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Nano Burst: N.M. Labs are Contributing to the Nanotechnology Explosion

By John Fleck

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While it may not have the cache of a spaceport or the limelight of the film industry, nanotechnology has some muscle behind it in New Mexico, as the state's researchers latch onto what many believe may be technology's Next Big Thing. Journal science writer John Fleck visited with some of the state's nanotech pioneers.

LOS ALAMOS— What is remarkable about the little chip covered with black fuzz in Lianxi Zheng's lab is not how tiny it looks. It's that it can be seen at all. And what Zheng and his colleagues seem to be on the brink of being able to do with it.

Nanotechnology, by definition, involves things too small to see— the truly tiny realm where individual atoms matter.

Scientists have long known that remarkable and potentially useful things happen down there. But until the last few decades, it was all but impossible to work at such tiny scales. That is changing, and

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the field now called "nanotechnology" is exploding with potential applications that range from superstrong, ultralight aircraft to remarkable medical cures to stain-free pants.

But to get this hot and sometimes overhyped technology out of the lab so that it can change the world, you've got to take the tiny things and make something big and useful out of them.

You would be hard-pressed to find a state that does not aspire to be a growing center of nanotechnology research. New Mexico is no exception.

It is home to two of the nation's 73 federally funded nanotechnology research centers. Among the state's nanotech stars are the carbon nanotube team from Los Alamos.

The scientists have already created the world's longest nanotubes. Now they have turned their attention to the practical challenge: how to use such technology to create a superstrength material that could have nearly unlimited uses.

In a high-tech oven as big as an oversized microwave, Zheng and his colleagues grow what amounts to a tiny shag carpet of carbon nanotubes, each about 7.5 nanometers in diameter. That's two-billionth of a meter. A human hair is 10,000 times thicker than Zheng's nanotube.

Their goal, like the miller's daughter in "Rumpelstiltskin," is to spin the fibers into something precious.

In "Rumpelstiltskin," the miller's daughter failed to spin her straw into gold. But Zheng and his colleagues seem to be succeeding in creating something that may, in the long run, be even more precious and useful.

Zheng's little black fuzzy carpet is made of strands of impossibly thin carbon nanofiber— arguably the strongest material ever made.

Spin a bunch of the tiny fibers together— as a weaver spins long, strong wool yarn from short pieces of a sheep's hair, and you'll end up, in theory, with one of the strongest and therefore most useful materials ever made.

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More North

Nature's nano

What we today call "nanotechnology" has actually been around for a very long time.

If you're willing to stretch the definition a bit, you could even argue that nanotechnology goes back 500 million years, when sea creatures began surrounding their soft bodies with hard shells.

The shells are a remarkable creation— alternating nanoscale layers of calcium carbonate and nanoscale thin protein. They are amazingly strong.

The structure gives the shell unique strength that human materials scientists— call them "nanotechnologists"— have only recently been able to duplicate.

Nature, local nanotech wizard Jeff Brinker from the University of New Mexico and Sandia National Laboratories likes to point out, has been doing nanotechnology for a very long time.

Science and engineering have also been doing nano for a very long time. They just didn't call it "nano," and the techniques were, by today's nanotechnology standards, pretty crude.

The catalytic converters that clean pollutants out of your car's exhaust, for example, have used nanoparticles for decades, noted UNM's Abhaya Datye.

"Catalysis"— nanoparticles to speed up chemical reactions in your car's exhaust system or a giant oil refinery— has been called "the accidental nanotechnology." People developed it through trial and error, and used it because it worked.

Today, with new technology like electron microscopes at their disposal, scientists like Datye can actually see what they are doing. Nanotechnology can be engineered and controlled, and the results can be monitored, rather than depending on serendipity.

In a basement lab at UNM's Farris Engineering Center, graduate student Andrew DeLaRiva uses an electron microscope to painstakingly measure the size of particles in a mock auto exhaust pollution control system.

Nanoscale is essential here, because the tinier you make the particles, the greater the amount of exposed surface area to do the work, grabbing the pollutants as the exhaust flows past.

The problem is that, over time, the natural process gums up the works, as the tiny particles begin clumping together into larger and less useful ones, eventually dooming the catalytic converter.

With the nanotech tool kit, DeLaRiva and the other members of Datye's team finally have a way to try to fix the problem— measuring the changing size of the particles and fabricating new ones less prone to the fatal clumping.

