
They may not be super, but semis are hot

A hot subject of late has been the new high-temperature superconductors and how they may revolutionize various technologies by allowing electricity to flow without losses and without much cooling — making magnetically levitated trains feasible, for example. But at the same time, advances in much higher-temperature *semiconductors* — the materials that make up transistors and other devices — have also been quietly brewing. And while these may not usher in any new physics or lead to quite as dramatic technological changes, semiconductor research is much closer to producing commercial high-temperature devices for use in a number of their own important applications — providing electronics in the hot environs of jet engines, drilling deep oil wells or operating the space station, to name a few.

One recent semiconductor advance comes from materials scientists Robert F. Davis, John Palmour and their colleagues at North Carolina State University in Raleigh. They have made silicon carbide transistors that perform at 650° C — the highest operating temperature ever reported for any transistor made from any material. Moreover, says Palmour, the electronic properties of these transistors are “astoundingly good. Their current-voltage characteristics are textbook [examples],” he says, and are comparable to the performance of more conventional silicon transistors operating at room temperature (20° C).

What Davis's group has done, says Tony Powell at NASA Lewis Research Center in Cleveland, “is extremely important . . . and represents a turning point in [30 years of] silicon carbide research.”

Davis discussed his group's achievements last week at the first International Conference on Amorphous and Crystalline Silicon Carbide, hosted by Howard University in Washington, D.C. A paper on the researchers' “metal-oxide-semiconductor field-effect transistor” (MOSFET), a switching device typically used to amplify signals, also appears in the Dec. 15 *APPLIED PHYSICS LETTERS*.

The need for electronic devices that can operate at high temperatures has been growing in part because automobile and jet engines are being designed to run at increasingly higher temperatures to maximize their performance. At the same time, the demand has grown for electronics to monitor pollution, increase engine efficiency and help diagnose problems from directly inside engines.

The best commercial silicon sensors can operate at temperatures of up to 250° C, and usually the other silicon devices that amplify and process the sensors' signals are connected by wires and kept in a remote, cool spot. This arrangement adds cost and bulk and degrades

reliability.

At temperatures much higher than 200° C, silicon becomes a full conductor, like a metal, and all control over the current, which is crucial for a semiconductor device's operation, is lost. In the language of semiconductor physics, these high temperatures excite most of the bound electrons in the silicon's “valence band” to jump up across silicon's “energy band gap” into the “conduction band.”

To make devices for higher temperatures, researchers have been hunting for materials with a much larger energy band gap than silicon — in other words, materials that become fully conducting at higher temperatures. Candidates being considered include boron nitride and diamond films (SN: 10/17/87, p.247; 8/23/86, p.118), but researchers have made the most progress with silicon carbide.

One of the main contributions of Davis's group is to grow electronic-quality silicon carbide crystals. In much of the past work, scientists had grown a cubic form of silicon carbide atop a pure silicon substrate. But, possibly because of a

Water, water everywhere, but . . .

Two new reports released within a week of each other have left some consumers feeling a bit parched. Connoisseurs of bourbons, sherries and fruit brandies were treated to the news that many of their favorite brands contain dangerously high levels of urethane, a potent carcinogen. Meanwhile, testimony before members of Congress revealed that many of the drinking fountains in the United States are spouting water that is contaminated with lead.

The report on tainted alcohol, released last week, lists urethane levels in more than 1,000 alcoholic beverages as determined by government and beverage industry laboratories. The data were compiled and released by the Center for Science in the Public Interest, a Washington, D.C.-based consumer group that obtained the test results through the federal Freedom of Information Act.

“Unlike some of the chemical controversies of the past, such as DDT and saccharine, there is no disputing the fact that urethane is a carcinogen,” says Michael Jacobson, the group's executive director. However, he says, while Canada established two years ago strict limits on urethane levels in alcoholic beverages, ranging up to 400 parts per billion (ppb), the U.S. Food and Drug Administration (FDA) “has neither set limits nor recalled products from the marketplace.”

