How can a big state like Texas become a leader in development of small products?

Introduction

Small is becoming big business. The worldwide market is growing for commercial products that are about 80,000 times smaller in size than the width of a human hair. In response to an increased demand measured in trillions of dollars, industry observers say the field of nanotechnology is poised for growth, especially in Texas. However, despite the tremendous projections, the nanotechnology industry is a select field that currently employs only a few hundred workers in Texas — most of whom have graduate degrees.

Capitalizing on this demand within the next five years, though, is the challenge. “Molecular technology and nanotechnology are young, immature and misunderstood as an industry,” said Zvi Yaniv, chief executive officer (CEO) of Applied Nanotech Holdings, Inc. in Austin. “The investors who have been attracted to this industry are not sophisticated and have lost a lot of money. But, over the next five years, states that do not have an established nanotechnology base will miss the train.”

That train is expected to be big and to have lots of highly paid proverbial passengers. Nearly all manufactured products can be improved — lighter, stronger, smoother — by having their atoms modified by nanotech methods and nanomaterials.

Nanomaterials are groups of atoms that are smaller than a red blood cell and only slightly larger than a strand of DNA. Nanomaterials gain value when scientists arrange them to perform tasks such as conduct electricity or chemically react to detect germs. Manipulating nanomaterials becomes even more valuable when it makes existing products smaller yet more powerful, such as liquid crystal display (LCD) televisions.

The potential market size of nanotechnology is catching the eye of investors, economic developers and public officials. In 2007, the total value of goods sold that featured nanotechnology improvements was $146 billion, according to Lux Research in New York City. Lux and other industry analysts project that by 2015 the market size will grow to $3 trillion.
What’s Happening

Scientists have reached a point at which they can not only see atoms but also begin to manipulate the atoms’ arrangement. This manipulation has the potential to alter thousands of products, creating smoother ball bearings, lighter sheet metal and germ-resistant medical instruments, to name just a few.

In the past 10 years, nanotechnology has created fibers in clothing that conduct heat away from a body or increase a fabric’s insulation ability. Cosmetics companies have begun using nanotechnology to enhance the colors and durability of makeup. Aerospace companies use nanotechnology to strengthen military jets. As more industries incorporate the rearrangement of atoms into their manufacturing processes, nanotechnology will revolutionize the world, said Kelly Kordzik, an Austin patent attorney who is also president of the Texas Nanotechnology Initiative trade group.

Most Texas nanotechnology companies fall into three types: those making products, those selling ideas and those developing research.

NovaCentrix in Austin, which has 30 employees, is an example of a company making products. NovaCentrix has developed metal powders at the tiny nano level and sells those powders to industrial companies for use in jets, television, medical products, photocells and radical, new circuit boards.

NovaCentrix started by making ultratiny, highly combustible aluminum powders for the U.S. Department of Defense to use in jets and munitions. The company then developed silver powders with antimicrobial properties, which were placed on medical products, particularly for wound care. NovaCentrix also created ink to “print” electronic circuit boards. The company then took the next step and developed “oven” products that fuse and burn the nano circuits onto a paper surface to make the process more efficient. “We’re not the only company doing this,” said Stan Farnsworth, vice president of NovaCentrix. “There’s a whole new industry springing up in printed electronics. And we’re trying to capture the market here in Texas.”

NovaCentrix: Growing an Ultratiny Company

Nanotechnology is so new that its entire supply chain has not been completely formed. Like other nanotech firms, NovaCentrix has to create products that show its customers what is possible for those customers to mass produce.

NovaCentrix has raised $25 million in the past nine years from angel investors, venture capital firms in Texas and customers in Texas and California. Thanks to private investment funding, NovaCentrix is developing products that are about to show up in solar cells, radio frequency identification tags, televisions and other future commercial and consumer products.

“We think our customers will be creating new jobs because of our technology,” said Stan Farnsworth, vice president. “But we realize that our customers will really be using our products to come out with new products in order to sustain the jobs they already have.”

Most of the employees at NovaCentrix have a Doctoral degree in physics or a Master’s degree in engineering and work in management and research and development. The six “technicians” at the production level have Associate’s degrees in lasers, semiconductors or biotechnology fields. Occupational specialties range from materials engineers to medical physicians to chemists.

