Black butterfly wings offer a model for better solar cells

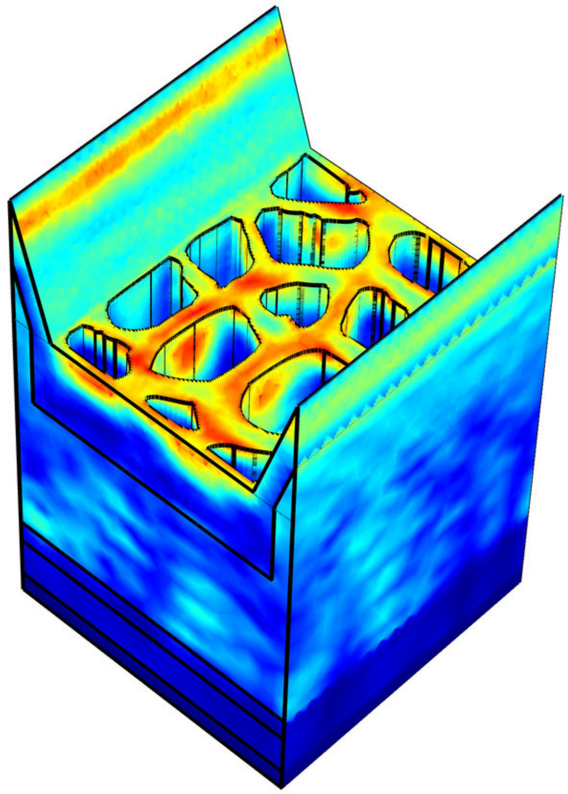
October 19 2017, by Bob Yirka

Black butterfly sketch. Credit: Radwanul Hasan Siddique, KIT/Caltech

(Phys.org)—A team of researchers with California Institute of Technology and the Karlsruh Institute of Technology has improved the efficiency of thin film solar cells by mimicking the architecture of rose butterfly wings. In their paper published in the journal *Science Advances*, the group explains their inspiration for studying the butterfly wings and the details of their improved solar cells.

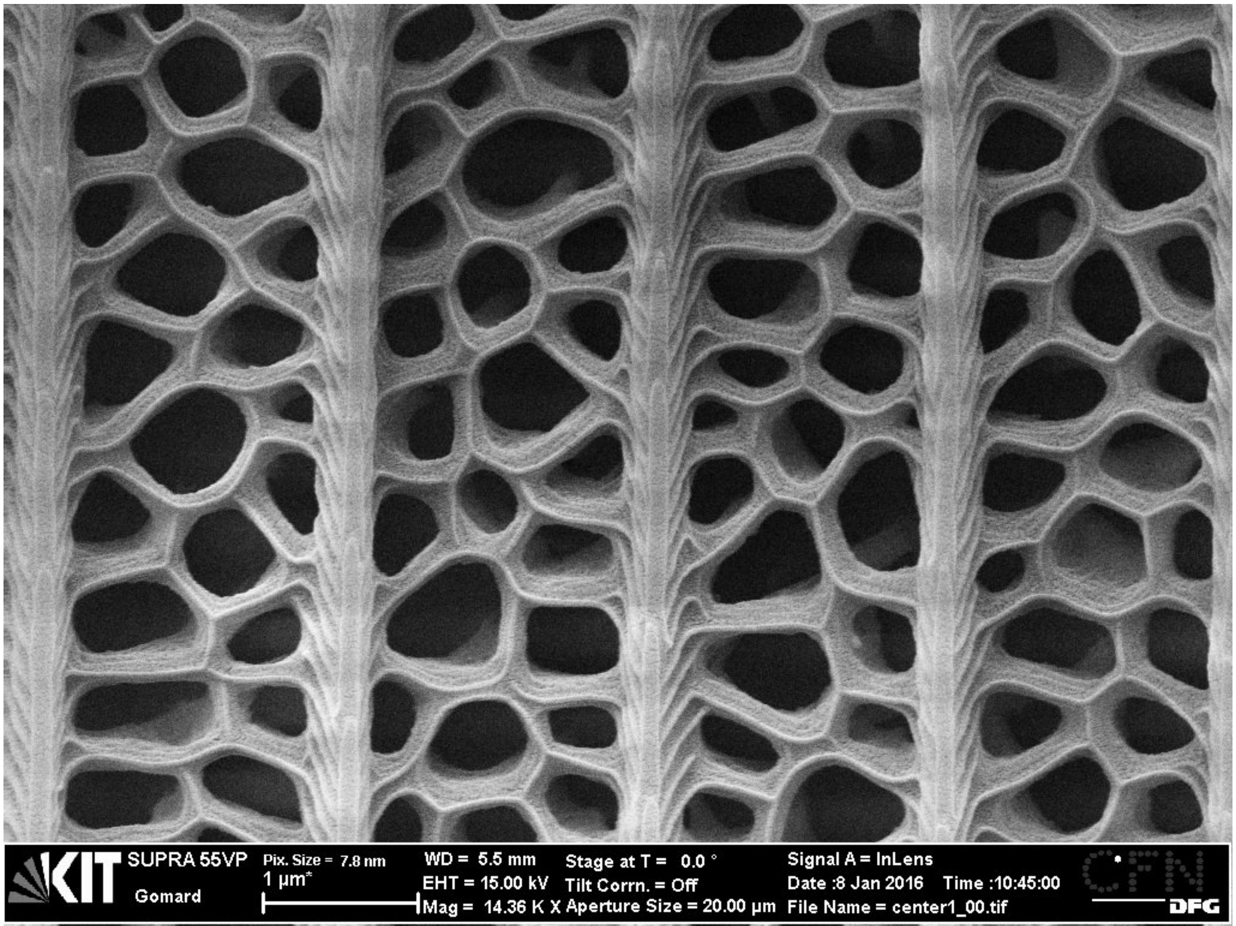
As scientists seek ways to improve the efficiency of solar cells, some have increasingly turned to thin film solar cells. Not only are such cells lighter and more manageable than traditional crystal-based cells, but they are expected to be more efficient if engineers can find a way to get them to work for longer periods of time. One of the roadblocks to improving the efficiency of solar cells in general is the high expense of motion hardware that tracks the sun. In this new effort, the researchers took inspiration from the rose butterfly, found commonly in India. It has soft black wings that warm the cold-blooded insect during cool periods.

