BIG INNOVATION

TINY PACKAGES

A new platform measures, tests, manipulates, and images nanomaterials

There can be huge potential in tiny objects. Consider how much more memory today's computers can hold than those of just a few years ago. Much of this added power comes from the emerging field of nanotechnology: the science of creating and manipulating materials so small they cannot be observed with normal microscopes. Such materials include the ultra-thin, diamond-like coatings used for compact disc drives and the similarly thin coatings used on razor blades.

Photos courtesy Hysitron

Nanomaterials, however, are challenging to develop and difficult to test for reliability. Electron microscopes allow users to see the materials but can't measure how hard or durable they are. And standard instruments used for stress and hardness testing can't give accurate results at such a small scale.

This was the challenge put to a Minnesota-based company, Hysitron, by the U.S. Army. With support from the Army's Small Business Innovation Research (SBIR) program, Hysitron was able to leverage its existing technology—specifically, an instrument used to measure and test nanomaterials—into a platform that allows users to not only measure but actively manipulate nanomaterials even while watching and capturing images of their reactions in real time. This technology allows both military and civilian manufacturers to test the durability of nanomaterials and better understand how they react under stress.

According to Hysitron CEO Thomas Wyrobek, the Army had noticed one of the company's early products, a sensor that allowed accurate, replicable measurement of the force and displacement needed to penetrate ultra-thin materials.

"The Army came along and said, 'Can you make a nanoindenter out of this?'" Wyrobek recalls. A nanoindenter is an instrument that measures the mechanical properties of nanomaterials, such as hardness and elasticity. "To this day, we don't know how they found us."

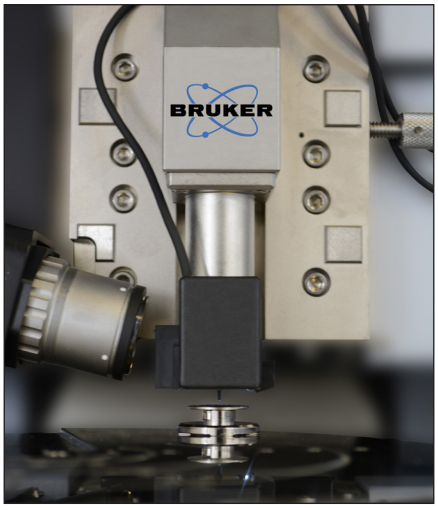
The Army's request, which led to Hysitron's first SBIR contract, was driven by the Army's need to test the durability and behavior of the extremely thin, laser-refractive coatings on the canopies of face shields worn by warfighters vulnerable to laser exposure. Existing technologies at the time were incapable of working at such small scales.

"These light carbon films are just a couple nanometers thick, or two billionths of a meter. There are 1,000 nanometers in a micron and 80 microns in the diameter of your hair. So that's how small it all is," Wyrobek said. "The films were so thin they couldn't measure how well it stuck on the face shields. One of the idiosyncrasies of nanoscale is that it's below the wavelength of light, so you can't see it with conventional equipment."

As the popularity and accessibility of nanomaterials grew, so did the demand for instruments that allowed for even more complex manipulation of these materials.

By coupling their sensor with an electron microscope, Hysitron was able to create a platform that allows users to watch the behavior of nanomaterials in real time. As the popularity and accessibility of nanomaterials grew, so did the demand for instruments that allowed for even more complex manipulation of these materials.

