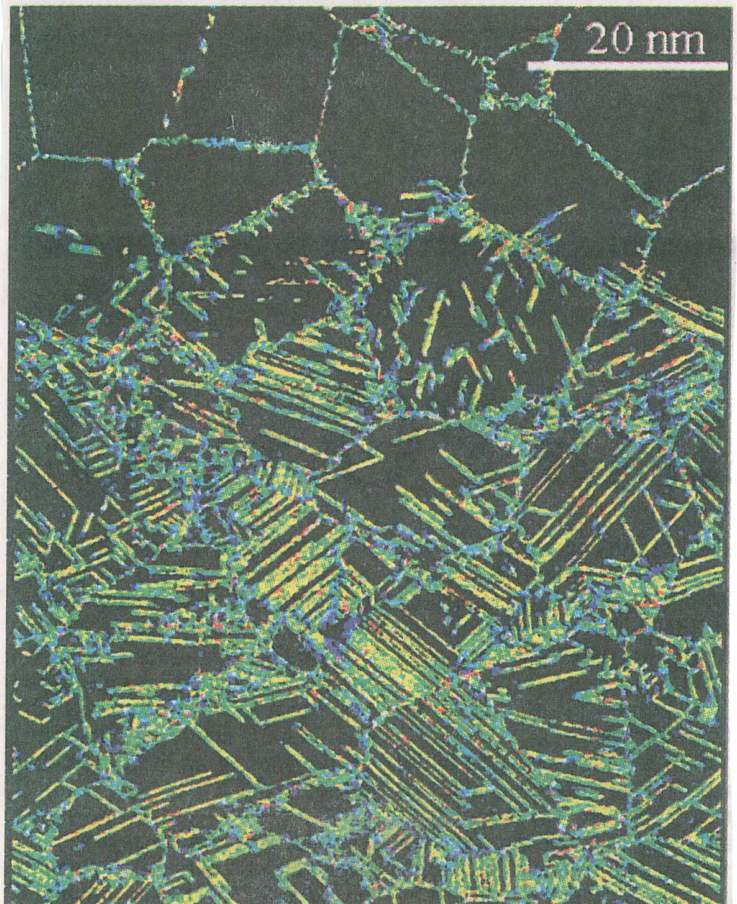

SCIENCE MAGAZINE

A COMPUTER simulation helped scientists at Lawrence Livermore Laboratory understand what effects a laser-induced shock wave traveling through nanocrystalline copper can have on hard metal.

Livermore lab scientists strengthen hardest metal

■ Breakthrough could be used on armored vehicles and shields for spacecraft

By Betsy Mason
TIMES STAFF WRITER

Harder is better, at least when it comes to metals, and Lawrence Livermore Laboratory scientists have discovered a way to make the hardest metals even harder.

The breakthrough could have applications for everything from armored vehicles to shielding for spacecraft and nuclear fusion experiments at the lab's National Ignition Facility.

"We've only just scratched the surface of how hard a material you can create," said Livermore laser physicist Bruce Remington.

Metals are made up of tiny "grains" that fit together like a geometric puzzle. Until recently, the pursuit of harder metals involved making those grains smaller and smaller. The strongest metals are nanocrystalline, which means their grains are smaller than a tenth of the thickness of a human hair.

At a certain point, however, smaller grains stop yielding stronger metals. Computer simulations suggest this is because extremely small grains can slide past each other as the metal is deformed, making it softer.

"It's like sand," Remington said. "When you step on sand, even though sand is solid, your feet penetrate and sink down through."

When metals with larger grains are deformed, defects are created within the grains that make the metal stronger. But for metals with exceedingly small grains, it becomes easier to deform by sliding grains past each other.

"To see even stronger materials, we have to somehow suppress this sliding mechanism," said Livermore materials scientist Yinmin Wang.

Using computer simulations, Lawrence Livermore team members, led by materials scientist Eduardo Bringa, found that by sending a high-pressure shock wave though nanocrystalline copper, they could stop the tiny grains from sliding and create the strengthening defects within the grains instead.

"It's a rather neat finding," Remington said. "We didn't expect to see that."

To test the simulations, Bringa's team took advantage of Livermore's world-class stable of powerful lasers. Using the lab's Janus laser, the team hit nanocrystalline nickel with a laser beam strong enough to vaporize the surface of the metal. As the surface heats up, expands and boils off in an instant, it creates a blast similar to rocket exhaust that sends a high-pressure shock wave through the metal.

The pressure from the shock wave kept the grains from sliding and defects formed instead, making the metal extremely hard.

The team is the first to do this kind of shock wave experiment in the real world instead of in a computer simulation. The study appears today in the journal Science.

"We are always looking for harder materials," said UC San Diego materials scientist Mark Meyers. "Their work is state of the art."

It is difficult to predict what these super hard metals will be used for, but Remington envisions shields for spacecraft that will withstand space debris impacts, armor for military vehicles that is even harder to penetrate and stronger frames for automobiles.

The super strong metals could also be used to make targets for the lab's National Ignition Facility that would need to contain a nuclear fusion reaction.

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