Materials Science

A denser, more perfect diamond


GE Research and Development Center

Synthetic, 3-carat superdiamond.

Scientists have created a diamond that packs in more atoms per cubic centimeter than any other material known to exist at atmospheric pressure. Chemists from the General Electric Research and Development Center in Schenectady, N.Y., made the synthetic diamond using carbon atoms containing an extra neutron. Natural diamond usually contains no more than 1 percent of this carbon-13 isotope, but carbon-13 represents 99 percent of the new gem, says William F. Banholzer, a GE chemical engineer.

High-resolution X-ray diffraction measurements of one natural diamond and five of GE's synthetic stones show that the heavier carbon atoms crowd a little more closely together than do carbon-12 atoms, says Harry Holloway, who carried out the analysis with his colleagues at Ford Motor Co. in Dearborn, Mich. In the Oct. 1 PHYSICAL REVIEW B, the Ford and GE scientists also describe the superior crystal quality of these synthetic diamonds. The quality almost matches that of silicon semiconductors, which include some of the least-flawed crystals known, Banholzer says.

The GE researchers produce the gems by first making clusters of very tiny diamonds that contain the desired amount of the heavier carbon. To do this, they use a process called chemical vapor deposition and control the diamond's composition by varying the isotopic content of the methane gas used as the carbon source. Then the researchers apply very high pressure to dissolve and recrystallize a cluster into a single gem.

Previously, GE scientists had discovered that by lowering the carbon-13 content below that of natural diamonds, they could make synthetic diamond that conducts heat more efficiently and withstands more laser energy than the best natural diamonds (SN: 7/21/90, p.37). The researchers are now testing the properties of the carbon-13 diamonds, and they expect the new synthetics to surpass the hardness of natural diamonds.

New materials from sand plus antifreeze

So many plastics and other petroleum-based products pervade our civilization that one might think of this as the age of carbon. But if a Michigan materials scientist has his way, silicon may one day challenge carbon as a ubiquitous building block for new materials.

Richard M. Laine has developed a simple technique that uses sand to create a reactive form of silicon. When sand is heated with an alkaline substance and ethylene glycol — the main ingredient in antifreeze — it transforms into a reactive silicon with five chemical bonds, report Laine and his colleagues at the University of Michigan in Ann Arbor in the Oct. 17 NATURE.

The researchers have inserted ions into this silicon starting material to make a clear polymer film that can conduct electricity and may prove useful in batteries or self-defrosting windshields, Laine says. They have also made liquid-crystalline polymers, high-temperature silicon glasses and a silicon-based fire retardant.

"We can make compounds in pound quantities," Laine says. "I think this is a very simple way to make a lot of things."

Substances that take many steps to make when carbon serves as their starting material will be easier and perhaps cheaper to produce with this new silicon chemistry, he predicts. Because sand and its constituents represent up to one-quarter of the world's minerals, Laine suggests that less developed nations may be able to produce silicon compounds more readily than they can petroleum-based ones.

Space Science

Reflections on a sunnier past

Standard models of solar evolution assume that the sun shone 20 to 30 percent less brightly during its first billion years than now — a reduction big enough to chill Earth's surface and freeze water. That poses a paradox, however, because fossils and other evidence indicate that water remained liquid throughout nearly the entire history of our planet. In the past, researchers have attempted to circumvent the mismatch between a dimmer sun and the warmth of our planet's surface by suggesting that Earth's atmosphere once contained a much higher concentration of carbon dioxide. This greenhouse gas exerts a warming effect by trapping the sun's infrared rays within the atmosphere.

But the high carbon dioxide levels assumed in this theory do not fit with accepted climate models for Earth's atmosphere and its oceans. Moreover, the standard "weak-sun" model calls for far more lithium than observed in the solar spectra.

Astrophysicist I.-Juliana Sackmann of the California Institute of Technology in Pasadena and her colleagues now suggest an alternative theory to explain the sun's lithium depletion and temperatures warm enough for liquid water to exist in Earth's past. In the October GEOPHYSICAL RESEARCH LETTERS, they propose that the sun may once have had as much as 10 percent more mass — a feature that would make it *more* luminous during its early history than today.

The new model suggests that the sun shed its extra mass during the last few billion years — a notion that can readily account for the lower lithium abundance, Sackmann notes.

Observations of Milky Way stars younger than the sun but which have a similar mass, she says, hint that they have shed some of their material. If further observations confirm mass loss in such stars, this might lend more credence to the idea that the sun lost a significant amount of mass during its youth, Sackmann says. She notes, however, that a modification of the standard weak-sun model could also account for lithium depletion. In the modified scenario, lithium sinks from the sun's outer layer into the hot interior, where it burns.

To help decide between the theories, researchers should monitor young, sun-like stars more closely and theorists should calculate the effects of solar brightening and mass loss on Earth and the other planets, Sackmann says.

It's a gas! Images from thin air

Carefully designed variations in the thickness of a piece of glass can act as a lens, focusing a light beam onto a small area. Likewise, changes in the density of a gas layer placed across an aperture can also focus light.

Scientists at the University of Natal in Durban, South Africa, have now used this principle to build a gas-lens telescope. (The device was proposed some 30 years ago as a way to concentrate laser beams without destroying glass lenses.) In their setup, room-temperature air passes through the center of a heated, spinning tube. This forces the gas molecules to rearrange so that cooler (denser) gas lies at the tube's center and hotter (thinner) gas lies at the edges. The resulting density pattern focuses an incoming light beam onto a lensless camera — much as the air above a hot road bends light to form a wavy mirage.

The researchers, led by M.M. Michaelis, have used their novel telescope to image craters on the moon and sunspots during maximum solar activity. Though the current version of the instrument has limitations, including a small field of view, it offers several advantages over glass, they say: The ultralight lens can function well in the near-zero gravity of space, and it focuses wavelengths ranging from ultraviolet to infrared.

"It has been suggested that 'gas telescopy' will never make its mark in astronomy, but we contend that gas lenses are in their infancy," the team writes in the Oct. 10 NATURE.