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Harvard scientists create high-speed integrated nanowire circuits

Low-temperature fabrication and high-quality results could reduce electronics' reliance on silicon

CAMBRIDGE, Mass. -– Chemists and engineers at Harvard University have made robust circuits from minuscule nanowires that align themselves on a chip of glass during low-temperature fabrication, creating rudimentary electronic devices that offer solid performance without high-temperature production or high-priced silicon.

The researchers, led by chemist Charles M. Lieber and engineer Donhee Ham, produced circuits at low temperature by running a nanowire-laced solution over a glass substrate, followed by regular photolithography to etch the pattern of a circuit. Their merging of low-temperature fabrication and nanowires in a high-performance electronic device is described this week in the journal Nature.

"By using common, lightweight and low-cost materials such as glass or even plastic as substrates, these nanowire circuits could make computing devices ubiquitous, allowing powerful electronics to permeate all aspects of living," says Lieber, the Mark Hyman Jr. Professor of Chemistry in Harvard's Faculty of Arts and Sciences. "Because this technique can create a high-quality circuit at low temperatures, it could be a technology that finally decouples quality electronics from single crystal silicon wafers, which are resilient during high-temperature fabrication but also very expensive."

Lieber, Ham and colleagues used their technique to produce nanowire-based logical inverters and ring oscillators, which are inverters in series. The ring oscillator devices, which are critical for virtually all digital electronics, performed considerably better than comparable ring oscillators produced at low temperatures using organic semiconductors, achieving a speed roughly 20 times faster. The nanowire-derived ring oscillators reached a speed of 11.7 megahertz, outpacing by a factor of roughly 10,000 the excruciatingly slow performance attained by other nanomaterial circuits.

"These nanowire circuits' performance was impressive," says Ham, assistant professor of electrical engineering in Harvard's Division of Engineering and Applied Sciences. "This finding gives us confidence that we can ramp up these elementary circuits to build more complex devices, which is something we now plan to do."

Lieber and Ham say these functional nanowire circuits demonstrate nanomaterials' potential in electronics applications. The circuits could be used in devices such as low-cost radio-frequency tags and fully integrated high-refresh-rate displays, the scientists write in Nature; on a larger scale, such circuits could provide a foundation for more complex nanoelectronics. The technique Lieber and Ham used to produce a nanowire-based circuit on a glass substrate is also compatible with other commonplace materials such as plastics, broadening its potential applicability.

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Lieber and Ham's co-authors are Robin S. Friedman and Michael C. McAlpine in Harvard's Department of Chemistry and Chemical Biology and David S. Ricketts in Harvard's Division of Engineering and Applied Sciences. Their work was supported by the Defense Advanced Research Projects Agency, the National Science Foundation, and the U.S. Air Force Office of Scientific Research.

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