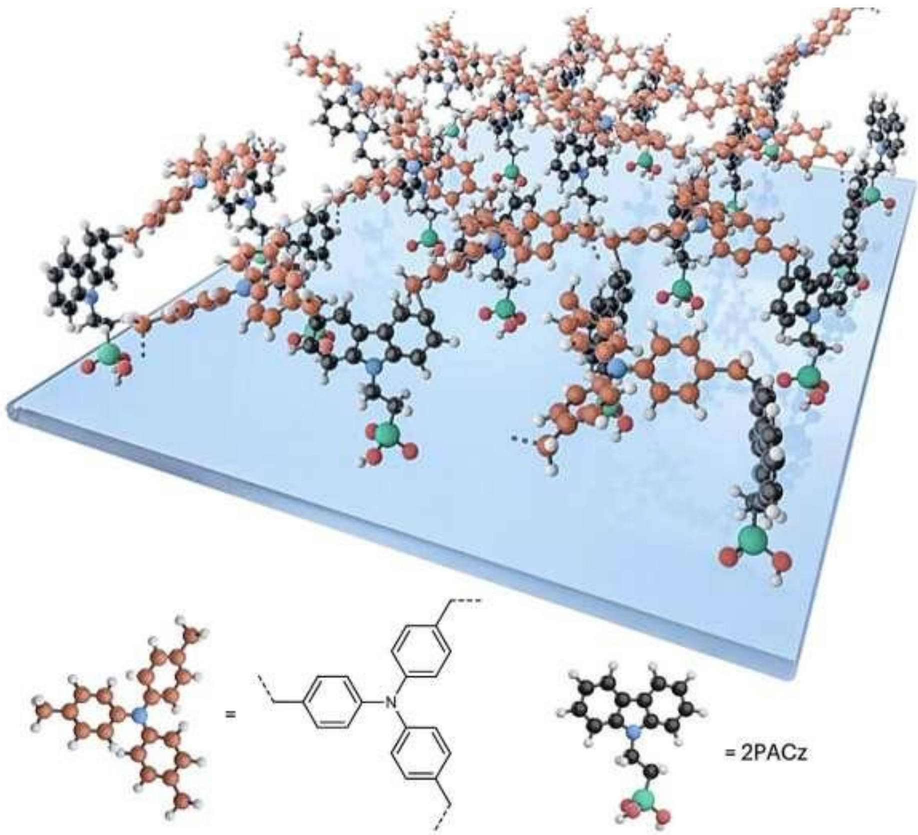
JANUARY 20, 2025

A self-assembled bilayer could enhance the thermal stability of perovskite solar cells



Schematic diagram illustrating the structure of the self-assembled bilayer (SAB).
Credit: *Nature Energy* (2025). DOI: 10.1038/s41560-024-01689-2

Over the past few years, photovoltaic (PV) technologies have become increasingly widespread, contributing to the ongoing quest to reduce greenhouse gas emissions. While most solar cells on the market today are made of silicon, other materials are emerging as promising alternatives for developing PV solutions.

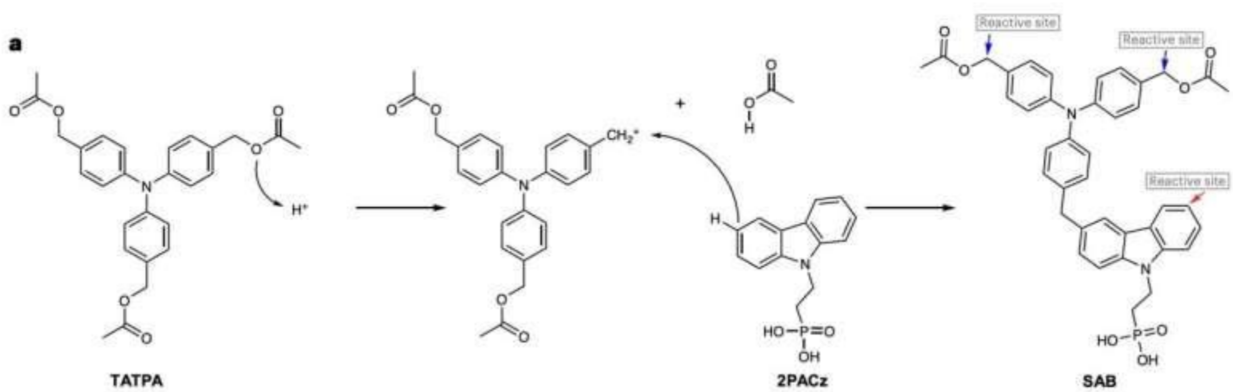
Perovskites are among these materials, as they could be used to create more affordable solar cells that exhibit high power conversion efficiencies. Despite their potential, perovskite solar cells (PSCs) are not as stable as their silicon counterparts and their performance tends to decline at high temperatures and under fluctuating environmental conditions.

A feature of these solar cells that can contribute to their degradation over time is their reliance on hole-selective self-assembled monolayers (SAMs), molecular films that help to attract positive charge carriers. These films often do not adhere well to the cells' surface and contribute to the thermal instability of PSCs.

Researchers at Xi'an Jiaotong University, Uppsala University and other institutes recently designed a self-assembled bilayer film that could overcome the limitations of conventional SAMs. Their paper, published in *Nature Energy*, shows that this structured bi-layer molecular film could adhere better to PSCs, enhancing their thermal stability and overall performance.

"The adoption of PSCs requires improved resistance to high temperatures and temperature variations," wrote Bitao Dong, Mingyang Wei and their colleagues in their paper.

"Hole-selective SAMs have enabled progress in the performance of inverted PSCs, yet they may compromise temperature stability owing to desorption and weak interfacial contact. We developed a self-assembled bilayer by covalently interconnecting a phosphonic acid SAM with a triphenylamine upper layer."



The mechanism underpinning the coupling reaction between TATPA and 2PACz.
Credit: *Nature Energy* (2025). DOI: 10.1038/s41560-024-01689-2
The new self-assembled bilayer designed by the researchers adds an upper layer to a conventional SAM based on phosphonic acid. This upper layer, made of the organic compound triphenylamine, forms covalent bonds with the SAM, producing a polymerized network.

"This polymerized network, formed through Friedel–Crafts alkylation, resisted thermal degradation up to 100 °C for 200 h," wrote Dong, Wei and their colleagues. "The face-on-oriented upper layer exhibited adhesive contact with perovskites, leading to a 1.7-fold improvement in adhesion energy compared with the SAM–perovskite interface."

Dong, Wei and their colleagues tested their self-assembled bilayer in a series of tests and found that it adheres better to perovskite surfaces than commonly employed mono-layer SAMs. Notably, the approach used to produce the bi-layer film is also versatile and can be applied to various SAM-forming molecules and alkylating agents.

The researchers also applied their self-assembled bilayer to inverted PSCs to explore how it affected their performance. Their findings were very promising, as introducing these films resulted in good power-conversion efficiencies while also limiting the cells' loss of efficiency over time and boosting their stability at high temperatures.

"We reported power conversion efficiencies exceeding 26% for inverted PSCs," wrote Dong, Wei and their colleagues. "The champion devices demonstrated less than 4% and 3% efficiency loss after 2,000 h damp heat exposure (85 °C and 85% relative humidity) and over 1,200 thermal cycles between −40 °C and 85 °C, respectively, meeting the temperature stability criteria outlined in the International Electrotechnical Commission 61215:2021 standards."

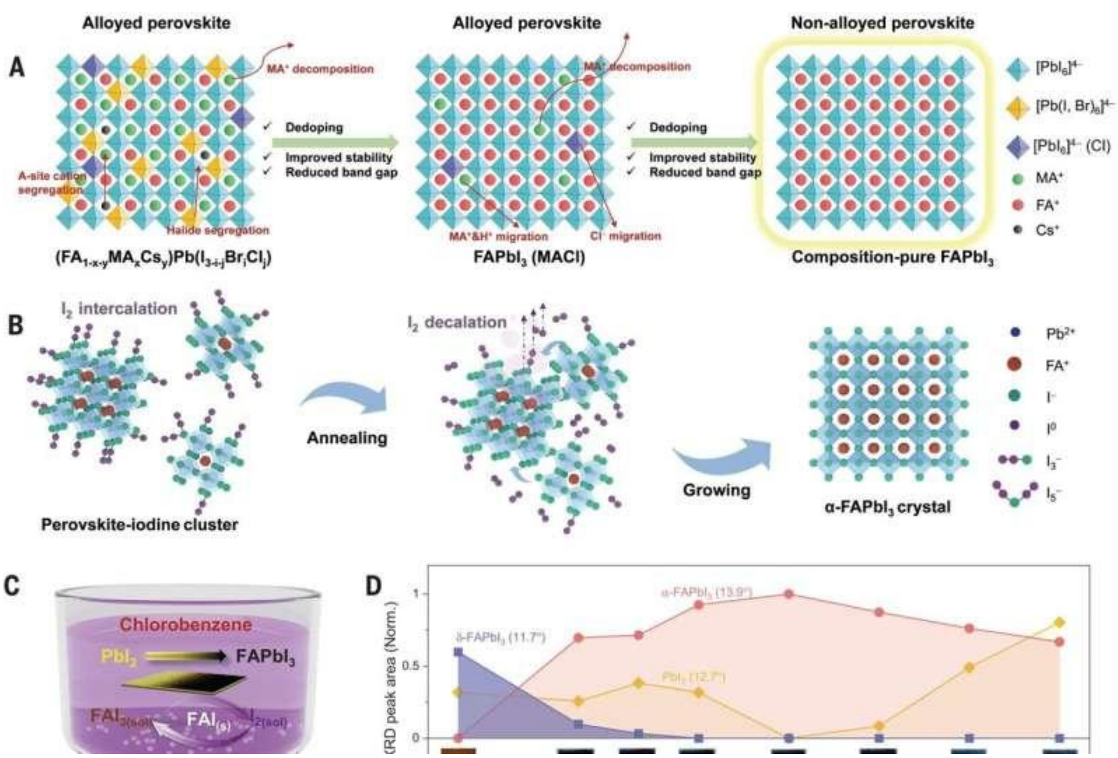
In the future, the approach devised by this research group could be used to create other self-assembled bilayer films to improve the stability of PSCs. Collectively, these efforts could help to advance perovskite-based photovoltaics, which could contribute to their widespread adoption.

More information: Bitao Dong et al, Self-assembled bilayer for perovskite solar cells with improved tolerance against thermal stresses, *Nature Energy* (2025). DOI: 10.1038/s41560-024-01689-2.
Journal information: Nature Energy

FEBRUARY 7, 2025

Perovskite solar cells achieve 24% efficiency with novel iodine technique

by Peking University



Design principle and proof of concept for iodine-mediated formation of nonalloyed α-$FAPbI_3$. Credit: *Science* (2025). DOI: 10.1126/science.ads8968

A team led by Professor Zhou Huanping from Peking University has published two papers in the field of perovskite solar cells in *Science*.

"Wafer-scale monolayer MoS_2 film integration for stable, efficient perovskite solar cells" was published on January 9, 2025, and "Nonalloyed α-phase formamidinium lead triiodide solar cells through iodine intercalation" was published on January 16, 2025.

Given its photovoltaic properties, low cost and thermal stability, formamidinium lead triiodide ($FAPbI_3$) has served as a competitive optimal absorber for high-efficiency single-junction perovskite solar cells but is prone to complex crystallization kinetics and thermodynamic metastability at room temperature, presenting huge challenges in its crystallization quality and stability in practical applications.

While alloying strategies such as adding methylammonium hydrochloride and Cs^+ can effectively control the crystallization process and photoelectric properties of formamidinium-based perovskites films, it may leave behind residual compositional additives that often lead to cation-anion separation, thermal decomposition and potential nucleophilic reactions.

Such obstacles complicate the preparation of high quality, non-alloyed α-$FAPbI_3$ perovskite films and related devices.

Professor Zhou, alongside her project group, proposed an innovative iodine intercalation-decalation strategy to produce high-quality, nonalloyed α-$FAPbI_3$ perovskite films, thereby improving the efficiency and stability of perovskite solar cells.

The strong bonding between cogenetic iodine (I_2) and I^- forms polyiodide ions, which changes the original $FAI+PbI_2 \rightarrow FAPbI_3$ reaction path to $FAI_3+PbI_2 \rightarrow FAPbI_3+I_2$, which is conducive to overcoming the barrier in α-$FAPbI_3$ formation.

Furthermore, owing to its volatility property, I_2 is removed from the lattice during annealing, ensuring the absence of any extrinsic residue on the high-quality, nonalloyed α-$FAPbI_3$ film.

The nonalloyed α-$FAPbI_3$ film produced from the iodine intercalation-decalation reaction demonstrates a substantial improvement in the crystal quality and uniformity. In addition, enhanced thermal stability of the film inhibits ion migration.

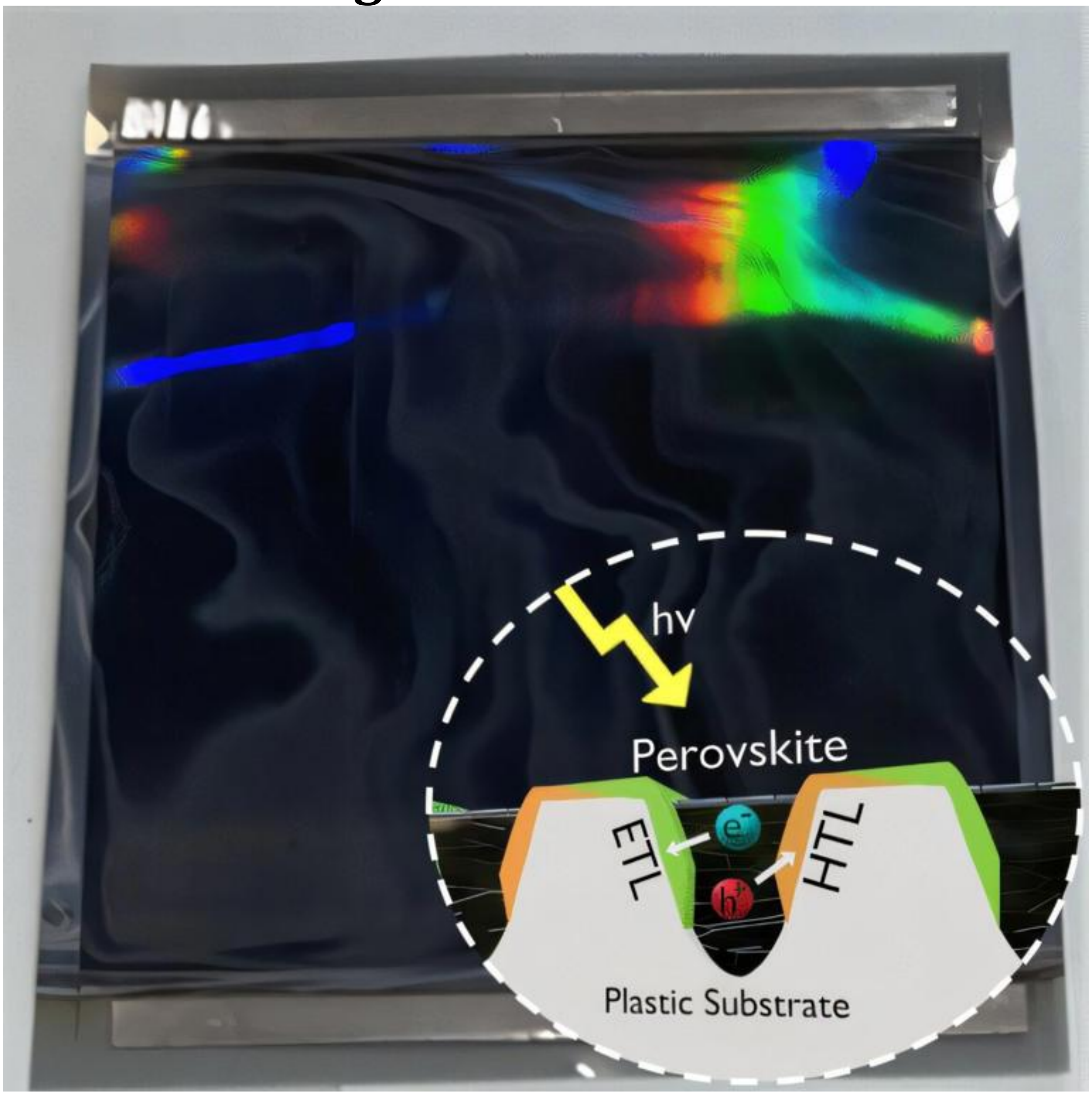
The nonalloyed α-$FAPbI_3$ film-based solar cells exhibited a power conversion efficiency of over 24% and retained 99% of their original efficiency after more than 1,100 hours of operation at 85°C under illumination.

This work underscores Professor Zhou and her team's innovations in photovoltaic technology, addressing the challenges in achieving stability and high efficiency in perovskite solar cells.

More information: Yu Zhang et al, Nonalloyed α-phase formamidinium lead triiodide solar cells through iodine intercalation, *Science* (2025). DOI: 10.1126/science.ads8968

Huachao Zai et al, Wafer-scale monolayer MoS 2 film integration for stable, efficient perovskite solar cells, *Science* (2025). DOI: 10.1126/science.ado2351
Journal information: Science
Provided by Peking University

Tiny grooves reshape future of solar cell manufacturing



Graphical abstract. Credit: ACS Applied Energy Materials (2025). DOI: 10.1021/acsaem.4c02734

Flexible solar cells that do not contain any rare earth metal are paving the way for the development of low-cost, efficient solar energy, according to new research by the University of Sheffield.

The research, which is in partnership with UK company Power Roll Ltd and published in *ACS Applied Energy Materials*, highlights the development of a new type of solar cell using a perovskite semiconductor. Unlike traditional solar cells, these cells are made by embossing tiny grooves into a plastic film and then filling them with the perovskite material.

This innovative approach presents a new way to produce lightweight, flexible solar films that can be used on surfaces such as rooftops and other unconventional surfaces that normally cannot stand the weight of solar panels. Together with their anticipated low cost, this could significantly enhance the roll out of solar, particularly in developing countries.This could make a real difference in the drive to replace fossil fuels with sustainable solar energy.

The new microgroove structure creates a new type of solar cell that has a back-contact format. Regular devices use a sandwich structure composed of a number of layers deposited in a specific order. The back-contact cells have all the electrical contacts on the back of the device, making it easier and cheaper to manufacture, with the potential for high efficiency.

To check the structure and composition of the solar cells, a hard X-ray nanoprobe microscope at Diamond Light Source in Oxfordshire was used to take very detailed images of the solar cells. These also helped to spot hidden problems like empty spaces, flaws and the boundaries between tiny crystals within the semiconductor material. This was the first time this type of analysis had been used on this kind of solar cell.

The new technology also avoids the use of rare and expensive materials such as indium, making it cost-effective, scalable, and sustainable.

Professor David Lidzey, from the School of Mathematical and Physical Sciences at the University of Sheffield and co-author of the paper, said, "A key advantage of these flexible films is that the panel can be stuck onto any surface. In the UK, you currently have to think twice about adding thick solar panels onto relatively fragile roofs of warehouses that are not really designed to be load-bearing. With this lightweight solar technology, you could essentially stick it anywhere. This could be a game-changer for solar energy in low- and middle-income countries.

"Solar energy is a strategic priority for our research and one of our key competences is developing innovative techniques for fabricating and depositing solution-processable solar cells.

"We've partnered with Power Roll for over 10 years, combining our expertise in materials science and advanced imaging techniques with their focus on manufacturing and this collaboration has been very successful, resulting in this exciting new product."

The University of Sheffield is globally recognized as a leader in sustainability and advanced manufacturing. The university's dedication to tackling global energy challenges and commitment to renewable energy make it the ideal partner for Power Roll, whose technology aims to shape global clean energy solutions via a secure and deployable product. In recent years, the two have worked together on multiple occasions to develop the technology needed to cultivate a brighter future for the UK.

Dr. Nathan Hill, Research Scientist at Power Roll and lead author of the paper, said, "This partnership demonstrates the potential of combining cutting-edge research with industrial innovation to deliver transformative solutions in renewable energy. We are advancing technology that could play a significant role in achieving global net-zero targets, and by combining our collective research and academic capabilities we are able to further prove out the science sitting behind Power Roll's technology.

"It's exciting to see our relationship with the University of Sheffield continue to strengthen. Previously, we have worked with the University's Department of Physics and Astronomy to further develop our solar designs, which not only reduced manufacturing costs but also enhanced solar efficiency."

With perovskite solar generation still an emerging field, ongoing research and academic focus is greatly accelerating the advance of product development and scientific understanding. The next phase of the work on this project will be to further develop the use of X-ray microscopy in characterizing these materials. New experiments are scheduled this summer, at the Diamond Light Source, to help understand key aspects of device operation, particularly device stability.

Dr. Jessica Walker, I14 beamline scientist at Diamond Light Source Ltd., said, "The techniques and resolution offered by I14 are ideally suited to help answer scientific questions that remain around perovskite based solar cell materials. It is exciting to see how our capabilities have contributed to both academic and industrial research, and culminated in such a promising development for the field of energy materials, as well as a direct and tangible application with high potential for impact."

