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Nanowire arrays line up for future devices

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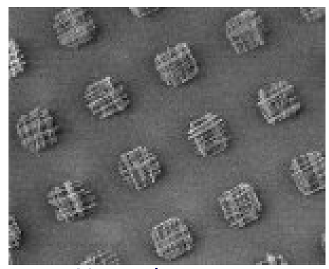
Researchers from Harvard University, US, have come up with a technique for building arrays of nanowires from the bottom up. The method, which can produce structures patterned on multiple length scales and over large areas, could have applications in making nanodevices.

"This solution-based process offers a flexible pathway for bottom-up assembly of virtually any nanowire material into highly integrated and hierarchically organized nanodevices needed for a broad range of functional nanosystems," researchers Dongmok Whang and Song Jin told *nanotechweb.org*.


Nanowire arrays

Whang, Jin and colleagues demonstrated the technique by making arrays from silicon nanowires prepared by nanocluster-catalysed chemical vapour deposition. They made a suspension of the nanowires in nonpolar solvents and spread the suspension onto the surface of an aqueous phase in a Langmuir-Blodgett trough. Compressing the film caused the nanowires to align along their long axes; the spacing between the nanowires depended on the compression process used. Then the scientists transferred the aligned film to a flat substrate.

The team made films of nanowires with spacings from 45 nm to 2 µm. Compression to spacings of less than 200 nm tended to cause the nanowires to aggregate. However, by using nanowires coated with sacrificial layers and removing the sacrificial layer after they had transferred the film to the substrate, the researchers were able to create films with nanowire spacings of 45 nm and 90 nm.

The Harvard scientists created multiple layers of aligned nanowires by transferring additional films to the substrate. In some cases they added films with the nanowires aligned in parallel to the earlier films, whereas in others they created crossed-nanowire structures by transferring additional layers of nanowires aligned perpendicular to those in the previous layer. Then they used photolithography to remove sections of the surface coating and create repeating arrays of nanowires.

"We wanted to develop approaches that enable controlled assembly and integration of nanowire - and nanotube - building blocks on a scale far beyond that of the individual or small numbers of devices produced previously," said Jin. "The Langmuir-Blodgett technique, in combination with photolithography, is flexible, general, parallel and scalable."

In one example, the researchers made an array of 10 x 10 µm squares of aligned nanowires with a 25 µm pitch. The array had order on multiple length scales - 40 nm diameter nanowires, 500 nm nanowire spacing, 10 µm array size and 25 µm array pitch. The largest area over which the scientists produced a repeating pattern was 20 sq. cm.

"In the simple case of parallel nanowire arrays, we are able to make

massive arrays of high-performance nanowire field-effect transistors in high yield, which are suitable as arrays of chemical and biological sensors as well as logic for computing," said Whang. "[The technique] also opens up a new venue in macroelectronics applications for bottom-up assembled single-crystal nanowires. The crossed-nanowire array structures can serve as the basis for addressable nanoscale light-emitting diode sources and universal computing structures."

The scientists reported their work in *Nano Letters*.

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