Engineers make first 'active matrix' display using nanowires

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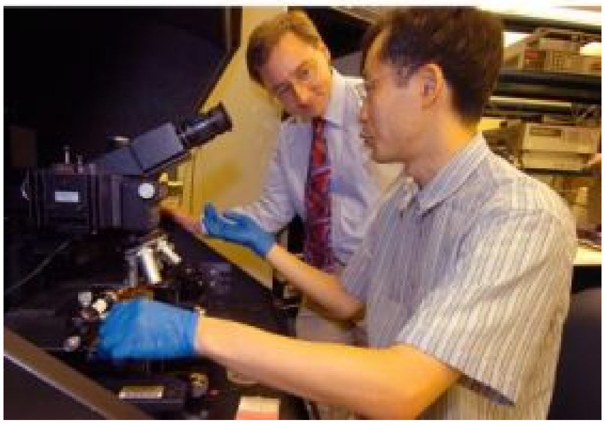

Purdue postdoctoral research associate Sanghyun Ju, sitting, and professor David B. Janes work at a "micro-manipulation probe station" in research using nanotechnology to create transparent transistors and circuits. The innovation represents a step that promises a broad range of applications, from e-paper and flexible color screens for consumer electronics to "smart cards" and "heads-up" displays in auto windshields. The transistors are made of single "nanowires," or tiny cylindrical structures that were assembled on glass or thin films of flexible plastic. Purdue News Service photo/David Umberger

Engineers have created the first "active matrix" display using a new class of transparent transistors and circuits, a step toward realizing applications such as e-paper, flexible color monitors and "heads-up" displays in car windshields.

The transistors are made of "nanowires," tiny cylindrical structures that are assembled on glass or thin films of flexible plastic. The researchers used nanowires as small as 20 nanometers - a thousand times thinner than a human hair - to create a display containing organic light emitting diodes, or OLEDS. The OLEDS are devices that rival the brightness of conventional pixels in flat-panel television sets, computer monitors and displays in consumer electronics.

"This is a step toward demonstrating the practical potential of nanowire transistors in displays and for other applications," said David Janes, a researcher at Purdue University's Birck Nanotechnology Center and a professor in the School of Electrical and Computer Engineering.

The nanowires were used to create a proof-of-concept active-matrix display similar to those in television sets and computer monitors. An active-matrix display is able to precisely direct the flow of electricity to produce video because each picture element, or pixel, possesses its own control circuitry.

Findings will be detailed in a research paper featured on the cover of the April issue of the journal *Nano Letters*. The paper was written by researchers at Purdue, Northwestern University and the University of Southern California.

"We've shown how to fabricate nanowire electronics at room temperature in a simple process that might be practical for commercial manufacturing," said Tobin J. Marks, the Vladimir N. Ipatieff Research Professor in Chemistry in Northwestern's Weinberg College of Arts and Sciences and a professor of materials science and engineering.

OLEDS are now used in cell phones and MP3 displays and prototype television sets, but their production requires a complex process, and it is difficult to manufacture OLEDs that are small enough for high-resolution displays.

"Nanowire-transistor electronics could solve this problem," said Marks, who received a 2005 National Medal of Science. "We think our fabrication method is scalable, possibly providing a low-cost way to produce high-resolution displays for many applications."

Unlike conventional computer chips - called CMOS, for complementary metal oxide semiconductor chips - the nanowire thin-film transistors could be produced less expensively under low temperatures, making them ideal to incorporate into flexible plastics that would melt under high-temperature processing.

Conventional liquid crystal displays in flat-panel televisions and monitors are backlit by a white light, and each pixel acts as a filter that turns on and off to create images. OLEDS, however, emit light directly, eliminating the need to backlight the screen and making it possible to create more vivid displays that are thin and flexible.

The technology also could be used to create antennas that aim microwave and radio signals more precisely than current antennas. Such antennas might improve cell phone reception and make it more difficult to eavesdrop on military transmissions on the battlefield.

Electronic displays like television screens contain millions of pixels located at the intersections of rows and columns that crisscross each other. In the new findings, the researchers showed that they were able to selectively illuminate a specific row of active-matrix OLEDS in a display about the size of a fingernail.

"Displays in television sets are able to illuminate a particular pixel located, say, in the 10th row, fifth column," Janes said. "We aren't able to do that yet. We've shown that we can select a whole row at a time, not a single OLED, but we're getting close."

Future research is expected to include work to design displays that can control individual OLEDs to generate images, Janes said.

"A unique aspect of these displays is that they are transparent," he said. "Until the pixels are activated, the display area looks like lightly tinted glass."

The nanowire transistors are made of a transparent semiconductor called indium oxide, a potential replacement for silicon in future transparent circuits. The OLEDS consist of the transistors, electrodes made of a material called indium tin oxide and plastic capacitors that store electricity. All of the materials are transparent until activated to emit light.

"This could enable applications such as GPS navigational displays right on the windshield of your car," Janes said. "Imagine having a local map displayed on your windshield so that you didn't have to take your eyes off the road."

The new OLEDs have a brightness nearly comparable to that of the pixels in commercial flat-panel television sets. The OLEDS have an average brightness of more than 300 candelas per square meter, compared with 400-500 candelas per square meter for commercially available liquid-crystal display televisions.

"Even in this first demonstration, we are fairly close to the brightness you'd see in an LCD television," Janes said.

The researchers also demonstrated they could create OLEDS of the proper size for commercial displays, about 176 by 54 microns, or millionths of a meter. OLEDS that size would be ideal for small displays in cell phones, personal digital assistants and other portable electronics.

Source: Purdue University