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Semiconductor Fabrication

Stamping Electronics

Simple process could deliver next-generation electronics

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Two recent advances in device fabrication could help move transistors off silicon wafers and onto flexible plastic substrates. There, they could be made into bendable electronic paper and skin-conforming sensors.

Video

Launch Video

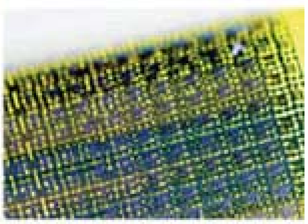
* Macromedia Flash Player 8 is required to view video.

Although the reports describe the fabrication of very different devices—one combines dissimilar classe of semiconductors, and the other consists of large arrays of single-crystal organic transistors—a silicone-stamping technique is key to both processes.

Electronics makers have been trying to create flexible electronic screens for years, but translating the technology that's been so successful on rigid silicon to pliable plastic has been a challenge. The main problem has been getting semiconductors, which are frequently grown at high temperature, onto flexible materials in a way that maintains performance but is also amenable to mass production. Unlike silicon, plastics can't tolerate high-temperature processing without getting gooey.

John A. Rogers and coworkers at the University of Illinois, Urbana-Champaign, have been able to put wide variety of materials onto flexible plastic by stamping. The group first grows semiconducting nanoparticles on one substrate. They then employ a soft silicone polymer to transfer the particles onto a flexible substrate in the same way that a rubber stamp transfers ink to paper.

Now, through repetitive stamping, Rogers' team has efficiently combined broad classes of material, such as single-walled carbon nanotubes, silicon ribbons, and gallium arsenide nanowires, onto a singl device (*Science* **2006,** *314,* 1754). "Important new types of electronic systems will rely on the ability to mix and match wide-ranging classes of devices in 3-D configurations on unusual substrates," Rogers explains.



Courtesy of Zhenan Bao (left)
Courtesy of John A. Rogers (right)
A flexible rubrene transistor array (left). Dissimilar semiconductors in a single device (right).

Silicone stamping also is at the heart of the new fabrication process reported by Stanford University's Zhenan Bao and colleagues. In Bao's technique, however, the stamping doesn't transfer the semiconducting material. Instead, it lays the groundwork for low-temperature semiconductor growth. Bao and coworkers use a stamp to deposit a patterned organic layer of significant roughness onto the substrate.

Organic semiconductors such as rubrene and C_{60} nucleate at these rough spots, growing into arrays of single-crystal organic semiconductors (*Nature* **2006,** *444,* 913).

"This work demonstrates for the first time that organic single crystals can be patterned over a large are without the need to laboriously handpick and fabricate transistors one at a time," Bao says.

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