ENGINEERING

Soft Circuits

New netlike circuits could create "cyborg tissues"

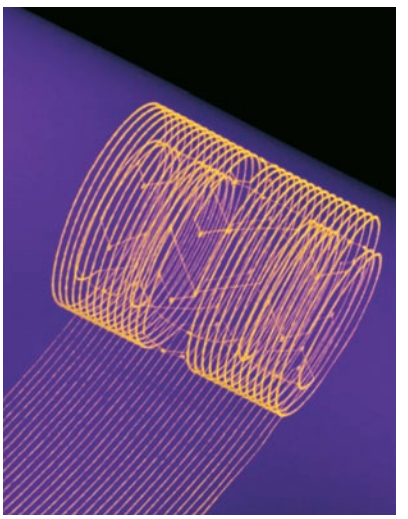
Seamlessly integrating powerful, 3-D computer circuits into soft materials such as rubber has been an elusive goal in engineering. Now researchers say they have developed a type of circuit that is soft and porous—more like a net than a chip. Manufacturers could weave these circuits into an extraordinary range of materials to create "smart matter" that scans and reacts to its surroundings or even "cyborg tissues"—human skin and organs that could report on their own health.

Nanoscientists Jia Liu and Charles Lieber of Harvard University and their colleagues began with silicon wires, each roughly 30 nanometers (billionths of a meter) wide, arranged in two-dimensional circuits. Although some hardened epoxy surrounded the nanowires, these flat circuits were more than 99 percent empty space, resembling nets with large holes. These flexible circuits could then be rolled up like scrolls, creating three-dimensional stacks that could lead to dramatically more powerful computers. The researchers could readily fill the voids in these novel electronics with a wide variety of materials by pouring liquids into the 3-D devices and letting them solidify. The resulting hybrid materials can be "very smart systems," says Liu, whose team detailed its findings online in April in *Proceedings of the National Academy of Sciences USA*.

For instance, electronic networks in silicone rubber can signal when and how the material is deformed—a system that can, for example, warn drivers of damage to a tire before it blows out. Future versions of smart matter could include furniture that tracks vital signs and contact lenses that record and display data, Liu suggests. "We believe our method opens up lots of opportunities to merge electronic systems into every aspect of our life," he says.

"This is groundbreaking research that pushes the electrical sensing device to a new level of complexity and functionality," says materials chemist Yat Li of the University of California, Santa Cruz, who did not take part in this work.

The lattices could also be combined with gels containing living cells. The resulting cyborg tissues could serve as replacements for damaged organs that can give feedback on how they are doing or even enhance human capabilities—cyborg skin, for example, could have extra senses to make it smarter, and cyborg bones and muscles could make people stronger. "Cyborg tissue," Liu says, "will be the most important application from this research." —*Charles Q. Choi*



3-D circuits could enable "smart matter" that reacts to surroundings.

COURTESY OF JIA LIU AND CHARLES LIEBER *Harvard University*

BY THE NUMBERS

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Percentage of U.S. adults who report having talked on a cell phone while driving in the past 30 days. The rate was higher than in seven European countries also surveyed, where the numbers ranged from 59 percent in Portugal to 21 percent in the U.K., according to a report released in March by the U.S. Centers for Disease Control and Prevention.