Physical Sciences

A ceramic that goes with the flow

The shattering experience of dropping a china dish is a helpful reminder that ceramics are brittle. On the other hand, they are hard and resistant to chemical attack, can survive high temperatures and have a low density — desirable properties that more malleable materials such as metals generally lack. The ideal answer would be to find a way to make ceramics more ductile at temperatures well below their melting points.

Now, a team of researchers from the University of Saarbrücken in West Germany reports the possibility of turning brittle, conventional ceramics into materials that can be deformed at low temperatures. They suggest in the Dec. 10 NATURE that the necessary ductility can be achieved by creating ceramics in which crystals are only a few nanometers in diameter. Such tiny crystals make possible the movement of atoms — acting like a lubricant — along the crystal interfaces when the material is deformed.

The researchers tested their idea by fabricating nanocrystalline specimens of calcium fluoride and titanium dioxide. They found that, as predicted, compressed specimens of these materials were more likely to deform than to crack.

A new family of stable quasicrystals

Under the right conditions, atoms in an aluminum-manganese alloy may line up into an arrangement that doesn't repeat itself at regular intervals yet appears to have the orderliness of a crystalline substance. Such a material, known as a quasiperiodic crystal, or quasicrystal, generally has an electron diffraction pattern that shows a fivefold symmetry. Ever since the discovery of the first quasicrystalline alloy, researchers have been looking for other materials with similar properties (SN: 3/7/87, p.152).

The latest addition to the quasicrystal family is an alloy made from gallium, magnesium and zinc. First prepared by Wataru Ohashi and Frans Spaepen of Harvard University, the samples are made up of icosahedral crystals as large as 100 microns across. Unlike all but one previously discovered quasicrystalline material, this alloy is stable. Heating doesn't transform it into a periodic crystal structure.

"This discovery of a second stable quasiperiodic crystal will be of interest for diffraction studies of the structure and defects of these phases," the researchers report in the Dec. 10 NATURE. "Their low melting temperatures and the chemical behavior of the alloys make the crystals quite easy to prepare."

Sun-powered, long-distance chemistry

Israeli researchers have successfully tested a device that converts solar energy into chemical energy, part of a proposed chemical system for transporting energy economically over long distances. Designed and built by the Sandia National Laboratories in Albuquerque, N.M., the device combines a solar collector with a chemical reactor.

The collector concentrates sunlight to vaporize sodium metal. The hot metal vapor is then conducted to the chemical reactor, where it condenses and releases heat to drive a chemical reaction between methane and carbon dioxide. The products are hydrogen and carbon monoxide, which can be transported as room-temperature gases. Piping these gases instead of a hot fluid reduces the possibility of significant heat losses and circumvents the need for heavy insulation. At their destination, the gases can be converted back into a hot fluid and used to heat buildings or generate electricity.

Last year, Sandia completed its initial laboratory tests on the concept, using electric heaters as sources of heat. The recent field tests, on a 10-times-larger scale and with concentrated sunlight, took place in a solar furnace at the Weizmann Institute of Science in Rehovot, Israel.

Science & Society

Offbeat learning methods off target

To help its recruits live up to the slogan "Be all that you can be," the Army has long hunted for methods of enhancing the performance of soldiers and technicians, who might have to operate complex machinery and work cohesively in groups under wartime conditions. The Army has looked into all kinds of methods, including many unconventional ones — such as meditation, biofeedback and split-brain learning — that grew out of the human potential movement of the 1960s.

To sort out the claims made about such techniques, the Army asked the National Research Council (NRC) in 1984 to assess the scientific validity of studies evaluating these methods. Last month, NRC released its report, "Enhancing Human Performance: Issues, Theories and Techniques." Says NRC committee chairman John Swets of Bolt Beranek and Newman, Inc., in Cambridge, Mass., "The underlying theme that emerges from our study is that there are probably no easy ways or quick fixes for helping people perform more effectively." Swets's committee could find little scientific support for parapsychology, neurolinguistic programming or methods that integrate activity from the left and right brain hemispheres. And while biofeedback can reduce muscle tension, says Swets, studies show it is not useful for reducing emotional or mental stress.

However, the committee did find that three techniques merit a closer look by the Army. It concluded that information first presented to subjects during the lighter stages of sleep appears to bolster their ability to learn the same material during waking hours (but the group could find no evidence that learning itself occurs during true sleep). And the committee writes that motor-skill learning may be enhanced by mental practice, such as envisioning the moves of an athlete as he or she performs. It also concluded that some accelerated learning programs — which may include relaxation exercises or special background music — may be beneficial, but it is hard to tell which parts of these programs are responsible for improved learning.

The Japanese do garbage better, too

Americans have found a lot to admire in Japan's ability to make products. But the United States also has much to learn about how Japan *disposes* of its used products and other solid wastes, according to a report by INFORM, a nonprofit research group in New York City. With its small land area, high population density and scarce resources, Japan long ago came to grips with waste disposal problems that the United States is just now facing, say study authors.

They found that while the Japanese put at most 20 percent of their unprocessed household wastes into landfills, Americans dump 90 percent of theirs. And unlike most U.S. dump sites, Japanese dumps use impermeable liners, leachate collectors and waste-water treatment to prevent pollutants from escaping into groundwater. Japan also greatly emphasizes recycling. For example, it recycles 50 percent of its paper, and 95 percent of its beer bottles are reused an average of 20 times. In contrast, 25 percent of U.S. paper and 7 percent of U.S. glass is recycled.

INFORM figures that after recycling, only half as much waste per person is generated in Japan as in the United States. And much of what is not recycled is incinerated in Japanese facilities that produce energy as a by-product. INFORM researchers found that the Japanese also take measures to ensure that the potentially toxic ash is insulated from groundwater, while in the United States, the Environmental Protection Agency does not regulate the disposal of incinerator ash because it has not decided how to test ash toxicity.

INFORM concludes that much of Japan's success is due to close coordination among national, regional and local governments in collecting disposal data and managing waste — a situation that does not exist in the United States.