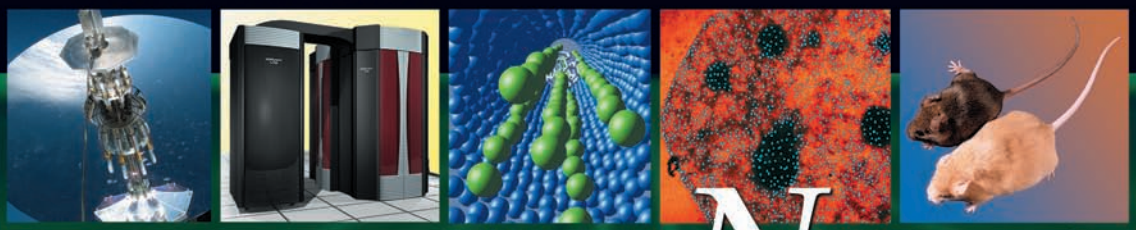
TECHNOLOGY TRANSFER
AND ECONOMIC DEVELOPMENT



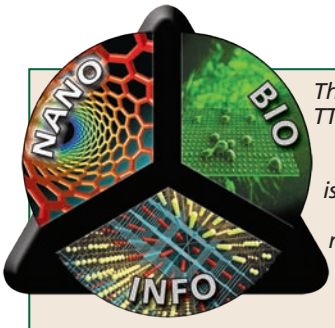
Putting Science to Work

SUMMER 2005
Newsletter

BUILDING
ECONOMIC DEVELOPMENT

East Tennessee Venture Capital Fund Established

Local business leaders in the Oak Ridge–Knoxville area recently launched Innovation Valley Partners (IVP), a $35-million venture capital fund. IVP is affiliated with Battelle Ventures, LP, a $150-million national fund investing in early-stage companies in the life sciences, information technology, homeland security, energy and advanced materials/nanotechnology.



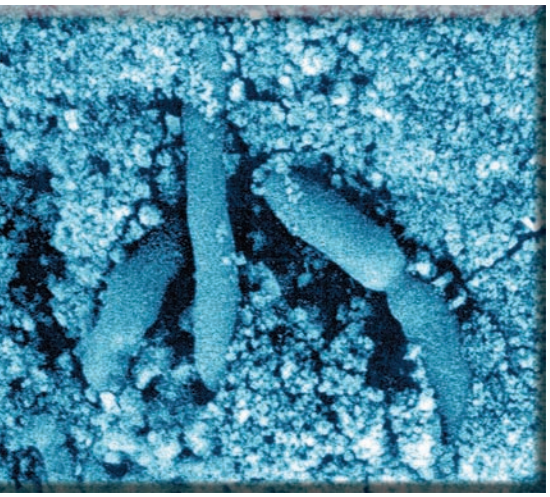
This issue of the TTED Newsletter is the first of three special issues on ORNL work in the nano, bio, and informational sciences. The center pages of this issue focus on nanotechnology.

ORNL Director Jeff Wadsworth and TTED Director Alex Fischer played key roles in recruiting the 12 local investors who have underwritten the fund. They recognized the importance of venture capital to ORNL's strategies to commercialize more ORNL technologies and grow new companies in the region.

As a Battelle Ventures affiliate, IVP will invest alongside Battelle Ventures, which provides capital to technology companies at many stages of development, from companies looking for seed or

(continued on page 2)

OUR
TECHNOLOGIES



A scanning electron microscope image of bacteria with magnetite crystals.

NanoFermentation: Bacteria Create Magnetic Powders

The relatively high cost of metal oxide nanopowders is one factor that has slowed the development of nanomaterials. A flexible, scalable, environmentally friendly process for making controlled batches of nanosized mixed metal oxide powders will encourage the development of novel products by making raw materials available in cost-effective quantities.

ORNL researchers, studying the ability of high-temperature ("thermophilic") bacteria to create mixed oxide nanoparticles, have developed a technology with just such potential. Their patented method, called NanoFermentation™, is believed to be the first fermentative process for making engineered inorganic materials. In the NanoFermentation process, metal-reducing bacteria are cultured

(continued on page 3)

In This Issue:

ORNL Technology Transfer & Economic Development (TTED) seeks to foster economic development and the growth of business and industry by making available the most innovative equipment, the latest technology, and the expertise of ORNL researchers to technology-based companies throughout the nation.

MESSAGE FROM THE DIRECTOR

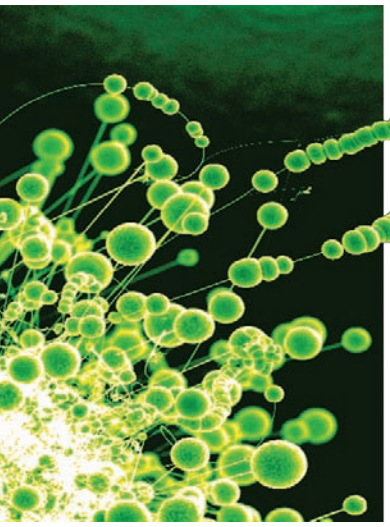
Alex Fischer

Summer at Oak Ridge National Laboratory has been a very busy time. Throughout this issue you will see articles related to our progress on several important fronts.

Perhaps most significant for our efforts to advance the long-term economic development in the region was the creation of Innovation Valley Partners, a new $35 million venture capital firm to be headquartered in the Knoxville/Oak Ridge area. This will be East Tennessee's first major venture capital fund established and underwritten entirely by a group of East Tennessee business leaders. Innovation Valley Partners joins the regional efforts of Technology 2020, Southeast Community Capital, the Southern Appalachian Fund, and the planned Meritus Ventures as another important step in ensuring that East Tennessee entrepreneurs have access to available capital.

