HARDWARE UPGRADE
il sito italiano sulla tecnologia

22 Mar 2023

Giulia Favetti

English translation

Photovoltaic: research points to lead-free perovskite cells

Sustainability.

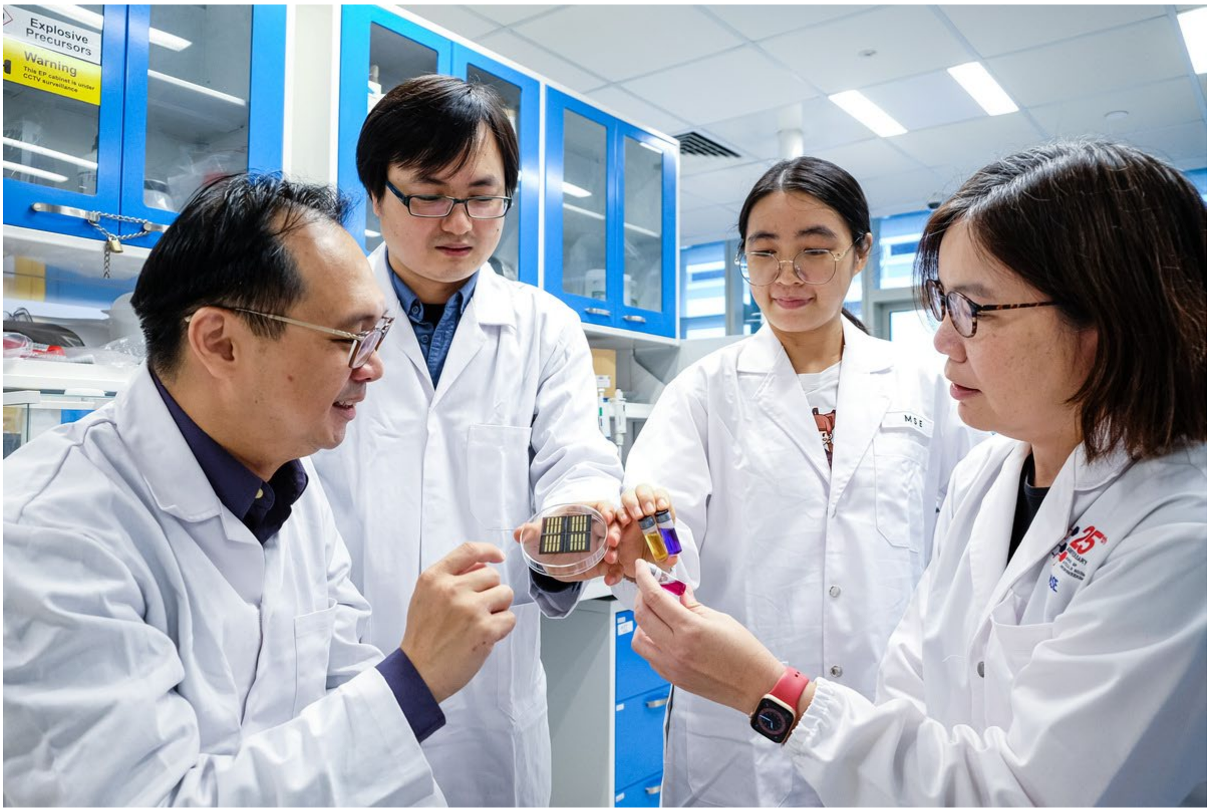
A word increasingly used in every sector, from normal daily activities to the mission of various companies, constantly and daily strengthened by our awareness of the impact that our activities have on the rest of the planet (resources, animals, climate).

In order to arrive at a level of technology that allows us to live with all the comforts and security we are used to, but which at the same time fits into the delicate balance of the earth without altering it, there are numerous research that question the modus operandi in use, looking for, finding and inventing alternative solutions.

