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New plastic circuits could replace paper

By Charles Choi
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NEW YORK, March 11 (UPI) -- Scientists at Lucent Technologies and an academic institution have created the highest performance plastic circuits ever seen, using a novel technique that avoids the hazards of conventional processing, which can damage the fragile devices.

Experts said a low-cost way of printing plastic-based transistors could emerge from this new method and help mass produce devices, such as video displays, thin and large enough to use as wallpaper or flexible enough to roll up.

"There's a hope here to print out circuits over large areas like you would print out a newspaper, with the resulting potential to drive costs down compared to silicon, which needs to be made in expensive clean room facilities," said project researcher John Rogers, a materials scientist at the University of Illinois at Urbana-Champaign.

Dozens of industry giants are pursuing plastic circuitry, with DuPont, Royal Philips Electronics and 3M leading the pack, Rogers told United Press International. Although conventional transistors are based on silicon, plastic circuits use crystals of organic semiconductors. In theory, organics can be processed much more cheaply than silicon, because organics can be poured from solution and printed in large mats. Silicon is fragile and must be made in smaller batches.

"Such a technology would not compete with high-speed computer chips, but it potentially

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could fabricate displays by the square yard and flexible smart cards for your wallet by means of a printing press," physicist Horst Stormer of Lucent told UPI.

Moreover, though silicon is brittle and difficult to embed in flexible materials, organics can prove far more pliable. This could produce a version of so-called electronic paper -- paper-thin flexible video displays. The potential impact of electronic paper alone could be vast, both financially and environmentally.

The value of shipments of electronic displays worldwide was estimated at roughly $64 billion in 2001. That figure is expected to grow to $114.8 billion by 2006, according to Business Communications Co. Inc., an analytical firm in Norwalk, Conn.

Electronic paper also could replace conventional books, cutting down on the consumption of paper. Philips, which unveiled a revolutionary form of electronic paper last January, plans by 2005 to be manufacturing millions of its flexible displays per year.

Much remains unclear about how an electrical charge moves through organic semiconductors, however.

"The world of plastic electronics now is about where the silicon world was 20 or 30 years ago," Rogers said.

This lag is due in part because it remains difficult to combine organic semiconductors with the other parts of a plastic circuit. The conventional mechanical and chemical processing steps used to manufacture such circuits easily damages organic crystals.

In findings published in the March 12 issue of the journal Science, the research team developed a way to synthesize an organic crystal separate "from the fabrication of the other elements needed for the transistors," Rogers said.

"It thereby eliminates exposure of the fragile surface of the organic crystals to the hazards of conventional processing," he said.

First, the researchers stick key ingredients for the circuits -- such as gold film electrodes -- onto a flexible block of siliconized rubber. These circuitry elements are then gently stamped onto the surface of an organic crystal.

The method has "made by far the highest performance organic transistor ever seen," Rogers said. Transistor performance often is measured by how well electrical charge can move inside them. The researchers saw charge mobility factors roughly 10 times higher than any before.

"This assembly process could be performed commercially to produce complex circuits," Rogers added. "We're looking very carefully at this method for commercial viability."

Still, Rogers said his team's new method originally was designed to help scientists tinker with organic circuits.

"I believe that this work represents a superb research tool," DuPont research fellow Graciela Blanchet told UPI. "It is promising and very interesting."

The fact that transistor components are only lightly stuck to one another makes it easy to take everything apart, so researchers have been able to perform quick trial-and-error experiments on circuit designs.

"The fact that you can use a rubber stamp pressed against the surface of a material to measure its electrical properties in one swoop is very exciting and powerful, and when you are finished you can peel it off and use it again," Stormer said.

The researchers also found a property of the circuits, called charge mobility, changed radically in the plastic transistors depending on how their organic crystals were aligned with the rest of the circuit components. Understanding why this happens could help scientists exploit that effect to squeeze better performance from plastic transistors, Rogers explained.

The Holy Grail that might come from this research would be a theory that could connect the molecular structure of a chemical with transistor properties.

"That way you could have the ability to design a molecule that leads to a high-performance device," Rogers said.

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