“We could look a lot like Applied Materials in a few years, with hundreds of workers,” said Farnsworth. “There are certainly opportunities for small companies like us. This is new, upon new, upon new technology.”
Applied Nanotech Holdings, Inc. is an example of a company that is selling ideas. Applied Nanotech employees listen to manufacturing companies describe their new product development problems. Then the Applied Nanotech team gives those companies ideas on how to solve those problems and collects royalties. Almost all of Applied Nanotech’s 40 employees have Doctoral degrees. Zvi Yaniv, CEO, admits his company’s business model will probably lead to adding only a few more highly educated employees, but the firm should bring new wealth to Texas.

Zyvex Labs in Richardson conducts nanotechnology research. With five employees with advanced degrees, Zyvex makes tools to measure and count atoms, with the goal of making complex molecular parts. CEO James Von Ehr said that once the company has mastered that process, it can transfer that understanding to manufacturing as a whole. He foresees manufacturing moving from the old Henry Ford assembly line model to a semiconductor production model where a smaller number of workers maintain complex machines that mass produce ultratiny components and then assemble those components into the final products used by consumers and companies.

“We want to be the machine shop of the future,” said Von Ehr. Zyvex Labs could then become a multibillion-dollar company with tens of thousands of employees. Still, Van Ehr notes that growth may take up to 20 years.

The National Science Foundation (NSF) estimates that two million workers will be needed to support nanotechnology companies worldwide within 15 years. Yet nanotechnology is not classified as a separate industry in the North American Industry Classification System (NAICS). Also, even companies in this field don’t agree on how tiny a product has to be to qualify for the “nano” label. Companies creating products, 10,000 of which can all fit on the head of a pin, are calling themselves nanotechnology firms, as are companies that make one product also the size of a pinhead.

“Nanotechnology is still in an early stage,” said Jennifer Lyon, assistant director of the University of Texas at Austin Center for Nano and Molecular Science and Technology. “Unfortunately nanotechnology was unveiled for the public with the idea that it could do anything. There’s a lot of confusion. Nanotechnology means a lot of different things to different people.”

Altogether, Texas has about 40 companies making ultratiny products. Located primarily in the Houston, Dallas and Austin areas, these companies employ from 2 to 30 people. Still, if companies incorporating nanotechnology into their own products — such as Bell Helicopter, Texas Instruments and Exxon Mobil — are counted, then the tally of nanotech firms in Texas exceeds 700.

Nanotechnology has evolved. Japanese scientists in the 1950s theorized about components, and even machines, the size of atoms, which could help society. Thirty years later, Japanese scientists discovered nanomaterials.

The big scientific leap came in Houston in 1985. Rice University chemistry professor Richard Smalley and several colleagues accidently discovered “buckyballs.” A buckyball is an arrangement of 60 carbon atoms that form a round, hollow sphere that looks like a soccer ball — except it is 7,000 times smaller than a red blood cell. When stretched out, the buckyball forms a carbon tube that is both strong and can conduct electricity.

In 1996, Smalley shared the Nobel Prize in Chemistry with fellow Rice chemist Robert Curl Jr. and British chemist Sir Harold Kroto for their 1985 discovery of buckminsterfullerene (“buckyball”), a new form of carbon. Buckyballs can be manipulated to form tiny carbon tubes that can conduct electricity, heat or other atoms. And this finding forms the basis of nanotechnology, the huge industry of tiny products.
During the past decade, federal funding of nanotechnology research more than tripled from about $464 million a year to almost $1.5 billion a year. In late 2005, $11 million in federal funding helped launch the Strategic Partnership for Research in Nanotechnology (SPRING) through a consortium of researchers at UT-Arlington, UT-Austin, UT-Brownsville, UT-Dallas, UT-Pan American, the University of Houston and Rice University.

