Environment News Futures

Major Challenge in Mass Production of Low-cost Solar Cells Solved

Spray coating could make perovskite an inexpensive alternative to silicon for solar panels, explains BYU Tandon School of Engineering's André D. Taylor

NYU Tandon School of Engineering— June 21, 2018

An international team of university researchers today reports solving a major fabrication challenge for perovskite cells—the intriguing potential challengers to silicon-based solar cells. The team reveals a new scalable means of applying the compound PCBM, a critical component, to perovskite cells.

These crystalline structures show great promise because they can absorb almost all wavelengths of light. Perovskite solar cells are already commercialized on a small scale, but recent vast improvements in their power conversion efficiency (PCE) are driving interest in using them as low-cost alternatives for solar panels.

In the cover article published online today for the June 28, 2018 issue of *Nanoscale*, a publication of the Royal Society of Chemistry, the research team reveals a new scalable means of applying a critical component to perovskite cells to solve some major fabrication challenges. The researchers were able to apply the critical electron transport layer (ETL) in perovskite photovoltaic cells in a new way—spray coating—to imbue the ETL with superior conductivity and a strong interface with its neighbour, the perovskite layer.

The research is led by André D. Taylor, an associate professor in the NYU Tandon School of Engineering's Chemical and Biomolecular Engineering Department, with Yifan Zheng, the first author on the paper and a Peking University researcher. Co-authors are from the University of Electronic Science and Technology of China, Yale University, and Johns Hopkins University.

Most solar cells are "sandwiches" of materials layered in such a way that when light hits the cell's surface, it excites electrons in negatively charged material and sets up an electric current by moving the electrons toward a latticework of positively charged "holes". In perovskite solar cells with a simple planar orientation called p-i-n (or n-i-p when inverted), the perovskite constitutes the light-trapping intrinsic layer (the "I" in p-i-n) between the negatively charged ETL and a positively charged hole transport layer (HTL).

When the positively and negatively charged layers are separated, the architecture behaves like a subatomic game of Pachinko in which photons from a light source dislodge unstable electrons from the ETL, causing them to fall toward the positive HTL side of the sandwich. The perovskite layer expedites this flow. While perovskite makes for an ideal intrinsic layer because of its strong affinity both for holes and electrons and its quick reaction time, commercial-scale fabrication has proved challenging partly because it is difficult to effectively apply a uniform ETL layer over the crystalline surface of the perovskite.

The researchers chose the compound [6,6]-phenyl-C(61)-butyric acid methyl ester (PCBM) because of its track record as an ETL material and because PCBM applied in a rough layer offers the possibility of improved conductivity, less-penetrable interface contact, and enhanced light trapping. "Very little research has been done on ETL options for the planar p-i-n design," said Taylor. "The key challenge in planar cells is, how do you actually assemble them in a way that doesn't destroy the adjacent layers?"

The most common method is spin casting, which involves spinning the cell and allowing centripetal force to disperse the ETL fluid over the perovskite substrate. But this technique is limited to small surfaces and results in an inconsistent layer that lowers the performance of the solar cell. Spin casting is also inimicable to commercial production of large solar panels by such methods as roll-to-roll manufacture, for which the flexible p-i-n planar perovskite architecture is otherwise well suited.

The researchers instead turned to spray coating, which applies the ETL uniformly across a large area and is suitable for manufacturing large solar panels. They reported a 30 percent efficiency gain over other ETLs—from a PCE of 13 percent to over 17 percent—and fewer defects. Added Taylor, "Our approach is concise, highly reproducible, and scalable. It suggests that spray coating the PCBM ETL could have broad appeal toward improving the efficiency baseline of perovskite solar cells and providing an ideal platform for record-breaking p-i-n perovskite solar cells in the near future."

New World Atlas of Desertification Shows Unprecedented Pressure on Planet's Resources

European Commission Joint Research Centre—June 21, 2018

The World Desertification Atlas by the European Commission's Joint Research Centre provides the first comprehensive, evidence-based assessment of land degradation at a global level and highlights the urgency to adopt corrective measures.

Climate Change to Overtake Land Use as Major Threat to Global Biodiversity

University College London—June 19, 2018

Climate change will have a rapidly increasing effect on the structure of global ecological communities over the next few decades, with amphibians and reptiles being significantly more affected than birds and mammals, a new report by UCL finds.

The pace of change is set to outstrip loss to vertebrate communities caused by land use for agriculture and settlements, which is estimated to have already caused losses of over ten per cent of biodiversity from ecological communities.

Previous studies have suggested that ecosystem function is substantially impaired where more than 20 per cent of species are lost; this is estimated to have occurred across over a quarter of the world's surface, rising to nearly two thirds when roads are taken into account.

The new study, published today in *Proceedings of the Royal Society B*, shows that the effects of climate change on ecological communities are predicted to match or exceed land use in its effects on vertebrate community diversity by 2070.

Machine Learning may be a Game-changer for Climate Prediction

Columbia University School of Engineering and Applied Science—June 19, 2018

A major challenge in current climate prediction models is how to accurately represent clouds and their atmospheric heating and moistening. This challenge is behind the wide spread in climate prediction. Yet accurate predictions of global warming in response to increased greenhouse gas concentrations are essential for policy-makers (e.g. the Paris climate agreement).