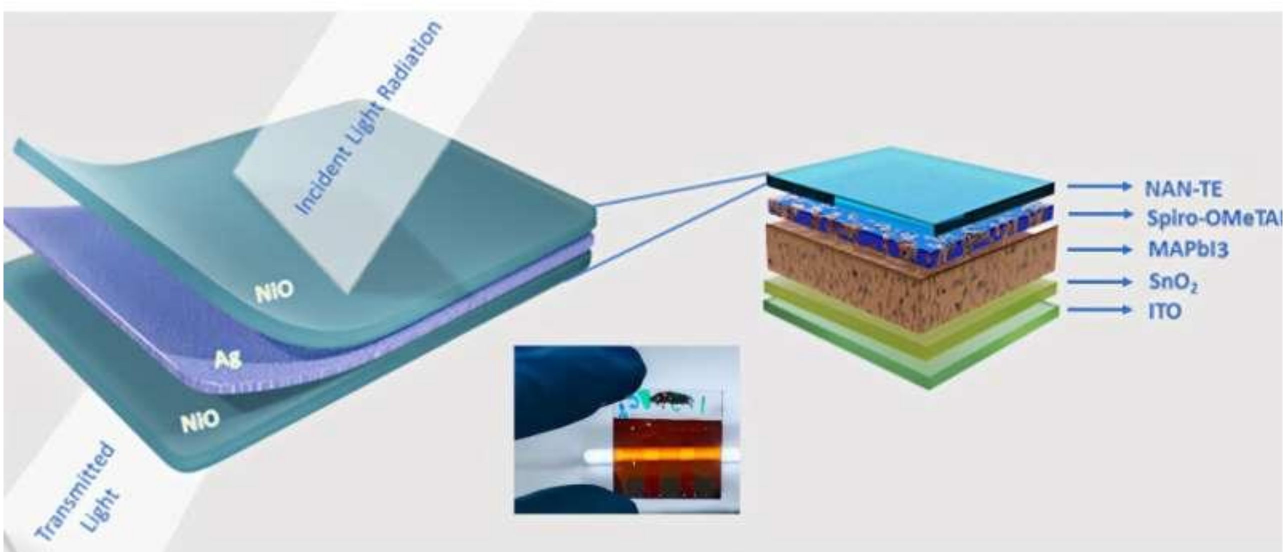
More information: Dominic Blackburn et al, Back-Contact Perovskite Solar Cell Modules Fabricated via Roll-to-Roll Slot-Die Coating: Scale-Up toward Manufacturing, *ACS Applied Energy Materials* (2025). DOI: 10.1021/acsaem.4c02734

Provided by University of Sheffield

FEBRUARY 20, 2025

Hybrid transparent electrodes enhance efficiency and longevity of perovskite solar cells

by SPIE

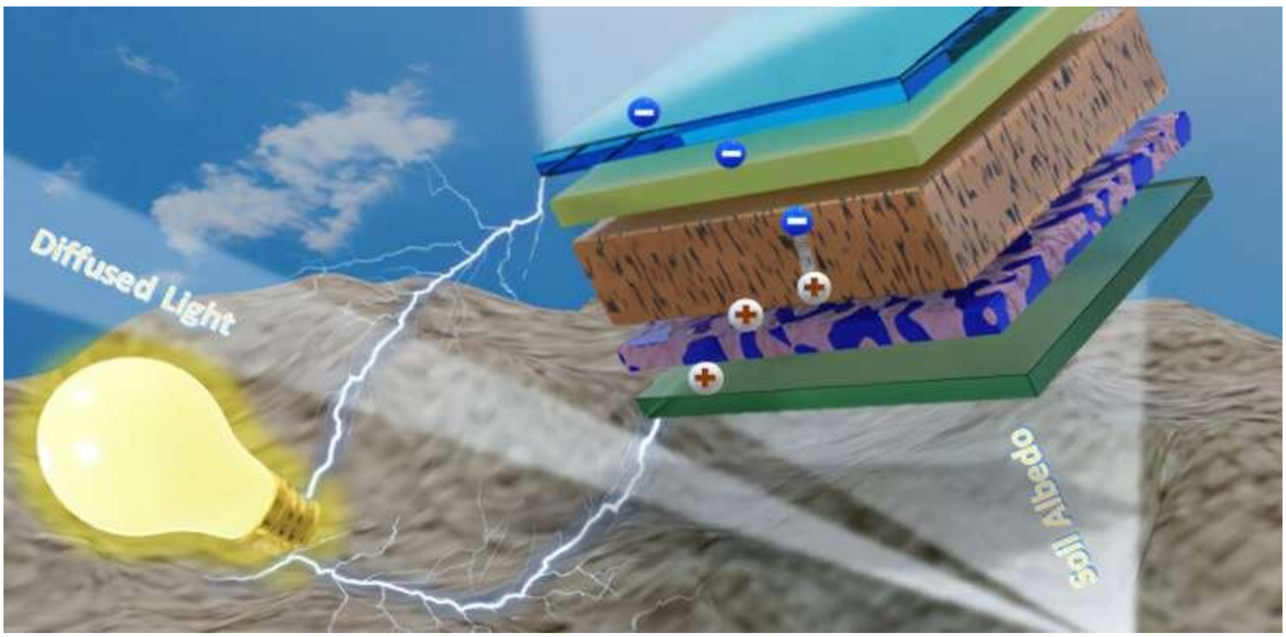


A three-layer transparent electrode is used in the fabrication of the bifacial perovskite solar cell. Credit: *Journal of Photonics for Energy* (2025). DOI: 10.1117/1.JPE.15.015501

Bifacial perovskite solar cells are known for their ability to harness sunlight from both sides. Researchers from the Indian Institute of Technology (IIT) recently made significant strides in their development with a novel NiO/Ag/NiO transparent electrode that helps to achieve high efficiency, durability, and infrared transparency, promising significant advances in solar energy applications.

As reported in the *Journal of Photonics for Energy*, a research team from IIT Dharwad designed and fabricated bifacial solar cells that are highly transparent to infrared light. They achieved this by incorporating a hybrid top transparent electrode (TE) in a three-layer structure of NiO/Ag/NiO (NAN). This innovative approach, using a low-energy physical vapor deposition technique, resulted in an electrode with very low electrical resistance and high visible light transmittance.

When integrated into the solar cell configuration, the NAN-TE demonstrated impressive power conversion efficiencies (PCE) of 9.05 and 6.54% when illuminated from different sides. A high bifaciality factor of 72% indicates the cell's ability to effectively capture light from both directions.



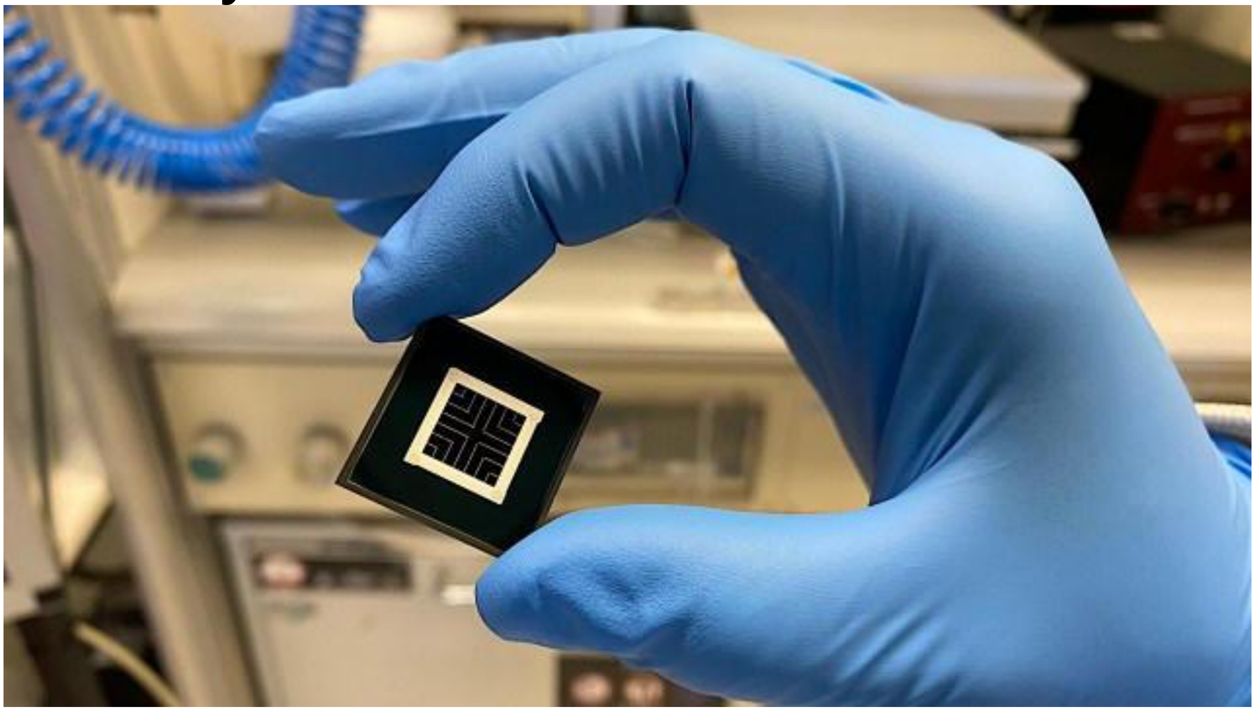
A bifacial solar cell can generate power by using the light coming directly from the sun as well as diffused light from clouds and reflected light from the ground surface (soil albedo). Credit: *Journal of Photonics for Energy* (2025). DOI: 10.1117/1.JPE.15.015501

Moreover, these bifacial solar cells exhibited remarkable durability, maintaining 80% of their initial efficiency for over 1,000 hours without any protective encapsulation. They also allowed significant light transmission in the near-infrared region, making them suitable for thermal windows and optoelectronic applications.

The thin profile of the NAN-TE—less than 40 nm—further enhances its potential for integration into building materials and tandem solar cell applications. Senior author Dhriti Sundar Ghosh, associate professor of physics at IIT Dharwad, remarks, "This work may provide a design strategy for TEs that can be included in bifacial perovskite solar cells for use in tandem devices, agrivoltaics, and automotive technologies, among other potential uses." This breakthrough highlights the immense potential of bifacial perovskite solar cells in advancing solar energy technology.

More information: Sonia Rani et al, Hybrid top transparent electrode for infrared-transparent bifacial perovskite solar cells, *Journal of Photonics for Energy* (2025). DOI: 10.1117/1.JPE.15.015501
Provided by SPIE

Researchers unveil game-changing solar tech after years of development — here's how it could revolutionize the energy industry



Researchers unveil game-changing solar tech after years of development — here's how it could revolutionize the energy industry

A major development has just struck the photovoltaic industry: perovskite–silicon tandem solar cells.

Photovoltaic cells — or solar cells — are, of course, devices that convert sunlight into electricity, found in solar panels and full-scale converters.

For the past five years, six institutes within the Germany-based Fraunhofer Society have collaborated on a project called "MaNiTU" to identify a sustainable and affordable way to market tandem solar cells manufactured using scalable processes, as reported by Tech Xplore.

They produced new materials using perovskite — a mineral made of calcium and titanium oxides with a specific crystal structure suitable for use in energy technologies like solar — and compared them with existing materials used at the cell level, finding that higher energy efficiency was more common with perovskite structures.

By then fabricating demonstrators such as a perovskite–silicon tandem solar cell, they created a production and recycling process perfect for producing a highly efficient and sustainable product.

Now, they can lace a high-quality perovskite thin film onto industrially textured silicon solar cells, achieving a fully textured perovskite–silicon tandem solar cell with 31.6% efficiency on a one-square-centimeter cell area.

"In particular, the scalable, semi-continuous perovskite synthesis in powder form using spray drying was shown to be a suitable screening method for a variety of compounds and their potential synthesis," said Dr. Benedikt Schug, head of particle technology at the Fraunhofer Institute for Silicate Research ISC, per Tech Xplore.

"This method can also be applied to industry-relevant quantities," he continued.

In other words, this process will allow for the industrial-scale production of small-sized solar cells that are highly efficient in their power capacity. Thousands will be produced frequently for use in solar panel production across Europe.

Although the only downside to using perovskite compounds is that they contain high lead levels, the researchers are currently investigating non-toxic alternatives and have found ways to recycle perovskite cells, ensuring consistent long-term reusability.

Next-generation solar cell is fully recyclable

Researchers at Linköping University have developed a method to recycle all parts of a perovskite solar cell repeatedly using water as the main solvent. (CREDIT: Thor Balkhed)© The Brighter Side of News

The increasing demand for electricity, driven by artificial intelligence, electrified transportation, and industrial expansion, has intensified the need for sustainable energy solutions.

Solar power, a renewable and abundant energy source, has been widely adopted through silicon-based photovoltaic panels. However, as these panels reach the end of their lifespan, the industry faces a growing challenge: managing solar waste.

The Mounting Problem of Solar Waste

Silicon solar panels, in use for over three decades, have significantly contributed to the global renewable energy transition. Yet, their disposal presents a pressing issue. With no efficient recycling process in place, many end up in landfills, creating vast amounts of electronic waste.

"There is currently no efficient technology to deal with the waste of silicon panels. That's why old solar panels end up in the landfill. Huge mountains of electronic waste that you can't do anything with," says Xun Xiao, a postdoctoral researcher at Linköping University.

When the water solvable solar cell is operational, it will be protected by a cover. (CREDIT: Thor Balkhed)© The Brighter Side of News

This challenge has pushed policymakers worldwide to enforce extended producer responsibility regulations. In the European Union, the Waste Electrical and Electronic Equipment (WEEE) directive mandates manufacturers to collect and recycle end-of-life photovoltaic products. Similar legislation exists in the United States and Asia, requiring producers to manage solar panel disposal sustainably.

As the industry shifts toward newer solar technologies, addressing these concerns early can prevent history from repeating itself. One of the most promising solutions comes from the next generation of solar cells: perovskite photovoltaics.

The Rise of Perovskite Solar Cells

Perovskite solar cells offer an attractive alternative to traditional silicon panels. They are lightweight, flexible, and can be applied to various surfaces, including windows and curved structures. Additionally, they exhibit high power conversion efficiency, with some reaching up to 25%—comparable to modern silicon cells.

"There are many companies that want to get perovskite solar cells on the market right now, but we'd like to avoid another landfill. In this project, we've developed a method where all parts can be reused in a new perovskite solar cell without compromising performance in the new one," says Niansheng Xu, another postdoctoral researcher at Linköping University.

Despite their advantages, perovskite solar cells have a shorter lifespan compared to their silicon counterparts. They also contain a small amount of lead, which is crucial for efficiency but poses environmental concerns. Proper recycling methods are essential to minimize waste and prevent harmful substances from leaching into the environment.

The Challenge of Recycling Perovskite Cells

Recycling perovskite solar cells is not a new concept. Conventional methods involve dissolving layers using hazardous solvents such as dimethylformamide (DMF), which is commonly found in paint removers. While effective in extracting materials for reuse, these solvents are toxic, environmentally damaging, and pose health risks.

Feng Gao, professor of optoelectronics at Linköping University, emphasizes the importance of integrating sustainability into solar technology development.

"We need to take recycling into consideration when developing emerging solar cell technologies. If we don't know how to recycle them, maybe we shouldn't put them on the market at all."

Recognizing this issue, researchers at Linköping University have developed a breakthrough solution: a recycling process that eliminates the need for hazardous solvents. Instead, their method uses water as the primary solvent, making it a safer and more environmentally friendly alternative.

A Breakthrough in Solar Recycling

The innovative process, published in Nature, enables the complete recovery of all solar cell components—covering glass, electrodes, perovskite layers, and charge transport layers—without compromising efficiency. The recycled solar cells maintain the same performance as newly manufactured ones.

Niansheng Xu and Xun Xiao are the main authors of the paper published in the journal Nature. (CREDIT: Thor Balkhed)© The Brighter Side of News

"We can recycle everything—covering glasses, electrodes, perovskite layers, and also the charge transport layer," says Xun Xiao.

This discovery represents a major step forward in solar sustainability. By using water as a solvent, the process reduces environmental risks and aligns with industrial safety standards. More importantly, it offers a scalable recycling approach that could be integrated into large-scale production.

Looking ahead, the researchers aim to refine their method for industrial application. If successful, this innovation could redefine the solar industry's approach to waste management, making perovskite solar cells not only efficient but also truly sustainable.

As the world transitions toward renewable energy, integrating recycling technologies into solar production is essential. With growing electricity demands and environmental concerns, breakthroughs like this could shape the future of solar power—ensuring clean energy without creating new waste problems.

These next-generation solar panels are 1000x more powerful than existing panels

Scientists discovered a new method to increase the efficiency of solar cells by a factor of 1,000 and revolutionize the solar industry

Published Dec 11, 2024

Researchers at Martin Luther University Halle-Wittenberg (MLU) have discovered a new method to increase the efficiency of solar cells by a factor of 1,000. (CREDIT: CC BY-SA 4.0)

Share this story

Researchers at Martin Luther University Halle-Wittenberg (MLU) have discovered a new method to increase the efficiency of solar cells by a factor of 1,000. The team of scientists achieved this breakthrough by creating crystalline layers of barium titanate, strontium titanate, and calcium titanate, which were alternately placed on top of one another in a lattice structure.

Their findings, which could revolutionize the solar energy industry, were recently published in the journal Science Advances.

Solar cells currently in use are mostly silicon-based, but their efficiency is limited. This has led researchers to explore new materials, such as ferroelectrics like barium titanate, which is a mixed oxide made of barium and titanium.

Ferroelectric materials have spatially separated positive and negative charges, which leads to an asymmetric structure that generates electricity from light. Unlike silicon, ferroelectric crystals do not require a pn junction to create the photovoltaic effect, making it easier to produce solar panels.

For their new approach, the researchers combined three crystal materials. (CREDIT: Uni Halle / Yeseul Yun)

However, pure barium titanate does not absorb much sunlight, resulting in a relatively low photocurrent. The new research has shown that combining extremely thin layers of different materials significantly increases the solar energy yield.

According to physicist Dr Akash Bhatnagar from MLU's Centre for Innovation Competence SiLi-nano, "The important thing here is that a ferroelectric material is alternated with a paraelectric material.

Although the latter does not have separated charges, it can become ferroelectric under certain conditions, for example at low temperatures or when its chemical structure is slightly modified."

Bhatnagar's research group discovered that the photovoltaic effect is greatly enhanced if the ferroelectric layer alternates not only with one but with two different paraelectric layers.
Yeseul Yun, a PhD student at MLU and first author of the study, explained the process involved, stating: "We embedded the barium titanate between strontium titanate and calcium titanate.
This was achieved by vaporizing the crystals with a high-power laser and redepositing them on carrier substrates. This produced a material made of 500 layers that is about 200 nanometers thick."

Structural characterization of superlattices. (A) Cross-sectional STEM acquired from sample SBC222. (B) High-resolution STEM from a part of the scanned region. The schematic depicts the arrangement of unit cells. RSM acquired around (103) reflection in (C) BTO, (D) SBC555, (E) SBC252, and (F) SBC222. Star and yellow arrows indicate the STO substrate and satellite peaks from SL, respectively.(CREDIT: Uni Halle / Yeseul Yun)
When conducting the photoelectric measurements, the new material was irradiated with laser light. The result surprised even the research group: compared to pure barium titanate of a similar thickness, the current flow was up to 1,000 times stronger, despite the fact that the proportion of barium titanate as the main photoelectric component was reduced by almost two thirds.
Bhatnagar explained, "The interaction between the lattice layers appears to lead to a much higher permittivity - in other words, the electrons are able to flow much more easily due to the excitation by the light photons." The measurements also showed that this effect is very robust: it remained nearly constant over a six-month period.
Further research is now necessary to determine the exact cause of the outstanding photoelectric effect. Bhatnagar is confident that the potential demonstrated by the new concept can be used for practical applications in solar panels. "The layer structure shows a higher yield in all temperature ranges than pure ferroelectrics. The crystals are also significantly more durable and do not require special packaging."
This new development has far-reaching implications for the solar industry. Solar panels made with this new material would be significantly more efficient, and the cost of producing them would be lower than silicon-based solar cells. Furthermore, they would require less space to generate the same amount of electricity, making them ideal for use in urban areas where space is limited.

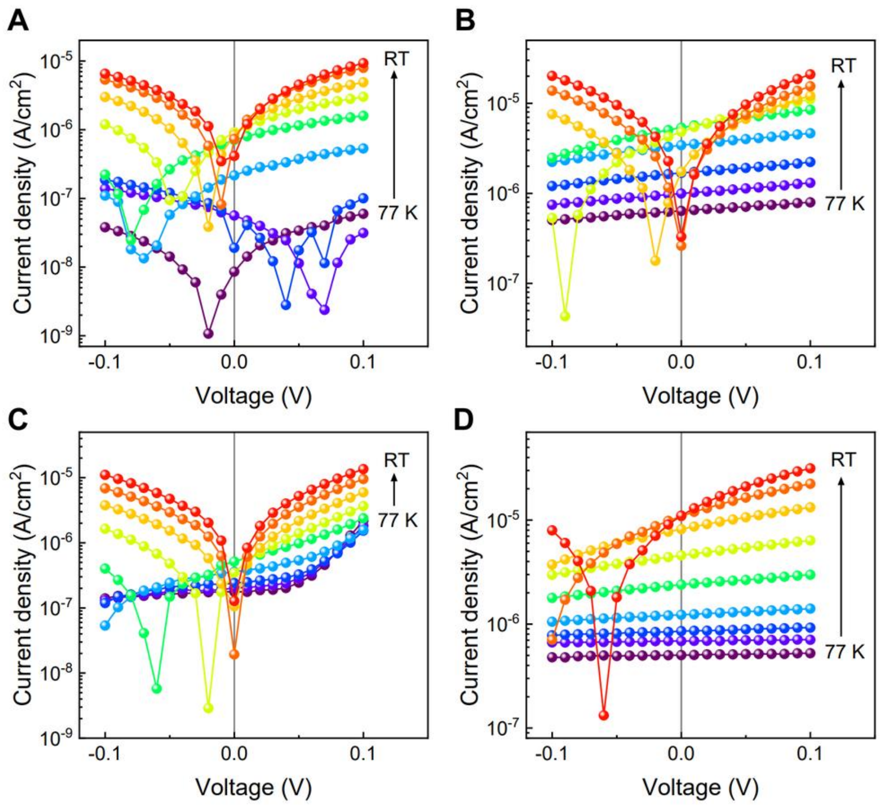
Enhancement of photovoltaic effect in tricolor superlattices. (A) Current-voltage (IV) characteristics measured with 3.06 eV at room temperature. (B) Current-time response acquired with the illumination ON and OFF. (CREDIT: Science Advances)
The MLU research team's discovery has already caught the attention of industry leaders. Dr. Jennifer Rupp, a professor at ETH Zurich who was not involved in the study, commented on the importance of the findings. "This is a very exciting discovery that could have a significant impact on the development of more efficient solar cells," said Rupp. "The

fact that the new material is also more durable and easier to produce than traditional silicon-based solar panels makes it even more promising."

Solar energy is one of the fastest-growing sources of renewable energy, and the demand for solar panels is expected to increase dramatically in the coming years.

According to the International Energy Agency, solar power is set to become the largest source of electricity by 2050, accounting for around one-third of global electricity generation. However, the efficiency of current solar panels needs to be improved if this is to become a reality.

The MLU research team's discovery could play a key role in this transition. By increasing the photovoltaic effect of ferroelectric crystals, the new material could significantly increase the efficiency of solar panels. This would not only make solar energy more cost-effective but also reduce our reliance on fossil fuels and help combat climate change.



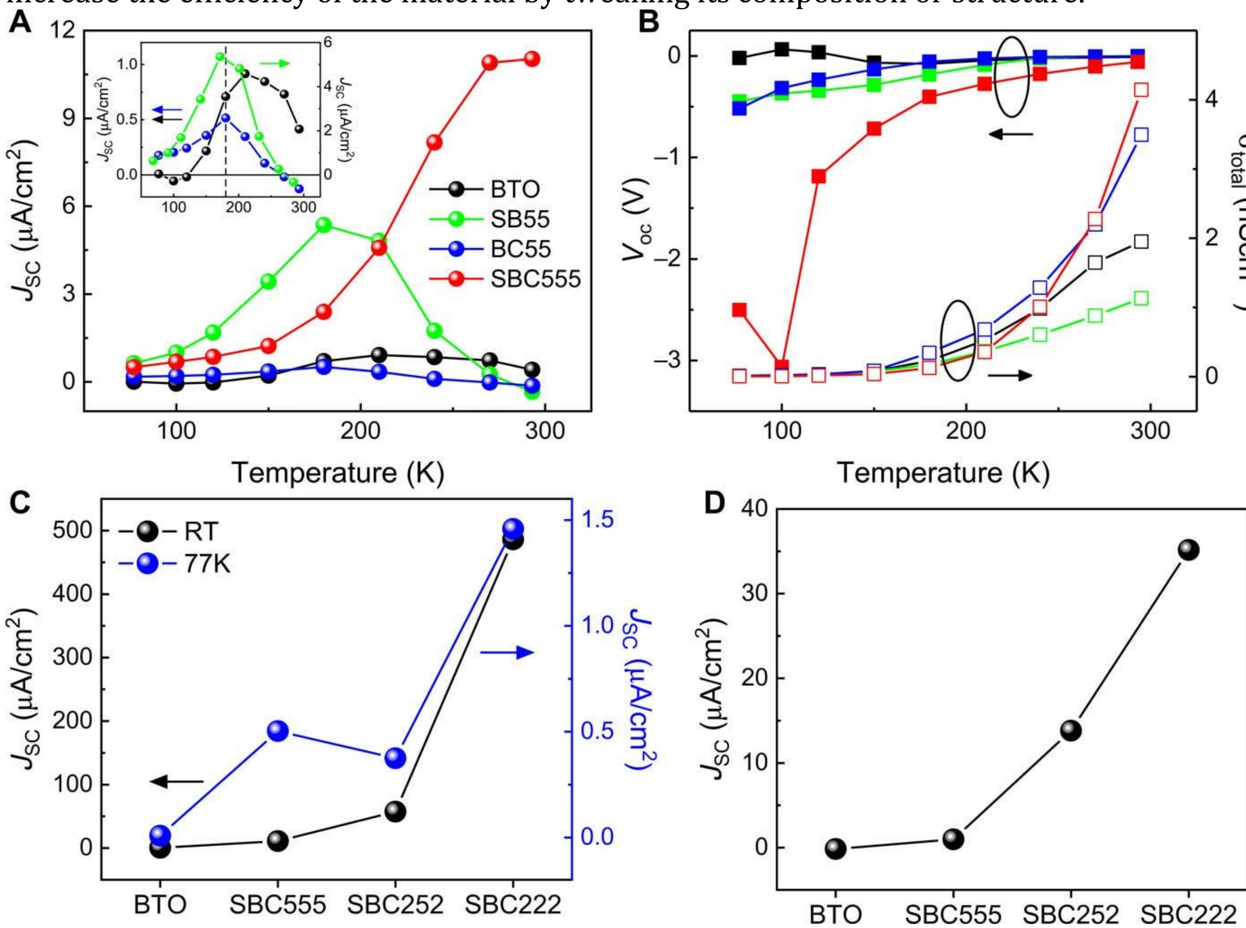
Temperature dependent photo IV characteristics. Current-voltage (IV) characteristics measured with 3.06 eV of (A) BTO, (B) SB55, (C) BC55 and (D) SBC555. (CREDIT: Science Advances)

The study's lead author, Yeseul Yun, is excited about the potential impact of the team's findings. "Our discovery opens up a new avenue for developing more efficient solar cells," said Yun.