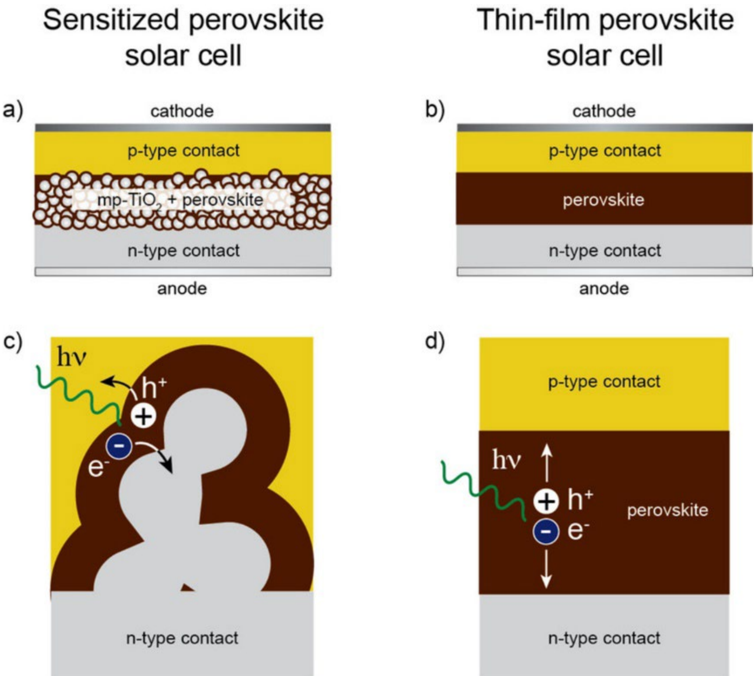
The RES [Renewable Energy Sources] sector is among those in which this research is most lively (and fruitful), breaking the cognitive bias that sees these technologies as unsustainable and guilty of creating - in the near future - heaps and heaps of waste.

Far from being true, we have talked about the recycling of components for wind farms and photovoltaic systems several times (here, here, here) as well as the research into creating easily recyclable materials right from the start (such as the Siemens Gamesa wind turbine blades) or to use substances with the least possible impact.

In this regard, scientists from Nanyang Technological University (NTU) and Singapore's Agency for Science, Technology and Research (A*STAR) have developed a new way to synthesise the cover layer of perovskite photovoltaic cells without using lead.

