Technique for "Growing" Electrical Connections Developed by UCSD Chemist Michael Sailor

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HOLD FOR SCIENCE EMBARGO:

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Media Contact: Warren R. Froelich, (619) 534-8564 Win Cox, (619) 534-3120

TECHNIQUE FOR "GROWING" ELECTRICAL CONNECTIONS DEVELOPED BY UC SAN DIEGO CHEMISTS

A chemical technique for "growing" electrical connections between two or more pairs of wires, accomplished without any outside mechanical help, has been developed by a team of chemists at the University of California, San Diego.

In some respects, the new technique resembles the way neurons reach out in the brain and make connections with each other.

"This is the only system of its kind, outside of a living system, that allows you to do this in three dimensions," said Michael Sailor, assistant chemistry professor.

The technique, described in the December 24 issue of the journal Science, could represent a significant advance in the nanoscale (millionths of a millimeter) construction of ultra-tiny electronic circuits, neural nets, or even molecule-sized machines or robots based on connections no thicker than a few atoms.

"I'd like to think that we are providing the tools for the next generation of electronics, which would be things on the size scale of molecules," said Sailor, who directed the research with Corrine L. Curtis and Jason E. Ritchie, UCSD chemistry students.

In their Science article, the UCSD chemists demonstrate how certain chemicals called conducting organic polymers can be made to form electrical connections between two separate pairs of platinum wires, without any mechanical assistance.

This "hands-off" technique takes advantage of a known trait of these chemicals to conduct electricity. By alternating the voltage at the wire from positive to negative, the polymer can be switched between a highly conductive state (where it transmits electricity) to a highly insulating state, (where electricity is prevented from passing).

If the voltage is positive, the organic polymer becomes conductive and forms a dense network of fibers; if the voltage is negative, it becomes insulating and growth stops. Left on their own, these fibers would grow into a veritable forest, whose limbs would touch in a random and useless fashion.

The key to the UCSD experiment was to find a way to direct this growth, so only those fibers that you want to connect would be allowed to touch.

In their experiment, the UCSD chemists discovered they could create a polymer link between two specific platinum wires by alternating the current at each node, from positive to negative. At the positive node, polymer fibers begin to grow; at the negative node, growth is suspended. After about 30 seconds, the current is switched at each node--growth stops at the first node, while it begins at the second. The switching continues, back and forth, until branches from the two fibers connect, a process which takes between a half-hour to 45 minutes.

Under the microscope, blue spindly formations can be seen sprouting in the polymer solution from each of wire nodes as the current is alternated between conducting and non-conducting states. The formations are called "dendrites," because of their resemblance to the branch-like structures on neurons.

Once the dendrites touch, they combine to form what is known as an electric shunt.

"It acts just like a wire, obeys Ohm's law, and allows current to flow in either direction," said Sailor.

When the external power is shut off, electricity through the connection also stops flowing.

"The analogy here is that the little platinum wires we have in our solution are the nodes between which we grow our neural connections," Sailor said. "Just like in our brain, you don't want your nerves to be connected to the wrong spots. You don't want your brain to short out.

"So it is here, we want to get things to connect up in a directed fashion."

In theory, Sailor said, the technique could be used to fabricate molecular connections between hundreds or thousands of nodes, each independent of the other. Or, it could be used to build large arrays of neural networks, patterned after the way the brain works.

Either of these projects would be virtually impossible to accomplish with conventional mechanical or photolithographic techniques used in today's electronics industry.

"The next step in electronics is to just keep making things smaller and smaller," said Sailor. "The ultimate limit is to do molecular electronics where computer chips are cut down to about five or six atoms, or a molecule, and each of these molecules are arranged with molecular connections that link them all together.

"The technology to accomplish this does not yet exist."

Sailor's group already is planning the next generation experiment which would create polymer links between 10 to 20 connections. Afterward, he said, it's only a matter of time before creating an array consisting of about 1,000 connections, with each node connected to a multiple number of nodes.

Although the analogy to the brain and how it is wired is not perfect, there are some similarities.

"The way your brain works is you have a lot of things working in parallel," Sailor said. "You fire one neuron and it will communicate with thousands of other neurons. That's the parallel process, and that's why your brain works so much faster "Our technique allows us to make such complex parallel connections."

Sailor added that a more mundane spinoff of the technology might be the repair of microchips.

"Say you have a spot on the chip where a wire connection is broken," he said. "This will reconnect it without using a soldering iron and a microscope.

"The nice thing about this it's all hands off."

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VIDEO IS AVAILABLE FOR TV UPON REQUEST.

PHOTOS ARE AVAILABLE FOR PRINT MEDIA UPON REQUEST.

Dear Assignment Editor:

Michael Sailor, a UCSD chemist, has developed an electrochemical technique for "growing" electrical connections between two or more pairs of wires, without mechanical or lithographic tools.

In an article published in the December 24 issue of Science, Sailor and his collaborators describe how this technique could represent a major advance in the construction of extremely small (nanoscale fabrication) electronic circuits or artificial neural networks.

In essence, the technique uses chemical procedures to direct the linking of a large number of "molecular wires." Sailor says it's the only system of its kind outside of living organisms. THIS IS AN EMBARGOED STORY!

A videotape of this process is available upon request. Thanks for your consideration.

Sincerely,

Warren Froelich

Director, UCSD Science Communications

PHOTO CAPTION

A tiny electrical connection, grown in a polymer solution without any outside mechanical assistance, is shown in this photograph. The technique, described by a team of UCSD chemists in the December 24 issue of Science, could offer the possibility of a new method for fabricating molecule-sized circuits and chips or artificial neural nets. (photo credit: Michael Sailor).