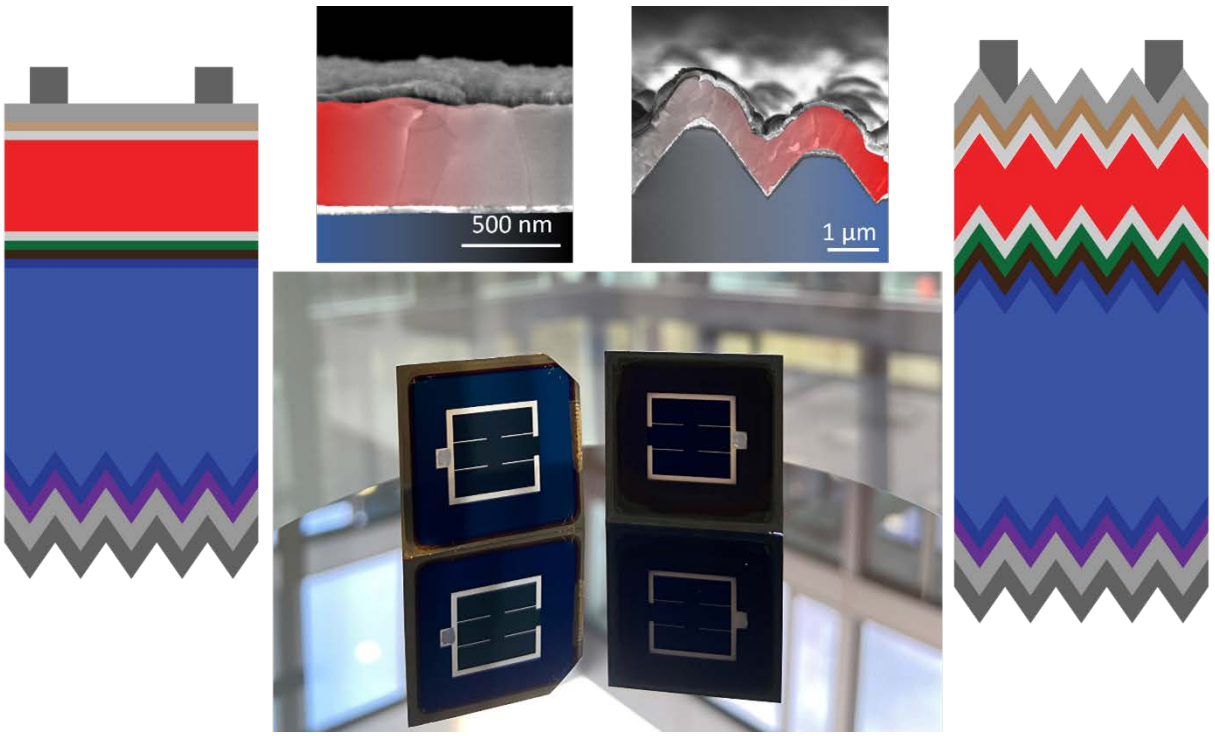
Press release

New world records: perovskite-on-silicon-tandem solar cells

EPFL and CSEM smash through the 30% efficiency barrier for perovskite-on-silicon-tandem solar cells—setting two certified world records

Neuchâtel, July 7, 2022 – For the first time, an efficiency of 30% for perovskite-on-silicon-tandem solar cells has been exceeded thanks to a joint effort led by scientists at EPFL's Photovoltaics and Thin Film Electronics Laboratory in partnership with the renowned innovation center, CSEM. Independently certified by the National Renewable Energy Laboratory (NREL) in the United States, these results are a boost to high-efficiency photovoltaics (PV) and pave the way toward even more competitive solar electricity generation. (Press kit / Images)



Left and right panels: Schematics of perovskite-on-silicon tandems that are either flat or textured on their front side. Upper central panels: scanning electron microscopy images of the two types of devices developed by EPFL and CSEM. Lower central panels: corresponding picture. Credit: D. Türkay (EPFL), C. Wolff (EPFL), F. Sahli (CSEM), Q. Jeangros (CSEM).

Increasing the power conversion efficiency of solar cells is important for two reasons. In the long run, it is the most effective way to reduce the levelized cost of electricity. In the short term, it is the best way to promote photovoltaics for applications where space is limited e.g., roofs, facades, vehicles, or even drones.

However, all solar cells are fundamentally limited by the materials they are made from, which in turn affects the efficiencies they can achieve. The most adopted solar cell technologies to date are made with

silicon. But despite silicon's success, it has a theoretical efficiency limit of around 29%. Current efficiencies for this technology stand slightly below 27%, leaving a very small margin for future efficiency gains.

