Physics Helps Redesign Dow Chemical

Developing innovative technologies and products for the integrated circuits (ICs) and light-emitting structures markets might appear to be outside the scope of the company that brought you Saran Wrap and Styrofoam. But the Dow Chemical Co. of today is looking well beyond its traditional role as a supplier of materials to other companies and aims to become a major force in high-tech product development—both on its own and through joint ventures.

Applied physics has long been a recognized strength in Dow Chemical's research and development efforts and its commercial successes. This commitment to physics is evident in Dow's date of joining the Corporate Associates—1936.

"To achieve the technology breakthroughs we're looking for, we need all the disciplines," says Rick Gross, vice president and director of research and development. "At Dow, we push the envelope on technical innovation. As we explore materials for the electronics industry, the interface between physicists and chemists becomes more intertwined and complementary."

As part of its strategy, Dow wants to take advantage of the expanding opportunities in electronics, which is a relatively new market for the company and one in which product innovation is almost a daily event.

Recently, Dow physicists and chemists developed SiLK dielectric resin, a polymer with a low dielectric constant used as insulating layers in semiconductor devices. SiLK dielectric resin can be processed between 400 and 450° C, which makes it compatible with current IC-manufacturing techniques. Its low dielectric constant permits circuit components to be packed more closely together without causing the devices to short-circuit, which reduces stray capacitance effects and increases operating speed. SiLK dielectric resin is currently undergoing testing by chipmakers for possible use in the next generation of ICs.

Dow has also entered the competitive race to develop new technologies for the flat-panel display (FPD) market (see *The Industrial Physicist*, 12/97, pp. 10-13). "Just as the market is pushing to make ICs smaller and more powerful, it is instigating a revolution in FPDs, and we expect to be an active part of that revolution," Gross says.

The quest is to develop alternatives to the bulky cathode-ray tubes (CRTs) used for most televisions and monitors, which have high power demands. Newer liquid-crystal display (LCD) panels are flatter and more energy efficient. However, their screens can only be read when looked at straight on, and they require backlighting or strong surrounding light.

Some have suggested using standard inorganic light-emitting diodes (LEDs) as replacements for LCDs in FPDs. However, creating an image on a display made of discrete LEDs would entail high manufacturing costs and require sending coordinated signals through separate wires attached to each LED. Such a system would be expensive and unacceptable for most uses.

To solve this problem, Dow Chemical scientists have created a class of thin, organic, light-emitting polymers that span the full color spectrum—from purple and blue to red and even white. One of these polymeric LEDs, or PLEDs, can produce 4,000 cd/m^2, which is comparable to fluorescent lighting yet requires a power supply of only 5 V. Typical illumination requirements would probably be closer to 100 cd/m^2, the brightness of a television screen.

PLEDs now have a lifetime of several thousand hours, although Dow researchers are working to increase this lifetime. "These new materials are both good film formers and highly fluorescent," says Edmund Woo, a Dow researcher. The fact that PLEDs are polymer-based means that they can be applied as thin films in a variety of shapes or even be included in flexible displays.

The light-emitting materials consist of a two-layer architecture and are thinner than a human hair. In a proprietary breakthrough, Dow scientists have discovered how to engineer the polymer's molecular band gap. This energy difference between a material's conductance band and valence band corresponds to a specific frequency and a characteristic color. By slightly varying the composition of one polymer layer in a PLED, Dow can change the color emitted. This enables the creation of multicolored panels and allows customers to select whatever colors they want for their FPDs. Electroluminescence occurs when electrons and holes flowing through the polymer layers combine to form excitons. Radiative decay of an exciton emits light at a frequency corresponding to the molecular band gap of the polymer.

Displays based on PLED technology would cost much less to manufacture than regular LEDs, yet they would be stimulated on a pixel-by-pixel basis, much like CRTs and LCDs, making possible inexpensive and even disposable display units. Working with potential customers, Dow Chemical is now evaluating material-processing and fabrication technologies for PLEDs and exploring joint ventures to bring them to market.

For information on the Corporate Associates program or an application form, please e-mail us at assoc@aip.com, visit our Web site (http://www.aip.org/aip/corporate), or call us at 301-209-3135.