Special Coating Greatly Improves Solar Cell Performance

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The energy from sunlight falling on only 9 percent of California's Mojave Desert could power all of the United States' electricity needs if the energy could be efficiently harvested, according to some estimates. Unfortunately, current-generation solar cell technologies are too expensive and inefficient for wide-scale commercial applications.

A team of Northwestern University researchers has developed a new anode coating strategy that significantly enhances the efficiency of solar energy power conversion. A paper about the work, which focuses on "engineering" organic material-electrode interfaces in bulk-heterojunction organic solar cells, is published online this week in the *Proceedings of the National Academy of Sciences*. The *PNAS* paper is titled "p-Type Semiconducting Nickel Oxide as an Efficiency-enhancing Anode Interfacial Layer in Polymer Bulk-heterojunction Solar Cells."

This breakthrough in solar energy conversion promises to bring researchers and developers worldwide closer to the goal of producing cheaper, more manufacturable and more easily implemented solar cells. Such technology would greatly reduce our dependence on burning fossil fuels for electricity production as well as reduce the combustion product: carbon dioxide, a global warming greenhouse gas.

Tobin J. Marks, the Vladimir N. Ipatieff Research Professor in Chemistry in the Weinberg College of Arts and Sciences and professor of materials science and engineering, and Robert Chang, professor of materials science and engineering in the McCormick School of

Engineering and Applied Science, led the research team. Other Northwestern team members were researcher Bruce Buchholz and graduate students Michael D. Irwin and Alexander W. Hains.

Of the new solar energy conversion technologies on the horizon, solar cells fabricated from plastic-like organic materials are attractive because they could be printed cheaply and quickly by a process similar to printing a newspaper (roll-to-roll processing).

To date, the most successful type of plastic photovoltaic cell is called a “bulk-heterojunction cell.” This cell utilizes a layer consisting of a mixture of a semiconducting polymer (an electron donor) and a fullerene (an electron acceptor) sandwiched between two electrodes -- one a transparent electrically conducting electrode (the anode, which is usually a tin-doped indium oxide) and a metal (the cathode), such as aluminum.

When light enters through the transparent conducting electrode and strikes the light-absorbing polymer layer, electricity flows due to formation of pairs of electrons and holes that separate and move to the cathode and anode, respectively. These moving charges are the electrical current (photocurrent) generated by the cell and are collected by the two electrodes, assuming that each type of charge can readily traverse the interface between the polymer-fullerene active layer and the correct electrode to carry away the charge -- a significant challenge.

The Northwestern researchers employed a laser deposition technique that coats the anode with a very thin (5 to 10 nanometers thick) and smooth layer of nickel oxide. This material is an excellent conductor for extracting holes from the irradiated cell but, equally important, is an efficient “blocker” which prevents misdirected electrons from straying to the “wrong” electrode (the anode), which would compromise the cell energy conversion efficiency.

In contrast to earlier approaches for anode coating, the Northwestern nickel oxide coating is cheap, electrically homogeneous and non-corrosive. In the case of model bulk-heterojunction cells, the Northwestern team has increased the cell voltage by approximately 40 percent and the power conversion efficiency from approximately 3 to 4 percent to 5.2 to 5.6 percent.

The researchers currently are working on further tuning the anode coating technique for increased hole extraction and electron blocking efficiency and moving to production-scaling experiments on flexible substrates.

Source: Northwestern University