Researchers develop dynamic templates critical to printable electronics technology

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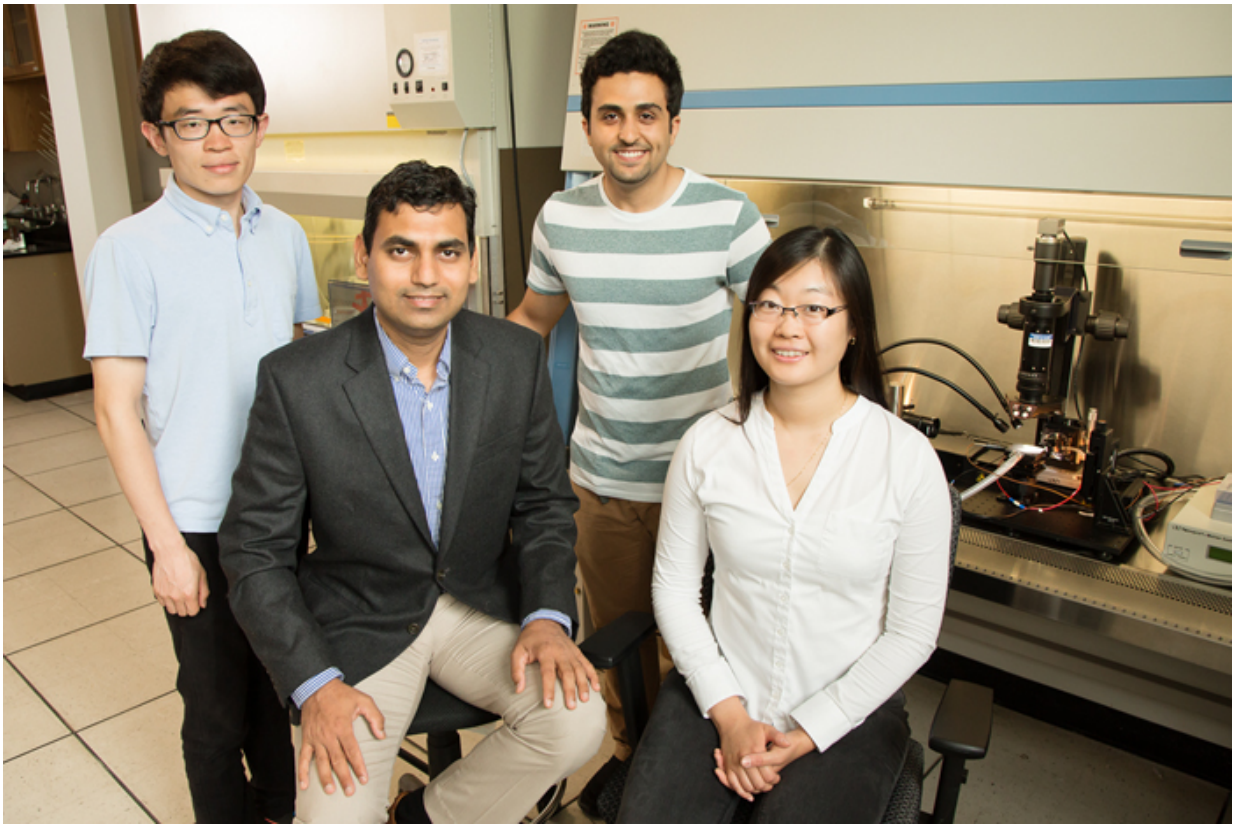

From bottom right, clockwise: Ying Diao and Diwakar Shukla, professors of chemical and biomolecular engineering; Chuankai Zhao and Erfan Mohammadi, graduate students. Credit: L. Brian Stauffer

When it comes to efficiency, sometimes it helps to look to Mother

Nature for advice - even in technology as advanced as printable, flexible electronics.

Researchers at the University of Illinois have developed bio-inspired dynamic templates used to manufacture organic semiconductor materials that produce printable electronics. It uses a process similar to biomineralization—the way that bones and teeth form. This technique is also eco-friendly compared with how conventional electronics are made, which gives the researchers the chance to return the favor to nature.

Templating is used for making near-perfect semiconductors to enhance their electronic properties, or to modulate the spacing between atoms for better electronic properties. These templates help to properly align the atoms of semiconductor materials, typically silicon or germanium, into the form that is needed.

However, this conventional methodology only works well for rigid nanoelectronic devices. The larger, more disordered organic polymer molecules needed to make flexible electronics cannot arrange around a fixed template.

In a new report in the journal *Nature Communications*, professor Ying Diao, graduate student Erfan Mohammadi and co-authors describe how the biomineralization-like technique works.

In nature, some biological organisms build mineralized structures by harvesting or recruiting inorganic ions using flexible biologic polymers. Similarly, the templates Diao's group developed are made up of ions that reconfigure themselves around the atomic structure of the semiconductor polymers. This way, the large polymer molecules can form highly ordered, templated structure, Diao said.

This highly ordered structure overcomes the quality control issues that

have plagued organic semiconductors, slowing development of flexible devices.

"Our templates allow us to control the assembly of these polymers by encouraging them to arrange on a molecular level. Unlike printing of newspapers, where the ordering of the ink molecules does not matter, it is critical in electronics," Diao said.

The manufacturing process that can use these dynamic templates is also eco-friendly. Unlike conventional semiconductor manufacturing methods, which require temperatures of about 3,000 degrees Fahrenheit and produce a significant amount of organic waste, this process produces little waste and can be done at room temperature, cutting energy costs, Diao said.

"Our research looks to nature for solutions," Diao said. "In nature, polymers are used to template ions, and we did the opposite - we use ions to template polymers to produce flexible, lightweight, biointegrated electronics at low cost and large scale."

More information: "Dynamic-template-directed multiscale assembly for large-area coating of highly-aligned conjugated polymer thin films" *Nature Communications* (2017).

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