Part of the problem, say beverage producers and federal regulators, is that

mismatch between the silicon carbide and silicon lattices, the silicon carbide film had too many defects to be useful. Davis's group instead was able to grow the cubic form on top of hexagonal silicon carbide crystals, which came from a factory that uses these tiny crystals to make sandpaper. The result was devices with fewer defects and better performance. The researchers have also learned how to grow much purer hexagonal crystals themselves, which they expect will lead to even better devices.

Davis's group has formed a spinoff company that is beginning to make prototype high-temperature diodes. The company is also interested in using silicon carbide to make light-emitting diodes that emit blue light; these are needed for digital color imaging and printing, processes that would produce color pictures without the use of film. In addition to high-temperature applications, silicon carbide's properties could make it ideal for high-power, high-frequency use in military and satellite communications, among other applications.

Davis's recent work, notes Powell, finally “brings silicon carbide close to being a viable commercial product. It's no longer a question of whether it's going to be successful, but when.” — *S. Weisburd*

urethane is a natural by-product of the fermentation process; none is intentionally added in the production process. Tiny amounts of it are present in such commonly consumed foods as bread and yogurt. According to Emil Corwin, a press officer with the FDA, the agency “has been meeting with key [beverage] industry groups in an effort to find production methods that will reduce urethane levels in alcoholic beverages. But we still need to figure out how it's produced and how to reduce it.”

The new report shows that most beers, with the notable exception of Foster's (Australia) and Golden Dragon (China), contain extremely low or undetectable levels of urethane. Fruit brandies have the highest levels — in some cases more than 2,000 ppb — with generally decreasing amounts appearing in bourbons, sherries and table wines, though many of them are still higher than Canadian standards. Backed by cancer specialist Marvin Schneiderman, a member of the National Academy of Sciences and a former associate director of the National Cancer Institute, Jacobson calculates that consumption of two drinks a day at levels just under the Canadian limit could lead to a cancer risk from 10 to 4,700 times greater than the FDA's “acceptable” cancer risk level of 1 in 1 million.

Lois Gold, a cancer risk specialist at the Lawrence Berkeley (Calif.) Laboratory, told *SCIENCE NEWS* that because the car-

cinogenicity of alcohol itself is still being disputed, the relative risk posed by urethane in alcohol is difficult to determine. It's possible, she says, that although urethane is much more carcinogenic than alcohol, even uncontaminated alcohol may prove to be the bigger problem since greater quantities of it are consumed.

Meanwhile, for those who might be inspired to stick with water, straight up, beware the friendly water fountain. A draft excerpt from a report being prepared for the U.S. Public Health Service states that "Virtually all electric drinking fountains in schools appear to have sizable elevations of lead in their water." The report's coauthor, Paul Mushak of the University of North Carolina in Chapel Hill, told a congressional subcommittee that although he mentioned only school water fountains in the report, the problem may be more widespread since most electric coolers contain lead plumbing.

The report is expected to boost congressional efforts to force the Environmental Protection Agency (EPA) to lower its drinking-water lead standard to 20 ppb from 50 ppb (SN: 10/24/87, p.269). Even at very low concentrations, lead damages the nervous system. Unfortunately, says Henry A. Waxman, the subcommittee chairman, "EPA's regulatory efforts to deal with the issue have moved at a snail's pace, if they've moved at all." — R. Weiss

New human retrovirus

Scientists have discovered another human retrovirus related to — but distinct from — those already associated with AIDS and certain cancers. Italian researchers at the University of Rome and the University of L'Aquila found the virus in seven patients with a relatively rare form of lymphoma cancer called mycosis fungoides, after first isolating it from a cell line derived from another mycosis fungoides patient. Tentatively called HTLV-V in their report in the Dec. 11 SCIENCE, the virus joins other members of the HTLV (human T-lymphotrophic viruses) retrovirus family, all identified since 1980. The previously described HTLV viruses include the AIDS virus (HIV-1), as well as HTLV-I and HTLV-II, which apparently can cause some leukemias and lymphomas. A fourth HTLV virus, now known as HIV-2, is thought by researchers to also cause AIDS or an AIDS-like syndrome.

