Enhanced efficiency of simple, inexpensive solar cells could transform energy-starved communities

May 18 2017, by Chris Spallino

Affordable solar cells would power communication devices, provide sterilization of medical equipment and offer hygeinic cooking in underdeveloped economies. Credit: Abbie Trayler-Smith / Panos Pictures / Department for International Development

Tonight, try this: Turn the main fuse in the house off and see how it feels to live without electricity for 24 hours. No lights for reading, no TV for information, no air conditioning to keep you cool, and no stove to heat a meal.

Would you survive? Probably. Would you like the experience? Probably not. Now, imagine how billions of people around the world without electricity, or with poor electricity supply, are living—every single day.

According to the International Energy Agency's World Energy Outlook 2016, an estimated 1.2 billion people—16 percent of the global population—do not have access to electricity. Approximately 2.7 billion people—38 percent of the world's population—do not have access to clean, hygienic cooking facilities.

Help could be on the way in the form of a simple, inexpensive solar cell conceived by a group of multi-university researchers led by Akhlesh Lakhtakia, Charles Godfrey Binder Professor in Engineering Science and Mechanics at Penn State. These solar cells could provide electricity for every home in underdeveloped and emerging economies; they could also light the way to more sustainable economic and social growth across the globe.

"The major difference between people who are wealthy and who are poor is this: The wealthy can afford their energy sources and have greater access to them," said Lakhtakia. "Because poor people can't afford their energy resources, they lack the wherewithal to improve their economic status. They don't need the most efficient sources. They need affordable ones and a helpful nudge to improve their lives. That motivated us in our research."

Solar cells are opto-electronic devices containing multiple layers of semiconductors that capture and absorb solar radiation (photons). Every absorbed photon creates an electron-hole pair (EHP); electrons and holes are sent in opposite directions to generate an electric current.

The main problem with this process is recombination, during which an electron recombines with a hole, thus reducing the initially generated current. Lakhtakia and his research team set out to develop a solar cell that could enhance photon absorption, maximize EHP generation and minimize recombination—and do so inexpensively.

"The majority of commercial solar cells employ silicon as a semiconductor, which is very efficient at approximately 25 percent and readily available, but also very expensive in underdeveloped economies," said Lakhtakia. "These cells contain three types of semiconductors, so their complex structure adds to the manufacturing cost."

Children could extend their study hours with nightime lighting provided by inexpensive solar cells. Credit: Abbie Trayler-Smith / Panos Pictures / Department for International Development

During his investigation into less-expensive solutions, Lakhtakia came across a solar cell structure called a Schottky-barrier solar cell, which is not normally known to be efficient, but only requires one type of semiconductor.

"Instead of using silicon with the Schottky cell, we explored materials that could give us some advantage with their semiconducting properties," said Lakhtakia. "We chose indium gallium nitride, an alloy in which the proportions of indium and gallium can be varied in the thickness direction."

By tailoring that proportion periodically and incorporating a periodically corrugated metallic back reflector, the research team discovered it could increase photon absorption by intensifying the electric field at optical frequencies inside the semiconductor. The team also realized an increased EHP-generation rate and a reduced recombination rate to generate more current. The efficiency rose from 13 percent to 17 percent—an acceptable level for everyday power usage.

With this simple architecture, less technical expertise would be required to produce the cells, which would save costs. The reduction in the types of semiconductors would significantly reduce manufacturing costs. The cells could also be deployed and installed with minimal resources.

"Sometimes, you have to solve societal problems not in the most efficient way but in the most economical way," said Lakhtakia. "These solar cells could be deployed widely in energy resource-poor areas and provide enough electricity to help individuals and families meet their most basic human needs."

Access to clean, reliable, sustainable and affordable modern energy would enhance the lives of the poor in countless ways, enabling them to not merely survive, but also thrive. Nighttime lighting would allow children to extend their study hours. Refrigeration could improve food quality and allow safe storage of medicines. Potable water could reduce incidence of disease, and modern cooking facilities could eliminate the use of solid biomass for cooking, which causes approximately 3.5 million premature deaths per year from indoor air pollution.

"The world has reveled in many magnificent feats of engineering," said Lakhtakia. "Look at the Concorde—it was a technological marvel—but who could afford to fly on it? What good is producing something if very few can afford to use it?

"What I'm interested in is providing 'affordable engineering' that is respectful of the environment and will enable and empower all people to achieve their full potential. If we can do that as engineers, it will truly be transformative for societies throughout the world."

Something to think about while you're sitting in the dark tonight.

Provided by Pennsylvania State University

Citation: Enhanced efficiency of simple, inexpensive solar cells could transform energy-starved communities (2017, May 18) retrieved 26 April 2024 from https://phys.org/news/2017-05-efficiency-simple-inexpensive-solar-cells.html