"Our ability to control those things has improved," Datye said.

Slow development

The legendary physicist Richard Feynman laid out what many consider the foundations of what we today call "nanotechnology" in a farsighted address delivered at the California Institute of Technology on Dec. 29, 1959.

"When we get to the very, very small world— say circuits of seven atoms— we have a lot of new things that would happen that represent completely new opportunities for design," Feynman said.

"Atoms on a small scale behave like nothing on a large scale, for they satisfy the laws of quantum mechanics. So, as we go down and fiddle around with the atoms down there, we are working with different laws, and we can expect to do different things."

It took longer than Feynman expected for scientists to reach the point where they could, in his words, "go down and fiddle around with the atoms down there."

But "fiddling" is a good word to describe what Brian Swartzentruber is doing.

Or maybe "playing video games." That really is an off-the-shelf video game controller in his hands. ("I got it at Best Buy," Swartzentruber said.) But this is the heart of nanotechnology, circa 2006.

In labs around the world, scientists are using increasingly clever techniques to make a host of fascinating new nanomaterials. But once they've made some, how do they figure out what they've got? Remember, this stuff is very small, which makes it very hard to work with and to measure.

In the macroscopic world, you could just plug your new wire into a circuit tester. But you can't do that with a nanowire. It's far too small. You can't even see it, let alone pick it up and do something with it.

So Swartzentruber pokes at a sample of tungsten oxide nanowires with a nanoscale probe. On the computer monitor in front of him, the image of the probe looks like the tip of a fat ice pick creeping up toward the tangled nest of nanowires, each far less than a thousandth of the width of a human hair.

The tip of the ice pick probe is similarly small. The fact that you can see it on his computer screen is the result of a stream of electrons bathing the sample in an electron microscope on the desk next to him. It's one of the technologies that is enabling the nanotechnology revolution, giving scientists better and better tools to see what they're doing.

When the probe touches, the skittering green line on an oscilloscope to his left starts bouncing, a sign he's made contact and can begin measuring the nanowire's electrical properties.

It's a fussy business. "This is kind of a patience-limited operation," Swartzentruber said as he slowly moved the probe toward its target. "It takes practice, definitely."

All the buzz

The list of places the nano toolkit is being applied is growing rapidly. Speaking to a recent gathering of nanotech specialists in Albuquerque, Neal Shinn of Sandia National Laboratories ticked off a growing list of nano buzzwords:

- nanoelectronics
- nanophotonics
- nanomaterials
- nano-bio-micro
- nanomechanics

Nanotechnology enthusiasts love to cite a classic exchange from the 1967 film "The Graduate."

Mr. McGuire, an older businessman, is trying to explain the future to a young Benjamin Braddock. "I want to say one word to you. Just one word," McGuire says. "Plastics."

McGuire turned out to be right. Plastics are now ubiquitous. Nanotechnology enthusiasts think their vision— of disruptive, world-changing technologies made possible by manipulating matter at the tiniest of scales— will be much the same.

But the joke's subtext also applies. "Plastics" was a

1960s buzzword, a bandwagon everyone wanted to jump on. Make "nano" your one word and you get the idea.

The U.S. government jumped on the wagon in a big way, establishing the National Nanotechnology Initiative in 2000, and now funneling about $1 billion per year into the work.

With another $3 billion per year being funneled into the field worldwide beyond the U.S. government investment, the editors of Nature Nanotechnology coined a new word to describe the funding picture: "nanolargesse."

The hype almost kept Paul Arendt out of the field. He's a Los Alamos scientist who is one of the leaders of the team making the superstrong carbon nanofiber yarn out of black fuzz.

"For a long time, I thought that nanotechnology was overhyped," Arendt said. "It's like all great science. Initially, everybody gets real excited but the hard engineering work takes a long time to grind through."

But like many, Arendt has been won over by the possibilities. Once he began to dig into the subject, "I felt like Dorothy in the tornado. I just got sucked up."

Imagine a plane's airframe or a bicycle frame, for example, that has the same strength but only a fraction of the weight of the best current aluminum or carbon composite structures. That's what could be built once Arendt's Los Alamos group, or one of the many others around the world working on the problem, finally figure out how to spin their tiny carbon nanotubes into a fiber, then build a composite material out of them.

"I think we're only starting to imagine the applications for this," Arendt said.

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