The new virus differs from the other two "cancer" retroviruses in that the cancer cells from HTLV-V infected patients do not have two specific surface receptors found on cancer cells from patients infected with HTLV-I and -II, say the authors. They also report that the wife of one patient had antibodies against HTLV-V, suggesting possible sexual transmission of the virus. □

The age of Aquarius

The world's most advanced underwater habitat was christened "Aquarius" last week by the National Oceanic and Atmospheric Administration (NOAA). Situated in the Caribbean near St. Croix, the 43-foot-long, movable home-away-from-home will enable scientists to live and work on the ocean floor for indefinite periods. For the next two years, it will be at its present site on the Salt Water Canyon seafloor, 50 feet below sea level. There, researchers plan to study physical oceanography, marine engineering problems, the habits of local fish and the cause of coral bleaching in the Caribbean. Without the undersea habitat to return to each day, scuba divers working on such projects would be limited to seafloor visits lasting only 70 minutes, according to NOAA.



The \$5.5 million Aquarius replaces NOAA's smaller, less sophisticated Hydro-lab, which hosted nearly 200 missions before it was retired in 1985. Aquarius, which will get its power and air via an umbilical system connected to a surface support boat, has a sleeping area, showers, laboratory equipment and a galley.

Giving potential AIDS vaccines a 'boost'

To ensure adequate immunity against disease, vaccinations frequently are followed by booster shots to stimulate an individual's "immunologic memory." Two studies — one in the first humans known to be injected with an experimental AIDS vaccine, the other in chimpanzees — are suggesting that this so-called anamnestic response could be a viable part of AIDS vaccination.

In March, Daniel Zagury of the Pierre and Marie Curie Institute in Paris and his co-workers announced that they had injected a small group of volunteers in Zaire (including Zagury) with a potential AIDS vaccine (SN: 3/28/87, p.198). The new vaccine — made by inserting a gene for the AIDS virus (HIV) envelope into vaccinia virus used to make smallpox vaccine — caused antibody production and activated immune cells.

After the initial immunizations, 12 of the volunteers each received one of four possible "booster" preparations: the recombinant vaccinia vaccine itself, a portion of the HIV envelope segment used to make the vaccine, whole cells taken from an immunized subject and infected *in vitro* with the recombinant vaccinia before being injected back into the same person (autologous cells) or just the membranes from the vaccinia-infected autologous cells. The researchers had "fixed" whole cells with paraformaldehyde to maintain their surface structures, recognized by an immune system already primed by vaccination.

On Dec. 11, Zagury discussed the results at the Fourth International Symposium on Cancer Research, held at the National Institutes of Health in Bethesda, Md., and organized by the French Association for Cancer Research. Ten days after booster shots were given, the most

"marked responses" of both antibody production and cellular immunity were seen with blood samples from Zagury himself, who was the only one to receive the whole autologous cells. Subsequent tests showed that the boosting treatment caused no side effects, and Zagury concludes that this treatment should be considered a possible "prototype of candidate vaccines."

A National Cancer Institute study in chimpanzees could give the booster-shot issue added insight: Unlike the human volunteers, laboratory animals can be "challenged" with actual HIV infection. Peter J. Fischinger, now at Health and Human Services headquarters in Washington, D.C., said at the symposium that yet-unpublished data indicate that — after several boosting immunizations with the vaccine followed by challenges with HIV — chimps showed an immune response not only against the HIV strain used to make the vaccine, but also against additional strains. This is encouraging for scientists who worry that HIV's high rate of mutation would make it difficult for a single vaccine to protect against multiple strains.

Zagury's group plans to add substances called adjuvants to the vaccine to heighten immune responses, in order to "mimic" the boosting protocol in a way more practical for larger groups, says Zagury.

In another study looking for cell cultures that might produce monoclonal antibodies against HIV, the group has isolated 42 antibody-producing clones out of 400 tested thus far. They hope to use these genetically engineered antibodies to protect developing fetuses in pregnant, HIV-infected women in Africa, says Zagury. — D.D. Edwards