To learn more about the butterfly wings, the group collected some samples and looked at them under an electron microscope. They found that the wings were covered with scales pockmarked with holes. In addition to making the wings lighter, the holes, the researchers found, scattered the light striking them, which allowed the butterfly to absorb more of the sun's heat.



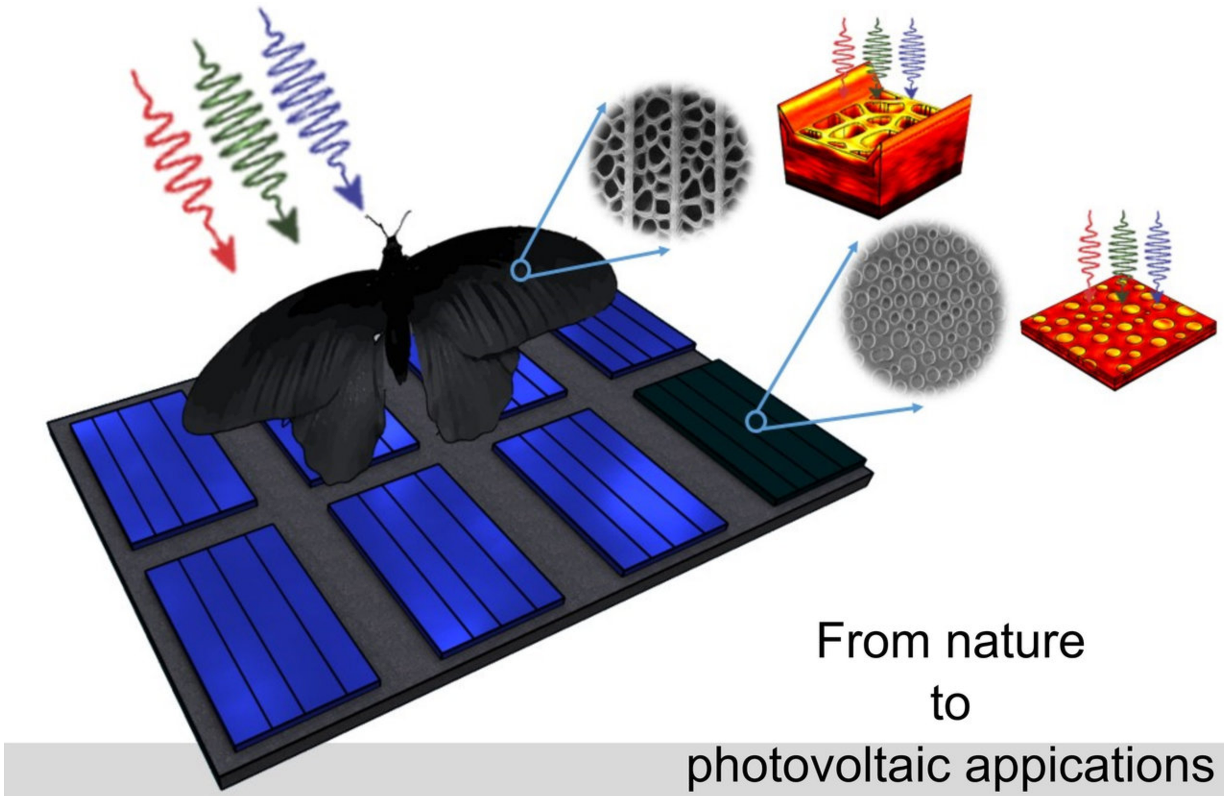
Optical simulation of the micro and nanostructures of the P. aristolochiae butterfly. Credit: Radwanul Hasan Siddique, KIT/Caltech

Intrigued by the butterfly design, the researchers created similar structures in their lab using sheets of hydrogenated amorphous silicon sheets. A top layer with extremely tiny holes of various sizes caused light to scatter and strike the silicon base below. The design, the team found, allowed for picking up roughly twice as much light as previous designs.

