# Prototype

## "Faster Than a Speeding Bullet"

New polymers developed by chemists and engineers at the University of Washington (UW) and the University of Southern California (USC) appear to achieve speed and capacity increases so great that they will revolutionize telecommunications, data processing, and sensing and display technologies.

The materials are used to create polymeric electro-optic modulators, or "opto-chips." These microscopic devices perform functions such as translating electrical signals—television, computer, telephone, and radar—into optical signals at rates up to 100 gigabytes per second (a gigabyte is 1 billion bytes). Polymeric electro-optic materials can achieve information-processing speeds as great as ten times those of current electronic devices and have significantly greater bandwidths than electro-optic crystals currently in use. In addition, the new materials require a fraction of a volt of electricity to operate, less than one-sixth of what crystals require.

New polymers that are being developed appear to achieve great speed and capacity increases. Larry Dalton, a chemistry professor at both the University of Washington and the University of Southern California, is the overall research leader in this area at both universities.

### Real-Time Communications

"These electro-optic modulators will permit real-time communication. You won't have to wait for your computer to download even the largest files," said Larry Dalton, a chemistry professor at both UW and USC, who is the overall leader of the research and has full research teams at both universities.

The breakthrough resulted from research by Dalton; William Steier, a USC electrical engineering professor; Bruce Robinson, a UW chemistry professor; and USC graduate students Cheng Zhang and Hua Zhang. (Their work is described in the April 7 edition of *Science*.)

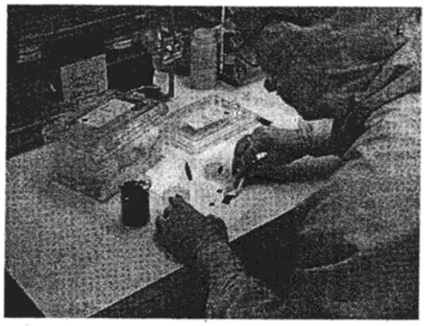
### Technology With Bandwidth to Burn

Polymeric electro-optic modulators can be used for information processing, to steer radio waves and microwaves to and from telecommunications satellites, to detect radar signals, to switch signals in optical networks, and as optical gyroscopes to guide planes and missiles.

They serve as a bridge between electronics and fiber optic, providing huge capacity with very low noise disturbance and very low power requirements. They are being tested for ultra-fast analog-to-digital conversion, optical switching elements in flat-panel displays, and voltage sensing for the electric utility industry, Dalton said. Currently, the most commonly pursued applications include signal transducers for cable television, directional couplers or routing switches in optical communications networks, and modulators in phased-array radar systems.

"It's a critical decision-determining technology because bandwidth, bandwidth, bandwidth—like location, location, location in real estate—is critical in making decisions in communications technology," Dalton said.

"This technology has bandwidth to burn."



A researcher works with the polymeric electro-optic modulators or "opto-chips" in a clean room.

**Testing and Applications**

During testing at Tacan Corp. in Carlsbad, CA, two other co-authors of the *Science* article—lead author Yongqiang Shi (now of Lucent Technologies) and James Bechtel—used the devices to translate electronic cable television signals into optical signals using less than one volt of electricity. Researchers at Lockheed Martin Corp.'s research laboratory in Palo Alto, CA have since replicated those results in tests involving other applications.

Tests indicate that a single modulator measuring one micron (about .000039 inch) can provide more than 300 GHz of bandwidth—enough to handle all of a major corporation's telephone, computer, television, and satellite traffic.

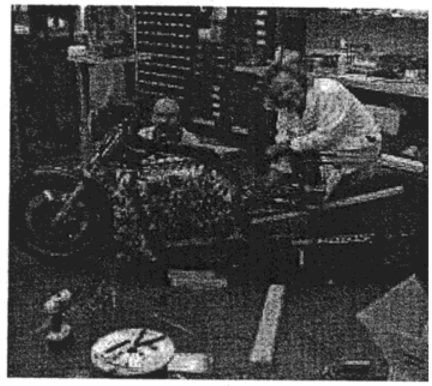
Other applications are so far ranging, Dalton said, that they even create the capability of full three-dimensional holographic projection with little or no image flicker. That makes possible a device such as the science-fictional holodeck, where characters in the "Star Trek: The Next Generation" television series and movies create elaborate holographic worlds in which they live their fantasies.