You'll also see several articles on new licenses coming out of our commercialization efforts. Our team has greatly exceeded 2005 revenue goals and is headed for another record year of income in what was expected to be an off year for commercialization income.

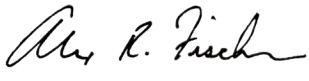
Several new hires show our continued commitment to our economic development efforts as well as to meeting the demands of our sponsored research organization.



Germanium beads on a zinc oxide nanowire.

We also have included an insert in this issue related to our nanotechnology initiatives. Over the past year, we have made a concerted effort to focus on leveraging ORNL's unique capabilities in the nanotechnology space, and the newly created Innovation Valley Nano Alliance has really begun to take hold. In fact, the Southern Growth Policies Board and its Southern Technology Council have begun an effort to help us expand our reach throughout the Southeast in a Southern Nano Alliance — an important development as we seek to contribute to the South's economic development strategy.

Thanks for your partnership as we continue to push the bar higher!



(BUILDING ECONOMIC DEVELOPMENT continued from page 1)

ET Venture Capital Fund (cont.)

Innovation Valley Partners

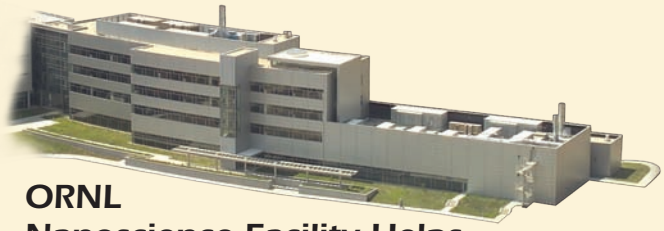
start-up capital through pre-revenue companies raising later rounds of financing. Battelle Ventures' general partners will manage the IVP fund, with the addition of a partner to be located in the Knoxville–Oak Ridge region.

Battelle Ventures, based in Princeton, N.J., has developed strong relationships with and made numerous visits to ORNL. The firm's sole limited partner, Battelle Memorial Institute, co-manages ORNL for the U.S. Department of Energy with the University of Tennessee (UT-Battelle).

"Innovation Valley Partners offers East Tennessee a unique opportunity to break into the national venture-capital network by leveraging Battelle Ventures' efforts and relationships," says local investor Jim Clayton, who notes that investments will be made with no geographic limitation. "The No. 1 criterion," he adds, "is that there is great potential for return on investment."

"Experience in other regions suggests that the way to build a venture-capital base is to start with funds that don't just focus on local economic development," says Battelle Ventures General Partner Jim Millar. "In this case, IVP can hit the ground running, leveraging our national scope and existing deal flow."

Millar adds, however, that the national scope of the fund certainly will not preclude local investments. Deals, he says, "will inevitably involve technologies emerging from the labs here. And having an IVP partner on the ground in the Knoxville region will keep us very plugged into local opportunities."



ORNL Nanoscience Facility Helps Develop Medical Compound Device

A device that could create custom-tailored medical compounds faster than ever before is one of the first technologies developed at ORNL's

ORNL Nanoscience Facility (cont.)

newest user center, the Center for Nanophase Materials Sciences (CNMS). Joseph Matteo, founder and CEO of the Oak Ridge research firm NanoTek, is building a small microfluidic machine to quickly and reliably synthesize drugs, medicines, diagnostic imaging agents, and other compounds.

Matteo is experimenting with technology developed at CNMS to manipulate ions in a stream of solution. Potential commercial applications are medicines and drugs tailored to each patient's needs; short-order manufacturing of drugs or chemicals that have a short shelf life; and a better way to make short-lived radioactive compounds for medical diagnostic imaging technology such as positron emission tomography (PET).

While current methods can rapidly explore thousands of variants of a compound to achieve a certain solution, their parallel, high-volume nature is not information-driven. A closed-loop, information-driven system offers a serial or sequential discovery method and promises a more "intelligent" drug-making process, Matteo says.

"Combinatorial or parallel processing chemistry can do a process thousands of times to get the right answer, but it's like casting a large net to capture a small solution," Matteo says.

Matteo cites Tech 2020 and ORNL's TTED for encouraging his project. He says the establishment of CNMS inspired him to pursue his ideas for nanotechnology applications. "I had a fundamental interest in nanotechnology for many years. Once I found an application and learned more about it, I became really intrigued, but the real launching pad for me was the CNMS facility being built here. Certainly, without that I would not have done this. It is absolutely the cornerstone."

(BUILDING ECONOMIC DEVELOPMENT continued on page 4)

Joseph Matteo of NanoTek is building a small, microfluidic machine to quickly and reliably synthesize drugs.

(OUR TECHNOLOGIES continued from page 1)

NanoFermentation (cont.)

in a large fermenter and "fed" with a starting mixture of selected metal compounds. The bacteria reduce these compounds as part of the normal metabolic process, creating new compounds such as doped ferrites in the form of nanosized single crystals. Because the product is formed externally to the cells, it can be harvested without disturbing the bacteria. Thus, a changeover from one product batch to another does not require that a new culture of bacteria be grown; the first product is simply harvested and the precursor material for the next batch is added in its place. This type of bioprocessing allows the creation of mixed oxide compositions that cannot be synthesized in other ways.

Black powder in NanoFermentation broths with magnets attracting plumes of magnetic particles. The bottles contain various compositions of magnetite.