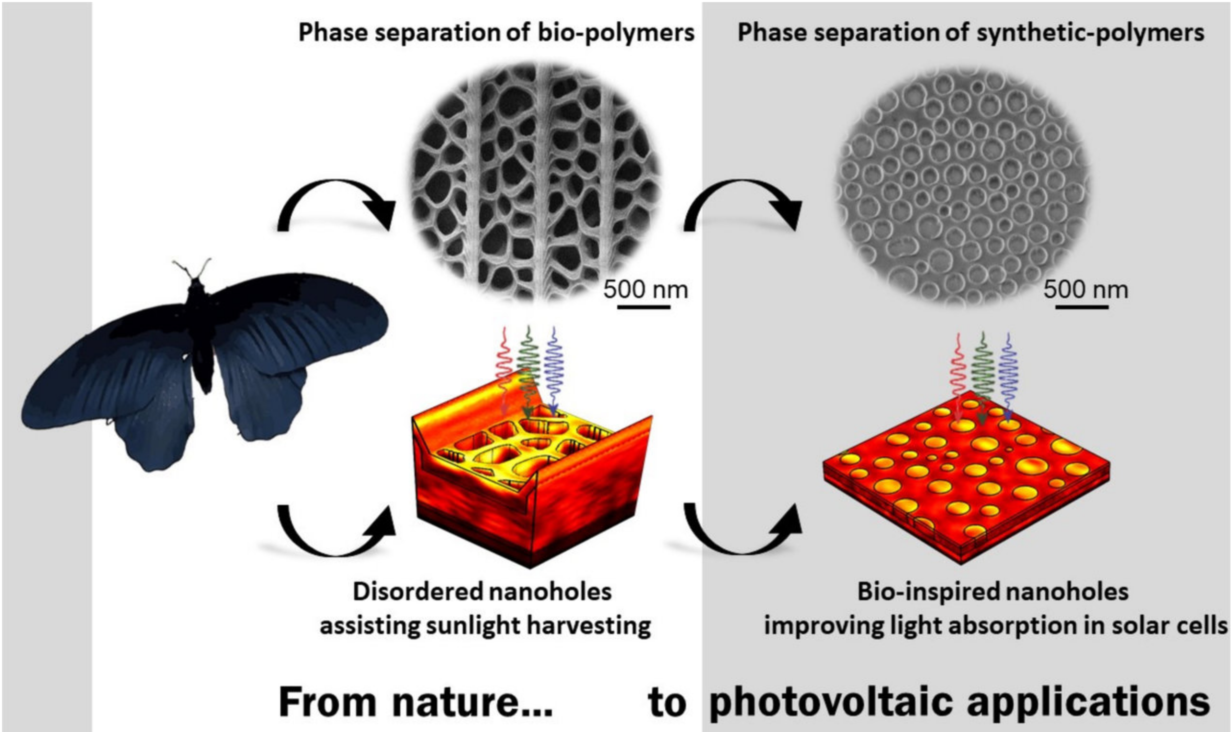


Scanning electron microscope image of black butterfly nanoholes. Credit: Radwanul Hasan Siddique, KIT/Caltech

The group reports that creating the cells was quick and easy. They made the holes by dropping bits of a binary polymer solution that did not mix with the type of polymer used to create the sheet. The process took just five to 10 minutes.



Scientists from KIT and Caltech utilize the disordered nanoholes of the black butterfly to improve solar cell performace. Credit: Radwanul Hasan Siddique, KIT/Caltech



Scientists from KIT and Caltech utilize the disordered nanoholes of the black butterfly to improve solar cell performace. Credit: Radwanul Hasan Siddique, KIT/Caltech

More information: R.H. Siddique el al., "Bioinspired phase-separated disordered nanostructures for thin photovoltaic absorbers," *Science Advances* (2017). advances.sciencemag.org/content/3/10/e1700232

Abstract
The wings of the black butterfly, Pachliopta aristolochiae, are covered by micro- and nanostructured scales that harvest sunlight over a wide spectral and angular range. Considering that these properties are particularly attractive for photovoltaic applications, we analyze the contribution of these micro- and nanostructures, focusing on the

structural disorder observed in the wing scales. In addition to microspectroscopy experiments, we conduct three-dimensional optical simulations of the exact scale structure. On the basis of these results, we design nanostructured thin photovoltaic absorbers of disordered nanoholes, which combine efficient light in-coupling and light-trapping properties together with a high angular robustness. Finally, inspired by the phase separation mechanism of self-assembled biophotonic nanostructures, we fabricate these bioinspired absorbers using a scalable, self-assembly patterning technique based on the phase separation of binary polymer mixture. The nanopatterned absorbers achieve a relative integrated absorption increase of 90% at a normal incident angle of light to as high as 200% at large incident angles, demonstrating the potential of black butterfly structures for light-harvesting purposes in thin-film solar cells.

Citation: Black butterfly wings offer a model for better solar cells (2017, October 19) retrieved 9 April 2024 from https://phys.org/news/2017-10-black-butterfly-wings-solar-cells.html