MATERIALS SCIENCE

Another Step Toward a Diamond-Beater

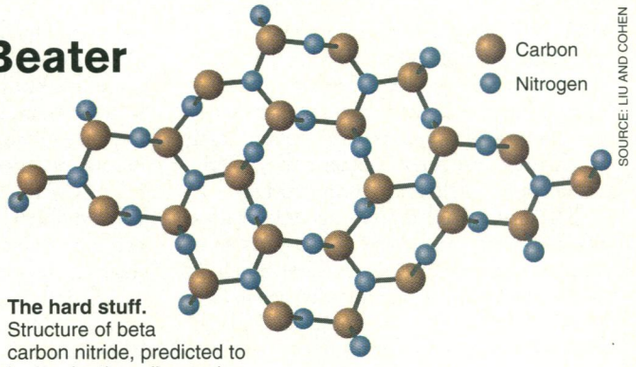
Five years ago, two researchers used a supercomputer to conjure up a crystalline material that could be harder than diamond—if it ever gets made. Since then, materials scientists have struggled without success to take that theoretical material—a form of carbon nitride—out of the computer and into the real world. But last week, at the annual meeting of the Minerals, Metals, and Materials Society in Las Vegas, Yip-Wah Chung reported that he and his colleagues at Northwestern University had created a new composite material that may include the predicted diamond-beater.

The composite, made up of atoms-thick layers of titanium nitride and carbon nitride, is already about as hard as diamond's nearest rival, cubic boron nitride. And it should be far easier than either diamond or boron nitride to apply as a wear-resistant coating to mechanical components such as computer disk drives and jet engines. But aside from any practical value, the composite demonstrates a strategy that could be the key to creating pure carbon nitride with the superhard crystal structure that was first predicted at the University of California, Berkeley, by physicist Marvin Cohen and materials scientist Amy Liu (*Science*, 25 August 1989, p. 841). "It's an exciting result," says Harvard University chemist Charles Lieber, although to really evaluate it, he says, "I'd like to see some data, or a manuscript."

Cohen and Liu had calculated that the short, strong covalent bonds of a hypothetical crystal form of carbon nitride could make it harder than diamond. Their computer model also predicted that this "beta" phase should be relatively stable. But researchers who have tried to create films of carbon nitride with the predicted structure have generally ended up with an amorphous form of the compound—one that has no predictable structure at all.

In fact, the only actual sightings of the desired structure, outside of the computer, have been contested reports from Lieber (*Science*, 16 July 1993, p. 334) and others of finding tiny areas of the beta phase in amorphous carbon nitride films. Lately, Lieber says, he has made progress toward creating films with a crystalline structure—albeit a different one from the structure predicted by Cohen and Liu.

The problem, Chung says, is that carbon and nitrogen atoms don't readily array themselves in the beta structure: "If you leave it to Mother Nature it just won't form." So 2 years ago, he and Northwestern materials scientists Ming-Show Wong and William Sproul decided to give beta carbon nitride "some incentive" to form by providing a template—titanium nitride—whose lattice nicely matched the predicted structure. The titanium nitride, they hoped, would coax the carbon nitride to adopt the sought-after crystal form. Using a deposition process called magnetron sputtering, they coated steel with alternating layers of the two materials.



SOURCE: LIU AND COHEN

The hard stuff. Structure of beta carbon nitride, predicted to be harder than diamond.

The resulting composite is remarkably hard. At 45 to 55 gigapascals (a measure of the pressure needed to dent the material), it's nearly twice as hard as amorphous carbon nitride and approaches the hardness of diamond, which ranges from 60 to 100 gigapascals. What's more—"and this is the exciting part," says Sproul—electron micrographs suggest the carbon nitride layers are nearly 100% crystalline. Because the layers are so thin, measuring just 4 or 5 nanometers, their crystal structure is very hard to discern, says Chung, so he and his colleagues don't know yet whether they really have created the predicted beta phase. They are now at work on electron diffraction studies that may yield a verdict.

Even if the diamond-beater has eluded them, they believe they have created an industrially valuable coating. Because the sputtering technique is widely used in industry, scaling up the process should be easy, and expressions of interest have already come in from the Air Force and several of the commercial partners of Northwestern's Basic Industry Research Lab, where much of the work was done. "To see something that is widely used, that would make me happy," says Chung.

But he and his colleagues haven't forgotten their original quest. They plan to vary the recipe for the nanocomposite by using different template materials, such as zirconium nitride, that might yield a thicker layer of carbon nitride. In the end, they hope not only to make the superhard beta phase—but to produce enough of it to be sure.

–Antonio Regalado

RISK ASSESSMENT

Agencies Decry Fuzzy Science in Bill

EPA has fought a 20-year war against lead by setting regulations aimed at reducing exposures among those most at risk from its toxic effects—children and, more recently, low-income African Americans. But some scientists fear that pending legislation, part of the House Republicans' Contract with America, could force agencies to base regulations on average risks to the entire exposed population rather than vulnerable subgroups.

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>
> **—Adam Finkel**

"Right now, agencies have had the latitude to focus on whatever part of the population they want to," says Adam Finkel, a senior fellow at the Cecil and Ida Green Center for the Study of Science and Society at the University of Texas, Dallas. "But from the tone of the bill, it's clear the authors think the estimates we're getting are not the best ones," he says.

The changes are part of a broad bill, H.R. 9, called the "Job Creation and Wage Enhancement Act of 1995" that is expected to be approved this week by the House of Representatives. The bill's supporters argue that it would remove what they see as unnecessary regulations that hamper industry. But the Clinton Administration contends it would raise the cost and delay the issuance of regulations. For their part, scientists worry that the bill would sanction environmental policies based on fuzzy scientific concepts. "I feel like a chemist waking up one morning to find an alchemy bill going through the House," says Finkel.

At first glance, the bill's tenets are hard to disagree with: "Too often," it says, "regulatory priorities have not been based upon a realistic consideration of risk. ... Resources need to be allocated to address the greatest needs in the most cost-effective manner."