In a paper recently published online in *Geophysical Research Letters* (May 23), researchers led by Pierre Gentine, associate professor of earth and environmental engineering at Columbia Engineering, demonstrate that machine learning techniques can be used to tackle this issue and better represent clouds in coarse resolution (~100 km) climate models, with the potential to narrow the range of prediction.

"This could be a real game-changer for climate prediction," says Gentine, lead author of the paper, and a member of the Earth Institute and the Data Science Institute. "We have large uncertainties in our prediction of the response of the Earth's climate to rising greenhouse gas concentrations. The primary reason is the representation of clouds and how they respond to a change in those gases. Our study shows that machine-learning techniques help us better represent clouds and thus better predict global and regional climate's response to rising greenhouse gas concentrations."

Palm Oil: The Carbon Cost of Deforestation

Ecole Polytechnique Fédérale de Lausanne—June 19, 2018

Palm oil has become part of our daily lives, but a recent study serves as a reminder that intensive farming of this crop has a major impact on the environment. Both short- and long-term solutions exist, however. The article analyzed the carbon costs and benefits of converting rainforests into oil palm plantations. *See also snapshot* 1.

Reduction in Sulphur Emissions from Power Plants in China

June 18, 2018

Air pollution has smothered China's cities in recent decades. In response, the Chinese government has implemented measures to clean up its skies. But are those policies effective? Now scholars ...

Cementless Fly Ash Binder Makes Concrete 'Green'

Engineers have developed a composite binder made primarily of fly ash, a byproduct of coal-fired power plants, that can replace Portland cement in concrete.

Rice University—June 18, 2018

Rice University engineers have developed a composite binder made primarily of fly ash, a byproduct of coal-fired power plants, that can replace Portland cement in concrete.

The material is cementless and environmentally friendly, according to Rice materials scientist Rouzbeh Shahsavari, who developed it with graduate student Sung Hoon Hwang.

Fly ash binder does not require the high-temperature processing of Portland cement, yet tests showed it has the same compressive strength after seven days of curing. It also requires only a small fraction of the sodium-based activation chemicals used to harden Portland cement.

The results are reported in the *Journal of the American Ceramic Society*.

More than 20 billion tons of concrete are produced around the world every year in a manufacturing process that contributes 5 to 10 percent of carbon dioxide to global emissions, surpassed only by transportation and energy as the largest producers of the greenhouse gas.

Manufacturers often use a small amount of silicon- and aluminum-rich fly ash as a supplement to Portland cement in concrete. "The industry typically mixes 5 to 20 percent fly ash into cement to make it green, but a significant portion of the mix is still cement," said Shahsavari, an assistant professor of civil and environmental engineering and of materials science and nanoengineering.

Previous attempts to entirely replace Portland cement with a fly ash compound required large amounts of expensive sodium-based activators that negate the environmental benefits, he said. "And in the end it was more expensive than cement," he said.

The researchers used Taguchi analysis, a statistical method developed to narrow the large phase space—all the possible states—of a chemical composition, followed by computational optimization to identify the best mixing strategies.

This greatly improved the structural and mechanical qualities of the synthesized composites, Shahsavari said, and led to an optimal balance of calcium-rich fly ash, nanosilica and calcium oxide with less than 5 percent of a sodium-based activator.

"A majority of past works focused on so-called type F fly ash, which is derived from burning anthracite or bituminous coals in power plants and has low calcium content," Shahsavari said. "But globally, there are significant sources of lower grade coal such as lignite or sub-bituminous coals. Burning them results in high-calcium, or type C, fly ash, which has been more difficult to activate.

"Our work provides a viable path for efficient and cost-effective activation of this type of high-calcium fly ash, paving the path for the environmentally responsible manufacture of concrete. Future work will assess such properties as long-term behaviour, shrinkage and durability."

Shahsavari suggested the same strategy could be used to turn other industrial waste, such as blast furnace slag and rice hulls, into environmentally friendly cementitious materials without the use of cement.

World's Oldest Sumatran Orangutan Dies aged 62

AFP—June 19, 2018

Perth: The world's oldest *Sumatran orangutan*, which had 11 children and 54 descendants spread across the globe, has died aged 62, Australian zoo officials said Tuesday. Puan, Indonesian for "lady", died on Monday at Perth Zoo, where she had lived since being gifted by Malaysia in 1968. "She did so much for the colony at Perth Zoo and the survival of her species," said primate supervisor Holly Thompson. "Apart from being the oldest member of our colony, she was also the founding member of our world renowned breeding programme and leaves an incredible legacy." Her genetics count for just under 10 percent of the global zoological population. Puan had 11 children and a total of 54 descendants in the United States, Europe, Australasia and the jungles of Sumatra. Her great grandson Nyaru was the latest individual to be released into the wild. Born in 1956, she was noted by the Guinness Book of Records as being the oldest verified Sumatran orangutan in the world. Female orangutans rarely live beyond 50 in the wild. Thompson said she was an aloof and independent individual. "You always knew where you stood with Puan, and she would actually stamp her foot if she was dissatisfied with something you did." She leaves two daughters at the zoo, along with four grandchildren and a great grandson. *See also snapshot* 2.