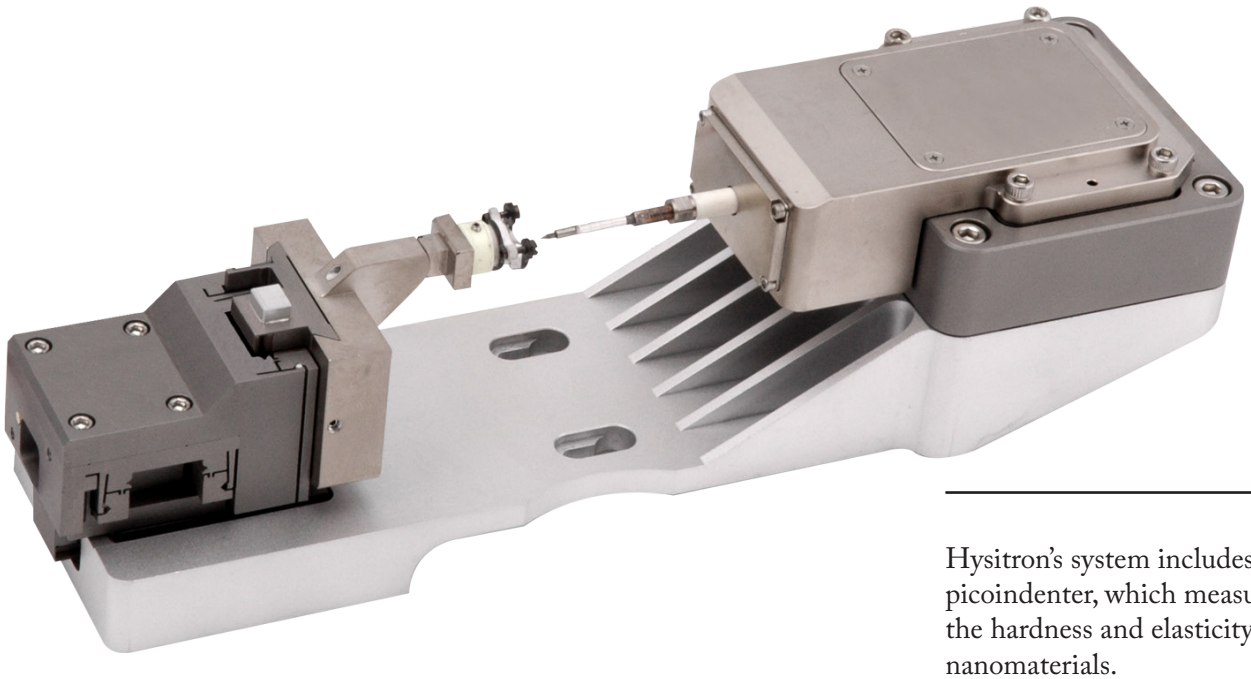
"They started to want to manipulate these atoms—we used to joke they wanted to play soccer with them," Wyrobek said. "These materials had gotten so thin by then, there was really no way to quantitatively test them. So we were able to interface to that microscope and they were able to get the imaging on the same instrument, then do the quantitative nanomechanical tests that they needed."



In 2017, Hysitron was acquired by the electron-microscope manufacturer, Bruker.

The technology has uses well beyond military applications.

"We succeeded in supplying an instrument to the Army, and at the same time, the disc drive community and the razor blade community came to us and said they were also working with thin films," Wyrobek said. "They're using diamond carbon films for the disc drives, and on razor blades, I believe it's Teflon; they're less than 10 nanometers thick. At that time in the disc-drive world,



Hysitron's system includes a picoindenter, which measures the hardness and elasticity of nanomaterials.

they were trying to get the films thinner so they could increase the recording density."

For both military and commercial users, another crucial benefit of Hysitron's technology is that it allows reliable reproduction of sensitive nanomaterials.

"The professor who makes three drops of something absolutely fantastic has to be able to measure what he has done and replicate its fundamental mechanical properties—how hard it is, how soft it is. It can't just look like what you made before," Wyrobek said. He cited the soft gels used to make contact lenses as an example.

Pure R&D can be cost-prohibitive for small businesses. Developing and refining such complex technology would not have been possible without SBIR support, Wyrobek said. "The SBIR actually gave us the vehicle to advance this project. Everybody thinks they have a better mousetrap, but they find out in the commercialization process that they missed the mark. And it happens—these companies get venture capital in there and they blow through a huge amount of money to find out their approach is wrong or is obsolete. Our commercialization record is good because the products that the SBIR program wanted were important."

This support has allowed Hysitron to grow from a three-person team at its founding in 1992 to a vibrant company of 111. Hysitron was acquired by the electron microscope manufacturer Bruker in January 2017, offering further opportunities for growth. More importantly, according to Wyrobek, it has freed the company to take the chances needed to push past existing technological barriers.

"The SBIR support allowed us to attract a very talented, very intelligent kind of employee. Some of them were not trained in nano, but they had an aptitude to be curious and to want to try. That kind of mentality is vital to taking on the kinds of challenges where you're not sure you're going to succeed," Wyrobek said. "The best fruit is sometimes hanging higher up."

Hysitron, Inc.
Modernization Priority: General Warfighting Requirements (GWR)
Minneapolis, MN • SBIR contract: DAAL01-95-C-0067 • Agency: Army • Topic: A93-115, Portable Micromechanical Measurement System with In Situ AFM Imaging