combinations are possible. "It gets very laborious to try to make and test them all one at a time," says Fuller.

To speed up the search with combinatorial chemistry, Mallouk and his Penn State colleagues took a hacksaw to a commercial inkjet printer and modified the machine to spray droplets of different metal salts instead of ink. They then used a computer to control the spraying of the salts, in the end creating an array of dots, varying both the component salts and their relative concentrations. Treating the dots with a strong reducing agent converted the salts to patches of metal alloy, each of which acted as a catalyst.

One way to pick out the best catalyst from such an array of candidates is to expose them to their target compound and detect the heat given off during the reaction. But fast-reacting catalysts can produce heat even when they make unwanted byproducts. So the Penn State researchers took a new approach: They simply spiked their array—which sits in an aqueous bath containing methanol—with a compound called nickel PTP, which fluoresces a faint blue in the presence of protons. To activate the catalysts, the researchers applied a small voltage across the array, sat back, and watched as their best catalysts lit up.

The Penn State team passed along their brightest prospects to their IIT colleagues, who made electrodes from the material and incorporated them into working fuel cells. They found that the best such catalyst works about 40% better than a straight platinum-ruthenium mix under simulated real-world conditions. Mallouk, Fuller, and others caution that this improvement may not be enough to justify using the more costly metals. But the promising results of this first attempt to use combinatorial chemistry suggest that there may be even better catalysts out there just waiting to be discovered.

–Robert F. Service

POLYMER ELECTRONICS

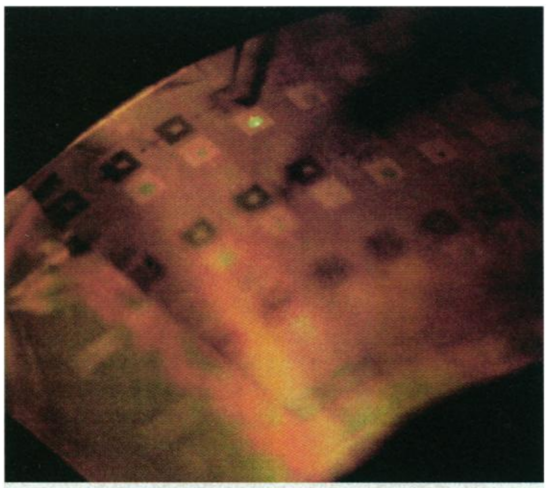
Transistors and Diodes Link and Light Up

Car bumpers, coffee mugs, computer casings: It seems that just about everything is made out of plastic these days. Researchers have even created plastic electronics, such as polymer-based transistors and glowing diodes. Now, separate teams of researchers in the United States and United Kingdom have managed to integrate these two types of devices for the first time, opening the way to lightweight, flexible displays made out of material not too different from garbage bags. Down the road, such displays could challenge conventional televisions and laptop displays and open up entirely new uses such as large-area illuminated signs that can be rolled up and carted away.

The new pairing between organic electronics and lights "is a breakthrough that the field of organic displays has been looking for," says Yang Yang, an organic-display expert at the University of California, Los Angeles. The advance, made possible by new polymers that carry higher currents, allows researchers to use simple, low-cost fabrication methods such as screen printing and inkjet printing to lay down all the different materials needed to create displays, says Yang. "It will be very exciting to see what you can do with all-organic systems," says James Sturm, an organic-display expert at Princeton University.

The prospect of all-organic displays has been tantalizing researchers for several years. Each point of light on such a display is a single light-emitting diode (LED) powered by an electric current, which is switched on and off by a transistor. The problem is that although organic LEDs typically need a rushing stream of current to shine, most organic transistors only put out a trickle. As a result, researchers have been forced to stick with conventional silicon-based transistors to drive their organic LEDs and so have lost some of the key advantages of plastics: flexibility, low cost, and low weight.

New hope for fully organic displays began to shine last year, when researchers at Lucent Technologies' Bell Laboratories in Murray Hill, New Jersey, and at Pennsylvania State University, University Park, came up with a new breed of high-current organic semiconductors. The two teams aiming to make all-organic displays, one at Bell Labs and one at Cambridge University, both settled on one of these new organics, a chainlike polymer known as regioregular poly(hexylthiophene). The polymer consists of a series of linked carbon and sulfur-based rings, with hydrocarbon chains dangling off each ring. When laid down in a solution, the chains and rings of different molecules prefer to associate with their own kind, and so the polymer assembles into alternating sheets of chains and rings. Current flows along the sheets of rings, and the close proximity of the rings in different molecules allows charges to jump freely from one molecule to the next. "This isn't perfect crystalline order, but it seems to be enough to boost the mobility of the electrical charges," says Cambridge physicist Henning Sirringhaus.



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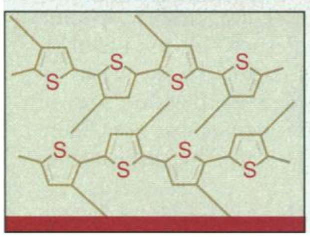

SIRRINGHAUS ET AL.

Bending light. Organic LED atop a thin silicon transistor. By replacing silicon with polymer *(left)*, new devices could be even more flexible.

On page 1741 of this issue, Sirringhaus and his Cambridge colleagues Nir Tessler and Richard Friend report fashioning this polymer into an organic transistor and using it to drive a conventional polymer-based LED built directly on top. Meanwhile, the Bell team, led by physicists Ananth Dodabalapur and Zhenan Bao, report in an upcoming issue of *Applied Physics Letters (APL)* that they made a similar transistor from poly(hexylthiophene) but then crafted an organic LED alongside.

The Bell Labs LED shines brighter, because the team coaxes light from a highly luminescent small organic molecule known as ALQ, says Bao. The downside is that this material must be laid down in a vacuum, a somewhat cumbersome process. Although the Cambridge LED is not as bright, it is made with a polymer-based light emitter, which can be applied from a simple solution—a process that is easier to scale up to coat large areas. Sirringhaus notes as well that he and his colleagues should be able to improve the performance of their devices considerably, for they were able to get much better performance out of their transistor by finding ways to encourage the polymer to order.

Bao says that since she and her group submitted their *APL* paper, they too have made all-polymer integrated transistors and LEDs. The two groups say they are now pushing ahead with efforts to create full arrays of the devices by screen printing and inkjet printing. If they succeed, plastics will display a whole new image.

–Robert F. Service