



Plastic-Powered Displays

During the last couple of decades, electronic displays have evolved steadily from cathode-ray tubes to flat panels. The next leap forward may produce a color display with a series of remarkable characteristics: easy to manufacture, efficient, inexpensive, light-weight, thin, wide-angle view, and made from plastic. The pixels in such a display would be organic light-emitting diodes (LEDs) of semiconducting polymers.

Research in conducting polymers started in the mid-1970s, when Japanese polymer scientist Hideki Shirakawa accidentally added too much catalyst to a reaction and produced a polymer sheet with the luster of aluminum foil. Just as in metals, free electrons caused the luster, and the material turned out to be an electrical conductor. At the University of Pennsylvania in the late 1970s, Alan G. MacDiarmid, Alan Heeger,

and Shirakawa improved the mobility of free electrons in this polymer through doping—adding small quantities of other materials. Those discoveries provided the fundamental knowledge that was required for making components from conducting polymers.

In 1990, Richard Friend, then of the Cavendish Laboratory in Cambridge developed the first polymer LEDs. Investigators have struggled to control the color and intensity of the emitted light, but that problem started giving way with discoveries made over the last couple of years. For instance, in 1995 Emiel Staring and his colleagues at the Philips Research Laboratory in Eindhoven, the Netherlands, generated emissions of light from red to blue with a polymer LED based on derivatives of 1,4-phenylene vinylene. In addition, Junji Kido and his colleagues at the Yamagata University in Japan fabricated a

device composed of three polymer layers, each emitting a different color, and the combination emitting white light. The device achieved a luminance of 2,200 candlepower/m², and the investigators expect that 8,000 candlepower/m²—the luminance of an ordinary fluorescent lamp—should be within reach with improved materials.

Expectations from industry

Alan Heeger, now at the University of California at Santa Barbara, and founder of the nearby Uniax Corporation, believes that his company will bring out its first engineering prototypes this year. In 1995, Uniax reported the creation of a polymer light-emitting electrochemical cell (LEC) that resembles the design of polymer LEDs. As a short-term goal, Heeger thinks the Uniax device could be used for backlighting in displays. “The

advantage of the polymer technology is that you can get uniform areas of light," Heeger points out.

Friend, cofounder and director of Cambridge Display Technology in Cambridge, England, sees broader possibilities. He says that the diversity of possible products—from simple single-color devices to full-color graphic displays—is “attractive for an enterprise in this technology-transfer exercise.” Furthermore, says Friend, “There is a huge diversity [between those] two ends of the spectrum. Logically one would expect the first products to emerge from the lowest point of that spectrum, because that would require the least effort.”

According to Nick Colanery of Uniax, polymer-based displays will surpass [liquid-crystal] displays in the near future. “I certainly have every expectation that [polymer-based displays] will be very competitive with existing active-matrix-LCD technology. Between here and there we have to figure out how to make them multicolored, as opposed to monochrome—this is what we can do today—and that is probably one of the most significant development challenges.”

Commercial challenges

Despite Colanery’s optimism, investigators in this field still face a number of challenges that must be solved before an array of polymer electronic components will reach the market.

“We are trying to take an advanced material from the research phase to a product, and there’s just a lot that has to be done to get it to work,” says Friend. “If you look at other materials that have made it to the market, they took quite a long time. [For example,] liquid crystals were around for a very long time before they appeared as displays.”

One major problem for polymer electronic components arises from chemistry. The material used in these devices oxidizes easily, making potential products unstable chemically. From a marketing standpoint, this problem produces a short shelf life—a definite liability for a commercial device. Nevertheless, Heeger thinks that this problem may be solved through packaging. “These are delicate materials and one needs

to package them in a hermetically sealed way to keep oxygen and water vapor out. One way is using glass substrates, [and] the technology for doing that exists.” In addition, Heeger’s polymer-based LECs provide a much longer shelf life than the polymer-based LEDs do.

If investigators solve these problems, semiconducting polymers may generate

unexpected applications. For instance, Heeger and his colleagues have described a plastic retina composed of light-sensitive polymer transistors, which produce a digital representation of patterns of light. Although the plastic retina has a long way to go before its first commercial application, Heeger believes that it could be used in many devices, such as digital video cameras. 