Toward the Polymer Chip

When Bruce Novak's undergraduate assistants noted last March that a polymer compound they were studying had an unusual electronic structure, Novak decided they might be on to something altogether unexpected. They were: Novak, a chemist at the University of California at Berkeley, announced at the 200th meeting of the American Chemical Society 2 weeks ago that the compound can be turned into a conductor just by shining ultraviolet light on it.

Technically known as arylated poly (*p*-phenylene sulfide), or APPS, the new polymer, once photoactivated, demonstrates a conductivity similar to that of silicon and other semiconductors. Since conventional polymers, like organic compounds generally, are insulators rather than conductors, the Novak team has at least a theoretical breakthrough. And, if a number of technical hurdles can be overcome, the new material could eventually transform the manufacture of computer chips.

Polymers have long played an important role in microcircuit fabrication. Traditionally, process engineers have used them as "photoresist," an application in which a thin film of polymer on a silicon wafer is masked by a circuit pattern and then exposed to ultraviolet light. This light renders the polymer soluble to certain solvents, allowing engineers to wash the exposed areas away and etch the circuit pattern into the underlying semiconductor material with an acid to which the remaining polymer is resistant. In a final step, electrical connections between the thousands of transistors etched into the chip are made by sputtering a conductor such as aluminum onto the surface.

Given the ease and precision with which most polymer films can be laid down on silicon wafers and then masked, they've long been a favorite tool of engineers, who would like nothing better than finding a way to make electrical connections with polymer coatings. But although a few polymers become conductors when exposed to strong oxidizing agents, it's impossible to deliver such chemicals to a wafer surface at the resolution needed to etch microcircuits.

Now Novak's APPS might provide just the technology engineers have dreamed of—but only if some technical obstacles can be overcome. For one thing, Novak has only masked APPS with a resolution of about 10 microns; submicron resolutions are required for today's densely packed chips. And for another, the conductivity of APPS will have to be increased substantially. On this point, Novak is bullish: He believes it will be possible to boost the conductivity of polymers which are structurally similar to APPS by as many as four orders of magnitude, which would put them into the range of low-conductivity metals—a startling achievement for organic compounds. In addition, these polymers must be stabilized to prevent degradation by ambient light and water vapor.

But if Novak's optimism is justified, a broad range of applications could open up. Take display screens in computers and televisions, for example. Today's screens use a phosphorous coating that flickers to life when a cathode-ray tube sprays electrons across it. With photolyzed polymers, however, it might become possible to wire each colored dot, or pixel, on the screen with a micron-wide line of conducting polymer, thereby obviating the need for the cathode-ray tube and making flat-screen display possible without liquid crystals.

Bullish. *Bruce Novak is optimistic that conducting polymers will find broad uses.*

Novak's more immediate goal, however, is to understand how APPS's electrical conductivity is achieved. In particular, he is anxious to determine whether the conductivity of the new polymer is ionic or electrical. So far, the circumstantial evidence amassed by his lab favors electrical conduction: APPS loses its conductivity when exposed to water. ■ DAVID P. HAMILTON

Co-opting the Chemists

A typical meeting of the American Chemical Society generally brings more than 10,000 chemical scientists from around the world to one major North American city for a week of gossip, networking, and discussion of their latest research. Concentrating so much scientific talent in one place creates an irresistible lure to anyone with a project to push. At last September's ACS meeting, it was climate change: some of the leading lights directed a symposium aimed at getting more chemists excited about atmospheric modeling. This year, the folks after converts were those running the Human Genome Initiative. Department of Energy genome chief Charles Cantor (biologist), along with Leroy Hood of Caltech (biologist), found time in their overcommitted calendars to fly to the nation's capital to put on sessions at this year's ACS fall meeting.

What they were selling was that analytical chemists have a lot to offer the genome project. "As much as 50% of the work [in the genome initiative] falls in the domain of traditional chemistry problems," says Lloyd M. Smith, an assistant professor of chemistry at the University of Wisconsin, who himself has a grant from the project, and who organized the sessions. "There's a lot of talent in the analytical chemistry community, but they don't know biology, so they're wary of the genome initiative."

But chemists have a big advantage over the genome project's more traditional adherents, molecular biologists, Smith says. "Analytical chemists are interested in technology development and developing new tools," he says. "The culture of the physical and biomedical communities isn't oriented that way. They're more problem-oriented."

Sequencing a gene, for instance, is essentially a chemical problem, since it boils down to determining the structure of an exceptionally large molecule—DNA, in this case. Chemists have a wide variety of tools to bring to bear on the problem, ranging from mass spectrometry to scanning tunneling microscopy. Even better, their training inclines them to develop new technologies that will speed the process of sequencing the genome, Smith says. For instance, chemists are now using fluorescent organic molecules to tag stretches of DNA; developing synthetic polymer gels for chemical separations that, unlike existing gels, are chemically and physically stable; and formulating new data-analysis strategies.

Chemists may get the message as they consider the $87 million that the federal government threw into genome-related research last year. And despite budget troubles on Capitol Hill, that number is likely to be still higher this year. Indeed, Smith says that since he had between 50 and 150 attendees at each session, the chances of attracting new blood into the genome project are probably pretty good.

■ DAVID P. HAMILTON