Ultrathin solar cells achieve a record of nearly 20 percent efficiency

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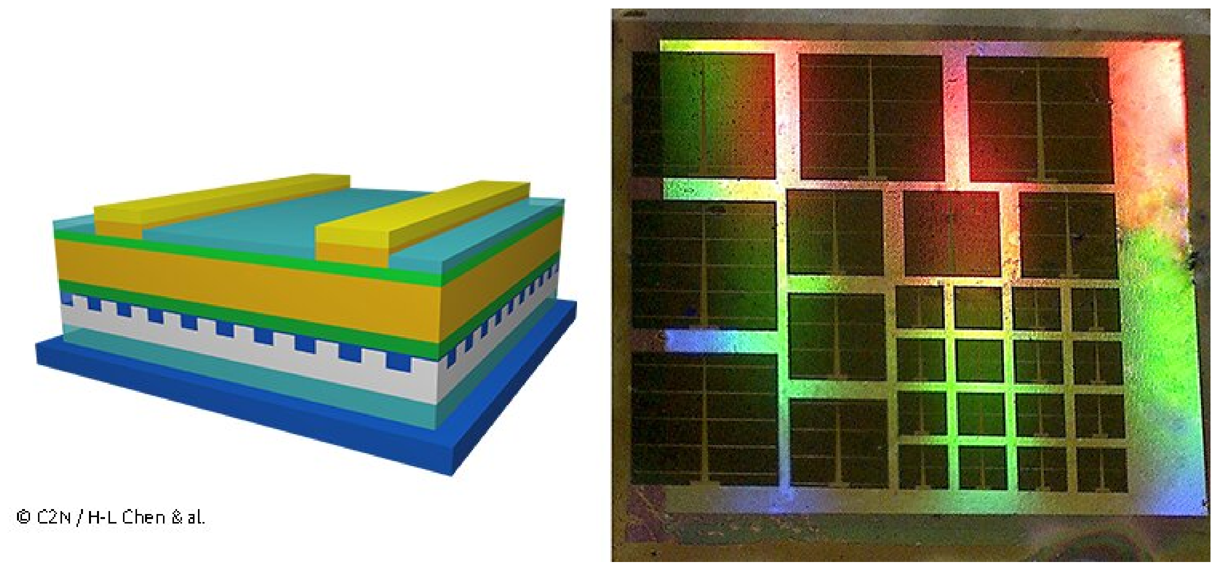

(left) Sketch of an ultrathin solar cell made of GaAs with a nanostructured back mirror. (right) Photograph of a sample showing the diffraction effect of a nanostructured mirror in air (colored shine) and the absorption enhancement effect in ultrathin solar cells (square black areas). Credit: © C2N / H-L Chen & al.

Researchers at the Centre de Nanosciences et de Nanotechnologies (C2N), in collaboration with researchers at the German Fraunhofer ISE, have trapped sunlight efficiently in a solar cell thanks to an ultrathin absorbing layer made of 205 nm-thick GaAs on a nanostructured back mirror. This new architecture raised efficiency of the cell to nearly 20 percent.

Up to now, state-of-the-art solar cells of 20 percent efficiency required at least one-micrometer-thick layers of semiconductor material (GaAs, CdTe or copper indium gallium selenide), or even 40 µm or more, in the case of silicon. A significant thickness reduction would enable material savings of scarce materials like tellerium or indium and industrial throughput improvements due to shorter deposition times. However, thinning absorber automatically reduces absorption of sunlight and conversion efficiency. A flat mirror at the backside of the cell can lead to double-pass absorption, but no more. Previous attempts at light trapping have been greatly limited in performance by the optical and electrical losses.

Researchers of the team led by Stéphane Collin and Andrea Cattoni at the Centre de Nanosciences et de Nanotechnologies-C2N (CNRS/University Paris-Saclay), in collaboration with the Fraunhofer ISE have developed a new strategy to trap light in ultrathin layers made of only 205 nm-thick gallium arsenide, a semiconductor of the III-V family. The guiding idea was to produce a nanostructured back mirror to create multiple overlapping resonances in the solar cell, identified as Fabry–Perot and guided-mode resonances. They constrain light to stay longer in the absorber, resulting in efficient optical absorption despite the low quantity of material. Thanks to numerous resonances, absorption is enhanced over a large spectral range that fits the solar spectrum from the visible to the infrared. Controling the fabrication of patterned mirrors at the nanometer scale was a key aspect of the project. The team used nanoimprint lithography, an inexpensive, rapid and scalable technique, to emboss a sol-gel derived film of titanium dioxide.

Can ultrathin solar cells be further improved? The work published in *Nature Energy* demonstrates that this architecture should enable 25 percent efficiency in the short term. Even if the limits are still unknown, the researchers are convinced that the thickness could be further reduced by at least a factor of two without efficiency loss. GaAs solar cells are still commercially limited to space applications due to their cost. However, researchers are already working extending this concept to large-scale photovoltaics made of CdTe, CIGS or silicon materials.

More information: Hung-Ling Chen et al. A 19.9%-efficient ultrathin solar cell based on a 205-nm-thick GaAs absorber and a silver nanostructured back mirror, *Nature Energy* (2019). DOI: 10.1038/s41560-019-0434-y

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