Funding has also been flowing at the state level. As of late 2008, the Texas Emerging Technology Fund awarded $43.3 million for nanotechnology-related projects. Research on the behavior and development of nano particles taking place at Texas universities is this state’s key competitive advantage, said Ray Baughman, director of the MacDiarmid NanoTech Institute at the University of Texas at Dallas. Texas A&M University in College Station, Texas State University in San Marcos and Texas Tech in Lubbock also have each created nanotechnology research institutes. And many nanotech firms in Texas have spun out of these institutes.

“Nanotechnology is more of an enabling technology than it is an industry.”
— James Von Ehr, Zyvex Labs

“Nanotechnology is more of an enabling technology than it is an industry,” said Von Ehr at Zyvex Labs. To highlight what nanotechnology is, Von Ehr uses photos showing dozens of his company’s products sitting atop a single penny.

Nanotech’s small size isn’t its only impressive quality. The potential economic impact of nanotechnology is staggering. Incorporating nanotechnology into the building process of almost all products is starting to revolutionize manufacturing fields. This increased demand should drive up demand for products from small nanotech firms — which in turn should increase demand for workers with graduate degrees in sciences.

The $3 trillion of market potential is a huge carrot luring regions to invest in nanotechnology infrastructure at their universities. The United States and Japan dominate the world’s nanotechnology industry in research and product development. While California, Massachusetts, Illinois and New York tout more established nanotechnology companies and researchers, Texas is poised to become a major player in the industry thanks to a foundation of established nanotechnology companies and a network of research universities offering programs in the field.

The Texas nanotechnology infrastructure started in the science departments of its universities. Federal and state grants for nanotechnology research have been spread out among more than 10 Texas universities. As a result, small nanotechnology companies tend to be located near Rice University, UT-Austin, UT-Arlington and UT-Dallas. Proximity allows businesspeople access to the ultraexpensive nanotechnology microscopes and other equipment on these campuses.

In this young industry, companies are not tied to any region. But the vast majority of nanotechnology employees need graduate degrees, so companies choose their location based on where they can find highly educated workers, established infrastructure and deep-pocketed investors intrigued by this growing field. “The truth is that I can do what I do anywhere in the world,” said Yaniv. “I am in Texas because my investors are here.”

Kordzik of the Texas Nanotechnology Initiative Institute said he wants Texas economic developers to work with the research universities and nanotech companies to focus on areas of specialization. Kordzik also wants to see Texas focus commercially leveraged nanotechnology that enhances medical science, military equipment, semiconductors and the energy industries.

Wade Adams, director of the Richard E. Smalley Institute for Nanoscale Science and Technology at Rice University, believes such focus is starting to take place. Rice now boasts 150 faculty members working

“Nanotechnology is more of an enabling technology than it is an industry.”
— James Von Ehr, Zyvex Labs

“It’s a food fight going on in the area of attracting nanotech companies, and Texas is sucking wind at attracting these companies.”
— Wade Adams, Rice University
in nanotechnology research, in specialties ranging from chemistry to engineering and even to economics. Their focus is on incorporating nanotechnology with medical science and energy production. Rice’s dedication to nanotechnology research and entrepreneurship helped create 15 new companies in the past five years, with another three companies to emerge in 2010.

Universities aren’t venturing into this field alone. Energy companies recognize the potential of nanotechnology and have donated research funds. The Advanced Energy Consortium brought together the major oil companies in Texas to contribute $10 million in research, which the companies hope will help fund development of nanotechnology devices to detect petroleum deposits inside the pores of rocks in depleted oil fields, which companies can then extract for additional energy supplies.

Over the next 10 years, Adams expects more manufacturing companies to reengineer existing factories or set up new factories that can incorporate nanotech equipment. He predicts that major manufacturers, such as Lockheed Martin, Texas Instruments and Hewlett-Packard, will work with Rice researchers to explore the integration of nanotechnology into product development. Such integration could lead to new jobs for skilled manufacturing workers in Texas. However, Texas will be challenged to attract and keep both nanotech firms and workers since California, China, Germany and Alberta, Canada, among others, are spending hundreds of millions of dollars on incentives for nanotech firms. For example, New York recently opened a 300-acre nanotechnology industrial park, the Marcy NanoCenter near Albany, armed with a marketing tag line — “New York Loves Nanotech.”