"By combining different materials in a specific way, we can create a material that generates much more electricity than traditional silicon-based solar panels. This could revolutionize the solar industry and help us transition to a more sustainable future."

The next step for the MLU research team is to further investigate the properties of the new material and optimize its performance.

"We are still trying to understand exactly how the different materials interact to produce such a strong photovoltaic effect," said Bhatnagar. "We also want to see if we can further increase the efficiency of the material by tweaking its composition or structure."



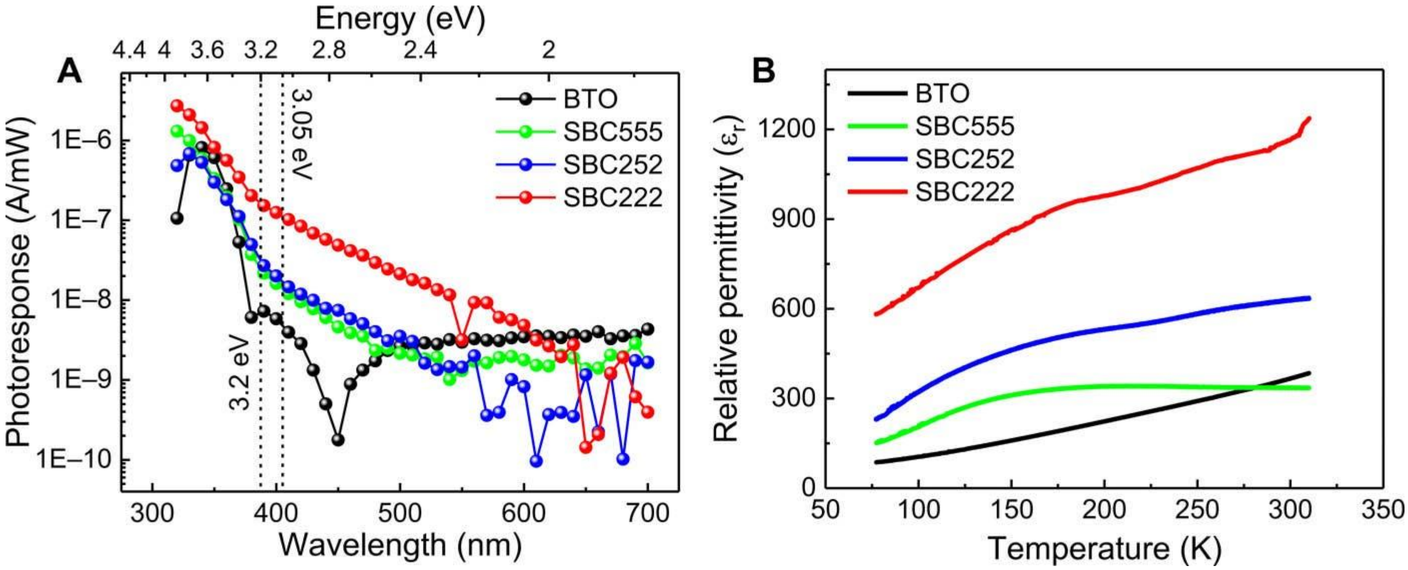
Temperature- and periodicity-dependent photovoltaic effect. (CREDIT: Science Advances)

The team is already working on a new prototype solar cell based on their findings. If successful, this could lead to the development of commercial solar panels based on the new material within the next few years.

"We are excited about the potential of our discovery to make a real difference in the world," said Yun. "If we can create solar panels that are more efficient, durable, and cost-effective, we could help accelerate the transition to a more sustainable future."

The MLU research team's findings have also generated interest among investors and entrepreneurs. Several start-ups are already exploring ways to commercialize the new technology, and venture capitalists are eager to fund further research in this area.

"This is a very promising field with huge potential," said Markus Ederer, CEO of a renewable energy start-up based in Berlin. "If we can create solar panels that are much more efficient and cost-effective, we could transform the energy sector and help tackle one of the biggest challenges facing humanity today."



Spectral photoresponse and dielectric characterization. (A) Spectral photoresponse measured at 77 K without any bias voltage. (B) Relative permittivity measured as a function of temperature with an ac signal of amplitude 100 mV and frequency 100 kHz. (CREDIT: Science Advances)

The MLU research team's discovery is just one example of the groundbreaking research being carried out in the field of renewable energy. With the world facing urgent environmental challenges, it is more important than ever to invest in clean energy technologies that can help us transition to a more sustainable future.

By harnessing the power of the sun, we can reduce our carbon footprint and create a more prosperous and equitable world for generations to come.

Breakthrough light-absorbing material significantly increases solar power output

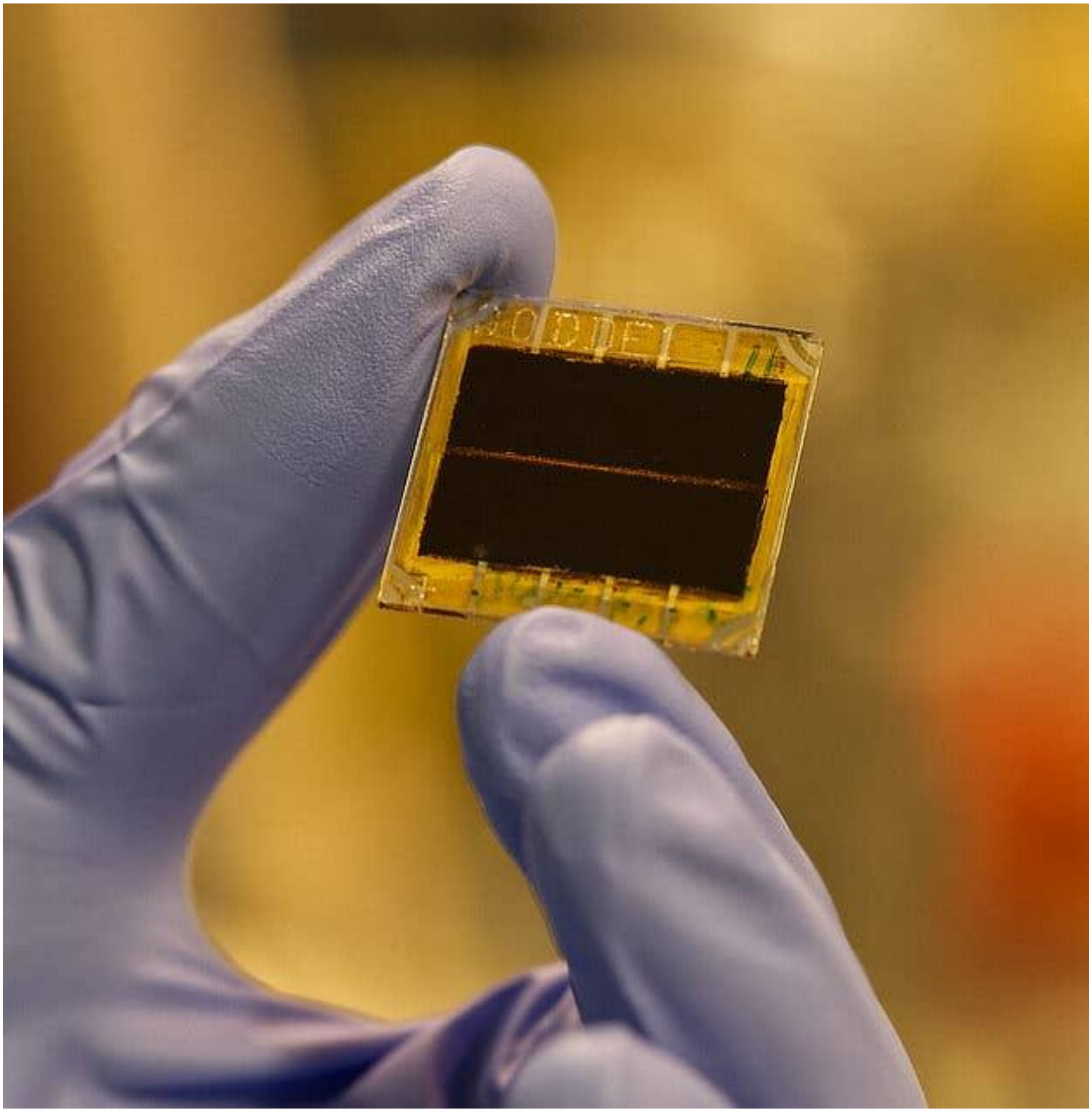
Oxford scientists have developed a flexible, ultra-thin solar material that could replace silicon panels, transforming everyday surfaces into power generators.

Published Sep 15, 2024

Dr Shuaifeng Hu, Post Doctoral Fellow at Oxford University Physics. (CREDIT: University of Oxford)

Scientists at Oxford University's Physics Department have developed a groundbreaking technology that could transform how we generate solar electricity, offering a departure from the reliance on traditional silicon-based solar panels. Their innovation introduces a new material that can be coated onto everyday objects like cars, mobile phones, and even buildings, providing a versatile and efficient way to capture solar energy.

For the first time, a light-absorbing material thin and flexible enough to coat nearly any surface has been developed. This new material uses a multi-junction design, which stacks several layers of light-absorbing cells. This design allows the solar cells to capture a broader spectrum of light, resulting in more electricity from the same amount of sunlight. Certified by Japan's National Institute of Advanced Industrial Science and Technology (AIST), this ultra-thin material delivers over 27% energy efficiency—marking the first time that a non-silicon solar material has matched traditional silicon photovoltaic technology.



Scientists at Oxford University Physics have created a highly flexible new material which can be applied to almost any surface to generate solar power. (CREDIT: Martin Small)

According to Dr. Shuaifeng Hu, a Postdoctoral Fellow at Oxford University, the efficiency increase is a significant breakthrough. “In just five years of using our stacking, or multi-junction, approach, we’ve raised power conversion efficiency from around 6% to over 27%. We believe this method could eventually lead to efficiencies exceeding 45%,” he explained. The material’s current efficiency of 27% rivals the energy output of existing silicon solar panels, which typically convert around 22% of sunlight into electricity. However, the new material's flexibility gives it a major advantage. It measures just over one micron thick, making it nearly 150 times thinner than silicon wafers. This flexibility opens the door to solar energy applications on an array of surfaces where conventional panels are impractical.

Dr. Junke Wang, another key figure in the research, highlighted the material's unique benefits. “By using new materials that can be applied as a coating, we’ve shown we can replicate and even outperform silicon, while gaining the advantage of flexibility,” she said. “This is crucial because it allows us to generate more solar power without needing silicon-based panels or specially-built solar farms.”

The researchers foresee this advancement not only improving solar efficiency but also reducing the overall cost of solar power. Since 2010, the average global cost of solar electricity has plummeted by nearly 90%, making it about one-third cheaper than electricity generated from fossil fuels. By utilizing innovative materials like thin-film perovskite, the cost of solar energy could drop even further, as the need for expensive silicon panels and large-scale solar farms decreases.

“We can envision perovskite coatings being applied to surfaces such as car roofs, building facades, and even the backs of mobile phones,” Dr. Wang noted. “If we can generate solar energy from these surfaces, we might reduce the long-term need for large solar farms or silicon panels.”

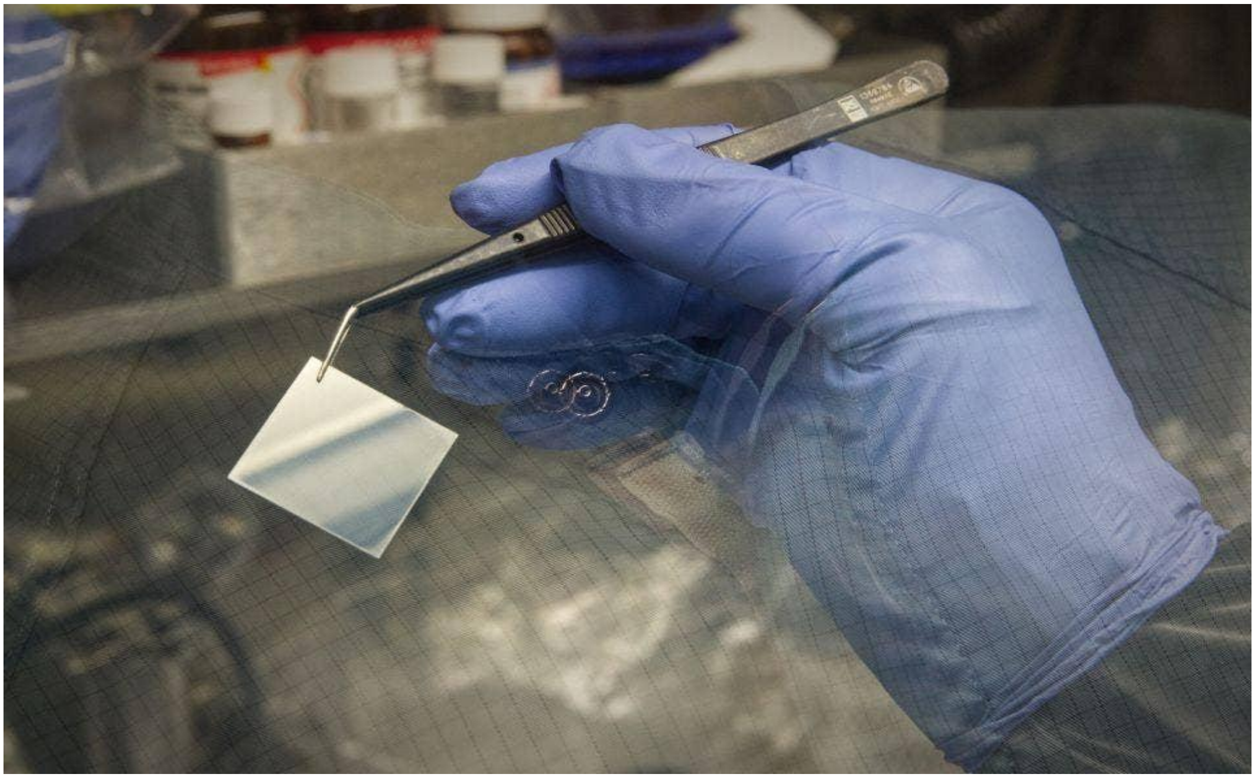
This pioneering approach to solar technology builds on Oxford University’s decade-long research into photovoltaics, led by Professor Henry Snaith, a prominent figure in the field of renewable energy. Professor Snaith’s team of 40 scientists at Oxford has been at the forefront of photovoltaics research, particularly in exploring thin-film perovskite materials.

Professor Henry Snaith, Oxford University Physics. (CREDIT: University of Oxford)

Their work has already caught the attention of several industries, including utilities, construction, and automotive manufacturing. Companies in these sectors see the potential for widespread commercial application, and the research team's developments have strong commercial viability.

Oxford PV, a UK-based company founded in 2010 by Professor Snaith to commercialize perovskite technology, recently opened the world’s first large-scale manufacturing line for “perovskite-on-silicon” tandem solar cells. Located in Brandenburg-an-der-Havel, Germany, the factory represents a significant leap in making the technology widely available. The tandem solar cells produced there could redefine how solar energy is harvested.

Professor Snaith explained why manufacturing was initiated in Germany rather than the UK. “We initially explored UK sites, but the government has not yet provided the financial or commercial incentives found in other parts of Europe and the United States,” he said. “Up to now, the UK has focused mainly on solar farms, but the real growth will come from bringing innovations to market.”



Scientists at Oxford University Physics have created a highly flexible new material which can be applied to almost any surface to generate solar power. (CREDIT: Martin Small)

The research being conducted in Oxford's laboratories has the potential to revolutionize solar energy. By moving away from large-scale solar farms and embracing flexible solar coatings, new industries could emerge around the production of solar energy-generating materials.

Professor Snaith believes the UK has an opportunity to lead in this global industry, but he warns that government support is critical. "Without new incentives and a clear pathway to scale up manufacturing, the UK could miss out on leading this rapidly growing sector in the green economy," he cautioned.

This innovation doesn't just promise cleaner, cheaper energy—it offers a more sustainable and flexible solution for generating solar power. As the demand for renewable energy grows, advancements like this could play a vital role in reshaping the global energy landscape, pushing the boundaries of what solar technology can achieve.

Solar innovation could help maintain electricity for millions around the world

Millions of people around the world lack access to electricity. Decentralized solar-battery systems are key for addressing this.

Published Feb 12, 2022

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[Feb 11, 2021: Gen Dale, University of Oxford]

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Millions of people around the world lack access to electricity. Decentralised solar-battery systems are key for addressing this whilst avoiding carbon emissions and air pollution. (CREDIT: BBoxx)

Millions of people around the world lack access to electricity. Decentralised solar-battery systems are key for addressing this whilst avoiding carbon emissions and air pollution, but are hindered by relatively high costs and rural locations that inhibit timely preventative maintenance. When batteries in such systems fail, it can be difficult to replace them and can leave people stuck without access to power.

Knowing when the batteries are likely to fail is therefore crucial in planning repair logistics and minimising power supply downtime. Now a unique approach to calculating battery failure, affiliated to the Faraday Institution's Multiscale Modelling project, has been shown to make predictions that are 15-20% more accurate than current approaches used on the same dataset. The paper, from the University of Oxford and the Faraday Institution, has been published today in *Joule*.

In order to test their approach, the authors partnered Bboxx, a next generation utility providing clean energy in developing countries, which provided real-world operating data. This avoided the limitation of past studies on battery health modelling, which have mainly used small datasets collected under laboratory conditions.

Over a period of up to 2 years, raw measured voltage, current and temperature data from more than 1000 operational batteries in Africa were collected via Bboxx. No additional sensors or requirements are required for this method, enabling the energy systems to stay continuously online.

Professor David Howey, from the Department of Engineering Science at the University of Oxford, says: ‘Our approach is unique in showing how physics-based machine learning can work in real-world battery applications at scale. We use advanced probabilistic machine learning techniques to infer battery internal resistance as a function of current, temperature, state of charge and time, enabling calibration to standard conditions.’

He adds, ‘The success of the approach is due to the combination of a population-wide health model and a battery-specific health indicator that becomes increasingly informative towards end of life.’

The techniques provide insight into the factors that drive battery aging, such as extremes of voltage and temperature, and the method is applicable to any battery that can be represented with a simple electrical circuit model.

Prof. Howey says, ‘These results are of interest to a wide audience of battery operators and customers and can be used to accelerate innovation in understanding battery performance, especially if organisations make operational data more widely available in the way Bboxx have pioneered here. We are delighted that this research paper is a first of its kind demonstration of a scalable approach for getting insights from field data.’

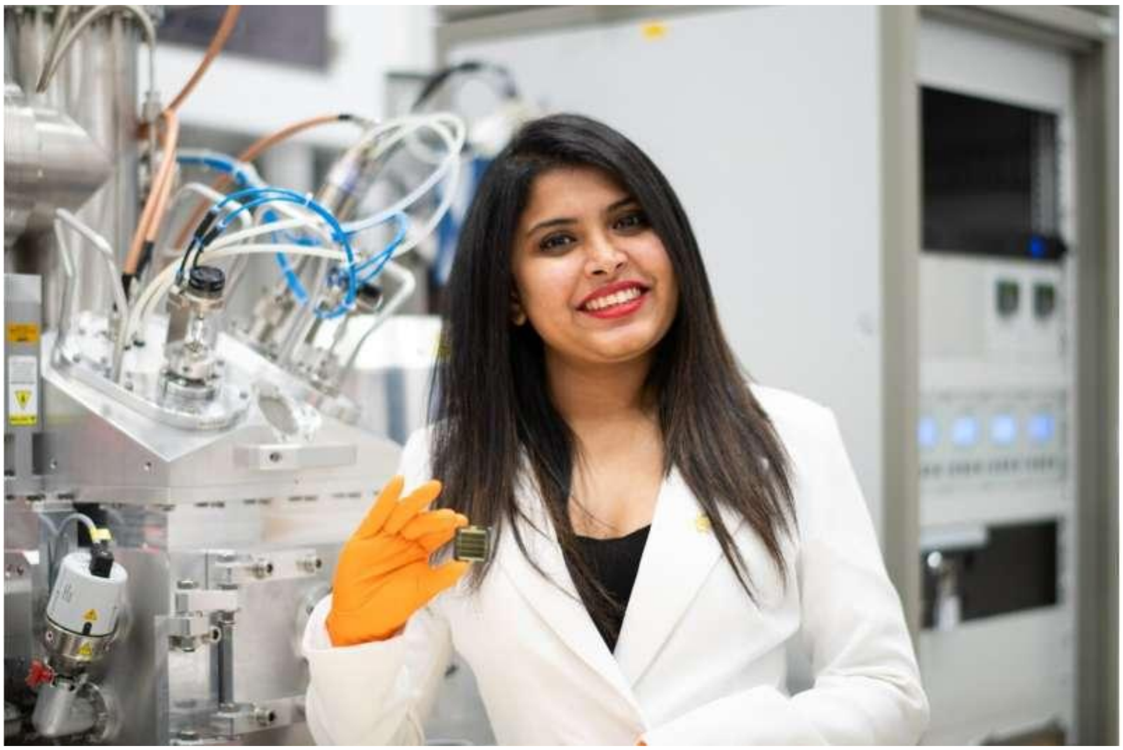
Bboxx, a next generation utility that manufactures, distributes and finances decentralised solar powered systems in developing countries, has agreed to make the data - more than 600 million rows of operational measurements from real battery systems - openly available.

Prof. Howey says: ‘We hope this will prove to be a key resource for the community and kickstart efforts to analyze field data for new insights into battery performance.’

FEBRUARY 27, 2025

Scientists crack the code to longer-lasting perovskite solar technology

by University of Surrey



Dr Hashini Perera, postgraduate research student at the University of Surrey's Advanced Technology Institute. Credit: University of Surrey

Perovskite solar cells could last 10 times longer thanks to new research led by the University of Surrey, which suggests alumina (Al_2O_3) nanoparticles significantly enhance the lifespan and stability of these high-efficiency energy devices.

The work is published in the journal *EES Solar*.

While perovskite solar cells offer a cost-effective and lightweight alternative to traditional silicon-based technology, their commercial potential has been limited due to a flaw in their structure—primarily caused by iodine leakage. Over time, this escape of iodine can lead to material degradation, reducing performance and durability.

Working in collaboration with the National Physical Laboratory and the University of Sheffield, scientists have now discovered a way to trap iodine by embedding tiny particles of Al_2O_3—aluminum oxide—within the cell, holding promise for longer-lasting and more affordable next-generation solar panels.

Dr. Hashini Perera, postgraduate research student and lead author of the study from the Advanced Technology Institute at the University of Surrey, said, "It's incredibly exciting to see our approach make such an impact. A decade ago, the idea of perovskite solar cells lasting this long under real-world conditions seemed out of reach.

"With these improvements, we're breaking new ground in stability and performance, bringing perovskite technology closer to becoming a mainstream energy solution."

The study tested the modified solar cells under extreme heat and humidity to replicate real-world conditions. Results showed that solar cells with embedded Al_2O_3 nanoparticles maintained high performance for more than two months (1,530 hours)—a tenfold improvement compared to just 160 hours without the alumina-enhanced modifications.

