The solar cell that builds itself

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Researchers have demonstrated a simple, cheap way to create self-assembling electronic devices using a property crucial to solid freezers.

The fact is that oil- and water-based liquids do not mix, forming devices from components that align along the boundary between the two.

The device is a raft of rafters toward self-assembling, but lends itself particularly well to small components.

The work is reported in Proceedings of the National Academy of Sciences. Crucially, it could allow the large-scale assembly of high-quality electronic components on materials of just about any type, in contrast to "inkjet printed" electronics or some previous self-assembly techniques.

Specific gravity

Some efforts have until now exploited the effect, assembling devices through so-called "sedimentation." In this approach, "blank" devices are formed with depressions that match precisely-shaped components. Simply dumped into a liquid, the components settle down into the blank device like sand onto a riveted, just in the right places. "That's what we tried for at least two years and we were never able to assemble these components with high yields and gravity wasn't working," said Heiko Jacobs of the University of Minnesota, who led the research.

SELF-ASSEMBLY EXPLAINED

The oil/water mix contains a number of individual solar cell elements.

Each is coated with a "water-loving" molecule on the bottom and a "water-hating" one on top.

The elements align neatly at the oil/water boundary in a two-dimensional sheet. The "blank" solar cell has pre-cut places for the elements and is dipped through the boundary.

As it slowly drains upwards, the elements pop into place.

"Then we thought if we could concentrate them into two-dimensional sheet and then have some kind of conveyor belt-like system we could assemble them with high yields and high speed," he told BBC News.

To do that, the team borrowed an idea familiar to fans of vinaigrettes: they built their two-dimensional sheets at the border of water and oil.

They first built a device blank as before, with depressions lined with low-temperature solder, designed for individual solar cell elements.

They then prepared the elements -- each a silicon and gold stack -- a few tens of millions of a metre across -- and put different coatings on each side.

On the silicon side, they put a hydrophobic molecule, one that has a strong tendency to avoid contact with water. On the gold side, they put a hydrophilic molecule, which has the converse tendency to seek out water.

By getting the densities of the oil- and water-based parts of the experiment just right, a "sheet" of the elements could be made to "float" between the two, pointing in the right direction thanks to their coatings.

The conveyor belt process is simply dump the device blank through the boundary and draw it back slowly; the sheet of elements rides up along behind it, each one popping neatly into place as the solder attracts its gold contact.

The team made a working device comprising 64,000 elements in just three minutes.

Bandy future

Proving that the concept works, the team is now investigating just how small they can go in terms of individual elements, or how large they can go in finished devices.

The approach should also work for almost any material, stiff or flexible, plastic, metal or semiconductor -- promising fast for future display and imaging applications.

BabaK Parviz, a nano-engineering professor at the University of Washington in Seattle, said the technique is a "clear demonstration that self-assembly is applicable across size scales."

"Self-assembly is probably the best method for integrating high-performance materials onto unconventional substrates," he told BBC News.

The method tackles what Dr Parviz said is the most challenging problem -- the proper alignment of thousands of parts, each thinner than a human hair. But it also works with the highest-performance materials, he said.

"For example, this method allows one to use single-crystal silicon, which is far superior to other types of silicon for making solar cells," he said.

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