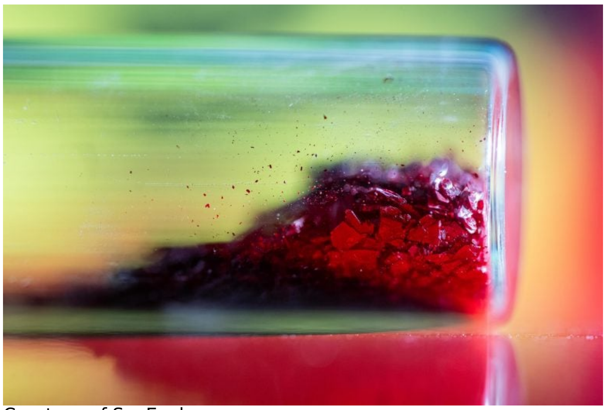
Solar Cells Are About to Reduce Prices and Increase Energy Production

Posted by Okachinepa 10/10/2024

Courtesy of SynEvol
Credit:Jeff Fitlow/ Rice University

Recently, scientists at Rice University have created a technique for creating ultrastable, superior photovoltaic films from formamidinium lead iodide (FAPbI3), the kind of crystal that is typically utilized to create the most efficient perovskite solar cells. After operating at 85 degrees Celsius (185 Fahrenheit) for over 1,000 hours, the resulting FAPbI3 solar cells' total efficiency dropped by less than 3%.

Aditya Mohite, a Rice engineer, stated, "At this point, we think that this is state of the art in terms of stability." Over the previous few years, Mohite's team has gradually improved the perovskites' performance and longevity. "The production of energy could be revolutionized by perovskite solar cells, but attaining long-duration stability has proven to be a significant challenge."



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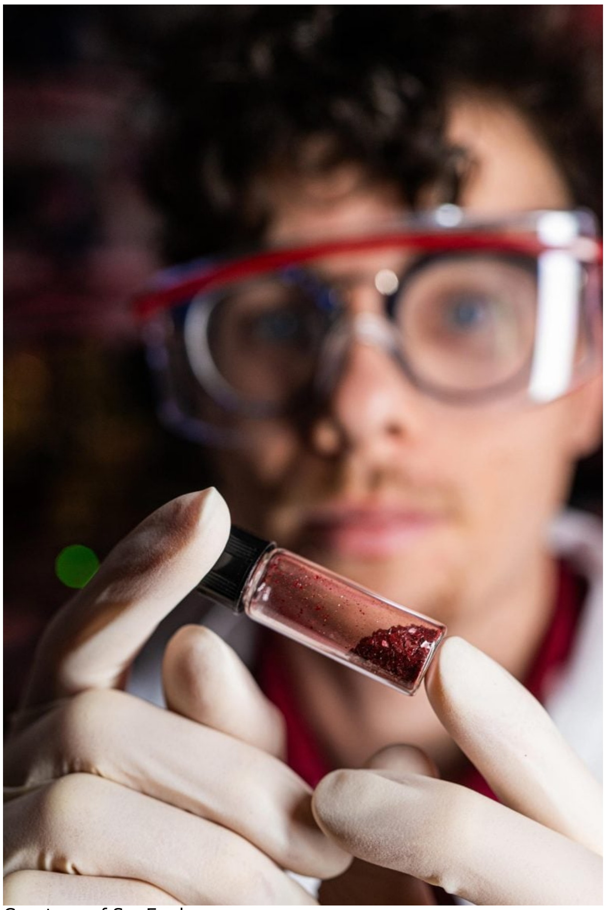
Mohite and associates have made significant progress toward bringing perovskite photovoltaics to the market with this most recent discovery. The secret was to add a small amount of specifically made two-dimensional (2D) perovskites to the FAPbI3 precursor solution in order to "season" it. These provided additional compression and stability to the crystal lattice structure by acting as a template to direct the formation of the bulk/3D perovskite.