NanoFermentation can be applied to many different metal oxide systems and has potential applications in ferrofluids, magnetorheological materials, paints, coatings, pigments, catalysts, dry toners, and other magnetic and electronic materials. Unforeseen products and applications will lead to increasing commercial and technical interest and pave the way for nanotechnology to achieve its full promise. Work is ongoing to extend the process to more compositions and continue scaling to larger, pilot-scale batches.

Sense Holdings to Develop ORNL's Microcantilever Sensors

Sense Holdings, Inc., a leading provider of biometrically secured and microsensor identification systems, recently entered into an agreement with ORNL to develop ORNL's micro-electro-mechanical sensors (MEMS), launching the first phase of a joint development project. Sense has acquired the exclusive worldwide patent licenses for chemical sensing devices for all security applications using the MEMS technology developed by ORNL through a Cooperative Research and Development Agreement (CRADA).

MEMS can be designed as sensors for a wide array of applications, including security sensors for transportation

(OUR TECHNOLOGIES continued on page 6)

PEOPLE AND EVENTS IN TTED NEWS

Mark Reeves Elected FLC Regional Coordinator

TTED's Mark Reeves was elected regional coordinator of the Federal Laboratory Consortium for Technology Transfer (FLC) for the Southeast Region at the FLC's recent national meeting in Orlando. The FLC is the nationwide network of federal laboratories that provides a forum to develop strategies and opportunities for linking laboratory technologies and expertise with the marketplace. As regional coordinator, Reeves is responsible for facilitating communications and interactions among the 43 laboratories in the region. He is the first ORNL employee to be elected to this post.

Mark Reeves

Reeves joined ORNL as a researcher in 1986. He managed research programs in the bioremediation of hazardous environmental chemicals and biomimetics/biomaterials, and from 1995 to 1998 was director of the Laboratory's Bioprocessing Research and Development Center. Prior to joining the Technology Transfer and Economic Development directorate in 2000, Reeves was technical assistant to ORNL's associate director for biology and environment.

In addition to holding a Ph.D. in microbial physiology and biochemistry (University of Tennessee, 1982), Mark also earned an MBA from Colorado State University in 2001. He has served as ORNL's alternate FLC representative since 2002.

Painter and Stewart Join TTED Staff

TTED recently welcomed two new staff members to its family, continuing the tradition of adding individuals with complementary strengths to the team.

Bill Painter, formerly a senior contracts administrator with ORNL, is now a sponsored programs manager in TTED's Technology Transfer arm. Leigha Stewart, a former branch manager for the ORNL Federal Credit Union, joins the Economic Development team as an economic development associate.

(PEOPLE AND EVENTS continued on page 5)

(BUILDING ECONOMIC DEVELOPMENT continued from page 3)

East Tennessee Nano Initiative Launched

An effort announced in May will help the East Tennessee region capitalize on and market its exceptional nanoscience research facilities. These facilities include the Spallation Neutron Source, the High

Rep. Zach Wamp announcing the East Tennessee Nano Initiative

Flux Isotope Reactor, the Center for Nanophase Materials Sciences, and the Center for Computational Sciences at ORNL; the University of Tennessee's nanofabrication facilities; and the precision machining capabilities of Y-12 National Security Complex.

In announcing the formation of the East Tennessee Nano Initiative on May 16, U.S. Rep. Zach Wamp noted that the new initiative "will help make sure our region benefits economically from this industrial revolution."

The goals of the initiative are to

- market the region's research capabilities to a national and international audience of government agencies, businesses, and entrepreneurs;
- help attract more nanoscience grants and research dollars to local institutions and companies;
- create new intellectual property and patents to stimulate growth of new companies in the region;
- serve as a focal point to recruit new nanotechnology companies to the region; and
- help local industries adopt new nanotechnology applications to improve their competitive position.

The founding partners are ORNL, the University of Tennessee, the Y-12 National Security Complex, Technology 2020, and Innovation Valley.

Meetings of the recently renamed Innovation Valley Nano Alliance are held on the first Thursday of each month at Technology 2020. The meeting

Protein Discovery managers Chuck Witkowski, Amanda Mravca, and Dean Hafeman display a prototype of the photo-biomolecular-comb.

ET Nano Initiative (cont.)

is open to all companies, entrepreneurs, and researchers interested in learning more about nanotechnology and how they can participate in the initiative.

Biotechnology Business Relocates to Downtown Knoxville

Protein Discovery, a biotechnology firm previously known as QGENICS, has moved from a suburban Knoxville business park into a 4,000-square-foot facility in downtown Knoxville. The company's move was prompted by a venture-capital deal with the Southern Appalachian Fund that requires the company to be located in a low-income area; Knoxville's downtown development district meets this requirement. In addition, the move may allow the company to receive a $130,000 grant from the city of Knoxville that was established to bring a biotechnology company to the downtown area.

Protein Discovery is a venture capital–backed life sciences company founded in 2001. The company holds the license to and is developing the ORNL photo-molecular-comb, which can separate proteins and other biomolecules for identification and analysis. This technology allows scientists and clinicians to simultaneously detect and monitor thousands of disease markers, in contrast to existing diagnostics that measure these markers one at a time.

In June, Protein Discovery and ORNL received the prestigious 2005 Award for Excellence in Technology Transfer from the Federal Laboratory Consortium (FLC) for outstanding collaborative work in developing the photo-molecular-comb technology for transfer to the commercial marketplace.

(PEOPLE AND EVENTS continued from page 4)

Painter and Stewart (cont.)

