IBM gets closer to a future of nanotube-based chips

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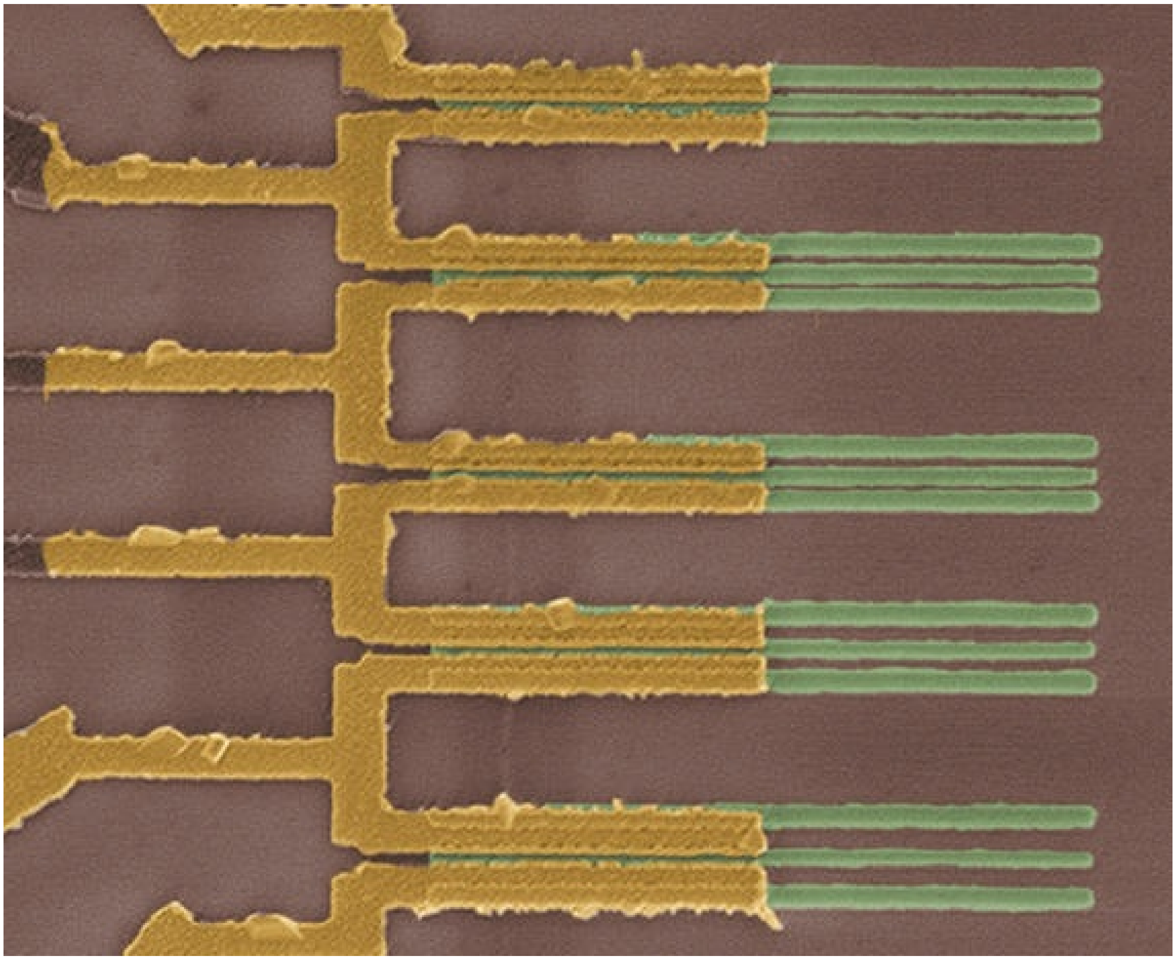

This microscopic view shows a faint vertical line consisting of carbon nanotube segments bonded to the golden-colored parallel wires. IBM Research

IBM researchers have licked a problem that stood in the way of a promising technology that could sustain the computing industry's remarkable march of progress.

The evolution of computers from refrigerator-sized mainframes to smartphones in your pocket has hinged on chips that keep getting smaller and working faster. The miniaturization that's central to that progress, though, is facing serious engineering problems as electronic components shrink down toward atomic-size scales.

On Thursday, IBM published research results that show how miniaturization can keep moving ahead, part of a $3 billion research effort to build chips using a foundation of carbon nanotubes. These nanotubes are hollow cylinders whose walls are made of a single layer of carbon atoms linked into a hexagonal lattice pattern. It looks like an extremely tiny roll of chicken wire, but about 10,000 times smaller than a human hair.

"This breakthrough demonstrates the technology can scale," enabling ever-smaller chip components, said Shu-Jen Han, a materials scientist at IBM's T. J. Watson Research Center, headquartered in Yorktown

Heights, New York. "And we believe it can happen in the decade, sooner than the industry thinks."

Making chips smaller and more capable is key to sustaining the computing industry's decades-long track record of progress called Moore's Law. That progress, with new chip manufacturing technologies arriving about every two years, has brought computers to our desks, pockets and now wrists. It's helped Google to make sense of the Web and enabled Facebook to recognize our friends' faces in photos. But that progress is slowing, and if it were to come to a halt, many of tomorrow's revolutionary computing ideas wouldn't have a chance to evolve.

IBM's new technique is "very good news, for sure. They've made good progress in this area," said Aaron Thean, director of the logic research program at IMEC, an independent nanoelectronics research center based in Belgium. A lot more work needs to be done to make nanotubes practical, though, he said.

Mike Feibus, a longtime chip-industry analyst at TechKnowledge Strategies, called IBM's work a breakthrough.

"This is huge," Feibus said. "This should quiet those who've been saying that Moore's Law may finally have run its course."

The entire microprocessor industry is trying to find a path beyond today's difficulties, but IBM has a particular focus on carbon nanotubes. Ultimately, it expects nanotubes to be used for chips in everything from mammoth supercomputers to the tiny computers spreading to places like clothing and car tire pressure gauges.

Today's chip transistors are made using the element silicon, taking advantage of the fact that under different circumstances it either conducts electricity or doesn't. Carbon nanotubes share this "semiconductor" nature that enables them to act as on-off switches that can process data.

What IBM has figured out is a better way to connect those nanotubes to the rest of the microprocessor so they can conduct electricity when in their "on" state. Previously, high resistance stopped electrons from flowing, but IBM figured a way to bond each end of a nanotube to the metal molybdenum. The bonds themselves are small, a crucial factor in making tiny chip circuitry.

The technique could be be built into chips three generations into the future of chipmaking technology, Han said. But it offers miniaturization abilities good enough that it can enable chips another three generations beyond that, a hard problem since electrical resistance can get worse as components shrink.

Thean sees other challenges, though. Although IBM has figured out how to lower resistance, researchers still need to address an electrical problem called capacitance that slows electron flow, he said. Resistance and capacitance both reduce the speeds at which circuits can switch on and off and therefore perform computing work.

IBM itself points to other hurdles, too. One is that carbon nanotubes come in two varieties: semiconducting and metallic. They're hard to separate, but transistors are ruined if they use the metallic kind.

Another challenge is in manufacturing. Today's core chipmaking technology, called photolithography, shines patterns of light on the silicon wafers used to make chips. Those patterns ultimately are used to carve away portions of material, leaving the chip circuitry behind.

Carbon nanotubes, though, require materials to be laid down on the chip with extraordinary precision.

"When building silicon chips out of wafers, it's akin to getting a piece of marble and sculpting it away to make a statue," Han said. For carbon nanotubes, "we are starting with the marble dust and have to figure out a way to make that into a statue."