In the innovative race to exceed this limitation, scientists have added one (or more) complementary solar cell(s) to silicon to form "tandem" solar cells. The higher-energy visible light of the sun is absorbed in the top cell, while the lower-energy infrared light is absorbed in the silicon cell placed at the rear of the tandem. Halide perovskites have been identified as an ideal partner for silicon, as they can convert visible light more efficiently to electrical power in comparison to silicon alone, without overly increasing fabrication costs.

Double World Record Success

"We have passed a psychological barrier," says Christophe Ballif, Head of the EPFL Photovoltaics Laboratory and CSEM's Sustainable Energy Center. "*We have validated experimentally the high-efficiency potential of perovskite-on-silicon tandems. The 30% efficiency mark had already been achieved with other types of materials, namely III-V semiconductors. However, these materials and the processes used to make them are too expensive to sustain the energy transition – these devices are a thousand times more expensive than silicon solar cells. Our results are the first to show that the 30% barrier can be overcome using low-cost materials and processes, which should open new perspectives for the future of PV,"* Ballif enthuses.

The researchers from Neuchâtel have succeeded in improving the efficiency of two kinds of perovskite-on-silicon tandems. Firstly, they adapted materials and fabrication techniques to deposit high-quality perovskite layers from solution on a planarized silicon surface, reaching a power conversion efficiency of 30.93% for a 1 cm^2 solar cell. Secondly, by working on a new version of a hybrid vapor/solution processing technique compatible with textured silicon surfaces, they have produced a solar cell with a power conversion efficiency of 31.25% (again on 1 cm^2). These results constitute **two** new world records: one for the planar and one for the textured device architecture. The latter approach provides a higher current and is compatible with the structure of current industrial silicon solar cells. The previous efficiency conversion record for perovskite-on-silicon tandem solar cells was set in 2021 by a team at the Helmholtz Zentrum Berlin, who achieved 29.8%. EPFL's and CSEM's new records were independently certified by the National Renewable Energy Laboratory (NREL) in the United States.

Bright Future Ahead

"These high-efficiency results will now require further R&D to allow their scaling up onto larger surface areas and to ensure that these new cells can maintain a stable power output on our rooftops and elsewhere over a standard lifetime," notes Quentin Jeangros of CSEM. *"Tandem perovskite-on-silicon technologies have been said to have the potential to exceed the 30% efficiency benchmark, but this is the first time this long-predicted potential has been demonstrated, which should hopefully pave the way for even cheaper sustainable electricity in the future,"* concludes Christian Wolff of EPFL.

This research was driven by the EPFL PV-lab team in Neuchâtel (Dr. Xin Yu Chin, Deniz Türkay, Kerem Artuk, Dr. Mathieu Boccard, and colleagues of the Tandem Photovoltaics team led by Dr. Christian Wolff), working in association with scientists at CSEM (Dr. Brett Kamino, Dr. Florent Sahli, Dr. Soo-Jin Moon, Arnaud Walter, and colleagues, led by Dr. Quentin Jeangros). It has received funding from the Swiss Federal Office of Energy, the Swiss National Science Foundation, the European Commission, the Services Industriels de Genève, and the Advanced Manufacturing Initiative of the ETH domain.

Additional information about the project

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About EPFL

EPFL is Europe's most cosmopolitan technical university. It welcomes students, professors, and collaborators of more than 120 nationalities. EPFL has both a Swiss and international vocation and focuses on three missions: teaching, research, and innovation.

EPFL collaborates with an important network of partners, including other universities and colleges, secondary schools and gymnasiums, industry and the economy, political circles, and the general public, with the aim of having a real impact on society.

The Photovoltaics and Thin Film Electronics Laboratory of EPFL (PV-lab) has been a pioneer in multiple aspects of thin film silicon devices and processes, silicon heterojunction, passivating contacts cells, and tandem solar cells, as well as in the science of reliability of PV modules. It also has activities in the field of specialty detectors, coatings for medical diagnostics, and energy management.

www.epfl.ch

About CSEM – Facing the challenges of our time

CSEM is an internationally recognized Swiss innovation center developing disruptive technologies with a high societal impact, which it then transfers to industry. A public-private organization, its mission is to support the innovation activity of Swiss companies and strengthen the economy. CSEM is active in the domains of precision manufacturing, digitalization, and sustainable energy. Daily, CSEM's 550 employees from 44 countries collaborate with leading universities, research institutes, and industrial partners. Headquartered in Neuchâtel, CSEM also has sites in the cantons of Basel, Bern, Obwalden, Zurich, and the Grisons.

The Sustainable Energy Center at CSEM is active in the fields of advanced silicon and tandem solar cells and modules, specialty PV solutions for building, energy harvesters, storage and batteries, energy management, and digital energy solutions.

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