Silicon now shines with optical potential

An illuminating rebirth of silicon — long considered an "optically dead" material — has delighted scientists who work with this vital semiconductor. After decades of unsuccessful attempts, researchers armed with lasers have finally teased visible light from specially treated silicon, achieving an effect known as photoluminescence.

Mastering silicon's photoluminescence and extending it to electrical stimulation of light emission, or electroluminescence, could revolutionize optical electronics and lead to superior computers. "It's pretty hot stuff," says Subramanian S. Iyer of IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y.

In May, British and French researchers presented the first evidence that acid-etched silicon wafers can emit light when illuminated. Several groups have since confirmed those observations, but new findings cast doubt on the initial explanation for silicon's puzzling glow.

Luminescence starts in semiconductors when electrons, stimulated by lasers or electricity, jump to the conduction bands from the valence bands within the material, leaving "holes" — the positively charged equivalent of electrons. Many semiconductors will release a photon when the electrons fall back across these energy gaps and combine with the holes.

Silicon, however, is an indirect band-gap material: It rarely produces visible photons when electrons and holes recombine. For this reason, light-emitting diodes, lasers and other optical electronic devices currently rely on gallium arsenide and other direct band-gap semiconductors, which are expensive and unwieldy.

Scientists now know that silicon can mimic a direct band-gap material, but they have yet to figure out what makes it do so. One theory, put forth by the British researchers who initially achieved the effect, holds that bathing silicon in hydrofluoric acid changes its light-emitting behavior. Leigh T. Canham and his colleagues at the Defense Research Agency in Malvern, England, proposed in May that the acid etches a forest of microscopic pillars into the silicon. These small, in effect one-dimensional structures — called "quantum wires" — then facilitate the electron-hole recombination by confining the electron's movement, they suggested.

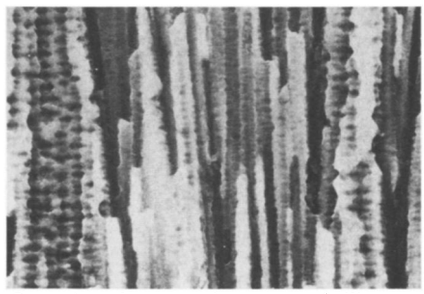
That simple theory now faces a challenge from new images of the acid-treated, light-emitting silicon taken with a transmission electron microscope. "[Canham's] pillars are far too large for quantum confinement," says John M. Macaulay of AT&T Bell Laboratories in Murray Hill, N.J., who led the team that produced the as yet-unpublished images. "[They] are not necessary in photoluminescence."

What luminescence requires, he says, is simply silicon structures of 10 nanometers or less. Many of the micrographs reveal a complex, sponge-like structure and not pillars.

Such minute structures create a "quantum size effect" that appears to broaden silicon's band gap and allow more efficient recombination of electrons and holes, suggests Reuben T. Collins of the Watson Research Center.

But before silicon can replace gallium arsenide, Collins notes, researchers must take the giant step from photoluminescence to electroluminescence.

In May, Canham and his co-workers claimed they had created a working silicon device that accomplishes electroluminescence, but they have refused to release any details because of pending patents, according to frustrated researchers. Such devices — if practical — might finally allow construction of the long-awaited optical computer.



Macaulay/AT&T Bell Labs

Scanning electron microscopy of silicon bathed in hydrofluoric acid shows pillar-like structures (above), which some researchers thought explained silicon's surprising luminescence. But newer, unpublished micrographs, taken with a transmission electron microscope, lead others to question that theory.

Silicon's shining breakthrough has clearly excited a once-dormant field. Light-emitting silicon "has tremendous potential," says Peter Searson, a materials scientist at Johns Hopkins University in Baltimore. "It's sort of like superconductivity in '86." — *J. Travis*

HIV poses hazards for breast feeding

A study conducted in Africa adds to evidence implicating breast milk as the culprit in some cases of mother-to-child transmission of HIV, the virus that causes AIDS.

Previous studies have shown a 10 to 60 percent chance that an infected mother will pass HIV to her unborn fetus. If the fetus escapes that *in utero* threat, it may acquire the infection during delivery. In addition, several case reports suggest that HIV-tainted breast milk may, at times, infect newborns.

Now, in the largest study of mother-to-child HIV transmission to date, Philippe Van de Perre at the AIDS Reference Laboratory in Kigali, Rwanda, demonstrates that women who test negative for the AIDS virus at the time of delivery, but who become infected, can later pass the virus on to their infants, probably via breast feeding.

Van de Perre and an international team of AIDS experts studied 212 pregnant women who tested negative for HIV when they delivered. Within three to 18 months later, 16 of these women tested positive for HIV, the team reports in the Aug. 29 NEW ENGLAND JOURNAL OF MEDICINE.

At some point during the 18-month period, nine of the 16 infants tested positive for HIV, either with an antibody test or with a method called polymerase chain reaction, which detects the virus itself.

The researchers believe one child acquired the infection *in utero* because it tested positive for HIV at birth. Another four infants, who tested negative at birth, showed signs of infection during the first three months of life. That time frame suggests HIV exposure in the womb or at delivery, says Philip A. Pizzo of the National Cancer Institute. Previous studies have suggested that infected newborns may initially test negative, and then test positive within three months after birth.

In four other cases, however, the study implicates breast feeding as the route of HIV transmission, Pizzo notes. These infants, who tested negative at birth, developed their infections at four to 21 months later — all within three months of their mothers' positive HIV tests.

If they had acquired the infection in the womb or during birth, these infants probably would have detectable amounts of HIV in their blood much earlier, Pizzo says. Thus, he says, the study affirms that "breast feeding can be a source of transmission."

Should at-risk mothers avoid breast feeding, even though they show no sign of HIV? In developing countries, notes Pizzo, breast feeding is complicated by the threat of unsafe water, which could lead to life-threatening diarrhea in bottle-fed infants. But in the United States, bottle feeding remains the safe alternative both for HIV-infected mothers and for those worried about their HIV status, asserts Peter Vink at the University of Maryland School of Medicine in Baltimore. — *K.A. Fackelmann*