the environmental stability of the cell. The overall efficiency approaches 3%.*

*A. P. Alivisatos , 06-05*