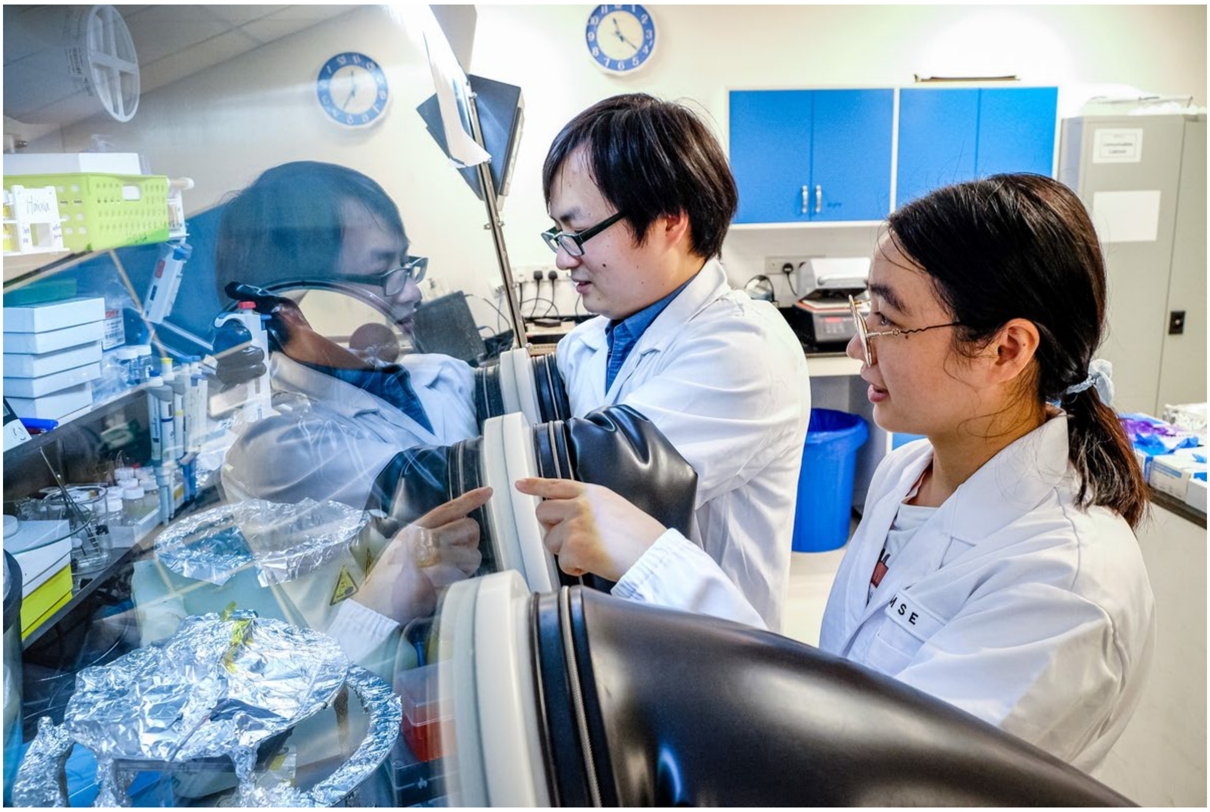


Since perovskites decompose when they react with moisture and oxygen, or when exposed to light, heat, or prolonged use, they are protected with a top layer. And one of the materials used for this purpose is lead, a toxic and heavy metal, potentially capable of polluting the environment if a cell is damaged.



Lead comes from both the perovskite material and a compound used to make a component of the solar cell itself, known as the overlay.

The research, led by Prof Sum Tze Chien, Director of NTU's Institute for Advanced Studies and Associate Dean of NTU's College of Science, and Prof Lam Yeng Ming, Chair of NTU's School of Materials Science and Engineering, investigated an alternative method to synthesise the capping layer. The study, a new approach to establish perovskite solar cells without lead, was published in the journal Nature Energy with the title Expanding the low-dimensional interface engineering toolbox for efficient perovskite solar cells.



As anticipated, perovskite solar cells are made up of several layers of materials, including a perovskite layer - which intercepts light - and a cover layer, which acts as protection.

To ensure that the overlay layer is compatible with the underlying perovskite layer, researchers typically use an approach called the half precursor [HP] method to create the 'shield' layer.

This process involves the deposit of a chemical precursor on top of the perovskite layer, starting a process known as a cation exchange reaction, where this precursor is allowed to react with the lead ions present in the underlying perovskite layer, forming a chemical compound containing lead, which will form the capping layer.

To make perovskite solar cells safer and more environmentally friendly, NTU scientists devised an approach, known as the full precursor [FP] solution method, to synthesize the protective layer without the use of lead.

Using the FP method, the scientists coated the cells with solutions containing metal halide salts (compounds made up of a metal and elements including chlorine, fluorine and iodine) and phenethylammonium iodide (PEAI) which is commonly applied to perovskites to improve their performance.