“It’s a food fight going on in the area of attracting nanotech companies, and Texas is sucking wind at attracting these companies,” Adams said. “I appreciate what the state of Texas has done, [but] I wish the state could get more serious about this.

They need to think about spending billions of dollars.”

Not every piece of research extols nanotechnology as the next great thing. The National Science Foundation (NSF) commissioned researcher David Berube to study the field of nanotechnology. His findings are published in the monograph *Nano-Hype: The Truth Behind the Nanotechnology Buzz*, which includes a foreword by Mihail Roco, senior advisor for nanotechnology at the NSF. Berube concluded that much of what is sold as nanotechnology is in fact a recasting of straightforward materials science, which is leading to a “nanotech industry built solely on selling nanotubes, nanowires, and the like [that will] end up with a few suppliers selling low-margin products in huge volumes.” According to Berube, a “nano bubble” may be already forming.

Many industry analysts stress that the more lofty aspirations for nanotechnology have not yet become a reality. Still, this small industry is growing. As of 2008, the Project on Emerging Nanotechnologies estimated that more than 800 manufacturer-identified nanotech products are publicly available, with new items hitting the market at a pace of three to four per week.
Think Globally, Plan Regionally

In Texas, the fledgling nanotechnology industry is fragmented, misunderstood and struggling for funding. Yet opportunity exists for high-paying jobs with companies that can grow over the next three decades.

According to those in the field, the small group of nanotechnology companies in Texas faces some key challenges:

- **Trailblazing without a road map is difficult.** The nanotechnology field is a young and immature industry, without a proven path to follow.

- **Investors have pulled back.** The hype and interest in nanotechnology among investors has diminished. Investors have learned that nanotechnology investments are especially risky and that the time horizon for nanotechnology development is measured in decades rather than fiscal quarters.

- **Continued federal and state funding of nanotechnology research is needed.** Federal underwriting of nanotechnology research has slowly increased in recent years, reaching $1.5 billion in fiscal year 2009. However, with little private investment, federal and state funding become more critical to fuel the industry’s growth in Texas.

- **Richard Smalley left big shoes to fill.** For more than a decade, the charismatic Rice professor leveraged his Nobel Prize cachet to consistently convince the White House and Congress to fund nanotechnology work in Texas. Smalley died in 2005, and a new Texas nanotech champion has yet to emerge.

If scientific research can lead to expansion of the nanotech industry in Texas and the United States, then research may be the best overall strategy for now. Venture capitalists and economic developers are still shying away from nanotechnology because they do not understand it and do not see big, immediate returns. The lack of private investor support cannot be understated. Also, other states see how nanotechnology is starting to change and improve traditional manufacturing industries and are pursuing nanotechnology more aggressively. Texas cannot ignore that these states are wooing companies with incentives, and their universities are grabbing precious federal grants to stimulate nanotech research.

“Right now we have gun-shy investors. Nanotechnology is risky. A lot of companies are going to fail,” said Baughman at UT-Dallas. Supporting universities as they push nanotechnology forward with research and gradually spin out new companies is key, according to Baughman.

The makeup of nanotech companies is attractive. About half of the employees at a standard nanotech firm have Doctoral degrees; the rest have Master’s, Bachelor’s and Associate’s degrees in specific sciences. Typically, as a nanotechnology company grows, it hires more employees with Doctoral degrees and Associate’s degrees. According to those in the industry, the pay for workers with a Doctoral degree is about $200,000 a year, and workers with specialized Associate’s degrees earn about $40,000 a year. Texas universities and community colleges are able to supply these workers now for a nanotech industry whose workers number in the hundreds. But as demand takes off and more of these tiny nanotech firms grow, universities and community colleges could soon be hard-pressed to train these workers.

Among other collaborative strategies, regional workforce boards can encourage community college training in nanotechnology and even the development of nanotech industrial parks near the universities. Workforce boards can also remind the business community and political leaders that this technological leap is happening gradually and demands a highly trained workforce.

Nanotechnology is a process for improving all kinds of consumer and industrial goods. The communities with innovative workers familiar with unique properties of nanotech development can create the innovative companies of the future.