Lead author of the study Isaac Metcalf, a graduate student studying materials science and nanoengineering at Rice University, explained that there are two ways that perovskite crystals can break: chemically, by destroying the molecules that make up the crystal, and structurally, by rearranging the molecules to form a new crystal. The most chemically stable crystals are also the least structurally stable among the several crystals we utilize in solar cells, and vice versa. At the structurally unstable end of that spectrum is FAPbI3.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Even while 2D perovskites are chemically and physically more stable than $FAPbI_3$, they are generally not very good at absorbing light, which makes them a bad material choice for solar cells. Nonetheless, the researchers postulated that the stability of 2D perovskites may be transferred to $FAPbI_3$ films through their employment as templates. They created four distinct types of 2D perovskites—two with surface structures almost identical to $FAPbI_3$ and two less well matched—and utilized them to create various $FAPbI_3$ film formulations in order to test this theory.

According to Metcalf, "our hypothesis was validated when well-matched 2D crystals were added, making it easier for $FAPbI_3$ crystals to form, while poorly matched 2D crystals actually made it harder to form." "$FAPbI_3$ films with 2D crystal templates were of higher quality, displaying a stronger response to illumination and less internal disorder, which translated into higher efficiency."

The $FAPbI_3$ solar cells' durability and efficiency were both increased by the 2D crystal templates. Solar cells with 2D templates did not begin to deteriorate even after 20 days of producing energy from sunshine in the air, in contrast to solar cells without any 2D crystals, which began to dramatically deteriorate after just two days. Through the addition of an encapsulating layer, stability was increased to the point where the 2D-templated solar cells were almost commercially relevant.

These discoveries could significantly alter photovoltaic, or light-harvesting, technologies by lowering production costs and facilitating the development of solar panels with a more straightforward design that are more flexible and lightweight than silicon-based alternatives.

"Since perovskites dissolve in water, you can apply a perovskite precursor ink on a piece of glass, heat it up, and voila! You have the absorber layer for a solar cell," explained Metcalf. "Perovskite films can be manufactured at temperatures below 150 degrees Celsius (302 degrees Fahrenheit), which theoretically means perovskite solar panels can be made on plastic or even flexible substrates, which might further cut costs," the statement reads.

Compared to emerging alternatives, silicon requires more resources during the manufacturing process, despite being the most commonly used semiconductor in solar cells. The most notable of them are halide perovskites, whose efficiencies have skyrocketed from 3.9% in 2009 to over 26% at present.

Because the procedure is so much simpler, producing high-quality perovskite solar panels should be far less expensive and energy-intensive than producing high-quality silicon panels, according to Metcalf.

Metcalf continued, citing figures from the UN Intergovernmental Panel on Climate Change that "make a strong case for solar as an alternative to fossil fuels" as evidence of the urgent need to switch the world's energy system to one that is emissions-free.

In order to meet the 2030 greenhouse gas emissions target and avoid a 1.5 degree Celsius increase in global temperatures, Mohite emphasized that developments in solar energy technologies and infrastructure are essential. This "would then set us on the right course to achieve net zero carbon emissions by 2050."

"Thermochemical or electrochemical processes for chemical manufacturing, as well as other processes that depend on green electrons from the grid, will not occur if solar electricity is not generated," Mohite stated. "Photovoltaics are vitally important."

Mohite is the faculty director of the Rice Engineering Initiative for Energy Transition and Sustainability, a professor of chemical and biomolecular engineering, and the William M. Rice Trustee Professor at Rice University. The study's principal author is Siraj Sidhik, a Rice doctorate alumnus, in addition to Metcalf.

"I want to give a lot of credit to Siraj for initiating this project based on a theoretical idea from University of Rennes Professor Jacky Even," Mohite stated. "I also want to express my gratitude to our partners at the national laboratories and various universities both domestically and internationally, whose assistance was crucial to this work."