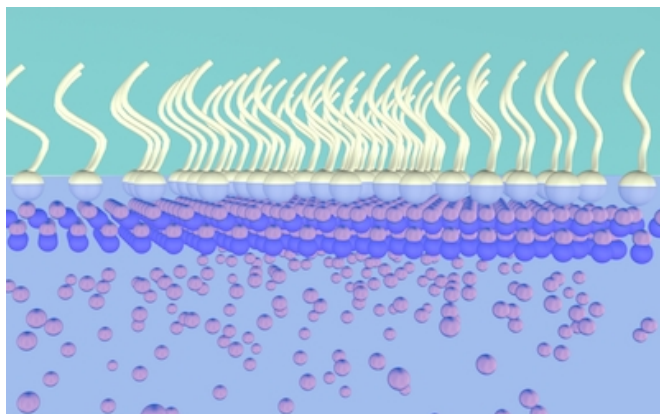


New nanosheet growth technique has potential to revolutionize nanotechnology industry

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Schematic illustration of the formation of ZnO nanosheets directed by surfactant monolayer

After six years of painstaking effort, a group of University of Wisconsin-Madison materials scientists believe their breakthrough in growing tiny sheets of zinc oxide could have huge implications for the future of nanomaterial manufacturing—and in turn, on a host of electronic and biomedical devices.

The group, led by Xudong Wang, an associate professor of [materials](#) science and engineering at UW-Madison, and postdoctoral researcher Fei Wang, has developed a novel technique for synthesizing two-dimensional nanosheets from compounds that do not naturally form the atomic-layer-thick materials. It is the first time such a technique has been successful, and the researchers described their findings 20, January, 2016, in the journal *Nature Communications*.

Essentially the microscopic equivalent of a single sheet of paper, a 2D nanosheet is a material that is constrained to up to only a few atomic layers in

one direction. Nanomaterials—materials that are constrained in at least one dimension to a maximum of a handful of atomic layers—have unique physical properties that alter their electronic and chemical properties in relation to their compositionally identical but conventional, and larger, material counterparts. "What's nice with a 2D nanomaterial is that because it's a sheet, it's much easier for us to manipulate compared to other types of nanomaterials," says Xudong Wang.

Until now, materials scientists were limited to working with naturally occurring 2D nanosheets. These natural 2D structures include graphene, a single layer of graphite, and a limited number of other compounds. Developing a reliable method to synthesize and manufacture 2D nanosheets from other materials has been a goal of materials researchers and the nanotechnology industry for years.

In their technique, the UW-Madison team applied a specially formulated surfactant—a detergent-like substance—onto the surface of a liquid containing [zinc ions](#). Due to its chemical properties, the surfactant assembles itself into a single layer at the surface of liquid, with negatively charged sulfate ions pointed in the direction of the liquid. Those sulfate ions draw the positively charged zinc ions from within the liquid to the surface, and within a couple hours enough zinc ions are drawn up to form continuous zinc oxide nanosheets only a few [atomic layers](#) thick.

Xudong Wang first had the idea for using a surfactant to grow nanosheets during a lecture he was giving in a course on nanotechnology in 2009.

"The course includes a lecture about self-assembly of monolayers," says Xudong Wang. "Under the correct conditions, a surfactant will self-assemble to

form a monolayer. This is a well-known process that I teach in class. So while teaching this I wondered why we wouldn't be able to reverse this method and use the surfactant monolayer first to grow the crystalline face."

After five years of trial and error with different surfactant solutions, the idea finally paid off about a year ago.

"We are very excited about this," says Xudong Wang. "This is definitely a new way to fabricate 2D nanosheets, and it has great potential for different materials and for many different applications."

Already the researchers have found that the 2D zinc oxide nanosheets they've grown are able to function as p-type semiconductor transistors, which is the opposite electronic behavior of naturally occurring zinc oxide. Researchers have for some time attempted to produce zinc oxide with reliable p-type semiconductor properties.

Zinc oxide is a very useful component of electronic materials, and the new nanosheets have potential for use in sensors, transducers and optoelectronics.

But the [zinc oxide](#) nanosheets are only the first of what could be a revolution in 2D nanomaterials. Already, the UW-Madison team is applying its surfactant method to growing 2D nanosheets of gold and palladium, and the technique holds promise for growing nanosheets from all sorts of metals that wouldn't form them naturally.

"It brings a lot of new functional material to this 2D material category," Xudong Wang says.

More information: Fei Wang et al. Nanometre-thick single-crystalline nanosheets grown at the water–air interface, *Nature Communications* (2016). [DOI: 10.1038/ncomms10444](https://doi.org/10.1038/ncomms10444)

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