Further analysis revealed that the Al_2O_3 nanoparticles contributed to a more uniform perovskite structure, reducing defects and improving electrical conductivity; it also formed a protective 2D perovskite layer, which acts as an additional barrier against moisture degradation.

Dr. Imalka Jayawardena, from Surrey's Advanced Technology Institute, said, "By addressing these common challenges we see with perovskite solar technology, our research blows the doors wide open for cheaper, more efficient and more widely accessible solar power.

"What we've achieved here is a critical step toward developing high-performance solar cells that can withstand real-world conditions—bringing us closer to their commercial use at a global scale."

Professor Ravi Silva, Director of the Advanced Technology Institute and interim Director at the Surrey Institute for Sustainability, added, "With the deadline for Net-Zero targets fast approaching, expanding access to renewable energy solutions is more critical than ever if we're to successfully reduce our reliance on fossil fuels.

"Breakthroughs like this will play a vital role in meeting global energy demands while supporting our transition to a sustainable future."

"Recent analysis by the Confederation of British Industry also highlights that training in the renewable energy sector not only improves career prospects but can lead to wages above the national average, reinforcing the economic and environmental benefits of investing in clean energy."

More information: W. Hashini K. Perera et al, Improved stability and electronic homogeneity in perovskite solar cells via a nanoengineered buried oxide interlayer, *EES Solar* (2025). DOI: 10.1039/D4EL00029C
Provided by University of Surrey

FEBRUARY 27, 2025

Researchers build stable solar panel without silicon

by Tess Malone, Georgia Institute of Technology

New solar panel prototype. Credit: Christopher McKenney/Georgia Institute of Technology

Solar power as an electricity source is growing in the United States, with 7% of Americans using it to run their homes. But scientists are still trying to make the solar panel production process more efficient.

Solar panels are composed of dozens of solar cells, which are usually made of silicon. While silicon is the standard, producing and processing it is energy-intensive, making it costly to build new solar panel manufacturing facilities. Most of the world's solar cells are made in China, which has an abundance of silicon. To increase solar cell production in the U.S., a new, easily produced domestic material is needed.

"We're developing technologies that we can easily produce without spending a ton of money on expensive equipment," said Juan-Pablo Correa-Baena, an associate professor in the School of Materials Science and Engineering.

For years, Correa-Baena's research group has explored using perovskite crystals as an alternative to silicon. A promising and prevalent replacement, perovskite is made of iodine atoms, lead, and organic elements. It is also as efficient as silicon.

However, perovskite has one major drawback: It lasts only about 5% as long as a silicon cell. Compared to silicon's 20 years, perovskite-made cells deteriorate after a year of use. The material is especially sensitive to hot summer temperatures and can decompose before the solar panel can help a homeowner save on energy costs.

Credit: Christopher McKenney/Georgia Institute of Technology

Using a new technology, Correa-Baena's lab has found a way to stabilize the perovskite solar cells, which are built like a battery. They have one positive and one negative electrode, with the perovskite cell sandwiched between them. Before placing a positive electrode at the top of the cell, the researchers exposed the perovskite to titanium gas under a light vacuum.

This process, known as vapor-phase infiltration, embeds titanium into the top layer of the solar cell. The technology is under patent review.

"We've made one of the layers that causes the longevity issue more robust and resilient to especially high temperatures," Correa-Baena said. "In this process of inserting titanium, we can prevent the degradation process, and then we can test the solar cell on roofs or anywhere."

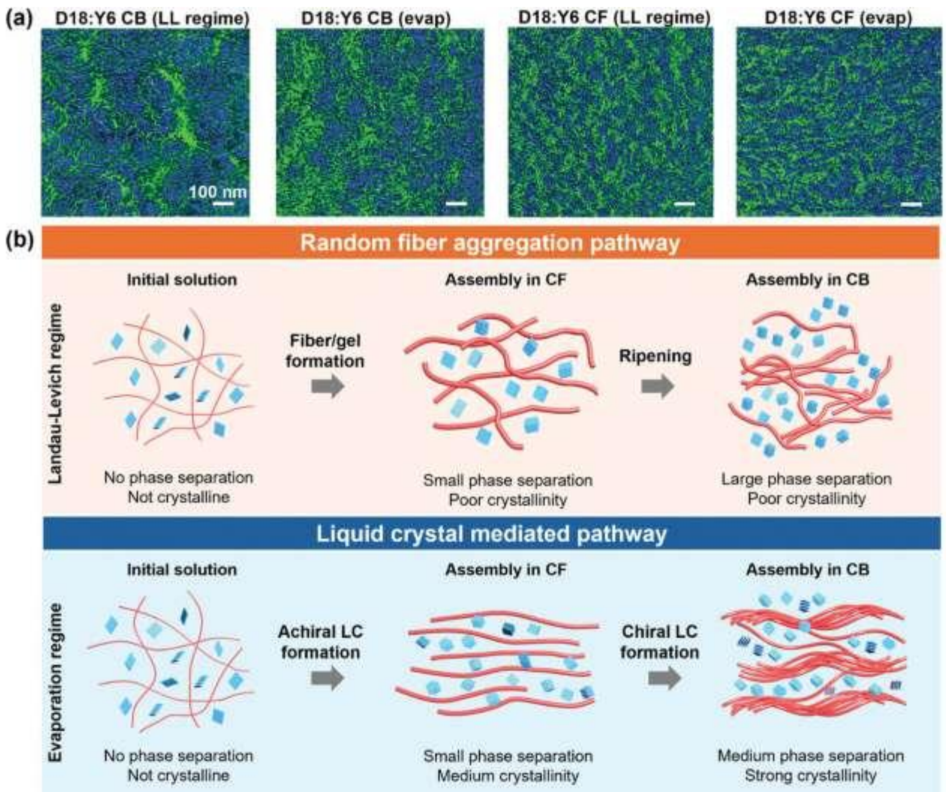
Ultimately, the shift from silicon to perovskite crystals in solar cell production could transform the solar industry. The innovative stabilization technique developed by Correa-Baena's team addresses the primary drawback of perovskite cells, making them more viable for long-term use. This progress not only enhances the potential for domestic solar cell production but also supports the broader goal of increasing renewable energy adoption in the United States.

Provided by Georgia Institute of Technology

MARCH 5, 2025

Chiral liquid crystals improve solar cell efficiency and stability by 50 times

by University of Illinois at Urbana-Champaign



a) Photo-induced Force Microscopy (PiFM) images of the blend films where the green and blue region represents the donor and acceptor domains, respectively. b) Proposed assembly pathways of D18 in the blend solution depending on the printing regimes. Credit: *Advanced Materials* (2025). DOI: 10.1002/adma.202414632

A new study by researchers at the University of Illinois Urbana-Champaign describes a breakthrough in the field of organic solar cells (OSCs), bringing the technology one step closer to commercial viability.

OSCs are a compelling technology that can turn any surface into a power generator. Their lightweight, transparent and foldable properties make them ideal for many applications where traditional silicon solar cells are impractical: think backpacks and tents outfitted with OSCs that can generate power on demand in the field, or windows that turn sunlight into electricity thanks to solar cells that are invisible to the naked eye.

But while OSCs offer many advantages over silicon solar cells and perform well in laboratory settings, they remain non-ideal for real world use because their efficiency and stability drop substantially during the manufacturing process.

To address this problem, the researchers—led by chemical and biomolecular engineering professor Ying Diao—zeroed in on the molecular assembly process during fabrication. An OSC is composed of several nanometer-thin layers of film. By manipulating the processing conditions when printing the films, they can force the molecules to adopt different structures, said Alec Damron, co-first author on the paper published in *Advanced Materials*.

"The ink evaporates while we're printing, so—depending on how fast we print and how slow the evaporation—we can lock the assembly into different stages," Damron said. "What we saw in this paper was that when you print our films slowly, as opposed to quickly, that allows for the evaporation portion of the physics to dominate and it will force the polymers to assemble into liquid crystals before a film forms."

This finding was important because the liquid crystal structures resulted in better OSC stability and efficiency when compared to cells fabricated using random aggregation pathways. Further manipulation during the process resulted in liquid crystal assembly pathways that were either achiral or chiral. Both resulted in a clear improvement in efficiency and stability of the OSC, but the chiral—or helical—structure yielded the best results.

"We discovered that chiral assembly of conjugated donor polymers improves the crystalline packing and phase-separated structure of the film," said Azzaya Khasbaatar, the other co-first author on the paper. "Improving film crystallinity not only enhances efficiency by improving charge transport but also makes the films much more morphologically robust/stable."

Overall, the researchers demonstrated that achiral liquid crystal pathways show a 20% improvement in efficiency and three-fold improvement in stability when compared to random aggregation assemblies. When printed with a helical structure, that number increased to 56% higher efficiency and 50 times more stable. These numbers are promising for successful manufacturing.

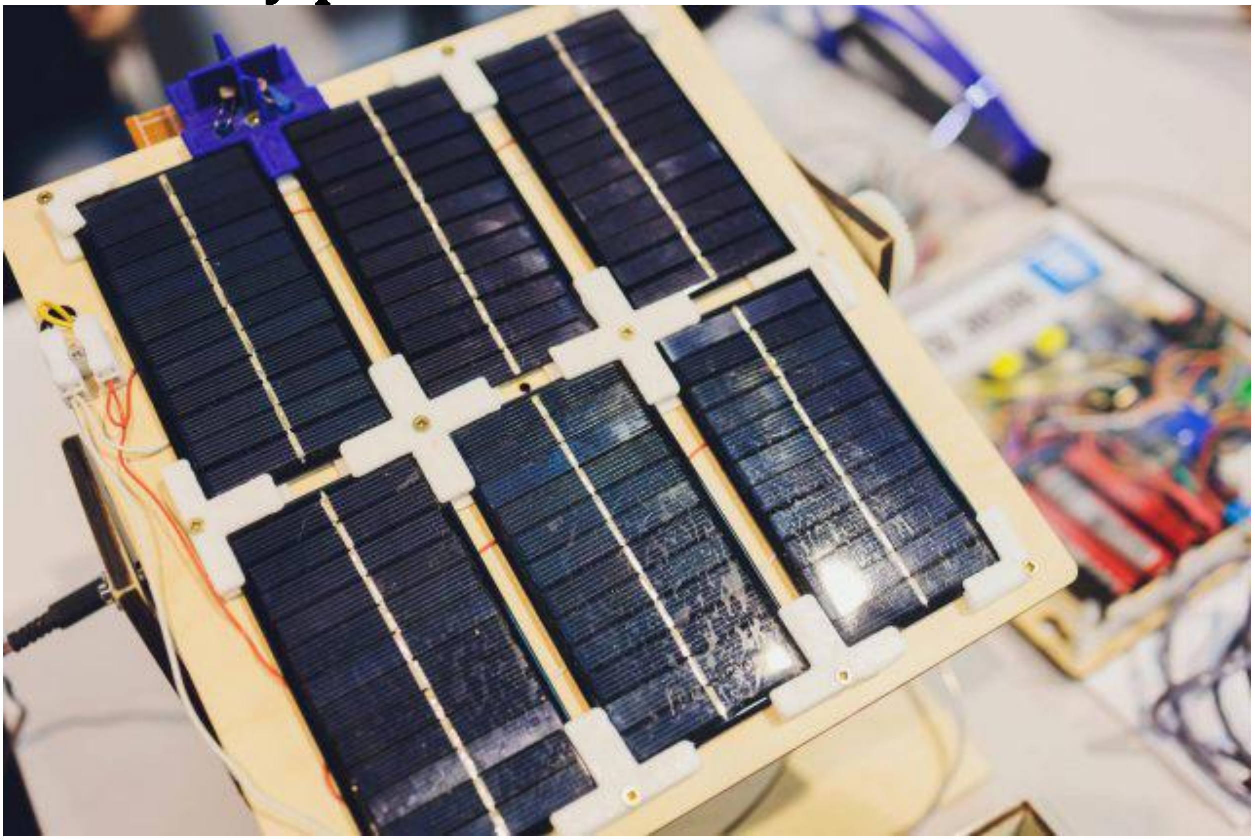
"This trend that we saw in improved performance through the liquid crystal phase versus the random fiber aggregation is general and can be applied to various types of organic solar cell materials," Damron said. "Since that relationship has been established, it is possible to start from that as a baseline and to continue building up on the engineering side of things."

Before their work, Diao said that very little was known about what happens between the time you apply the ink to a substrate and when you print the device, calling it a "black box."

"People mainly focus on the material side and then the device side, but the middle is neglected," Diao said. "And that's something we basically shed light on. We're lifting the curtain on the hidden process and, by doing so, we are providing pathways to creating better devices."

More information: Azzaya Khasbaatar et al, Lyotropic Liquid Crystal Mediated Assembly of Donor Polymers Enhances Efficiency and Stability of Blade-Coated Organic Solar Cells, *Advanced Materials* (2025). DOI: 10.1002/adma.202414632
Journal information: Advanced Materials
Provided by University of Illinois at Urbana-Champaign

Researchers achieve first-of-its-kind breakthrough by marrying solar panels and futuristic fuel source: 'We are extremely pleased'



Researchers achieve first-of-its-kind breakthrough by marrying solar panels and futuristic fuel source: 'We are extremely pleased'

SunHydrogen makes clean hydrogen fuel using only sunlight and water — and the company just posted some record-breaking test results, according to Fuel Cell Works.

On a trip to visit with consultants in Japan from the University of Tokyo, the SunHydrogen team put its hydrogen modules to work under laboratory conditions. They previously found a 10% efficiency for the company's 100 square centimeter size modules. This time, the spotlight was on a large-area test of the bigger 1,200 square centimeter modules, FCW explained.

After the tests, the company reported that the larger-sized hydrogen modules still ran an efficiency of 9%, a record for that size. The performance also stayed consistent over a wide range of temperatures, FCW reported.
"We are extremely pleased to have maintained such high efficiency in our first large-area test. To our knowledge, this remains the highest reported efficiency for a hydrogen module of this scale," said SunHydrogen CEO Tim Young, per FCW.

The achievement bodes well for the continued growth of the hydrogen market, which Goldman Sachs predicts will be worth $12 trillion by 2050. The industry has applications in car batteries and data centers, as well as industrial uses for things like fertilizer and oil refining, the outlet explained.

Plus, research breakthroughs like this one help bring down the costs associated with the power source, which means solar-to-hydrogen panels available for your rooftop might be closer than you think.

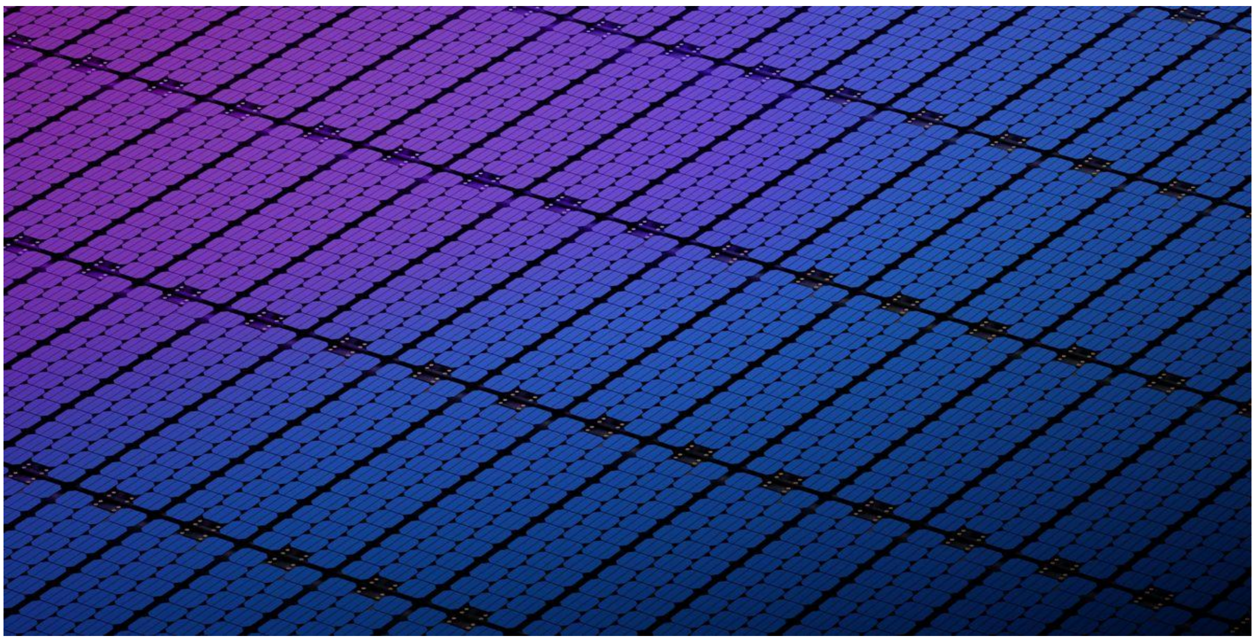
When in action, hydrogen cells only emit water vapor. However, the fuel source is not always entirely eco-friendly, since certain cells need to burn planet-heating and air-polluting materials just to make the hydrogen. Luckily, that's not the case with SunHydrogen; powered hand in hand with solar energy, it's human health-friendly and green as can be.

Next, the company plans to continue testing its modules under a range of conditions — including real sun with help from the Honda Research and Development team — with the end goal being to become a major supplier in the clean energy market.

"These results give us confidence that with further design optimization ... we can push efficiencies to 10% and beyond in future generations of larger modules," said SunHydrogen's chief technology officer, Dr. Syed Mubeen, per FCW.

Nanoparticle breakthrough could bring 'holy grail' of solar power within reach

Perovskite cells are much cheaper and more flexible than their silicon alternatives, but they have major durability problems. A new breakthrough could be about to change that.



Digital generated image of solar panel with purple-blue reflection. (Image credit: Andriy Onufriyenko/Getty Images)

Scientists have made a cheap and flexible solar cell that lasts nearly 10 times longer than others of its type, an advance that could one day help to revolutionize solar energy production.

Often referred to as the "holy grail" of solar power, perovskite cells offer a lightweight alternative to traditional silicon-based solar technology. Their flexible structure enables them to be applied to cars and phones in the form of a printable layer so they can charge on the go.

Sounds too good to be true? So far, you're right. Perovskites come with some major flaws. Notably, they degrade quickly due to chemical reactions with moisture in the air that make them leak iodine.

But now, a team of researchers has found a solution to this problem. By embedding nanoparticles within the perovskites, they produced a new cell that lasts for 1,530 hours, a near-tenfold increase on previous perovskite solar cell designs. The researchers published their findings Feb. 20 in the journal EES Solar.

"By addressing these common challenges we see with perovskite solar technology, our research blows the doors wide open for cheaper, more efficient and more widely accessible solar power," study co-author Imalka Jayawardena, an engineering researcher at the University of Surrey's Advanced Technology Institute in the U.K., said in a statement. "What we've achieved here is a critical step toward developing high-performance solar cells that can withstand real-world conditions — bringing us closer to their commercial use at a global scale."

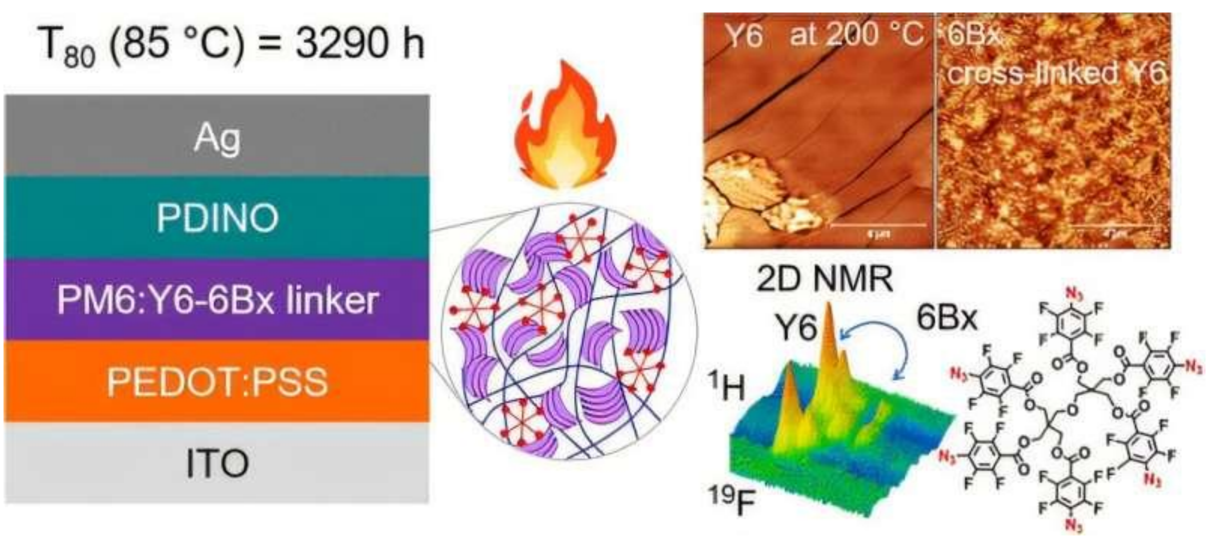
Solar power surge

As the fastest-growing and cheapest form of renewable energy, solar power is key to cutting greenhouse gas emissions. But the technology's growth is hampered by its reliance on silicon, a finite and non-renewable resource that, in its purest form, is costly to produce. To get around this bottleneck, scientists have looked to develop perovskite alternatives — synthetic versions of naturally occurring calcium titanium oxide crystals that can be made at a fraction of the cost. But unlike pure silicon cells, which can last for decades, solar cells made from perovskite only last for 100 or so hours, drastically limiting their utility.

MARCH 13, 2025

Cross-linker additive boosts organic solar cell lifespan by 59%

by JooHyeon Heo, Ulsan National Institute of Science and Technology



Graphical abstract. Credit: *ACS Energy Letters* (2025). DOI: 10.1021/acsenergylett.4c02897

An international team of researchers affiliated with UNIST has unveiled a novel cross-linker additive that significantly addresses the longstanding stability issues associated with organic solar cells, also known as organic photovoltaics (OPVs).

With the incorporation of just 0.05% of this cross-linking agent, the lifespan of OPVs can be improved by over 59%. Industry analysts suggest this breakthrough brings the commercialization of OPVs—regarded as next-generation solar cells—closer to reality.

Led by Professor BongSoo Kim in the Department of Chemistry at UNIST, the research team, in collaboration with researchers from the University of California, Santa Barbara (UCSB), the University of Lille in France, and the French National Center for Scientific Research (CNRS), identified the operational principles of this innovative cross-linker using a variety of advanced analytical techniques.

The findings were published in *ACS Energy Letters*.

OPVs are emerging as promising next-generation solar cells due to their ease of manufacturing and flexibility, allowing them to be applied as films. However, the inherent nature of organic materials poses challenges for long-term stability, particularly under heat exposure.

While previous strategies have explored the addition of cross-linkers to enhance stability, excessive amounts have often led to a decrease in battery efficiency.

The research team developed a six-bridged azide cross-linker (6Bx), a highly efficient photo-crosslinker that demonstrates superior stabilizing effects with minimal additive quantities. 6Bx is composed of six azide cross-linkable units, which enables an impressive theoretical cross-linking efficiency of 96%.

This efficiency significantly surpasses that of conventional cross-linkers, with four azide units yielding an efficiency of 82% (4Bx) and two azide units resulting in only 36% (2Bx).

The reported OPVs fabricated with the new cross-linker demonstrated an impressive efficiency of 11.70% even after 1,680 hours (70 days) at 85°C, retaining 93.4% of their initial efficiency. In contrast, OPVs produced without the cross-linker experienced a decline in efficiency to 8.17%, representing only 58.7% of the initial efficiency of 13.92%. This signifies a more than 59% improvement in performance longevity.

The research team also discovered that the elevated performance can be attributed to the effective suppression of molecular movement of the Y6 acceptor molecule in the photoactive layer of OPV devices, enabled by cross-linking reactions.