"Bill and Leigha bring strong knowledge and established relationships to our team," TTED Director Alex Fischer says. "In Bill, we have a person who has worked at three federal labs and spent the past 12 years at ORNL. Leigha has established a strong network within the Lab as well as in the Oak Ridge community through her credit union activities."

Painter has worked for the past 12 years at ORNL in procurement, technology transfer, and contracts. Before joining ORNL, he was a supervisor of major subcontracts at Martin Marietta Aerospace in Denver and a subcontract administrator for both the National Renewable Energy Laboratory in Denver and Los Alamos National Laboratory in New Mexico. Painter earned a B.S. in industrial management and an MBA from Auburn University. He is a Certified Professional Contracts Manager and was awarded fellow status by the National Contracts Management Association.

Leigha Stewart

Bill Painter

A graduate of the University of Tennessee with a B.A. in English, Stewart worked for the ORNL Federal Credit Union in a variety of roles for almost 10 years. She is a 2004 graduate of Leadership Oak Ridge and a member of the 2005 class of the East Tennessee Regional Leadership Association. Stewart is also active in a number of Oak Ridge community groups.

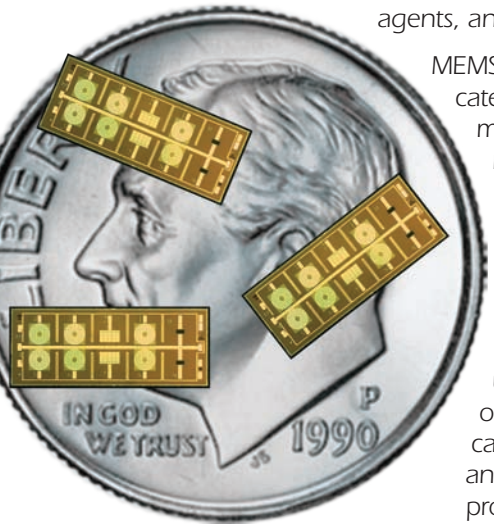
"Leigha will spend a good deal of her time supporting the ED team efforts locally as well as across East Tennessee, the state, and the South," says Tom Ballard, director of Economic Development and Partnerships.

(PEOPLE AND EVENTS continued on page 6)

(OUR TECHNOLOGIES continued from page 3)

Sense Holdings (cont.)

facilities and public buildings, power stations, and land mine removal. The exclusive patent licenses acquired by Sense include detection of explosives, chemical warfare agents, and narcotics.



ORNL Microchips on a Dime. *Sense Holdings will develop microsensors based on patented ORNL microcantilever technology into a handheld device for detecting explosives, chemicals, and narcotics. Each 2 x 5 mm chip contains ten individual microsensors, a heater, and a thermometer.*

MEMS-based chemical sensors are fabricated in the form of extremely sensitive microcantilever structures. Microcantilevers designed as explosives sensors are coated on one side with a chemical substance designed to absorb specific explosives molecules. Absorbed molecules induce the respective microcantilevers to immediately undergo changes in deflection or resonance response which can then be detected electronically and measured in real time by a microprocessor-based system.

The first phase of this project will involve the development of a commercial explosives sensor chip and a custom readout chip. On the basis of these, Sense plans to develop a handheld explosives detector. The advantages of this new handheld explosives detection technology are low cost, very high sensitivity, and real-time results.

"We are very excited to have Sense Holdings as a commercialization partner for our MEMS technology," states Alex Fischer, TTED director. "The application areas on which the company is focusing the technology will not only provide a financial return but will also address issues of national and international importance, such as explosives detection."

(OUR TECHNOLOGIES continued on page 7)

(PEOPLE AND EVENTS continued from page 5)

TTED Supports CEO Education Summit

ORNL occupied center stage during the mid-August CEO Summit on Math and Science Education sponsored by the Tennessee Business Roundtable. More than 250 people attended the day-long conference, which featured Tennessee Governor Phil Bredesen and ORNL Director Jeff Wadsworth. During a luncheon presentation, Wadsworth talked about the Laboratory's future workforce needs and pledged $50,000 a year for several years to help provide signing bonuses for K through 12 science teachers. After lunch, TTED staff coordinated tours for Summit participants to four of ORNL's new facilities: the Spallation Neutron Source, the Center for Nanophase Materials Sciences, the National Leadership Computing Center, and the EVEREST computer visualization facility.

Gov. Phil Bredesen

Tom Ballard Given Tennessee Valley Corridor "Champion" Award

Tom Ballard, TTED's director of economic development and partnerships, was given the 2005 Tennessee Valley Corridor "Champion" award earlier this year at the Corridor's National Summit in Washington, D.C. The Corridor Champion award was designed

Rep. Zach Wamp and Tom Ballard

DOING RESEARCH WITH ORNL

How to Partner with ORNL

Industry, governments, and universities can partner with ORNL and its facilities for performing research under one of several types of agreements:

- Cooperative research and development agreements, or CRADAs, govern partnerships with industry for collaborative R&D.
- Work for Others (WFO) projects are projects in which a nonfederal-government sponsor provides funding to ORNL for performance of R&D or services.

Tom Ballard (cont.)

to recognize a person who has significantly contributed to promoting the mission, vision, and work of the Corridor and its partners.

Congressman Zach Wamp (R-Tenn.), who presented the award, said that Ballard has been an outstanding leader in promoting the Tennessee Valley Corridor as one of the nation's premier science and technology centers, and in helping leverage the valley's abundant research and technology assets and institutions for maximum regional economic development and new job creation.

Ballard served as the Corridor's board chairman for six years, from the Corridor organization's inception in 1999 until February of this year. He will continue to serve on the Corridor's executive committee and is the first board chairman of the newly created Tennessee Valley Corridor Foundation.