The research, funded by the National Science Foundation, the U.S. Air Force Office of Scientific Research, and the Office of Naval Research, is aimed at developing new materials based on the principles of condensed-matter theory. Design and molecular synthesis are done at UW; and materials are then sent to state-of-the-art production facilities at USC, where the modulators are fabricated and integrated with both silica fibers and VLSI silicon chips.

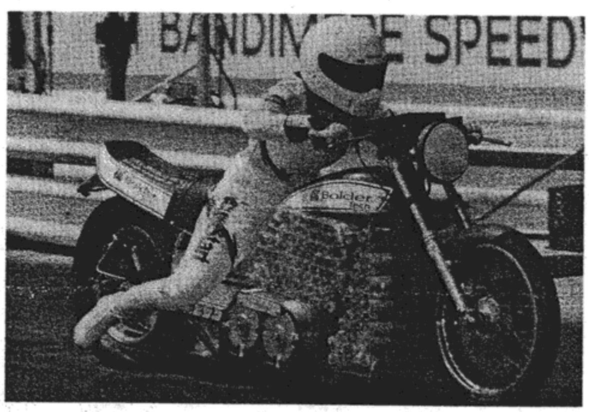
The electro-optic modulators in use today are grown as lithium niobate crystals and, rather than being integrated into silicon chips, must be hard wired. Besides having far less capacity and requiring substantially more electrical power than the new materials, they also have greater signal loss because of electronic interference and generate substantially more heat. The special properties of the new polymers, including low heat generation, are particularly important for futuristic device application, Dalton said. PT

# More Power to You

The "KillaCycle" set the current record as the world's quickest electric motorcycle. It was set by 23-year-old Kerry Hogan the first day she drove the bike on a dragstrip on March 18, 2000—10.539 seconds @116.565 mph. Designed, built, and until recently driven by engineer Bill Dube, the KillaCycle does 0 to 60 mph in 2.9 seconds. That's a lot like being shot out of a cannon, according to Dube.



Designer and engineer Bill Dube (left) and another team member assemble a new pack of Bolder TMF cells into the KillaCycle.



Record-breaking driver Kerry Hogan on the KillaCycle.

The bike is a product of the marriage between state-of-the-art battery technology and old-fashioned "do-it-in-the-garage" workmanship, using a converted '77 Kawasaki KZ100 frame. The batteries are thin-metal-film lead-acid cells, each about the size of a roll of Lifesavers, developed and manufactured by Bolder Technologies, Inc. in Golden, CO, for their new SecureStart automobile jump-starter. Six of these powerful little cells are enough to start a car. The cycle uses 456 of them, interconnected in such a way as to produce a nominal open-circuit voltage of 304 volts and up to 3000 amps (at about 150 volts). The 92-pound battery pack supplies a peak power of about a third of a million watts during a run down the dragstrip, enabling the two 7-inch-diameter traction motors to churn out well over 300 horsepower.

"Based on the performance I have seen to date, I believe that when the full power potential of TMF cells is exploited, electric vehicles can have a power-to-weight ratio greater than that found in high-performance engines," Dube said. "The TMF cells have the greatest power-to-weight ratio of any battery currently in production. This makes TMF cells ideal for applications requiring high amperage for short periods or the ability to recharge very quickly."

Constructed with an extremely thin lead foil, TMF batteries are wound tightly to achieve the maximum amount of surface area in the smallest volume. More surface area equates to more power. Unique cast-on end connectors transfer the energy efficiently in and out of the battery cell, eliminating the "power bottleneck" common with ordinary batteries. Think of it as a battery built like a capacitor.

Manufactured using inexpensive, readily available raw materials, the batteries have numerous advantages. This technology does not suffer from the memory effect that reduces the capacity