Professor Kim states, "We have successfully addressed the chronic stability issues in organic solar cells through the development of high-efficiency photo-crosslinking agents and comprehensive investigations into their mechanisms. This research will significantly contribute to the development of stability enhancement technologies for the commercialization of OPVs."

More information: Sangcheol Yoon et al, Molecular Cross-Linking Enhances Stability of Non-Fullerene Acceptor Organic Photovoltaics, *ACS Energy Letters* (2025). DOI: 10.1021/acsenergylett.4c02897
Journal information: ACS Energy Letters
Provided by Ulsan National Institute of Science and Technology

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MARCH 14, 2025

Scientists unveil rapid technique for creating uniform polymer nanostructures

by University of Birmingham

Credit: CC0 Public Domain

Researchers at the University of Birmingham have developed a new method for the rapid, scalable preparation of uniform nanostructures directly from block polymers.

This novel approach, led by the Dove and O'Reilly groups, significantly reduces processing time from a week to just minutes, enabling high-throughput production of precision polymer nanomaterials.

Publishing their findings in *Nature Chemistry*, the teams outline a rapid seed preparation technique that supersaturates polymer solutions in a flow system.

The process facilitates uniform seed micelle formation and allows for the integration of seed preparation and living crystallization-driven self-assembly (CDSA). This achieves end-to-end production of nanostructures in just three minutes, surpassing existing synthetic methods by orders of magnitude.

This new method offers a powerful, scalable, and precise approach to developing diverse and complex polymer nanoparticles and paves the way for their scalable synthesis and potential applications in catalysis, biomedical engineering, and energy transfer.

Overall, the versatility and efficiency of this new method open numerous possibilities for its application in various fields and marks a significant step forward in the field of precision nanomaterials.

Dr. Rachel K. O'Reilly, one of the lead researchers, comments, "This innovative method represents a significant leap forward in the field of nanomaterials. By drastically reducing the processing time and increasing throughput, we can now produce high-quality nanostructures at a scale that was previously unattainable."

Dr. Andrew P. Dove adds, "The integration of seed preparation and living CDSA in a continuous flow setup is a game-changer. It not only enhances efficiency but also ensures uniformity and reproducibility, which are critical for the practical application of these nanostructures."

Laihui Xiao, the first author of the study, comments, "Our flash-freezing strategy is a key innovation that allows us to achieve rapid and uniform seed formation. This breakthrough opens up new possibilities for the scalable synthesis of precision nanomaterials."

Precision polymer nanomaterials have several potential applications, including significantly advancing drug delivery systems—allowing therapeutic agents to be carried directly to targeted cells, enhancing the treatment of diseases such as cancer.

Being able to produce well-defined nanostructures quickly and efficiently also opens new possibilities in energy transfer applications—developing advanced materials for solar cells and other renewable energy technologies.

More information: Direct Preparation of 2D Platelets from Polymer Enabled by Accelerated Seed Formation, *Nature Chemistry* (2025).
Journal information: Nature Chemistry
Provided by University of Birmingham

MARCH 14, 2025

Growing solar: Optimizing agrivoltaic systems for crops and clean energy

by SPIE

Agrivoltaics integrates solar power generation with agriculture. Researchers at Fraunhofer Institute for Solar Energy Systems (ISE) are exploring different scenarios to optimize both the photovoltaic panel positioning and the underlying crops. A pilot project in Nussbach will contribute to a deeper understanding of the impact of agrivoltaic systems on apple orchards and the surrounding environment. Credit: *Journal of Photonics for Energy* (2025). DOI: 10.1117/1.JPE.15.032703

Agrivoltaic systems, which combine solar power generation with agricultural practices, offer a promising solution to the growing demand for both renewable energy and food production. By integrating solar panels with crops, these systems not only address the land use conflict between agriculture and energy production, but they also provide important benefits such as reducing crop water stress and offering protection against extreme weather events.

In addition, agrivoltaics can contribute to biodiversity by providing pollinator habitats and forage production. For ecosystems in water-scarce regions, these systems have been shown to increase flower production and delay blooming, which supports late-season pollinators. Research also shows that solar panels can perform better in agrivoltaic systems, thanks to the microclimate created underneath them.

As agrivoltaic systems become an increasingly important part of the global energy transition, the need for tailored tracking strategies to optimize their performance is growing.

Horizontal single-axis tracker (HSAT) systems, which adjust the angle of solar panels throughout the day to track the sun, offer significant potential in this regard.

Effective control of panel positioning helps balance the dual objectives of maximizing energy generation and preserving agricultural yields. Such optimization is particularly relevant as agrivoltaic systems need to meet yield loss thresholds in order to qualify for subsidies, thus improving their economic viability.

A recent study published in the *Journal of Photonics for Energy* provides valuable insights into how solar panel positioning can be optimized to achieve this balance. The research focuses on a case study of apple orchards in southwestern Germany, but the findings are broadly applicable to various agricultural settings.

The study proposes a new methodology for dynamically optimizing solar panel positioning based on the light needs of crops. Unlike traditional shading strategies, which are based on general guidelines or structures like hail nets, this new approach uses specific irradiation targets to meet the precise light requirements of different crop varieties. The research team ran simulations using a custom tool called APyV to assess how varying solar panel positions would impact light availability for the crops.

APyV uses advanced ray tracing techniques to evaluate the distribution of solar radiation and its impact on both the photovoltaic panels and the underlying crops. The tool automates design optimization of agrivoltaic systems based on key performance indicators, the interface with different crop models, and the integrated simulation of specialty crops. It allows direct calculation of the light received by the crop and a more accurate simulation of its impact on the overall agrivoltaic system.

The results of the case study revealed that with tailored solar panel control, 91% of the light needed for the apple trees was delivered over the course of the year, with only a moderate 20% reduction in solar energy production. However, the study also identified periods when the light requirements of the apple trees were not fully met, indicating the challenges of achieving optimal crop and energy performance simultaneously. Despite these limitations, the study lays a strong foundation for future research, which is already underway.

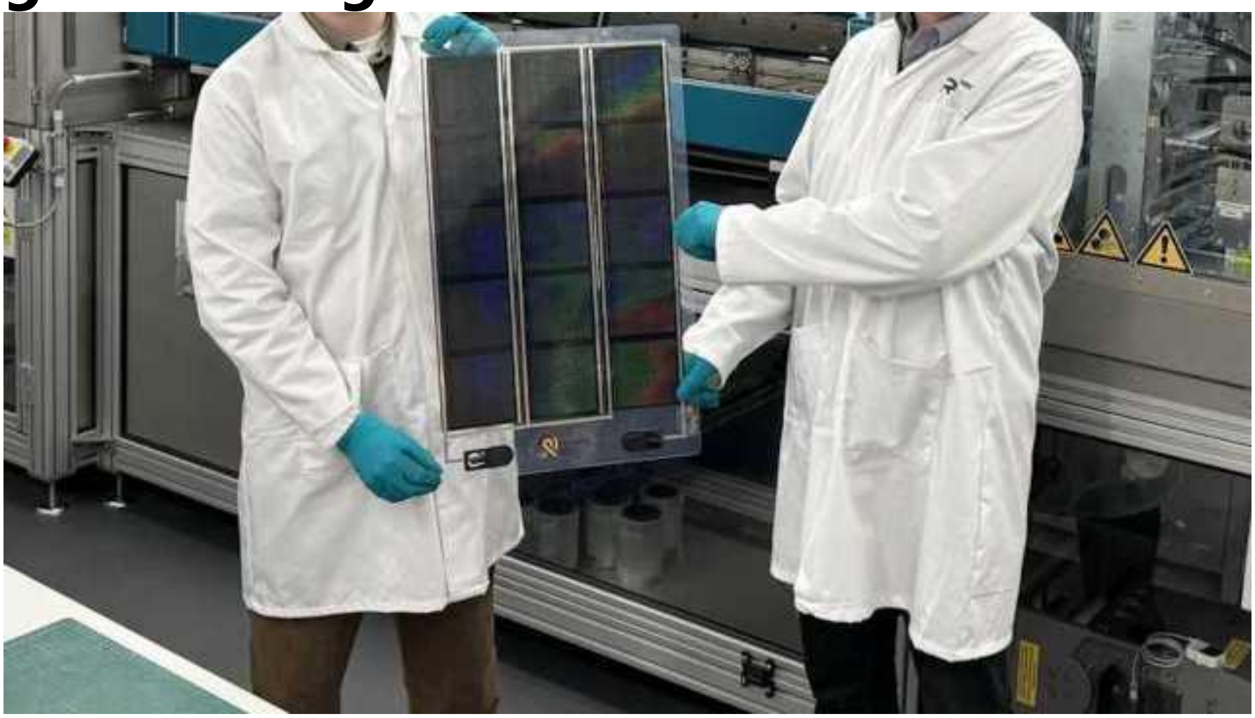
According to corresponding author Maddelena Bruno, who is leading the study as a doctoral candidate at Fraunhofer ISE, "Our study shows that the combination of solar energy and farming can be enhanced by smart PV-trackers that adjust the position of solar panels based on weather conditions, crop types, and their growth stages. This approach ensures an optimal balance between light available for photosynthesis and light available for electricity production."

Bruno notes that the proposed irradiation targets and tracking strategy are to be field-tested during the current growing season in Nussbach, providing an opportunity to validate or challenge the reported results. These field tests will contribute significantly to a deeper understanding of the impact of agrivoltaic systems on apple orchards and the surrounding environment.

Ultimately, this research will provide critical insights that can guide the optimization of agrivoltaic systems, making them more effective in balancing agricultural productivity and renewable energy generation while supporting the ongoing energy transition.

More information: Maddalena Bruno et al, Enhancing agrivoltaic synergies through optimized tracking strategies, *Journal of Photonics for Energy* (2025). DOI: 10.1117/1.JPE.15.032703
Provided by SPIE

Scientists develop sticker-like tech that could bring lower energy costs to millions of homes: 'This could be a game-changer'



Scientists develop sticker-like tech that could bring lower energy costs to millions of homes: 'This could be a game-changer'

A groundbreaking solar technology could soon transform how we harness energy, making solar power more affordable and accessible.

In collaboration with U.K.-based Power Roll Ltd., scientists at the University of Sheffield have developed an ultra-thin, sticker-like solar film that offers a lightweight, flexible, and cost-effective alternative to traditional solar panels.

Unlike conventional solar panels, which are often bulky, expensive, and difficult to install, this innovative solar film can stick to almost any surface.

That means even buildings with weak rooftops, vehicles, and remote areas can generate clean energy without costly infrastructure upgrades.

The potential benefits are massive: lower electricity bills, reduced dependence on fossil fuels, and expanded access to renewable energy in regions where traditional solar panels are impractical.

For homeowners and businesses looking to adopt solar power, solutions such as rooftop installations and community solar programs are becoming more accessible than ever.

This cutting-edge solar film is made by embossing tiny grooves into a plastic sheet and filling them with perovskite — a highly efficient semiconductor material.

Unlike standard panels, which require multiple layers and expensive components, this design enables back-contact solar cells, significantly reducing production costs.

Another key advantage is sustainability. This film is produced with readily available and affordable materials, making it a greener alternative.

To fine-tune its performance, researchers have used advanced X-ray microscopy to analyze and optimize the film's structure.

With additional tests scheduled for this summer, they're working to enhance its sProfessor David Lidzey, one of the lead researchers, emphasized its global potential: "With this lightweight solar technology, you could essentially stick it anywhere. This could be a game-changer for solar energy in low- and middle-income countries."

If successful, this solar film could hit commercial markets within the next few years, offering a more practical and scalable alternative to traditional solar panels.

As innovations continue to emerge, homeowners, businesses, and cities have more choices than ever for switching to clean energy.

If you're considering solar power, check out resources such as EnergySage, which helps consumers compare solar options.

With solar power now as simple as applying a sticker, the future of clean energy is looking brighter than ever.

Quantum dot solar panels are a type of solar cell design that uses **quantum dots as the photovoltaic material**. These tiny, circular semiconductor crystals are highly efficient at absorbing and emitting light. The initial lead sulfide quantum dot solar cells had an efficiency of 2.9 percent.

A **quantum dot solar cell** (**QDSC**) is a solar cell design that uses quantum dots as the captivating photovoltaic material. It attempts to replace bulk materials such as silicon, copper indium gallium selenide (CIGS) or cadmium telluride (CdTe). Quantum dots have bandgaps that are adjustable across a wide range of energy levels by changing their size. In bulk materials, the bandgap is fixed by the choice of material(s).[1] This property makes quantum dots attractive for multi-junction solar cells, where a variety of materials are used to improve efficiency by harvesting multiple portions of the solar spectrum.[2]

As of 2022, efficiency exceeds 18.1%.[3] Quantum dot solar cells have the potential to increase the maximum attainable thermodynamic conversion efficiency of solar photon conversion up to about 66% by utilizing hot photogenerated carriers to produce higher photovoltages or higher photocurrents.[4]

Typical quantum dots solar cells consist of a glass substrate followed by a transparent electrically conducting indium tin oxide(ITO) that allows light to penetrate the solar cell. It also contains a conducting polymer, poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS), to enroll as electron blocker and hole injector to the ITO layer. Finally, quantum dots(QDs) such as cadmium selenide along with poly(3-hexylthiophene) (P3HT) are used between the metal cathode and the conductive polymer layer to ensure optimal function.[5]

The Future of Solar Power: How New Tech Could Change the World

Harnessing the power of the sun has always been an age-old dream for humanity. As the world grapples with climate change, the potential of solar energy shines brighter than ever. Solar power, once an expensive and inefficient energy source, is now on the brink of a revolution. Thanks to new technological advancements, it holds the promise of a cleaner, more sustainable future. This article delves into how these innovations could reshape our world.

Innovative Solar Applications

Solar power is no longer confined to just rooftops. Innovations are allowing solar technology to be integrated into various aspects of our lives. Think solar-powered roads that generate electricity as cars drive over them or solar windows that not only let in light but also produce energy. These applications are opening up new possibilities for harnessing solar power in ways previously unimaginable, making it a versatile energy solution.

Solar Farms and Energy Independence

Large-scale solar farms are sprouting up around the world, generating vast amounts of clean energy. These farms are crucial for achieving energy independence. Countries can reduce their reliance on imported fossil fuels, enhancing their energy security. Moreover, solar farms create jobs and stimulate economic growth in the regions where they're established. As more countries invest in solar farms, the global energy landscape is set to change dramatically.

Community Solar Initiatives

Not everyone has the means or space to install solar panels on their property. Community solar initiatives offer a solution. These programs allow multiple households to benefit from solar energy by sharing a centralized solar array. Community solar not only democratizes access to clean energy but also fosters a sense of community and shared responsibility for the environment.

It's an innovative approach that ensures everyone can participate in the solar revolution.

Solar Energy in Agriculture

Agriculture is an energy-intensive industry, but solar power offers a sustainable alternative. Farmers can use solar panels to power irrigation systems, reducing their reliance on diesel generators. Solar technology can also be integrated into greenhouses, providing energy for temperature control and lighting. By adopting solar energy, the agricultural sector can reduce its carbon footprint and promote sustainable farming practices.

Solar Tech in Developing Countries

Many developing countries face energy challenges, with millions lacking access to reliable electricity. Solar power offers a viable solution. Off-grid solar systems can provide electricity to remote areas, improving the quality of life for countless people. This technology empowers communities, enabling them to access education, healthcare, and economic opportunities. As solar tech becomes more widespread, it has the potential to transform lives in developing countries.

Solar Technology and Job Creation

The solar industry is a significant driver of job creation. As the demand for solar power grows, so does the need for skilled workers. From manufacturing to installation and maintenance, the solar sector offers numerous employment opportunities. These jobs not only support local economies but also contribute to the global transition to clean energy. By investing in solar technology, we can create a brighter future for both the planet and its people.

Government Policies and Solar Energy

Government policies play a crucial role in promoting solar energy. Incentives like tax credits, rebates, and grants can encourage individuals and businesses to adopt solar technology. Supportive policies can also drive innovation, making solar power more accessible and affordable. By prioritizing clean energy initiatives, governments can lead the way in the global transition to a sustainable energy future.

Solar Power and Global Collaboration

The transition to solar power requires global collaboration. Countries must work together to share knowledge, resources, and technology. International partnerships can accelerate the adoption of solar energy, ensuring a sustainable future for all. By uniting in the pursuit of clean energy, we can address the challenges of climate change and create a better world for future generations.

The Impact of Solar Power on Society

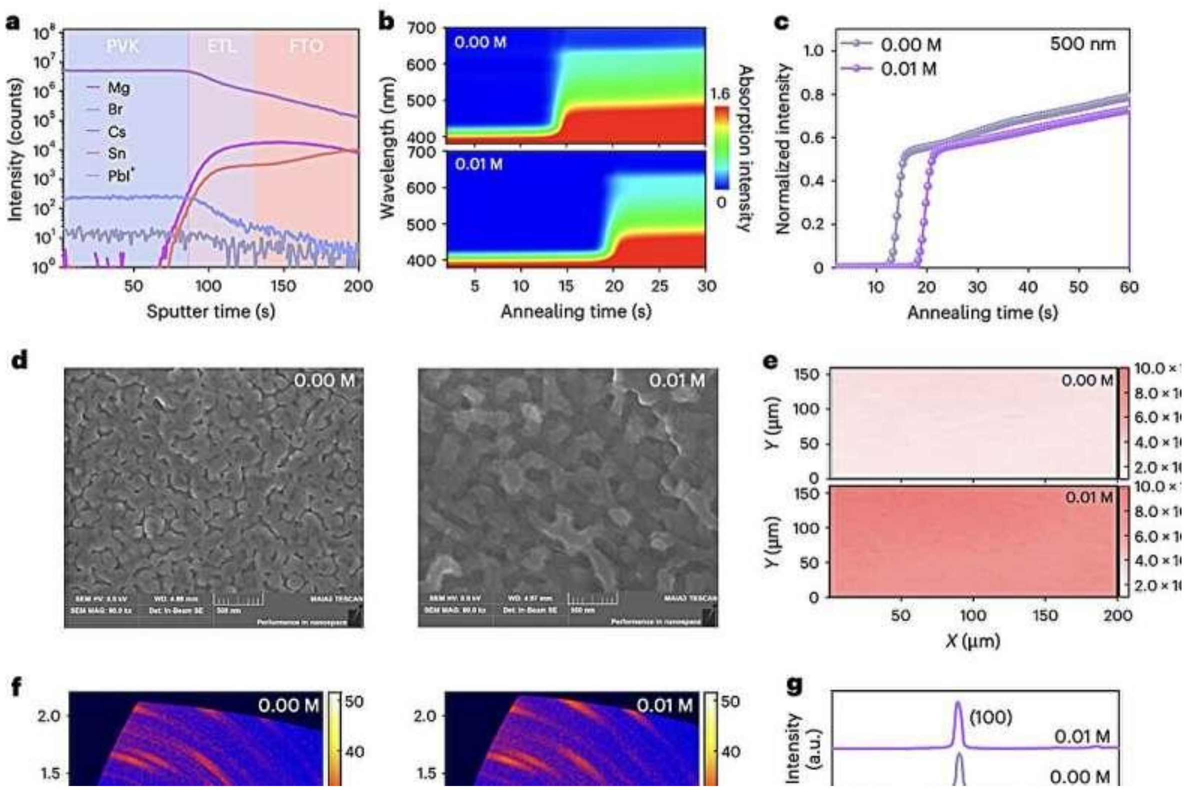
Solar power has the potential to reshape society. By reducing our reliance on fossil fuels, we can create a cleaner, healthier environment. This transition also promotes energy independence, reducing geopolitical tensions over energy resources. As solar technology becomes more widespread, it can drive economic growth, create jobs, and improve the quality of life for people worldwide.

Solar power is poised to change the world. New technologies are making it more efficient, affordable, and versatile than ever before. As we embrace this clean energy source, we can create a sustainable future for all. The sun's energy is limitless, and with continued innovation, we can harness its power to transform our world for the better.

MARCH 27, 2025

Magnesium-doped quantum dots boost perovskite/organic tandem solar cell stability

by Ingrid Fadelli , Tech Xplore



Characterizations of CsPbI2Br perovskite on modulated bottom ETL contacts. **a**, ToF-SIMS depth profiles of $CsPbI_2Br$ perovskite on M-SQDs-coated FTO substrate. PVK, perovskite film. **b**, Time-resolved in situ UV–vis absorption spectra of $CsPbI_2Br$ perovskite crystallization on modulated bottom ETL contacts. **c**, Time-resolved absorbance at the wavelength of 500 nm for samples. **d**–**f**, SEM of $CsPbI_2Br$ perovskite on SQDs (left) and M-SQDs (right) coated FTO (**d**), PL mapping (**e**) and GIWAXS patterns of CsPbI2Br perovskite on SQDs (left) and M-SQDs (right) coated FTO (**f**) of $CsPbI_2Br$ perovskite on SQDs (M-SQDs) coated FTO substrate. **g**, GIWAXS intensity profiles along the q_z direction of the perovskite films. Colour bars indicate GIWAXS signal intensity. **h**, The intensity azimuthal pole (**f**) along the (110) plane. The (110) planes were fitted with Gaussian distribution method. Credit: *Nature Energy* (2025). DOI: 10.1038/s41560-025-01742-8

Photovoltaic (PV) solutions, which are designed to convert sunlight into electrical energy, are becoming increasingly widespread worldwide. Over the past decades, engineers specialized in energy solutions have been trying to identify new solar cell designs and PV materials that could achieve even better power conversion efficiencies, while also retaining their stability and reliably operating for long periods of time.

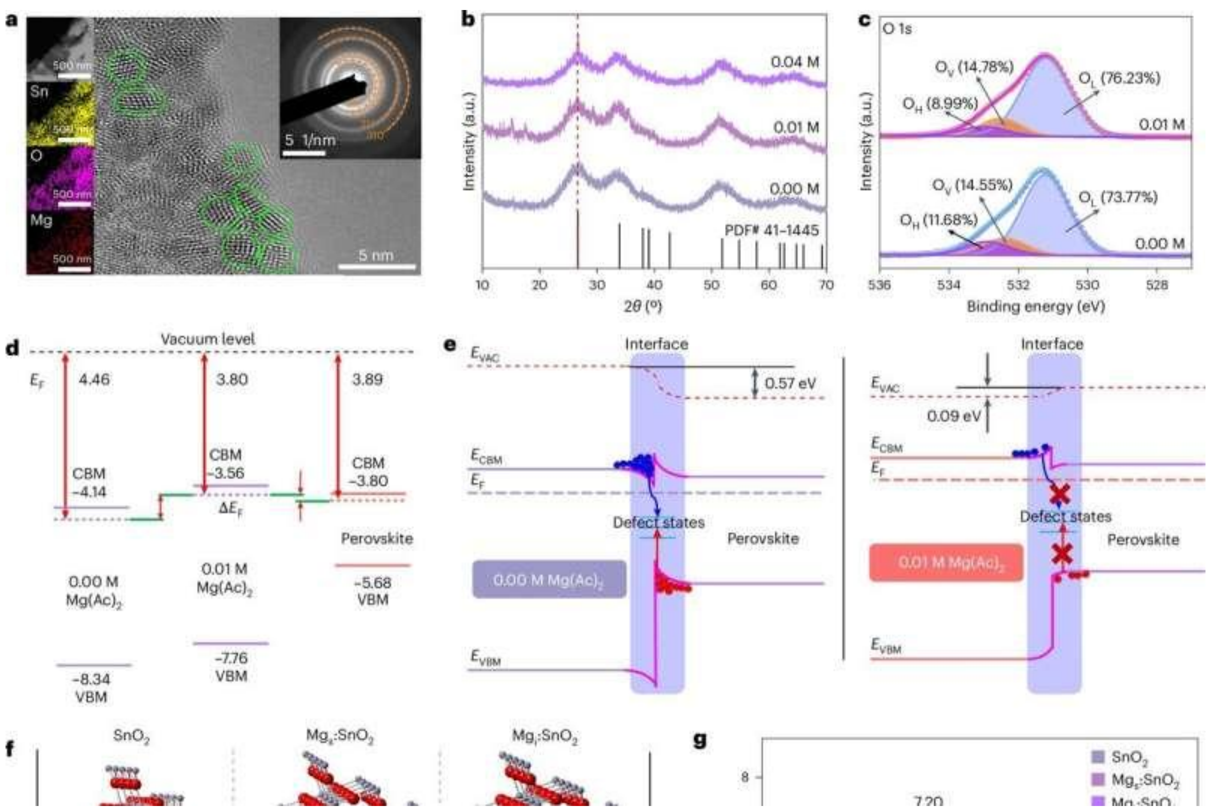
The many emerging PV solutions that have proven to be particularly promising include tandem solar cells based on both perovskites (a class of materials with a characteristic crystal structure) and organic materials. Perovskite/organic tandem solar cells could be more affordable than existing silicon-based solar cells, while also yielding higher power conversion efficiencies.