Ballard came to TTED as regional economic development director in 2004, after having held a variety of posts at the University of Tennessee for over 30 years—most notably as the university's vice president for public and government relations.

(OUR TECHNOLOGIES continued from page 6)

Precision Mirrors Enhance Study of Micro-, Nano-Materials

Precision mirrors to focus X-rays and neutron beams could speed the path to new materials and perhaps explain why computers, cell phones, and satellites go on the blink. In the last few years, a team of ORNL researchers has improved by a factor of nearly 10 the performance of mirrors that enable researchers to examine variations in structure and chemistry and even individual nanoparticles.

The first of these differentially deposited X-ray micro-focusing mirrors, installed a few years ago on a beam line at the Advanced Photon Source at Argonne National Laboratory, allowed resolutions of 500 nanometers. Recent advances in the optics and manufacturing processes have improved the resolution to 70 nanometers. The ultimate goal is 1 nanometer.

The X-ray mirrors are about 20 millimeters long, or about the size of a quarter. Neutron mirrors are much bigger—about 800 millimeters (31.5 inches) long—and increase the effectiveness of small neutron beams by a factor of about 100.

X-ray and neutron mirrors developed at ORNL will assist in the examination and improvement of materials

The advantage of using mirrors instead of other techniques is that their focal properties are nearly independent of X-ray or neutron wavelengths. This allows them to be used to perform experiments that could not be done with other methods.

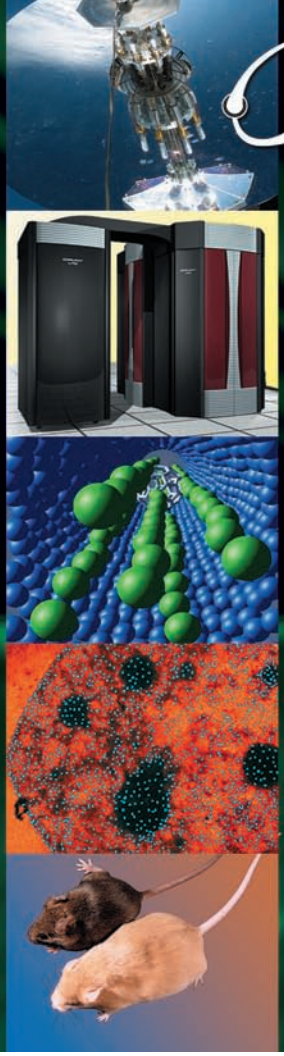
These mirrors will enable a better understanding of three-dimensional grain growth, deformation of polycrystals, and cracks at the so-called mesoscale—materials between a tenth of a micron to hundreds of microns. With this knowledge, researchers hope to answer questions about electrical migration in interconnects within integrated circuits. Failures at this level lead to problems with electronic equipment in everything from automobiles to satellites.

This research has attracted considerable attention from NASA and several potential industry partners, including Ford Motor Corp. and General Electric.

- User agreements allow the user access to certain unique designated ORNL facilities for R&D.

The goals of the partner or the sponsor, along with funding sources for the agreement and ORNL's strategic business objectives, are used to determine the most appropriate agreement type. A variety of nondisclosure agreements are available to protect information.

The Collaborations and Sponsored Research pages of the TTED web site (http://www.ornl.gov/adm/tted/collaborations/coll_research.shtml) provide much more information on working with ORNL and its facilities, as well as a comprehensive list of ORNL user facilities. In addition, many of ORNL's user facilities provide information about working with the facility on their web sites.



TECHNOLOGY TRANSFER
AND ECONOMIC DEVELOPMENT

UPCOMING EVENTS

September 30	Tennessee Manufacturing Extension Program (TMEP) Advisory Council meeting, Oak Ridge National Laboratory
October 6–7	9th Annual Tennessee Valley Venture Forum, Knoxville Convention Center, Knoxville, Tennessee. For more information: http://www.tvvf.biz/
October 13	Tennessee Automotive Manufacturers Association (TAMA) Cost Reduction Seminar, DoubleTree Hotel, Oak Ridge, Tennessee. For more information: http://www.tennauto.org/

The Innovation Valley Nano Alliance meets on the first Thursday of every month at Technology 2020, Oak Ridge, Tennessee. For more information: 865-220-2020 or e-mail rsvp@tech2020.org.

OAK RIDGE NATIONAL LABORATORY
• MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY •
TECHNOLOGY TRANSFER
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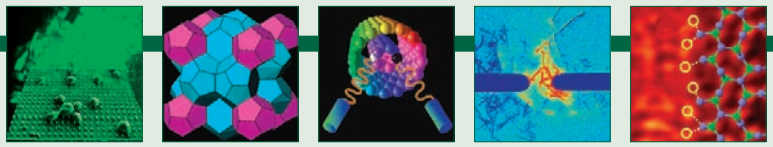


Thinking Small: Nanoscience at ORNL

THE NANOTECHNOLOGY REVOLUTION

Imagine over $2 billion worth of brand new science laboratories in East Tennessee. This isn't a dream; an amazing transformation has been taking place at Oak Ridge National Laboratory during the past five years. We are no longer that laboratory "behind the fence" working on classified projects. We are now the nation's largest basic science research laboratory, with more than 3900 employees, many new science facilities, joint research institutes, and researchers coming here from around the world.

