

at Parkfield, more or less in line with the variability of the actual record over the past 140 years. Rice's can produce regular sequences of quakes too, but only for short spurts. In the long run, this model's variability is twice what the relatively short, and therefore possibly misleading, historical record shows.

With complications multiplying in earthquake prediction, many seismologists weren't surprised that Parkfield failed to live up to the forecast. But that doesn't mean that they have given up on more modest kinds of predictions. They've recently had a couple of notable successes in forecasting where—if not when—future earthquakes will strike.

On 15 January, just as seismologists were settling into the post-Parkfield prediction blues, a magnitude 5.1 earthquake struck the southern end of the Calaveras fault, a branch of the San Andreas running east of San Francisco Bay. Much to the delight of David Op-

penheimer of the USGS in Menlo Park, Bakun, and Lindh, the quake fulfilled a partial prediction they had developed in 1989 (*Science*, 21 April 1989, p. 286). They had divided the southern 60 kilometers of the fault into six segments, based on patterns of background microseismicity, and found that three of the segments had been broken by recent quakes. After checking the historical record to see which segments might be due to break again, they concluded that the two segments at either end of the study area were "the most likely sites for the next [greater than magnitude] 5 earthquakes."

Oppenheimer and company were right on the money when the January quake ruptured the designated southern segment. And in another successful prediction of a quake's location and magnitude, a magnitude 7.6 shock struck offshore of Nicaragua last September at a location seismologists had predicted more than a decade earlier

(*Science*, 30 October 1992, p. 743).

Such successes, along with the historical record of frequent Parkfield quakes, convince researchers that the 1985 forecast is still likely to be right on a very basic level: Sooner rather than later, a good-sized quake will strike Parkfield. Eventually, the \$1.8 million being spent each year on the Parkfield Earthquake Prediction Experiment will pay off, most researchers say, and probably sooner than if the experiment were moved to any other fault segment. "No matter how you cut it," says McEvelly, "we're in the last quarter of a magnitude 6 cycle...and the experiment is heading for a conclusion." Better late than never.

—Richard A. Kerr

Additional Reading

Abstracts for the sessions "Parkfield as the Prediction Window Closes I and II," *EOS Trans. AGU* **73**, Fall Meeting Supplement, 396, 406 (1992).

MATERIALS SCIENCE

Shiny Molecules Gain New Luster

San Jose was teeming with thousands of points of light on 1 and 2 February as researchers gathered at a meeting sponsored by the Society for Imaging Science and Technology and the International Society for Optical Engineering. Much of that sparkle came from a symposium devoted to light-emitting organic molecules—"the first worldwide meeting of people working in this field," says Milan Stolka, a meeting chairman and research supervisor at Xerox Corp.'s Webster Research Center in Rochester. These substances, which give off light when sandwiched between electrodes, are brightening prospects for new kinds of computer monitors, area lighting, even TVs.

Stolka and his colleagues have been following this guiding light for years, but the meeting was marked by a new optimism. For one, it was energized by the announcement, during a talk by Shogo Saito of Kyushu University in Fukuoka, that colleagues at the Pioneer Electronic Corp. in Saitama had built an experimental electroluminescent (EL) patch that shone, at least for a short time, with an eye-shocking brightness about 2000 times that of a computer monitor. And while the Pioneer device, like most organic EL devices so far, is a short-lived parfait made up of molecular layers, researchers at the meeting were also talking about a newer approach that could be more practical: coaxing light from durable sheets of polymers.

Although the research is only now coalescing into a field, its roots go back to the discovery, some 30 years old, that certain organic molecules emit light when oppositely charged particles recombine within them, says Ching Tang of the Eastman Kodak Co. in

Rochester. That discovery acquired a new significance with the rise of laptop computers. Liquid crystal displays, a leading technology, quickly drain laptop batteries because they make inefficient use of light: They often work by blocking or reflecting light coming from fluorescent tubes behind the liquid crystal layer.

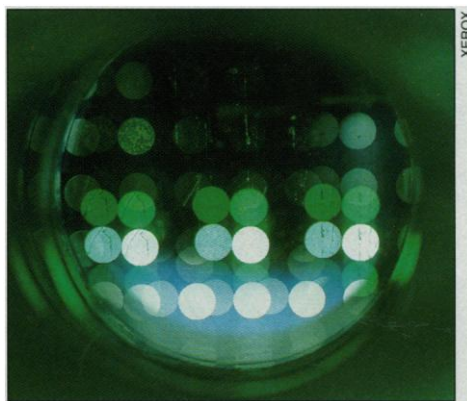
The alternative may turn out to be a multidecker sandwich centered on a thin layer of organic molecules. Electrodes on the outer layers of the sandwich supply negative charges, carried by electrons, and positive

In a standard recipe for these illuminating sandwiches, the light-emitting layer is a thin film of small organic or organometallic molecules such as the quinolium-aluminum complex (which consists of an aluminum atom flanked by a trio of quinolium molecules). Several groups, including Tang's group and the Pioneer researchers, are striving to increase the intensity or efficiency of the light emission by chemically modifying the emitting layer. Many of the designs rely on additives—such as electron-friendly oxadiazole or hole-hosting aromatic amines—that act as social directors, encouraging more excitonic meetings between opposite charges.

For all their bright promise, however, organic films are handicapped by their need for brittle components, such as transparent indium-tin-oxide electrodes, that restrict their flexibility and by chemical instabilities that limit their lifetimes. That's why many researchers, including Xerox's Gordon Johnson and Kathleen McGrane and Richard Friend and his colleagues at Cambridge University, are replacing the fragile layer of discrete organic molecules with more durable and flexible polymers such as poly-(phenylene vinylene)s. "These are more mechanically and thermally stable than the molecular thin films," Tang admits. But so far, he adds, they are only about one-tenth as efficient.

Everyone agrees that it is too early to place bets on which strategy will emerge in the commercial arena. But plenty of established companies are now earnestly investigating both approaches. And in another measure of the vogue for shiny molecules, it has already spawned at least two startup companies, one in Cambridge, Massachusetts, and another in Santa Barbara.

—Ivan Amato



Bright stuff. An electroluminescent polymer.

charges, which are called holes. The electrons and holes migrate inward; when they encounter each other they join in a transient liaison called an exciton. The organic layer has the rare property of allowing excitons to persist awhile, and instead of recombining in a lightless process, as would happen in most organic materials, the opposite charges in some excitons collapse in light-emitting unions.