These solar cells are manufactured using wide-bandgap perovskites, which have an electronic bandgap greater than 1.6 electronvolts (eV) and can thus absorb higher-energy photons. Despite their enhanced ability to absorb high-energy light particles, these materials have significant limitations, which typically adversely impact the stability of solar cells.

Researchers at the Hong Kong Polytechnic University recently devised a new strategy to improve the stability and efficiency of perovskite/organic tandem solar cells. This strategy, outlined in a paper in *Nature Energy*, relies on the use of acidic magnesium-doped tin oxide quantum dots.

"Wide-bandgap perovskites in monolithic perovskite/organic tandem solar cells face challenges such as unregulated crystallization, severe defect traps, poor energetic alignment and undesirable phase transitions, primarily due to unfavorable bottom interfacial contact," wrote Yu Han, JieHao Fu, and their colleagues in their paper.

"These issues lead to energy loss and device degradation. In this article, we synthesize acidic magnesium-doped tin oxide quantum dots to modulate the bottom interface contact in wide-bandgap $CsPbI_2Br$ perovskite solar cells."



Properties of acidic M-SQDs with adjustable features and DFT theoretical calculation. Credit: *Nature Energy* (2025). DOI: 10.1038/s41560-025-01742-8

Quantum dots are nanoscale semiconductor particles that exhibit unique optical and electronic properties. The researchers synthesized quantum dots doped with acidic magnesium and then used them to enhance the connection between the perovskite layer and underlying material in perovskite/organic solar cells.

"This design balances physical, chemical, structural and energetic properties, passivating defects, optimizing energy band alignment, enhancing perovskite film growth and mitigating instability," wrote the researchers. "We also elucidate the instability mechanism caused by alkaline-based tin oxide bottom contact, emphasizing the impact of the tin oxide solution's acid/base properties on the stability and performance of the device."

The researchers used their new quantum dot-based design strategy to create a wide-bandgap $CsPbI_2Br$ solar cell and then tested the performance of this cell in a series of tests. Their results were promising, as their approach yielded good power conversion efficiencies, while also boosting the solar cell's stability under a variety of environmental conditions.

"The wide-bandgap $CsPbI_2Br$ solar cell achieves a power conversion efficiency of 19.2% with a 1.44 V open-circuit voltage," wrote the researchers. "The perovskite/organic tandem solar cell demonstrates an efficiency of 25.9% (certified at 25.1%), with improved stability under various conditions."

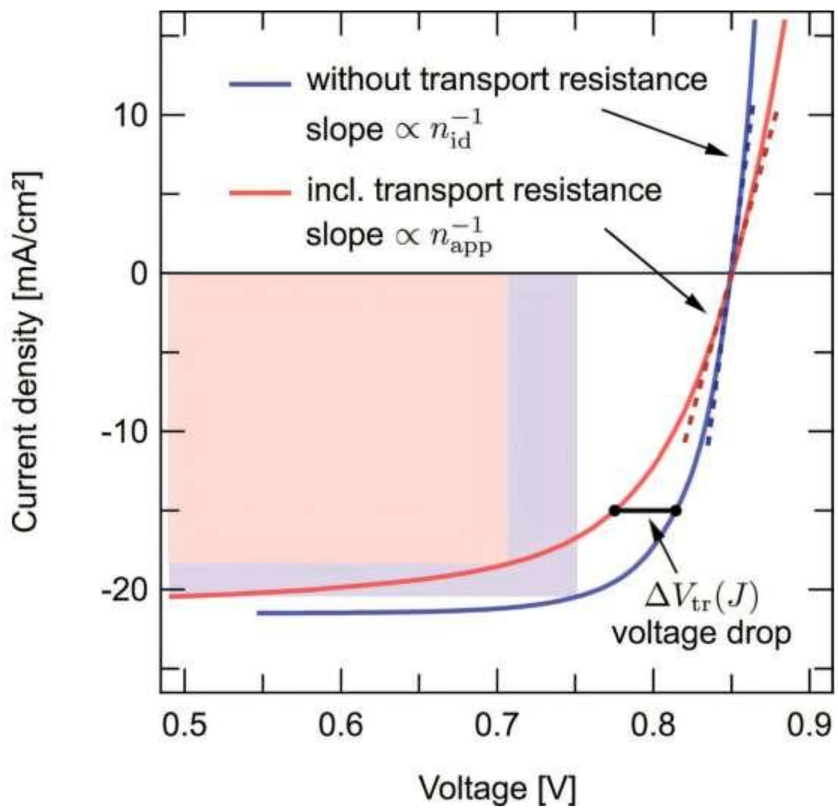
The recent work by Han, Fu and their collaborators could contribute to the advancement of perovskite/organic tandem solar cells, potentially facilitating their future widespread deployment. The quantum dot-based strategy they developed could soon be improved further and applied to similar solar cells based on other materials.

More information: Yu Han et al, Inorganic perovskite/organic tandem solar cells with 25.1% certified efficiency via bottom contact modulation, *Nature Energy* (2025). DOI: 10.1038/s41560-025-01742-8
Journal information: Nature Energy

MARCH 31, 2025

Organic solar cells face efficiency challenge due to slow current flow, researchers show

by Mario Steinebach, Chemnitz University of Technology



Current–voltage characteristics of a solar cell with and without transport resistance, with the shaded areas indicating the maximum output power. Credit: *Advanced Energy Materials* (2025). DOI: 10.1002/aenm.202405889

Researchers from the Chair of Optics and Photonics of Condensed Matter led by Prof. Dr. Carsten Deibel at the Chemnitz University of Technology and other partner institutions are currently working on solar cells made from novel organic semiconductors that can be produced using established printing processes. The scientists are collaborating interdisciplinarily to fundamentally understand these photovoltaic cells in order to further improve them.

"Organic solar cells can be produced very easily and cheaply using printing processes," says Deibel. In contrast to established solar modules made of crystalline silicon, however, the current flow in organic solar cells is very slow.

"Due to the production of the solar cells from a kind of ink, the organic, light-absorbing layers are very disordered. Therefore, the current flow is very slow," explains Deibel. A consequence of the slow transport of light-generated electrons and holes is the so-called transport resistance, which reduces the fill factor of the solar cells and thus the power.

Deeper understanding: Transport resistance limits the performance of organic solar cells

To better understand the performance characteristics of organic solar cells, Deibel and his scientific assistant Maria Saladina have produced and thoroughly investigated different types of organic solar cells and uncovered the negative influence of transport resistance. The current-voltage characteristics under illumination, which result from the interplay of charge generation by light, recombination of electrons and holes, and charge transport, were measured. They contain information on the power efficiency of the solar cells.

These measurements were compared with the so-called suns-Voc method, which allows the construction of an alternative current-voltage curve that is not limited by charge transport losses such as transport resistance. "Transport resistance is a result of the slow charge carriers in the disordered solar cells processed from organic ink. Thus, the charge carriers get in their own way and lead to a loss of fill factor and thus power," says Saladina.

The research results were published in *Reports on Progress in Physics*. Although the optimization of organic solar cells must be re-evaluated due to these new results, there is no fundamental obstacle to producing highly efficient, printed organic solar cells.

In a perspective article published in the journal *Advanced Energy Materials*, written by Chen Wang, Deibel, and Saladina together with co-authors from various German universities, the physical origin of transport resistance and its significance for solar cells is explained in detail.

"In recent years, charge transport has been continuously improved without the research community knowing the exact relationship between fill factor losses and transport resistance," says Deibel.

Saladina adds, "In addition to recombination, transport resistance is also determined by the shape of the density of states of organic solar cells. This shows that we are, step-by-step, understanding the physical foundations of these photovoltaic devices better and better."

These results have been achieved within the framework of the DFG Research Unit POPULAR, which continues to work on understanding and improving printed organic solar cells.

More information: Maria Saladina et al, Transport resistance strikes back: unveiling its impact on fill factor losses in organic solar cells, *Reports on Progress in Physics* (2025). DOI: 10.1088/1361-6633/adb20c

Chen Wang et al, Transport Resistance Dominates the Fill Factor Losses in Record Organic Solar Cells, *Advanced Energy Materials* (2025). DOI: 10.1002/aenm.202405889
Journal information: Reports on Progress in Physics , Advanced Energy Materials
Provided by Chemnitz University of Technology

APRIL 18, 2025

Perovskite solar modules show year-long outdoor durability

by Anurag Krishna

Perovskite solar modules developed by imec. Credit: Anurag Krishna

Perovskite photovoltaics (PV) are poised at the brink of commercialization, yet stability remains the foremost hurdle to overcome for widespread adoption. While extensive research has addressed the degradation of perovskite PV through accelerated indoor testing, outdoor testing remains relatively underexplored and primarily focused on small cells rather than modules.

This gap underscores the urgent need to comprehensively study outdoor degradation processes. Understanding how perovskite PV modules perform under real-world environmental conditions is crucial for advancing toward commercial viability.

In our work published in *ACS Energy Letters*, we present a two-year outdoor evaluation of perovskite modules, shedding light on their degradation under real-world conditions. Our findings highlight a significant milestone in perovskite PV research, with the most robust module maintaining 78% of its initial performance after one year. Performance loss rates during the burn-in period were found to be about 7%–8% per month.

We provide quantitative insights into diurnal performance degradation and recovery, revealing a decrease in daytime performance and improvement overnight, with long-lasting modules experiencing degradation and recovery of up to 20%.

Analysis of diurnal current, voltage, and Fill Factor degradation shows daytime current decreases and nighttime increases, while voltage and Fill Factor exhibit opposite trends. Temperature and irradiance studies showed higher degradation and recovery rates at elevated temperatures, with minimal impact from irradiance.

Seasonal performance variations demonstrated a consistent linear diurnal degradation trend across all modules over two years, independent of environmental conditions. Furthermore, we developed and implemented a data-driven predictive model using XGBoost regression to forecast power output. This model demonstrated robust predictive capability with a normalized root mean square error (nRMSE) of 6.76% on the test set, affirming a strong correlation between predicted and actual power outputs.

We believe that this research represents a major advancement in understanding the degradation of perovskite solar modules in real-world conditions. With further improvements in the efficiency of our mini-modules, which are designed with upscaling in mind, these findings can accelerate the path toward commercialization of this promising technology.

Next, we plan to test the modules in a range of climates—from the wet and cloudy environment of Brussels to the dry heat of New Mexico, as well as moderate climates like Madrid and Freiburg. Comparing performance across these diverse locations will give us a more complete picture of how perovskite modules stand up to real-world conditions.

This story is part of Science X Dialog, where researchers can report findings from their published research articles. Visit this page for information about Science X Dialog and how to participate.

More information: Vasiliki Paraskeva et al, Diurnal Changes and Machine Learning Analysis of Perovskite Modules Based on Two Years of Outdoor Monitoring, *ACS Energy Letters* (2024). DOI: 10.1021/acsenergylett.4c01943

Bio:

Dr. Anurag Krishna is an R&D Project Leader in the Thin Film Photovoltaics team at the Interuniversity Microelectronics Center (imec) in Belgium—one of the world's leading research hubs for nanoelectronics, digital, and energy technologies. He manages a portfolio of national, European, and industrial projects aimed at pushing the boundaries of perovskite photovoltaic technologies. Prior to joining imec, he was a Marie Skłodowska-Curie Fellow at the École Polytechnique Fédérale de Lausanne (EPFL), where he conducted high-impact research under the guidance of Professors Michael Graetzel and Anders Hagfeldt. He earned his Ph.D. from Nanyang Technological University (NTU), Singapore. His research expertise lies at the intersection of advanced materials, device engineering, and state-of-the-art characterization techniques. His work bridges fundamental science and applied innovation, contributing significantly to the development of high-efficiency, stable perovskite solar cells. He has authored more than 35 publications in journals, including *Nature Communications*, *Energy & Environmental Science*, *Joule*, *Advanced Materials*, *Journal of the American Chemical Society* (*JACS*), and *Angewandte Chemie*.

Journal information: Journal of the American Chemical Society , Joule , Energy & Environmental Science , ACS Energy Letters , Nature Communications , Advanced Materials , Angewandte Chemie

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APRIL 18, 2025

Flexible tandem solar cells achieve 24.6% efficiency and withstand 3,000 bends in new study

by Chinese Academy of Sciences

Flexible perovskite/CIGS tandem solar cells developed using the antisolvent-seeding approach. Credit: NIMTE

Chinese scientists have found a way to make flexible tandem solar cells more efficient and durable by enhancing the adhesion of top layers to the bottom layers of the cell.

Copper indium gallium selenide (CIGS) is a commercial semiconductor known for its outstanding adjustable bandgap, strong light absorption, low-temperature sensitivity, and superior operational stability, making it a promising candidate for bottom-cell use in next-generation tandem solar cells.

Flexible perovskite/CIGS tandem solar cell combines a top layer of perovskite—a material that efficiently converts sunlight into electricity—with a bottom layer of CIGS. Thus, this tandem cell holds great potential for lightweight, high-efficiency applications in the photovoltaic field.

However, the rough surface of CIGS makes it difficult to produce high-quality perovskite top cells on top, which limits the commercial prospects of these tandem cells.

In a study published in *Nature Energy*, a research group led by Prof. Ye Jichun from the Ningbo Institute of Materials Technology and Engineering (NIMTE) of the Chinese Academy of Sciences has developed an innovative antisolvent-seeding strategy to enhance the performance of perovskite top cells on rough surfaces.

Scientists separated the processes of self-assembled monolayer (SAM) adsorption and dissolution while simultaneously integrating perovskite seeding.

They utilized a high-polarity solvent to prevent SAM clustering during dissolution, while a low-polarity solvent acted as an antisolvent to promote the formation of a dense SAM during adsorption. Additionally, a pre-mixed seed layer improved the wettability and crystallinity of the perovskite, ensuring strong adhesion to the substrate.

With these innovations, the team fabricated a 1.09 cm^2 flexible monolithic perovskite/CIGS tandem solar cell. Competing with top rigid counterparts, the device achieved an impressive stabilized efficiency of 24.6% (certified at 23.8%), one of the highest reported values for flexible thin-film solar cells to date.

After 320 hours of operation and 3,000 bending cycles at a radius of 1 cm, the device retained over 90% of its initial efficiency, demonstrating exceptional mechanical durability and long-term stability.

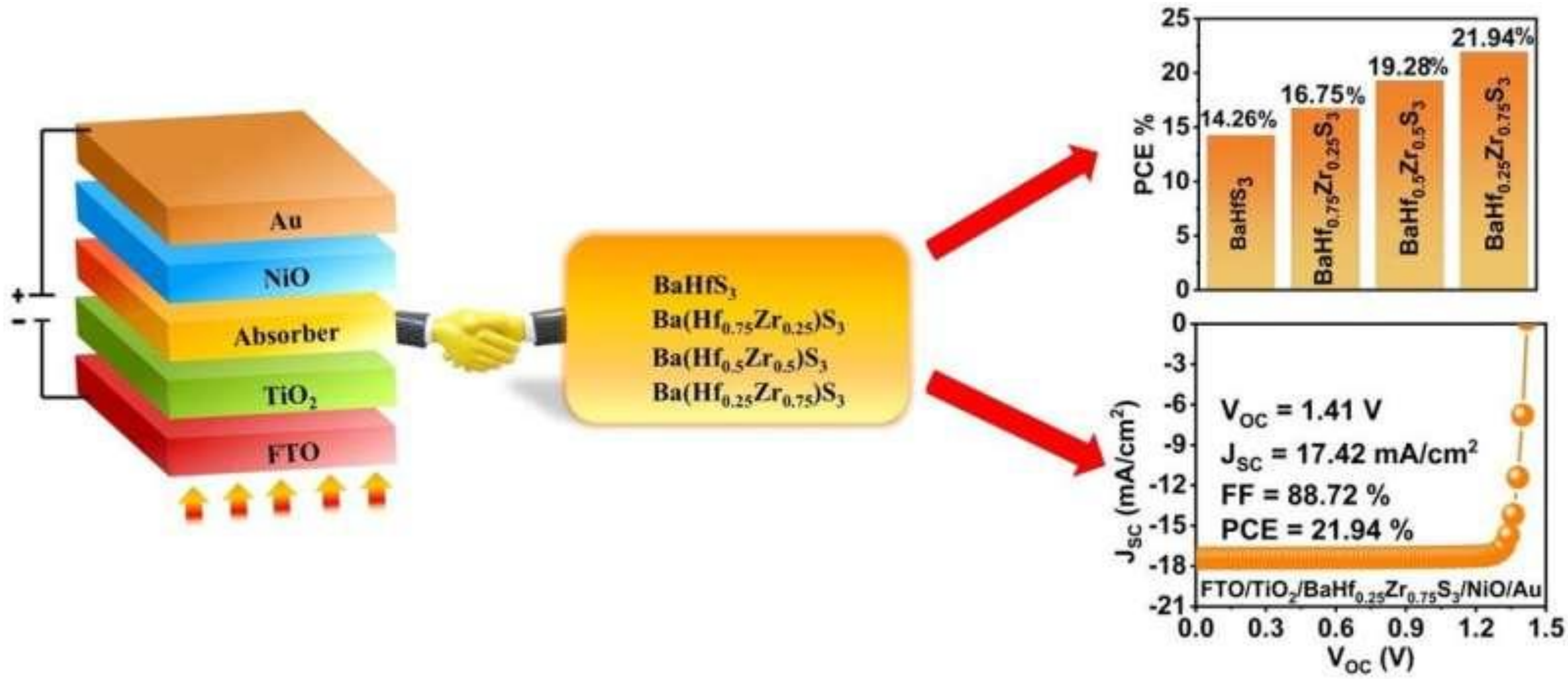
This achievement paves the way for developing cost-effective, high-performance flexible tandem solar cells, advancing the commercial application of tandem solar cell technology.

More information: *Nature Energy* (2025). DOI: 10.1038/s41560-025-01760-6
Journal information: Nature Energy
Provided by Chinese Academy of Sciences

APRIL 16, 2025

Improving solar cell performance: The impact of Zr alloying on the engineering of $BaHfS_3$

by Latha Marasamy



Schematic illustration of the novel chalcogenide perovskite solar cell structure featuring Zr-alloyed BaHfS3 as the absorber layer. Credit: *Materials Science and Engineering: B* (2025). DOI: 10.1016/j.mseb.2025.118126

Lead halide perovskite solar cells (LHPSCs) have rapidly gained prominence in the field of photovoltaics, boasting impressive power conversion efficiencies (PCEs) of up to 26.1% in single-junction devices. However, despite their high performance, these materials suffer from critical drawbacks, including degradation when exposed to moisture, oxygen, heat and ultraviolet light, as well as concerns regarding the toxicity of lead.

Overcoming these challenges is vital for the commercial viability and environmental safety of next-generation solar technologies, but how can we engineer stable and sustainable alternatives without compromising efficiency?

To address these limitations, my research team at the Autonomous University of Querétaro in Mexico focused on chalcogenide perovskites, particularly by alloying zirconium (Zr) into barium hafnium sulfide ($BaHfS_3$), as a promising alternative.

These materials offer unique properties that make them highly suitable for photovoltaic applications. They demonstrate excellent chemical stability, essential for maintaining long-term performance in real-world conditions. Furthermore, they exhibit a tunable bandgap, a high absorption coefficient for photons, and enhanced carrier mobility with p-type conductivity.

Our study explored the use of $BaHfS_3$ and its Zr-alloyed variants, such as $BaHf_{0.75}Zr_{0.25}S_3$, $BaHf_{0.5}Zr_{0.5}S_3$, and $BaHf_{0.25}Zr_{0.75}S_3$, as absorber layers in photovoltaic devices.

To evaluate and optimize their performance, we utilized SCAPS-1D (Solar Cell Capacitance Simulator in One Dimension), a simulation tool developed by Mark Burgelman at the University of Ghent. This tool enabled us to simulate real-world conditions and fine-tune key device parameters such as absorber acceptor density, defect density, and layer thickness.

Our findings, published in *Materials Science and Engineering: B*, show that careful optimization of these chalcogenide perovskites can significantly enhance photovoltaic performance. The results indicate a promising path toward efficient, stable, and lead-free solar cells.

This approach led to improvements in light absorption, reduced recombination losses, enhanced built-in potential, and minimized non-radiative recombination and charge transfer resistance. Additionally, we improved the band alignment between layers and strengthened interfacial properties, resulting in notable increases in PCE.

We conducted a comparative analysis of both base and optimized solar cells for all absorber compositions using techniques such as C-V profiling, Mott–Schottky analysis, C-F measurements, QE, and energy band alignment.

The enhancements in PCE were attributed to increased short-circuit current density, greater quasi-Fermi level splitting, higher carrier generation rates, stronger electric fields, improved quantum efficiency, and extended carrier diffusion lengths. Ultimately, we achieved PCEs exceeding 20% for $BaHfS_3$, and its Zr-alloyed forms.

Overall, our research highlights the potential of $BaHfS_3$ and its Hf/Zr variants ($BaHf_{1-x}Zr_xS_3$) as high-performance, lead-free chalcogenide perovskite solar absorbers. We believe our work will spark further interest among materials scientists and photovoltaic researchers.

This story is part of Science X Dialog, where researchers can report findings from their published research articles. Visit this page for information about Science X Dialog and how to participate.

More information: Dhineshkumar Srinivasan et al, Engineering BaHfS3 with Zr alloying to improve solar cell performance: Insights from SCAPS-1D simulations, *Materials Science and Engineering: B* (2025). DOI: 10.1016/j.mseb.2025.118126

Bio:

Dr. Latha Marasamy is a Research Professor at the Faculty of Chemistry at UAQ, where she leads a dynamic team of international students and researchers. Her mission is to advance renewable energy, particularly in the development of second and third-generation solar cells, which include CdTe, CIGS, emerging chalcogenide perovskites, lead-free perovskites, quaternary chalcogenides of I2-II-IV-VI4, and hybrid solar cells. She is working with a range of materials such as CdTe, CIGSe, CdS, MOFs, graphitic carbon nitride, chalcogenide perovskites (ABX_3, where A = Ba, Sr, Ca; B = Zr, Hf; X = S, Se), quaternary chalcogenides (I2-II-IV-VI4, where I = Cu, Ag; II = Ba, Sr, Co, Mn, Fe, Mg; IV = Sn, Ti; VI = S, Se), metal oxides, MXenes, ferrites, plasmonic metal nitrides, and borides for these applications. Additionally, Dr. Marasamy is investigating the properties of novel materials and their influence on solar cell performance through DFT and SCAPS-1D simulations.