The Next Major Science Revolution

Not only that—we are at the center of the next major revolution in scientific discovery, the study of materials, devices, and systems on the scale of a nanometer. In October of this year, we will open the first of five new Department of Energy (DOE) Nanoscale Science Research Centers. Called the Center for Nanophase Materials Sciences (CNMS), the attractive new building houses state-of-the art instruments and is open to users from universities, businesses, and other labs. As if overnight, one of the world's leading centers for nanotechnology has emerged in East Tennessee.

The Center for Nanophase Materials Sciences and Spallation Neutron Source are among the new facilities positioning ORNL as a nanotechnology magnet.

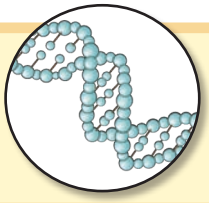
How Small Is a "Nano"?

You might recall, in high school, seeing a red blood cell from a drop of blood from your finger under a microscope. In the same class you may have studied how two hydrogen atoms attached to an oxygen atom and formed a water molecule (H_2O)—but the water molecule was too small to see with the high school microscope. Here at ORNL, we can look at not only the actual atoms making up a water molecule but those in many other molecules as well; we have actually set a world record in achieving a resolution that is less than the diameter of an atom.

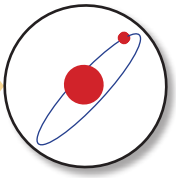
A two-meter-tall man is two billion nanometers tall.

HOW SMALL IS A NANO?

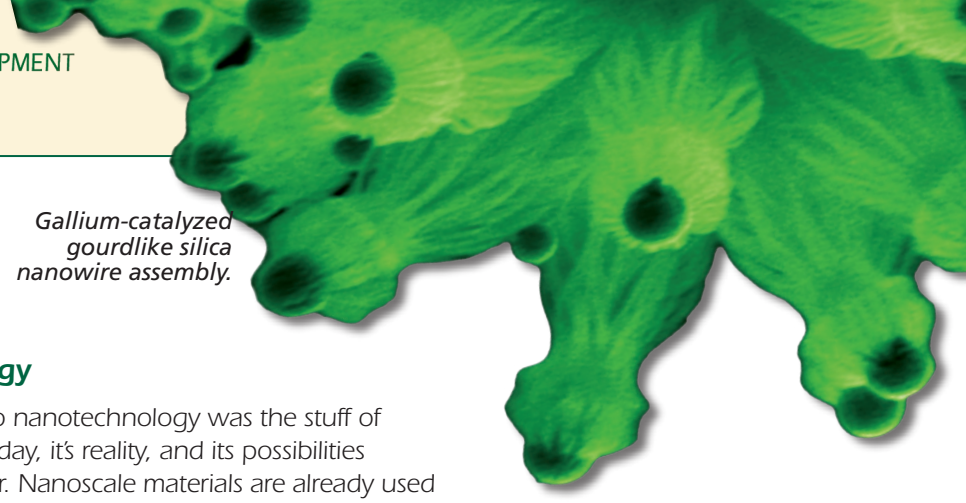
Biological cells, such as these red blood cells, are about 10,000 nanometers across.



DNA molecules are about 2.5 nanometers wide.



Individual atoms, such as hydrogen, are only a few tenths of a nanometer in diameter.

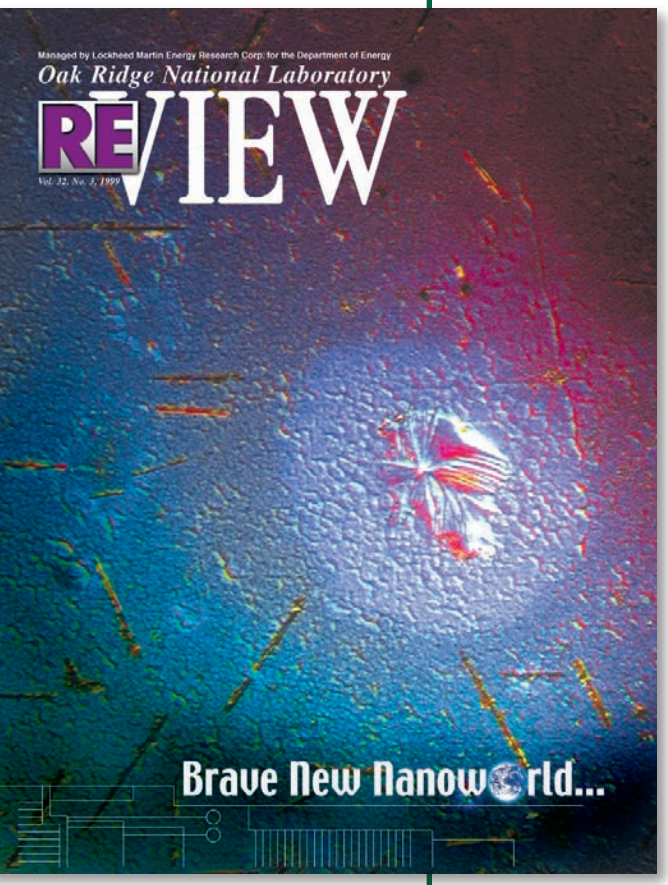


Gallium-catalyzed gourdlike silica nanowire assembly.

Nanotechnology

Not very long ago nanotechnology was the stuff of science fiction. Today, it's reality, and its possibilities expand every year. Nanoscale materials are already used in applications ranging from electronics to biomedical to new materials— examples are magneticrecording tapes, sunscreens, automotive catalyst supports, biolabeling, electroconductive coatings, and optical fibers.

