Liquid crystal coating controls light

A material that combines silicon with a liquid crystal could one day serve as the foundation for microchips used in light-based computers, according to a new theoretical study.

Researchers at the University of Toronto have demonstrated that liquid crystal molecules provide a way to tune the optical properties of a silicon photonic crystal, a structure designed to exclude light within a chosen range of wavelengths (SN: 11/16/96, p. 309). By engineering switches and waveguides into a photonic crystal, researchers hope to create optical computer chips that rely on light signals instead of electrical currents.

Toronto's Sajeev John and his colleague Kurt Busch, now at the University of Karlsruhe in Germany, calculate that applying an electric field to the composite material will shrink its forbidden range of wavelengths, or band gap.

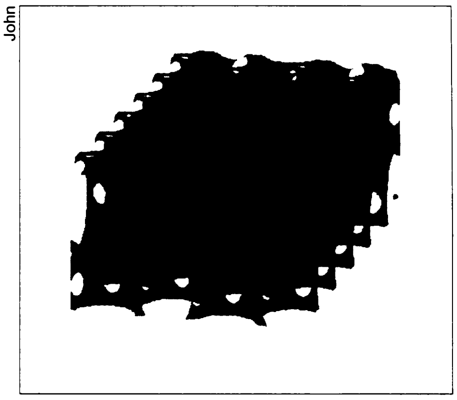
The team's theoretical analysis begins with a type of photonic crystal known as an inverse opal, which looks something like a hunk of Swiss cheese. Researchers make inverse-opal crystals by molding silicon around a stack of tiny glass balls, then etching away the glass with acid. What's left is a chunk of silicon containing an orderly arrangement of spherical, air-filled voids. These structures block light with wavelengths approximately equal to the diameter of the voids.

The researchers determined that by coating the inner surfaces of these hollow spheres with a common liquid crystal, they can control the size of the photonic-crystal band gap. Applying an electric field "rotates the axis of the liquid crystal materials, and that scatters light in a different way," John explains. By changing the orientation of the liquid crystal molecules, they can shrink the band gap down to zero. Light of all wavelengths can then pass through.

One way to design an optical computer chip is to build switches (SN: 11/15/97, p. 310) and waveguides (SN: 10/24/98, p. 271) into the photonic crystal to allow through particular wavelengths of light.

With the composite material, "you could change the architecture of your optical chip simply by applying an electric field," John says. "You could rewire the circuit at will on a millisecond time scale." The researchers describe their analysis in the Aug. 2 Physical Review Letters.

"It's interesting that you can get enough tunability in the liquid crystal to get the job done," says Eli Yablonovitch of the University of California, Los Angeles. Researchers have always thought that liquid crystals could not change the material's index of refraction enough to close the band gap, he explains. "What [Busch and John] noticed is that you don't need that big a change, so that's quite significant," he says.



John

A silicon photonic crystal contains air voids arranged in a lattice pattern (blue). Liquid crystal molecules (green in one example) coat the inner surface of the voids.

Yablonovitch, however, is reserving final judgment until the researchers fabricate the composite material. John says that his team hopes to have a sample constructed by the end of the year.

They have already made a simplified version, which has a forest of hollow cylinders etched through a silicon wafer and coated with liquid crystal molecules. These structures exclude only light propagating perpendicular to the cylinders, while the Swiss cheese photonic crystal can block light coming from any direction, John says. —*C. Wu*

Shedding light on an ancient supernova

The twinkling light appeared low on the horizon, outshining everything but the sun and the moon. This "guest star," witnessed by Chinese and Japanese astronomers in A.D. 1054, was a supernova explosion—the violent death of a massive star.

The remnant of that explosion, the Crab nebula, is one of the most photographed objects in the heavens and has endured for nearly a millenium.

So has a mystery about the supernova that forged it.

Asian astronomers carefully documented the supernova, and some Native Americans may have drawn it. However, no evidence clearly revealed that the supernova was seen in Europe. That omission had been attributed to bad weather, but poor viewing conditions in Europe couldn't have lasted the entire 2 years that the supernova was visible, says George W. Collins II of Case Western Reserve University in Cleveland.

"It just stuck in my craw to have to try to weasel out of a perfectly reasonable question with an unreasonable answer," he says. So he set out to investigate.

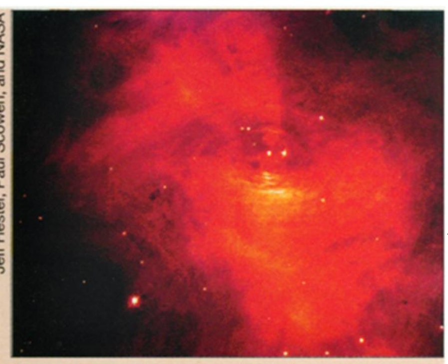
Reexamining chronicles and religious documents that touch on events from 1054 but were written several hundred years later, Collins' team has gathered a string of clues that European skywatchers did indeed observe the supernova in the evening sky. He and his Case Western collaborators, William P. Claspy and John C. Martin, describe their findings in the July Publications of the Astronomical Society of the Pacific.

Those documents had never been assembled in a single analysis, Collins notes. He adds that some of the material had been misconstrued. For example, a new interpretation of the *Rampona Chronicles*, an Italian treatise on the universe, indicates the evening appearance of a bright star.

In searching for consistency among the various texts, Collins' team finds that the supernova may have exploded a few months earlier than July 4, 1054, when Asian astronomers first reported it.

Pushing the supernova's debut back several months jibes with the suggestion of other researchers that "an orb of extraordinary brilliance," as was reported shortly after the death of Pope Leo IX on April 19, 1054, was in fact the supernova. The pope was promptly made a saint.

Collins' team "is the first to put together all these disparate (and weak) claims to make a plausible whole," says Bradley E. Schaefer of Yale University. He gives the earlier supernova date "a 50-50 chance" of being correct.



Jeff Hester, Paul Scowen, and NASA

The Crab nebula resulted from a supernova observed in A.D. 1054.

One puzzle remains, notes Collins. No surviving document indicates that Europeans ever saw the supernova in the morning, as the Asians did. His team speculates that the Roman church may have suppressed such recordings, fearing that an opposing faction would herald the morning apparition as a bad omen for changes the clergy was enforcing. "This is at least as good a hypothesis as bad weather," quips Collins. —*R. Cowen*