Lead-free chalcogenide perovskites $ABSe_3$ show promise for high-efficiency solar cells

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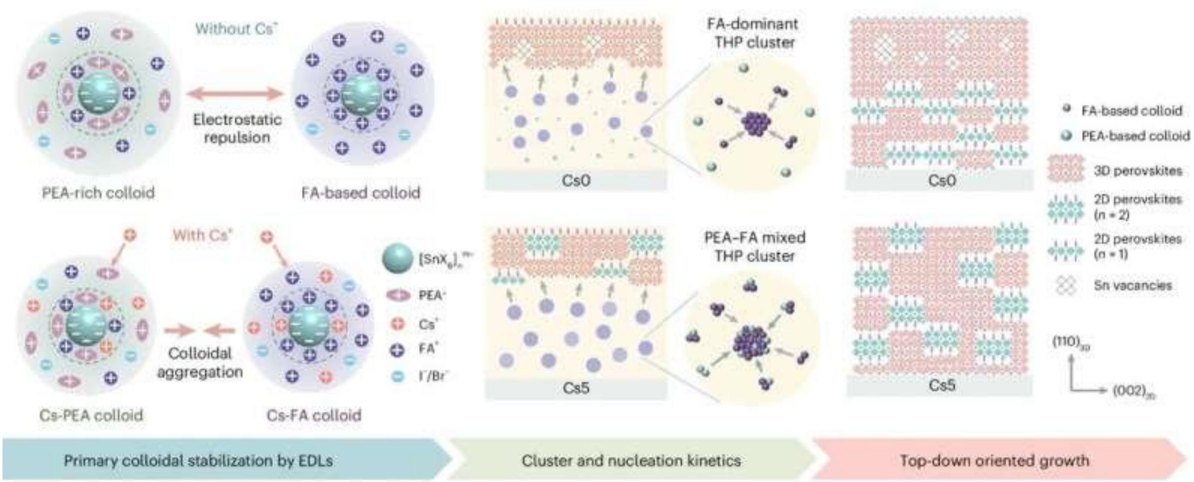
APRIL 16, 2025

Solar cell efficiency record achieved with tin halide perovskite

by University of Queensland



Schematic illustration of the primary colloidal stabilization of PEA-rich colloids and FA-based colloids, cluster formation and nucleation kinetics, and the growth processes of 2D/3D THPs with and without Cs+ incorporation. Credit: *Nature Nanotechnology* (2025). DOI: 10.1038/s41565-025-01905-4

University of Queensland researchers have set a world record for solar cell efficiency with eco-friendly perovskite technology. A team led by Professor Lianzhou Wang has unveiled a tin halide perovskite (THP) solar cell capable of converting sunlight to electricity at a certified record efficiency of 16.65%. The research is published in the journal *Nature Nanotechnology*.

Working across UQ's Australian Institute for Bioengineering and Nanotechnology and the School of Chemical Engineering, Professor Wang said the certified reading achieved by his lab was nearly one percentage point higher than the previous best for THP solar cells.

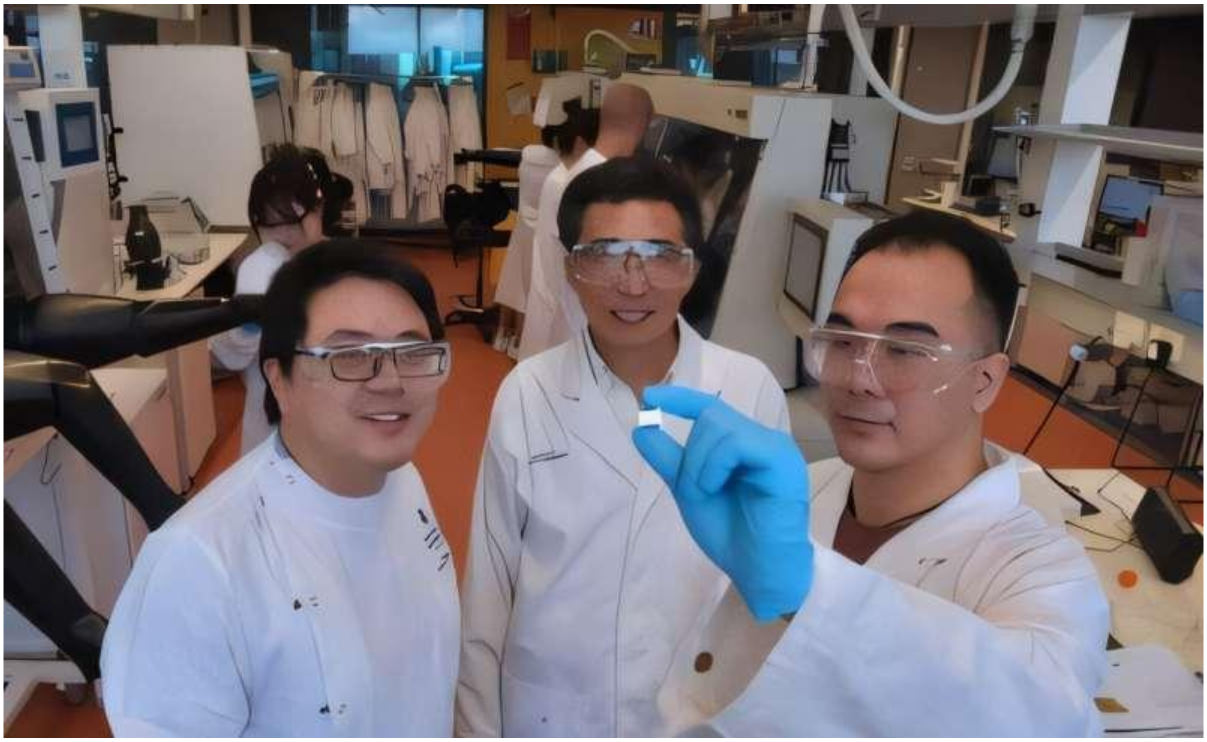
"It might not seem like much, but this is a giant leap in a field that is renowned for delicate and incremental progress," Professor Wang said.

"The reading is in line with many silicon-based solar cells currently on the market but with the potential to be cheaper and quicker to make.

"We are thrilled with the record and also to be contributing to the progress of cost-effective renewable energy technology."

Professor Wang's THP solar cell record comes five years after his lab set a benchmark for power conversion efficiency in solar cells using another type of technology, quantum dots.

Research group member Dr. Dongxu He said many of the methods, processes and materials used to set the quantum dot record in 2020 inspired efforts to improve the performance of the highly promising THP thin-film solar cells.



Examining the small but mighty solar cell technology set to revolutionise photovoltaics after another world-record efficiency breakthrough are (from left) Dr Peng Chen, Professor Lianzhou Wang and Dr Dongxu He. Credit: University of Queensland

"There is great commercial potential in THP solar cells because perovskite devices are more sustainable to produce than silicon-based solar cells," Dr. He said.

"The benefit of THPs is that we're dealing with more eco-friendly tin and not the toxic lead that is widely used in most of the perovskite solar cells, meaning they can be safely installed around the home."

The use of tin precursor had previously been problematic because of the substandard quality of the fast-crystalline thin films used in manufacturing THP solar cells, leading to a dip in efficiency.

Dr. Peng Chen said the group overcame this hurdle by incorporating cesium ions to improve the microstructure and reduce defects in the THP film.

"This is what allowed us to reach a record level of efficiency while still having a product that would pass stringent environmental checks," Dr. Chen said.

"I think we have a formula now that will only keep improving."

Professor Wang said he was happy to see other researchers jostle to break the THP record because it ultimately meant better and more eco-friendly renewable energy technology.

He said the flexibility and versatility of THP cells—when coupled with improved efficiency—could make them the ideal candidate for household photovoltaic solar panels to be used both outdoors and indoors.

"Beyond solar panels, the approach we've used in this paper could also be used for other devices that require high-quality perovskite films like lasers, photodetectors, and transistors," Professor Wang said.

"We could eventually see THPs used for engineering challenges, including as a lightweight solution to power electric aircraft—the sky really is the limit."

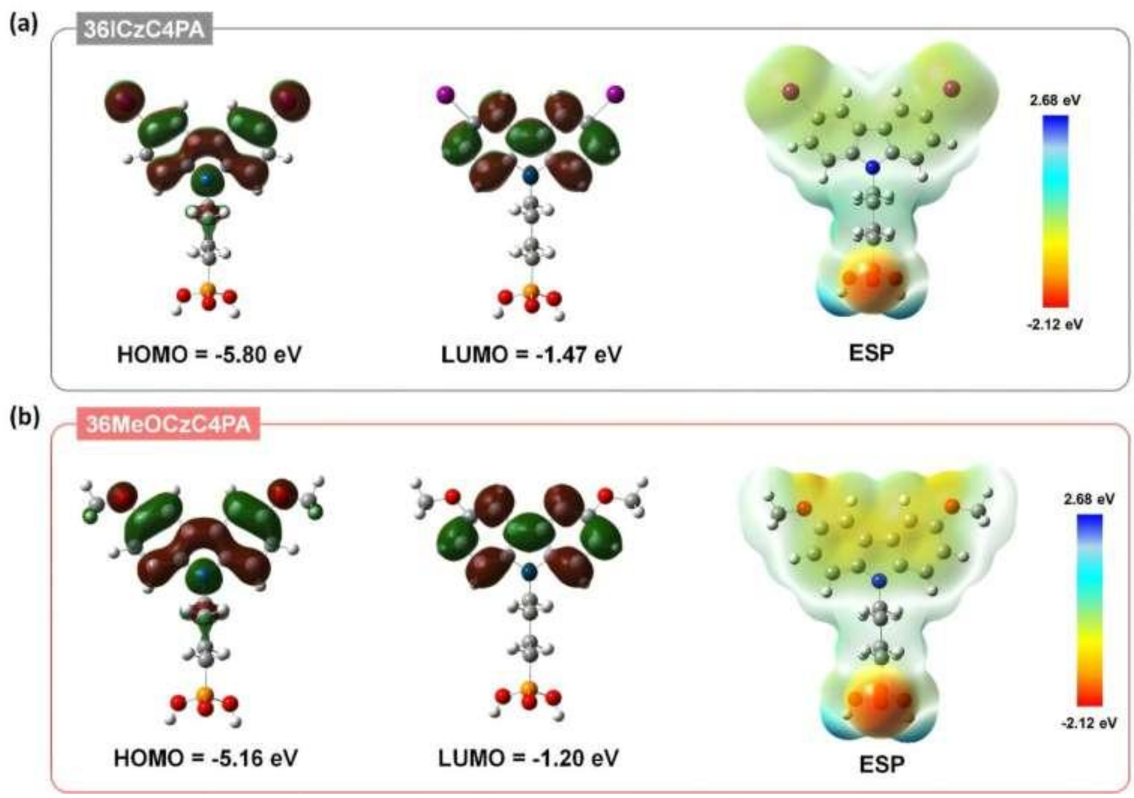
More information: Dongxu He et al, Homogeneous 2D/3D heterostructured tin halide perovskite photovoltaics, *Nature Nanotechnology* (2025). DOI: 10.1038/s41565-025-01905-4
Journal information: Nature Nanotechnology
Provided by University of Queensland

MAY 19, 2025

New thin-film material achieves both high efficiency and durability in tandem solar cells

by Ulsan National Institute of Science and Technology

edited by Lisa Lock, reviewed by Robert Egan



The calculated HOMO/LUMO orbitals and electrostatic potential maps (ESP) of (a) 36ICzC4PA and (b) 36MeOCzC4PA. Credit: *Advanced Energy Materials* (2025). DOI: 10.1002/aenm.202404092

A novel thin-film material capable of simultaneously enhancing the efficiency and durability of tandem solar cells has been developed.

Led by Professor BongSoo Kim from the Department of Chemistry at UNIST, in collaboration with Professors Jin Young Kim and Dong Suk Kim from the Graduate School of Carbon Neutrality at UNIST, the team developed a multi-functional hole-selective layer (mHSL) designed to significantly improve the performance of perovskite/organic tandem solar cells (POTSCs). Their study is published in *Advanced Energy Materials*.

Tandem solar cells are advanced photovoltaic devices that stack two different types of cells to absorb a broader spectrum of sunlight, thereby increasing overall energy conversion efficiency. Among these, combinations of perovskite and organic materials are particularly promising for producing thin, flexible solar panels suitable for wearable devices and building-integrated photovoltaics, positioning them as next-generation energy sources.

The research team successfully developed a hole-transport layer (HTL) by blending two self-assembled molecules, achieving a record open-circuit voltage (VOC) of 2.216 V and a power conversion efficiency (PCE) of 24.73%. The VOC, which reflects the maximum voltage the cell can produce without current flow, is a critical indicator of device performance.

This efficiency level is among the highest ever recorded for perovskite-organic tandem solar cells globally. Moreover, the device maintained over 80% of its initial efficiency after prolonged exposure to high temperatures of 65°C and continuous illumination, demonstrating excellent long-term stability.

The newly developed HTL is carefully engineered to align its energy levels with the perovskite active layer, selectively extracting holes while blocking electrons, thereby reducing charge recombination losses. Efficient charge extraction is essential because, after light absorption, electrons and holes must reach their respective electrodes to generate current; misaligned energy levels cause charge loss and reduced efficiency.

Additionally, this HTL reduces interface defects that hinder charge transport and stabilizes the crystal structure, thanks to the strong chemical bonds formed between the substituents of the self-assembled molecules—36ICzC4PA and 36MeOCzC4PA—and the metal ions within the perovskite layer. The self-assembly property of these molecules ensures a uniform, ultra-thin coating over large areas, simplifying manufacturing processes and facilitating scalable production for commercialization.

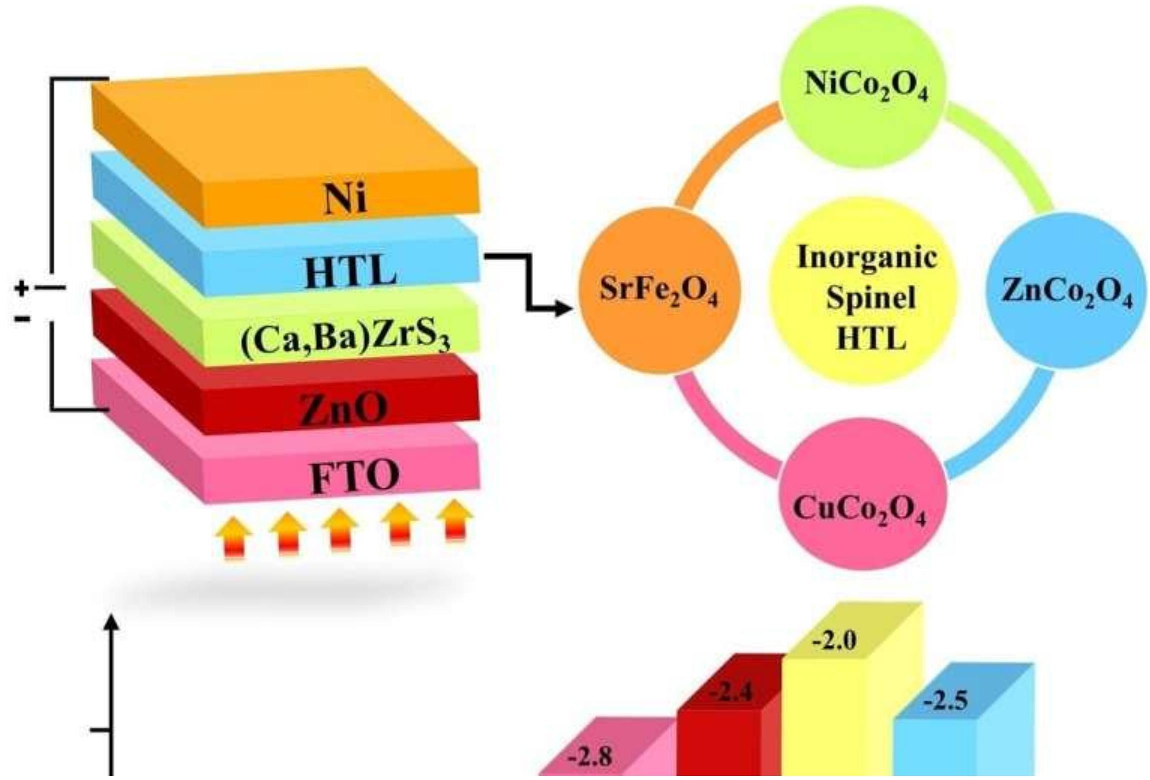
Professor Kim commented, "By developing a self-assembled hole transport layer that improves charge extraction, interface stability, and structural durability, we have made a significant leap forward in enhancing the performance of tandem solar cells. This development brings us closer to realizing thin, flexible, and high-efficiency next-generation solar panels for practical applications."

More information: Jung Geon Son et al, Exceeding 2.2 V Open-Circuit Voltage in Perovskite/Organic Tandem Solar Cells via Multi-Functional Hole-Selective Layer, *Advanced Energy Materials* (2025). DOI: 10.1002/aenm.202404092
Journal information: Advanced Energy Materials
Provided by Ulsan National Institute of Science and Technology

MAY 22, 2025

Advancements in $(Ca,Ba)ZrS_3$ solar cells using innovative spinel hole transport layers

by Latha Marasamy edited by Lisa Lock, reviewed by Robert Egan



Credit: *Optical and Quantum Electronics* (2025). DOI: 10.1007/s11082-025-08228-7

Solar power has long been a beacon of hope in our pursuit of clean energy. However, the road to sustainable, high-efficiency photovoltaics has been riddled with roadblocks such as toxicity and instability in widely used lead halide perovskites. Could we engineer a solar cell that delivers not just high performance, but also durability, stability and environmental safety?

That question led us to $(Ca,Ba)ZrS_3$, a chalcogenide perovskite with immense promise. Unlike its lead-based counterparts, this material boasts strong thermal and chemical stability. More importantly, its bandgap can be finely tuned down to 1.26 eV with less than 2% calcium doping, placing it squarely within the Shockley-Queisser limit for optimal photovoltaic conversion.

For the first time, my research team at the Autonomous University of Querétaro explored an innovative idea of pairing $(Ca,Ba)ZrS_3$ with next-generation inorganic spinel hole transport layers (HTLs). We integrated $NiCo_2O_4$, $ZnCo_2O_4$, $CuCo_2O_4$, and $SrFe_2O_4$ into solar cells and simulated their performance using SCAPS-1D.

Our work, published in *Optical and Quantum Electronics*, has significantly raised the power conversion efficiency (PCE) to an impressive rate of over 34% by meticulously engineering layer thickness, carrier concentration, and interface properties.

We observed depletion widths up to 0.4 μm, 0.5 μm, 0.6 μm, 0.7 μm, and 0.2 μm for $NiCo_2O_4$, $ZnCo_2O_4$, $CuCo_2O_4$, and $SrFe_2O_4$ based solar cells, improving the charge carrier generation within the solar cells.

In particular, $SrFe_2O_4$ based cells delivered a stellar 34.24% PCE with less energy deficit (~ 0.11 V), elevated J_{SC} (~34.12 mA/cm^2) and improved absorption (~ 42%) due to their superior recombination resistance, enhanced built-in potential and optimized band alignment.

We are particularly encouraged by the superior performance of spinel HTLs compared to conventional organic counterparts. The combination of low cost, widespread availability, ease of synthesis, low electrical resistivity, environmental friendliness, and exceptional thermal and photochemical stability makes them highly compatible with emerging chalcogenide absorbers.

Beyond efficiency, we found that interface engineering plays a critical role. By minimizing defect densities and achieving ideal conduction and valence band offsets, effectively blocked charge recombination pathways, while allowing seamless hole transport. This fine-tuned architecture proves that sustainable solar technologies can be both high-performing and scalable.

Our research marks a pivotal step toward developing non-toxic, stable, and highly efficient thin-film solar cells. As we continue refining material properties and device configurations, we believe (Ca,Ba)ZrS_3 solar cells integrated with spinel HTLs will soon become a cornerstone of next-generation photovoltaics. The future of solar energy is being reshaped and we are honored to contribute to this promising transformation.

This story is part of Science X Dialog, where researchers can report findings from their published research articles. Visit this page for information about Science X Dialog and how to participate.

More information: Eupsy Navis Vincent Mercy et al, Modeling of (Ca,Ba)ZrS3 solar cells with next-gen spinel hole transport layers via SCAPS-1D, *Optical and Quantum Electronics* (2025). DOI: 10.1007/s11082-025-08228-7

Bio:

Dr. Latha Marasamy is a Research Professor at the Faculty of Chemistry–Energy Science Program at UAQ, where she leads a dynamic team of international students and researchers. Her mission is to advance renewable energy, particularly in the development of second and third-generation solar cells, which include CdTe, CIGS, emerging chalcogenide perovskites, lead-free $FASnI_3$ perovskites, quaternary chalcogenides of I_2-II-IV-VI_4, and hybrid solar cells. She is working with a range of materials such as CdTe, CIGSe, CdS, MOFs, $FASnI_3$, graphitic carbon nitride, chalcogenide perovskites (ABX_3, where A = Ba, Sr, Ca; B = Zr, Hf; X = S, Se), quaternary chalcogenides (I_2-II-IV-VI_4, where I = Cu, Ag; II = Ba, Sr, Co, Mn, Fe, Mg; IV = Sn, Ti; VI = S, Se), antimony based Sb_2Se_3, $Sb_2(S,Se_3)$ and $CuSb(S,Se)_2$, metal oxides, MXenes, ferrites, plasmonic metal nitrides, and borides for solar cell applications. Additionally, Dr. Marasamy is investigating the properties of novel materials and their influence on solar cell performance through SCAPS-1D simulations.

MAY 22, 2025

Rooftop solar and EV batteries could supply 85% of Japan's electricity needs

by Tohoku University edited by Lisa Lock, reviewed by Robert Egan

Credit: Unsplash/CC0 Public Domain

A new study led by Tohoku University has revealed that rooftop solar panels, when combined with electric vehicles (EVs) as batteries, could supply 85% of Japan's electricity demand and reduce carbon dioxide emissions by 87%. The research provides a promising pathway for Japan's local governments to achieve carbon neutrality by taking advantage of existing infrastructure—rooftops and vehicles—rather than relying solely on large-scale energy systems.

As the urgency of climate change accelerates, cities and municipalities around the world are exploring ways to decarbonize their energy systems to slow down these changes. Japan, with its mountainous terrain and limited available land for solar farms, faces unique challenges. However, the country has more than 8,000 km² of rooftops and a rapidly growing EV market.

The combination of rooftop photovoltaic (PV) systems and EV batteries—referred to as the "PV + EV" system or "SolarEV City"—offers a practical and cost-effective solution to help transition to renewable energy and energy self-sufficiency.

The study, published in *Applied Energy*, aimed to answer three critical questions: What is the decarbonization potential of PV + EV systems across all municipalities in Japan? What regional factors influence their effectiveness? How can these findings inform national and local energy policy?

To find answers, the research team conducted a comprehensive techno-economic analysis for all 1,741 municipalities in Japan. They assumed that 70% of rooftops would be fitted with 20%-efficiency PV panels, and that EVs with 40 kWh batteries would serve as household storage, using about half their battery capacity for grid flexibility.

Their findings were striking: rooftop PV could generate 1,017 TWh annually—more than Japan's total electricity generation in 2022. On average, a PV-only system could supply 45% of municipal electricity needs, while the PV + EV system boosted this figure to 85%.

In addition to drastically reducing CO_2 emissions from both electricity and driving, the system could lower energy costs by 33% by 2030.

These results carry broad implications not only for Japan, but for countries worldwide that face similar constraints. Rooftop PV + EV systems are particularly promising for urban and rural regions where centralized renewable energy systems may not be feasible.

In rural areas, the study found that some municipalities could generate several times their electricity demand through rooftop PV alone. While highly urbanized areas like Tokyo face greater limitations due to smaller rooftop areas and fewer vehicles, they still benefit from the integration of EV batteries to increase energy flexibility and reduce peak demand.