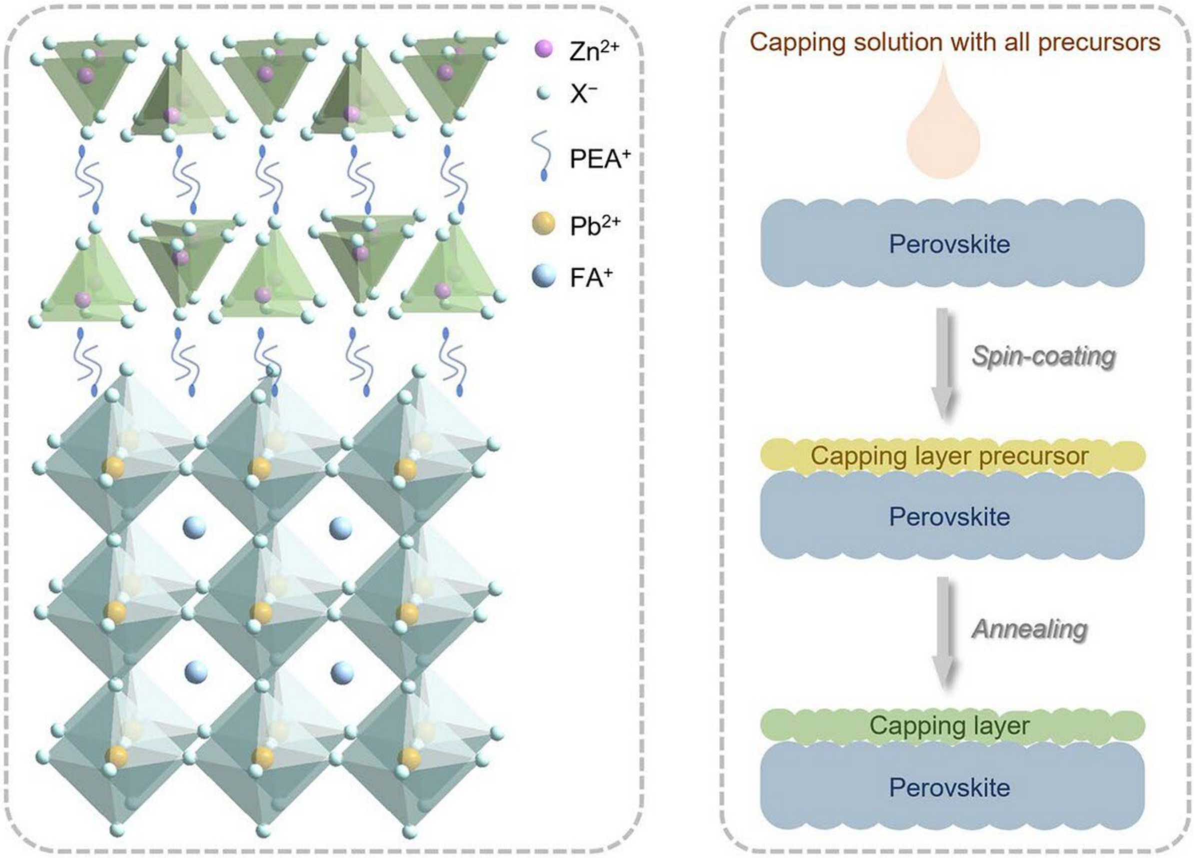
During the tests, the researchers made important discoveries: first, they could verify that the FP method is more effective than the HP method in manufacturing the cover layer since the chemicals in the solution are able to react with each other directly on the surface of the perovskite, without taking the lead inside.

Second, by comparing various compounds, the team found the zinc-based compound [PEA_2ZnX_4] to be the most effective and sustainable.

To fabricate a PEA_2ZnX_4-coated solar cell, the researchers first dissolved zinc halide salts and PEAI in a solvent called acetonitrile, which is commonly used for industrial applications. They then deposited the solution onto a rapidly spinning layer of perovskite attached to an electrically conductive glass substrate, resulting in a thin, uniform layer, in a process known as spin-coating.

The coated perovskite was heated at 100 degrees Celsius for 10 minutes in order to bond the two layers [coating and perovskite].

The researchers then used the vacuum evaporation process to deposit the material on the perovskite in a homogeneous way: the procedure involves heating the material in a vacuum chamber until it evaporates and finally depositing - by cooling - homogeneously on the surface you want to cover. In this case the remaining layers of the perovskite solar cell.