Within the next several years, nanotechnology products are likely to include solar cells in roofing tiles and siding that provide electricity for buildings, nano composites in tires to improve skid resistance and reduce abrasion, and advanced drug delivery systems, including implantable devices that automatically administer drugs and sense drug levels. Over the longer term, nano medicine will revolutionize disease detection and treatment; help fight terrorism through detection of biological and chemical agents; and create plants that can manufacture fuels.



In 1999 an issue of the ORNL REVIEW magazine *(http://www.ornl.gov/info/ornlreview) was devoted to nanoscience at the laboratory.*

NANOSCIENCE PIONEERING AT ORNL

ORNL scientists have been pioneers in nanoscience and nanotechnology since the earliest days of the laboratory, beginning with neutron scattering experiments conducted by Ernie Wollan and Clifford Shull at the Graphite Reactor in 1945. By the mid-1980s ORNL researchers were among those calling for a neutron scattering facility (which became the Spallation Neutron Source) that would allow major breakthroughs in the visualization of atomic particles. ORNL work in nanoscience in the 1990s included ceramic nanoparticles to improve scratch resistance of automotive paints and the first digital images of the carbon buckeyb all (one of the basic forms of carbon). The work continued with discovery of "nanobugs" to convert wood to sugar and coal to liquid fuel, and even the development of a "molecular broom" to move individual atoms around. In the mid-1990s, using computer simulations, a buckyball piston was developed inside a carbon nanotube. By the end of the 1990s, we had created the first biomolecular "electronic" device using spinach proteins as diodes.

This focus on nanoscience discovery has accelerated rapidly in the past few years, with amazing discoveries such as nanosensors that act like an electronic nose, and radioactive nano-particles that can be attached to an antibody, potentially for the treatment of non-Hodgkin's lymphoma. New nanotube polymer composite materials are being developed for the storage of electrical energy or hydrogen. Nanomagnetic materials being created will enable devices that greatly improve battlefield surveillance and detection of biological and chemical warfare agents. A proposed molecular memory cell that would allow laptop computer batteries to last 100 times longer than today's batteries is being modeled computationally on an IBM supercomputer at ORNL.

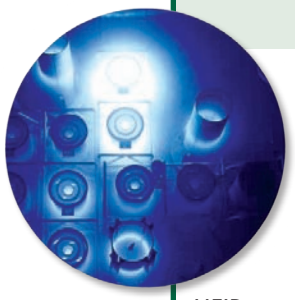
ORNL's NANO RESEARCH FACILITIES

In our high-tech society, we have an increasing need for new materials that are stronger, lighter, and cheaper yet perform well under severe conditions. More than ever, major research facilities—X-ray and neutron sources, advanced microscopes, and advanced computer modeling—are used to understand and "engineer" materials at the atomic level. A number of ORNL research facilities and groups are involved in investigations into the nanoworld.

Neutron Imaging: The Spallation Neutron Source and High Flux Isotope Reactor

The properties of any material are determined by how atoms are arranged and how they interact. Measurement of the directions and energies of neutrons bounced, or "scattered," off materials is a powerful method of investigating material properties. ORNL is becoming home to the world's leading neutron science capabilities.

When the $1.4 billion Spallation Neutron Source (SNS) is fully operational in 2006, it will provide the most intense pulsed neutron beams in the world for scientific research and industrial development. The SNS will allow scientists to examine materials ranging from liquid crystals to superconducting ceramics, from proteins to plastics, and from metals to metallic glass magnets—and result in improvements in all these materials. The results could be precise-delivery drug systems, lubricants especially tailored for tomorrow's car engines, superconducting wires and stronger magnets, environmentally friendly plastics.



HFIR reactor pool

ORNL's $1 billion High Flux Isotope Reactor (HFIR), which recently received a $65 million upgrade, provides a powerful collection of spectrometers and unique thermal-neutron scattering capabilities to study the structure and dynamics of nanoscale materials. Together, SNS and HFIR make East Tennessee the world's foremost center for the study of neutrons and their potential to shape nanotechnology.

HRIR research includes examining the strength of new blends of high- and low-density polymers, analyzing residual stresses in materials, and producing medical isotopes.

The "clean room" nanofabrication research laboratory at ORNL's new nanocenter.

Nanoscience Integration: Center for Nanophase Materials Sciences

DOE's newest user center at ORNL, the CNMS, will open in October as a collaborative research facility integrating nanoscale science with neutron science; synthesis science; and theory, modeling, and simulation. (Indeed, even before its opening, CNMS is already operating a "jump-start" program that involves 75 projects.) CNMS is located next door to the SNS and will provide access to other ORNL research facilities.

The 85,000-ft^2 facility will include a nanofabrication research laboratory focused on the development and assembly of nanomaterials, as well

More information on ORNL's Nano Facilities

Spallation Neutron Source
www.sns.gov

High Flux Isotope Reactor
www.ornl.gov/sci/rrd/

Center for Nanophase Materials Science
www.cnms.ornl.gov

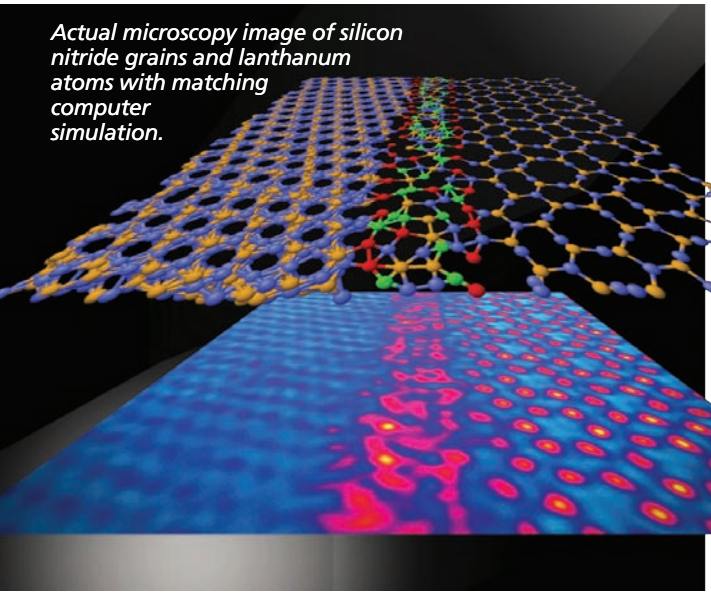
Advanced Microscopy Laboratory
www.ms.ornl.gov/htmlhome/