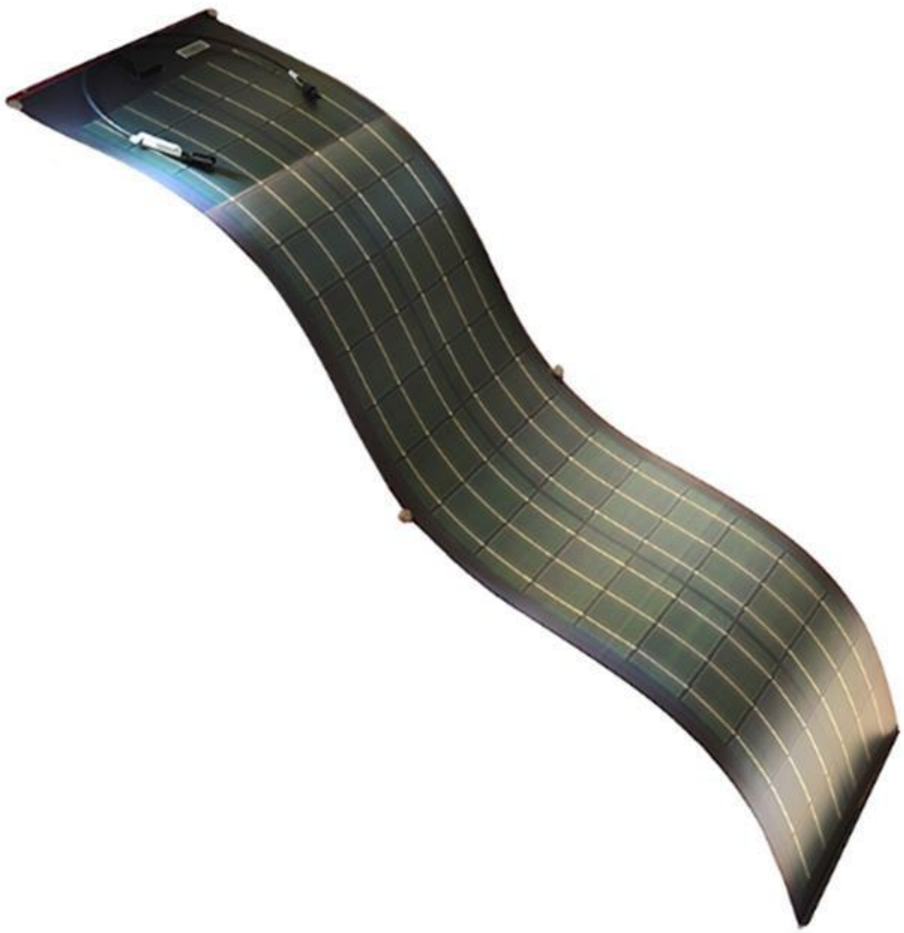
"To make this system a reality and move toward a greener society, we need policy support at the end of the day," remarks Takuro Kobayashi from Tohoku University. "A major goal of this study was to provide a wealth of scientific information that policymakers can refer to when making decisions about implementation."

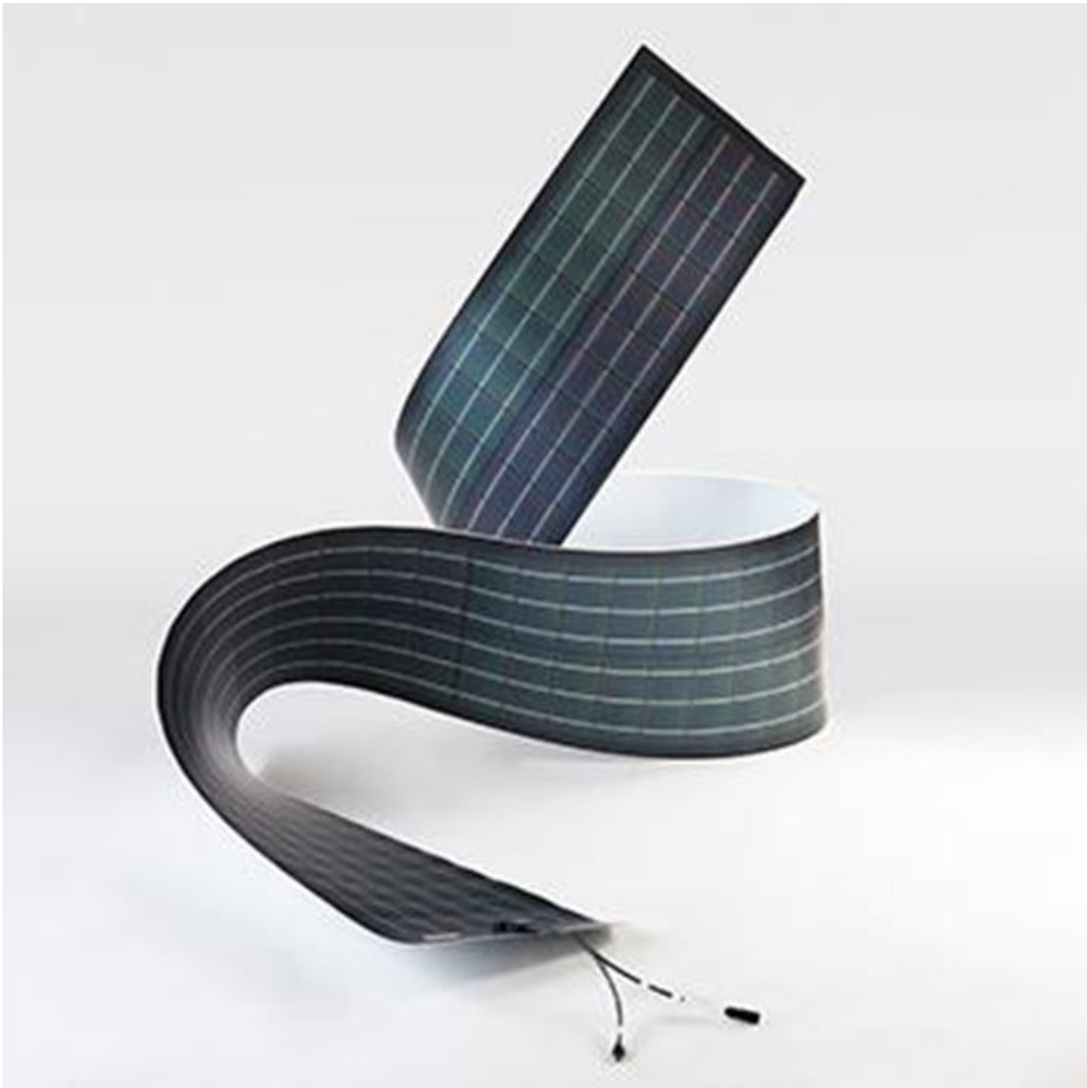
When making these policies, there are many factors to consider. Policymakers must address regional disparities, especially for northern areas with lower solar potential, where energy poverty could be exacerbated during the transition period. Furthermore, while Japan currently offers subsidies for EVs and rooftop PV systems, stronger support is needed for bidirectional charging infrastructure (V2H and V2G), battery integration technologies, and public awareness. This research exploring the potential of PV + EV systems is a crucial step closer toward decarbonization.

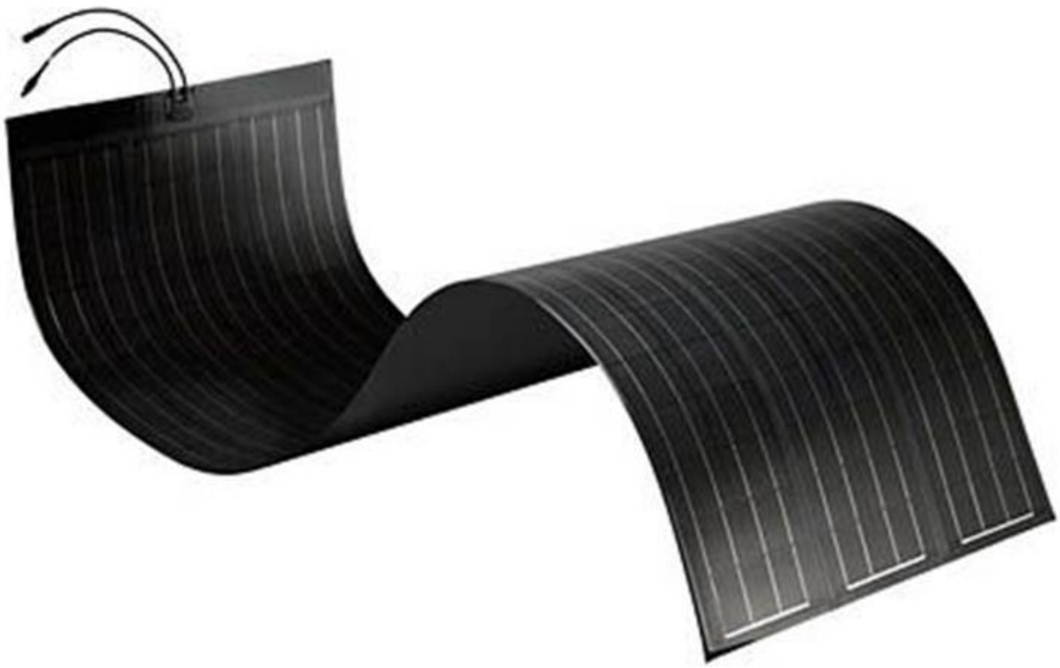
The research was led by Tohoku University in collaboration with the University of Tokyo, the National Institute for Environmental Studies, Radboud University (Netherlands), and the Meteorological Research Institute.

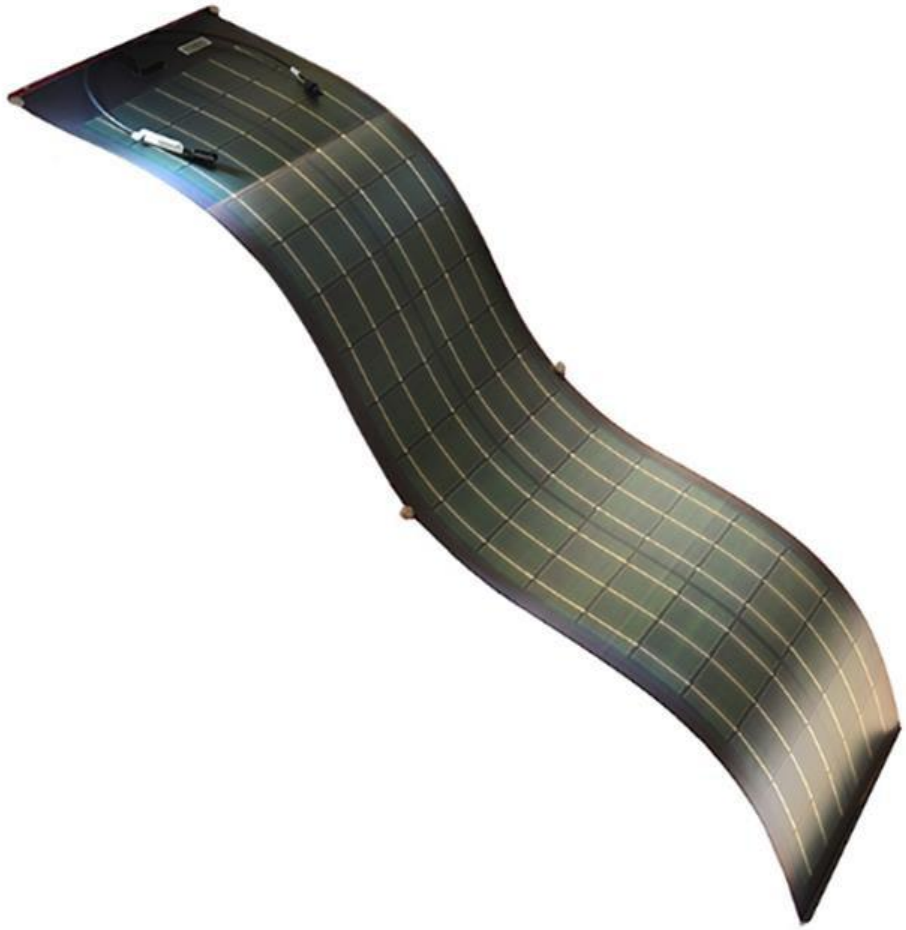
More information: Nguyen Thi Quynh Trang et al, On the decarbonization potentials of rooftop PVs integrated with EVs as battery for all the municipalities of Japan, *Applied Energy* (2025). DOI: 10.1016/j.apenergy.2025.126067
Provided by Tohoku University

140W Flexible CIGS Solar Module









Product Introduction:

Thin-film PV, in particular CIGS, is a key technology to be one of the future technologies of photovoltaics and has great potential for further technological developments. CIGS thin-film modules have attracted more and more attention in the solar industry. CIGS solar module can be widely used for off grid solar power plant, grid tie solar power plant, portable electronics and other customized applications.

Send Inquiry

【Product introduction】	
Cell	Copper Indium Gallium Diselenide CIGS solar cell
Substrabe of solar cell	Polymer or glass or metal foil
Rated Maximum Power(Pmax)	140W
Junction Box	IP68
Maximum System Voltage	1000VDC(IEC)

Operating Temperature	-40℃ ～ +85℃
Dimensions	2583mm×348mm×17mm
Weight	2.1kg

【Product description】

Thin-film PV, in particular CIGS, is a key technology to be one of the future technologies of photovoltaics and has great potential for further technological developments. CIGS thin-film modules have attracted more and more attention in the solar industry.

CIGS solar module can be widely used on off grid solar power plant, grid tie solar power plant, portable electronics and other customized applications.

CIGS solar module on different substrate can be featured as:

Best Power-to-Weight Ratio (50 - 250 watt/kg)

More applications compared to rigid based PV

Allows for easy Roll-to-Roll fabrication

More efficient use of equipment and manufacturing floor space

Plastic substrate does not crack or shatter upon impact

Customizable (with Monolithic Integration)

Simplified electrical and mechanical construction

Customized cell shapes easily integrated into manufacturing process

Meaningful Output in Small Area

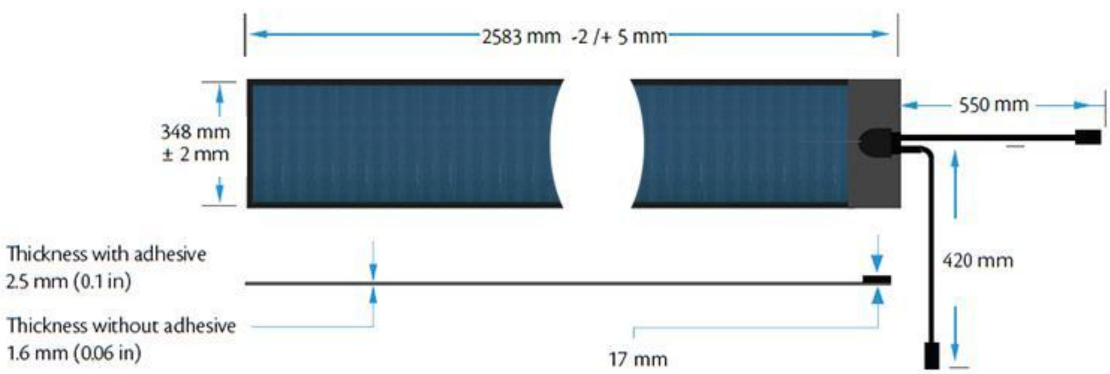
Higher voltages economically achieved in smaller areas

CIGS solar modules range from 90 to 300 Watts DC, and could make your PV installation quicker, easier and less costly for your commercial and industrial use.

1 KEY FEATURES

● Aesthetic appealing ● High efficiency of up to 18.5% ● Flexible and bendable ● Light weight and portable ● Waterproof ● Easy installed on many surfaes ● Reliable and durable	

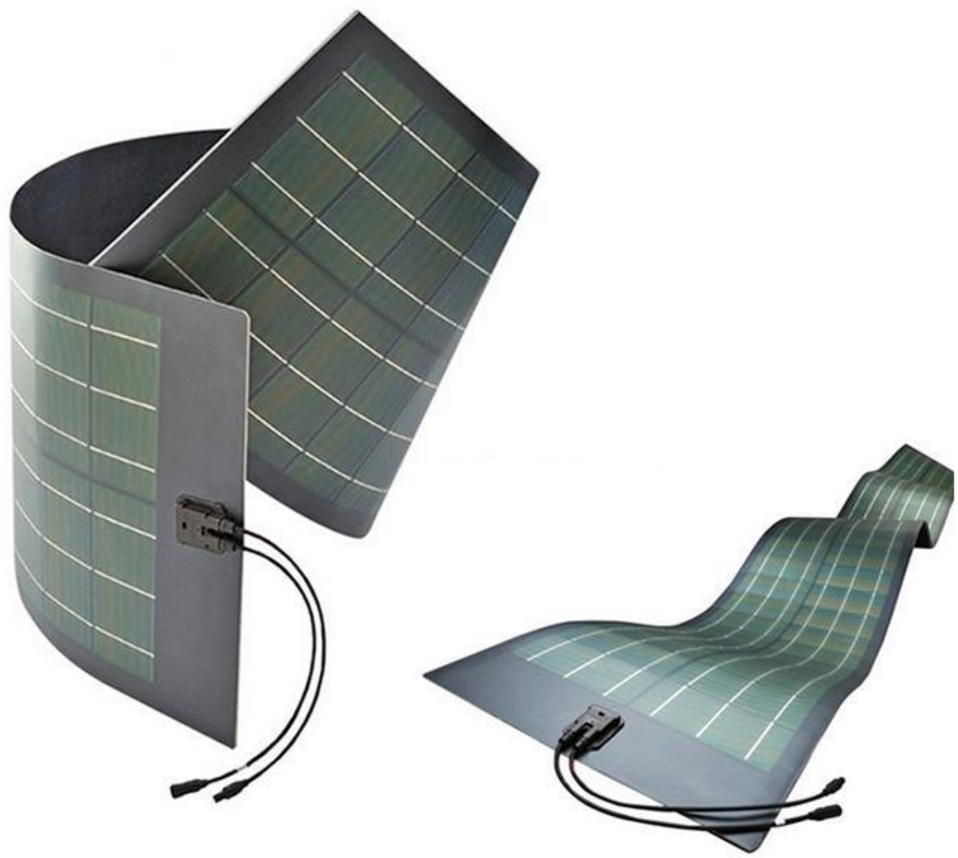
2 MECHANICAL DIAGRAMS



3 ELECTRICAL PARAMETERS at STC

Rated Maximum Power(Pmax) [W]	110	115	120	125	130	135	140
Open Circuit Voltage(Voc) [V]	36.33	37.2	37.81	38.65	39.44	40.13	40.92
Maximum Power Voltage(Vmp) [V]	28.41	29.32	30.34	31.26	32.12	33.06	33.92
Short Circuit Current(Isc) [A]	4.67	4.62	4.59	4.54	4.51	4.46	4.52

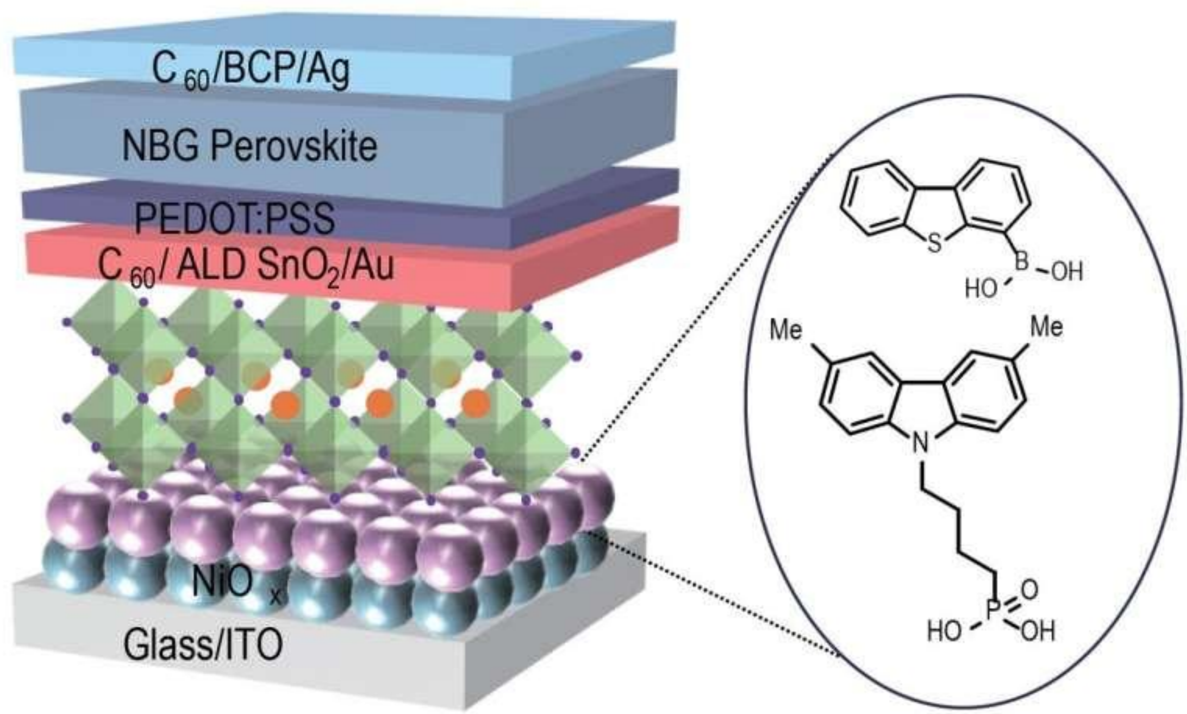
Maximum Power Current(Imp) [A]	3.91	3.93	3.98	4.03	4.07	4.13	4.15
Module Efficiency [%]	14.40 %	15.00 %	15.70 %	16.40 %	17.00 %	17.70 %	18.30 %
Power Tolerance	0~+5W						
Temperature Coefficient of Isc(α_Isc)	0.008%/℃						
Temperature Coefficient of Voc(β_Voc)	-0.281%/℃						
Temperature Coefficient of Pmax(γ_Pmp)	-0.379%/℃						
STC	Irradiance 1000W/m², cell temperature 25℃, AM1.5G						



JUNE 23, 2025

Scientists develop stable all-perovskite tandem solar cells

by Li Yali, Chinese Academy of Sciences edited by Lisa Lock, reviewed by Robert Egan



The device architecture of the developed all-perovskite tandem solar cells. Credit: NIMTE
A research group led by Prof. Ge Ziyi from the Ningbo Institute of Materials Technology and Engineering (NIMTE) of the Chinese Academy of Sciences has developed an innovative strategy to alleviate NiO_x corrosion, enabling more efficient and stable all-perovskite tandem solar cells (TSCs).

Perovskite material efficiently converts sunlight into electricity, making it a promising candidate for TSCs. In all-perovskite TSCs, a wide-bandgap (WBG) top cell captures high-energy photons, while a narrow-bandgap (NBG) bottom cell absorbs lower-energy wavelengths. This exquisite design optimizes solar spectrum utilization, significantly boosting overall efficiency.

However, the strongly acidic phosphoric acid (PA) anchors in self-assembled monolayers (SAMs) would corrode NiO_x. This interaction in WBG top cells degrades device performance in terms of both efficiency and stability.

To address this issue, the researchers employed less-acidic boric acid (BA) as a milder anchoring group to construct BA-SAMs. Via strong coordination between $-BO_2-$ and Ni, these BA-SAMs form robust interfacial bonds with the NiO_x surface, which exhibits higher binding energy than conventional PA-SAMs. The study was published in *Nature Communications*.

"This enhanced interaction facilitates uniform SAM distribution, effectively preventing molecular aggregation on the NiO_x surface," said Prof. Ge.

With these innovations, the team fabricated a WBG cell with an improved power conversion efficiency (PCE) of 20.1%. When integrated with a NBG bottom subcell, this wide-bandgap subcell forms a tandem architecture that delivers an impressive PCE of 28.5%.

After 500 hours under one sun illumination, the device retained 90% of its initial efficiency, demonstrating exceptional long-term stability.

This achievement paves the way for developing high-performance TSCs, advancing the commercial application of advanced photovoltaic technology.

More information: Jingnan Wang et al, Less-acidic boric acid-functionalized self-assembled monolayer for mitigating NiOx corrosion for efficient all-perovskite tandem solar cells, *Nature Communications* (2025). DOI: 10.1038/s41467-025-59515-6
Journal information: Nature Communications
Provided by Chinese Academy of Sciences