

Solar cell breakthrough paves the way for new applications

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An international scientific collaboration has successfully integrated a sub-micron thin, nanophotonic silicon film into a crystalline solar cell for the first time.

Thinner crystalline silicon cells absorb less light. While the addition of nanophotonic structures can strongly improve light absorption, their integration into the cells has been challenging thus far, due to the electrical losses they cause.

However, the research, published today in the journal *Nano Futures*, demonstrates that the newly-developed film improves light absorption of the crystalline silicon cells, without compromising on electrical efficiency.

The researchers hope their discovery could open the door to new applications for crystalline silicon cells, such as flexibility or semi-transparency, which are not possible with current – much thicker – wafer-based cells.

The team, representing the international photoNvoltaics project, funded by the European

Union, was led by Dr Valerie Depauw of imec in Leuven, Belgium.

Dr Depauw said: "We strived to enable the development of a new and disruptive solar cell generation, resulting from the marriage of crystalline-silicon photovoltaics with advanced light-trapping schemes from the field of nanophotonics. The core of this project was to bring together researchers from the different fields needed (photovoltaics, photonics, nanostructuring) to interact directly."

Standard solar cells feature micron-scale surface textures to enhance the absorption and trapping of light. Shrinking the features to the nanoscale can improve the optical properties even further, and results in less material waste during fabrication. However, nanoscale features so far sacrificed electronic performance, limiting the solar cells' overall energy-conversion efficiencies.

The cost of silicon, meanwhile, contributes significantly to the overall price of solar cells, and manufacturers have a strong incentive to make devices that use ever-thinner layers of the material. Crystalline silicon is not a strong absorber of light – especially at long wavelengths – meaning photons can pass through silicon films that are too thin before their energy can be deposited in the cell.

The research team started by separating a micron thick silicon film from a monocrystalline wafer. Conventional methods of slicing thin sections from bulk silicon result in a loss of material from the cut – termed "kerf loss". The team instead used the kerfless "empty-space-in-silicon technique," which makes more efficient use of the raw material.

This process involves the etching of an array of narrow pits on the silicon which, upon annealing, form a single planar void beneath the surface. The thin layer remaining above the void can undergo passivation and metallization before being bonded

to a low-cost substrate and removed.

Provided by Institute of Physics

Surface nanopatterns with amorphous order can improve silicon's light-absorption properties, compared to perfectly periodic structures. The researchers imprinted a nanotexture by reactive ion etching (RIE) after shaping the mask from a self-assembled layer of charged polystyrene beads. The result was an imperfectly periodic pattern of gently sloping, rounded nanocups.

Compared to the microscale structures more commonly used on solar cells, the new technique represents a more efficient use of material, with far less silicon discarded during the patterning process. And, most of all, the nanoscale structures enables playing with the wave-nature of light, and strongly improves light capture.

Although surfaces of nanowires or nanocolumns have been shown previously to be even more effective absorbers of incident light, the hugely increased surface area leads to more [surface](#) recombination losses when used in solar [cells](#). High-quality passivation layers and antireflective coatings are also difficult to apply to such surfaces, lowering the overall efficiency.

The method and pattern the team used represent the best compromise between these conflicting needs, and yielded an overall conversion efficiency higher than any yet seen for a [silicon](#) film of such thinness.

A complete solar cell based on this nanophotonic structure, and using kerfless fabrication methods, could be as thin as desired, opening up uses not available to conventional devices.

Dr Depauw said: "The main applications of our thin c-Si [solar cells](#) could be in buildings as windows and skylights, where they will bring more freedom for integration, and possibly lighter and thinner module designs."

More information: Valérie Depauw et al. Sunlight-thin nanophotonic monocrystalline silicon solar cells, *Nano Futures* (2017). [DOI: 10.1088/2399-1984/aa7d7c](#)

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