Shared Research Equipment User Facility
www.ornl.gov/sci/share/

National Center for Computational Sciences
http://nccs.gov/

as a nanomaterials theory institute to provide simulation and modeling for nanomaterials design research.

Researchers at CNMS will focus on several "grand challenges" to scientific understanding and nanotechnology opportunities and needs, including complex macromolecular systems, nanomaterials, catalysis and nano-building blocks, magnetism and quantum transport, and nanofabrication research.



Actual microscopy image of silicon nitride grains and lanthanum atoms with matching computer simulation.

Advanced Microscopy

Being able to "see" things at the nano scale is crucial to advancement in our understanding of materials. Thus, nanoscale science and microscopy are natural research partners. This past year, ORNL researchers achieved a new world record in electron microscopy, attaining a resolution of 0.6 angstrom, less than the diameter of an atom.

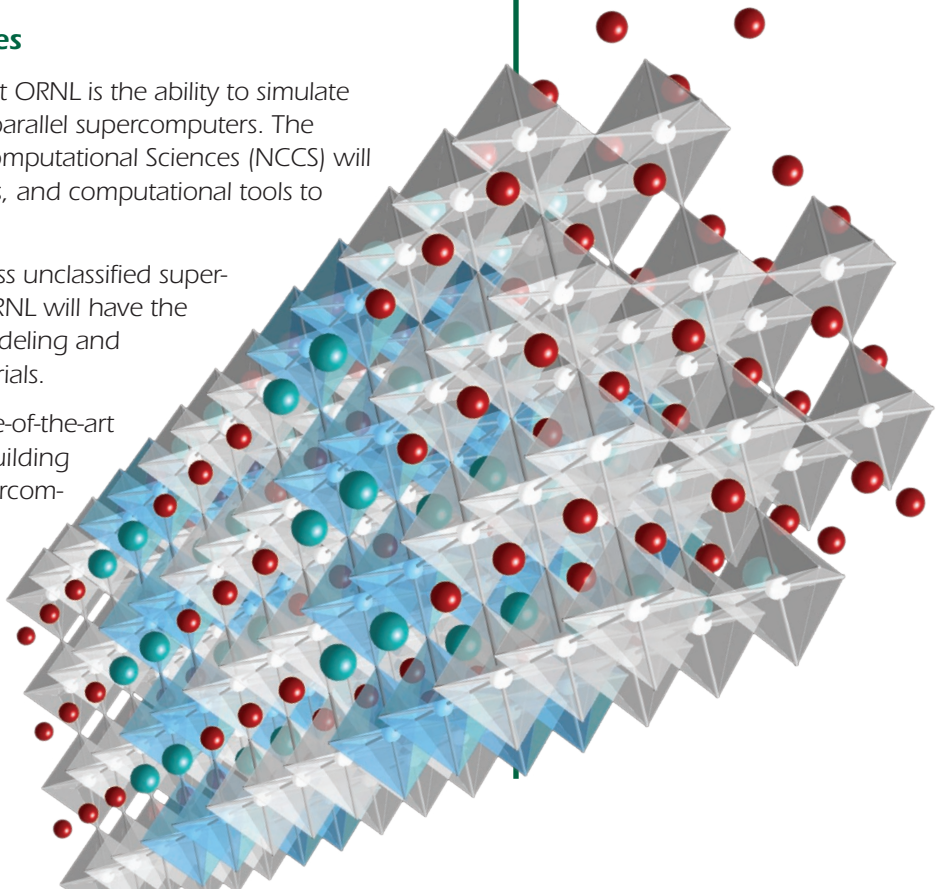
Together, the new $6 million Advanced Microscopy Laboratory and the Shared Research Equipment (SHaRE) User Facility contain the record-setting aberration-corrected electron microscope and an array of other analytical electron microscopes, scanning electron microscopes, atom probe field ion microscopes, mechanical properties microprobes, and an atomic force microscope.

National Center for Computational Sciences

Another part of the science story coming together at ORNL is the ability to simulate nanoscale structures through the use of massively parallel supercomputers. The proximity of the CNMS to the National Center for Computational Sciences (NCCS) will bring together world-class experimentalists, theorists, and computational tools to tackle the challenges of the nanoscale.

ORNL's new computational facilities house world-class unclassified supercomputers as well as massive data storage. Soon ORNL will have the world's most powerful unclassified computer for modeling and simulation of hard, soft, and hybrid nanoscale materials.

ORNL's computational facilities are bolstered by state-of-the-art connectivity, with a strong research capability for building even better and faster networks to connect its supercomputers with national networks. These networks will enable industrial firms to collaborate more efficiently with ORNL researchers on projects of interest to industry. Also at NCCS, first-class visualization expertise and equipment help researchers obtain insights from their calculation results and communicate the significance of their findings.



Computer simulation performed at ORNL of a model of an artificial oxide solid.