The zinc-coated prototype created in Singapore with the FP method was examined by the team using electron microscopy and spectroscopy: the researchers found that the protective layer had not only not affected the efficiency of the perovskite, but had actually improved it the capabilities and covered the defects.

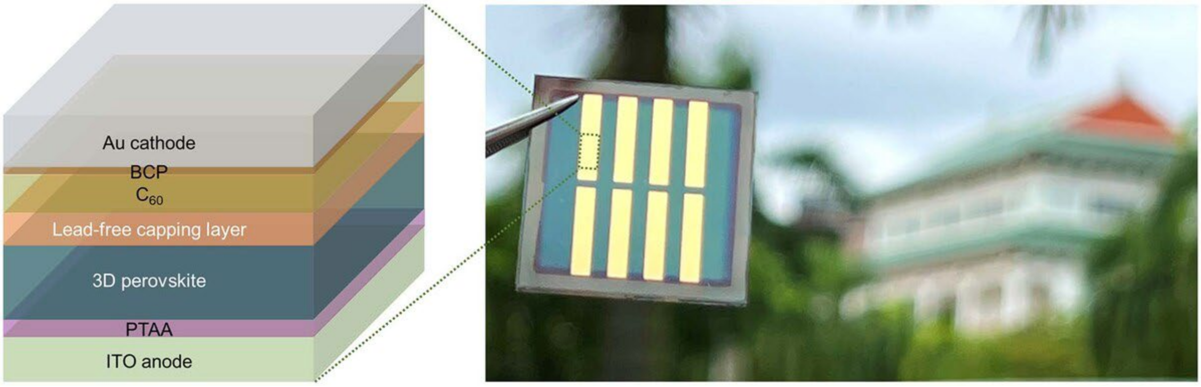
During experiments with light beams, simulating sunlight, the cell was found to be able to convert 24.1% of the captured light into electricity, coming close to the maximum efficiency achieved so far by perovskite solar cells.

In comparison, the highest certified light conversion efficiency of silicon solar cells is 25.2%.

The prototype also demonstrated good reproducibility, with an average light conversion rate of almost 23% out of 103 cells tested. It also had a long service life, retaining over 90% of its conversion capacity for more than 1,000 hours of full capacity operation.

“The overlay layer is a vital component of a perovskite solar cell. This new approach is an important milestone in the design of perovskite solar cells with improved properties,” said Prof. Michael Grätzel, director of the photonics and interfaces laboratory at the École Polytechnique Fédérale de Lausanne in Switzerland [EPF, who we talked about in connection with Grätzel cells], who was not involved in the study.

At the moment, research is evaluating various alternatives to lead continent perovskite cells, which would make the HP method, which is based - fundamentally - on this, unusable. The study of the NTU therefore assumes enormous importance, because it can be used on any solar cell composition.



“One of the biggest drawbacks of using perovskite solar cells is their impact on the environment. By allowing zinc and other non-toxic metals to be used in the cover layer, our innovation potentially solves a major barrier preventing the use widespread use of perovskite solar cells," said Dr. Ye Senyun, a researcher at NTU's School of Physical and Mathematical Sciences, one of the study's lead investigators.

The co-lead author, Dr. Rao Haixia, a researcher at NTU's School of Materials Science and Engineering, added, "Because our method does not require the extraction of lead ions from the perovskite it allows us to use a wide range of materials to increase the stability and l efficiency of perovskite solar cells."

Prof Sum commented: 'By expanding the variety of materials that can be used, our results open up new opportunities for the development of superior cover layer materials for more efficient and stable perovskite solar cells. This method of protective cover lead-free can also be extended to other applications such as perovskite light-emitting devices, lasers, and detectors."

Finally, Professor Lam concluded:

“Since fossil fuels are depleting rapidly, we need to make much better use of renewable energy resources such as solar energy. Green and stable perovskite solar cells could be the answer, and this innovation can be effective.”