OAK RIDGE NATIONAL LABORATORY

Big Discoveries at Small Scales

At the Center for Nanophase Materials Sciences (CNMS) at Oak Ridge National Laboratory (ORNL), researchers make big discoveries about small materials. A nanometer is a billionth of a meter—about 100,000 times thinner than a human hair. Nanoscience aims to understand advantageous yet sometimes strange physical and chemical behaviors that arise in structures 1 to 100 nanometers wide that do not occur in larger structures.

Nanotechnology can help address challenges in energy, medicine, manufacturing, and global security. It can present unprecedented advantages in areas ranging from drug delivery to computing. Because a nanoscale building block may be a million times smaller than an ant, much more of its surface area interacts with the surrounding environment compared to a conventional material—a factor that drives advances in batteries, chemical and biological sensing, catalysts for low-energy fuel and chemical production, and breakdown of toxins for environmental restoration. Other nanoscale factors derive from the nature of quantum mechanics and fuel innovations in efficient solar energy collection and conversion, energy-efficient lighting, and stronger and lighter materials for transportation.

In the CNMS clean room, researchers wear specialized clothing to protect samples from contamination during materials synthesis.

CNMS is one of five US Department of Energy (DOE) Nanoscale Science Research Centers. The centers provide leading-edge tools and scientific expertise for synthesis, characterization, and computation for interdisciplinary research at the nanoscale. Providing its own unique capabilities, CNMS enables scientists worldwide to "see," make, control, and understand nanoscale matter.

<0.07 nanometer
Resolution of CNMS electron microscopes

68,000+
Scientific publications to date that cite CNMS research

>800
CNMS users in 2022

>1Billion
Number of atoms identified in a single atom probe tomography experiment at CNMS

"At the CNMS we are at the leading edge of breakthroughs in electron microscopy, which enables us to directly see and manipulate individual atoms. We're on the horizon of great impacts to materials for energy and quantum sciences."

Miaofang Chi,
CNMS Distinguished Scientist

Oak Ridge National Laboratory
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Specialized Capabilities

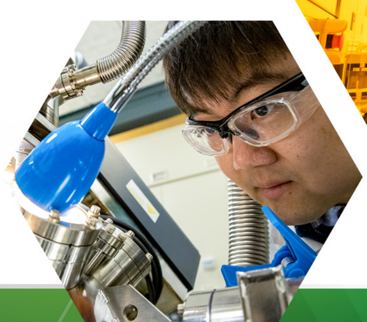
Located alongside ORNL's world-class neutron scattering and computing facilities, CNMS welcomes hundreds of users each year from universities, companies, and research institutes around the world. The center provides state-of-the-art clean rooms and nanofabrication tools; laboratories for the synthesis of low-dimensional, hybrid, and polymer materials; theoretical approaches to understand nanomaterials; and instruments for atomic-scale imaging and characterization of chemical, structural, and functional properties. This broad spectrum of capabilities and the benefits of in-house research that focuses on nanomaterials capturing, transporting, or converting energy creates an environment that would be difficult to replicate anywhere other than at a national laboratory.

Making an Impact

Nanoscience is rapidly approaching the point where researchers will be able to build a nanoscale structure with atomic precision, measure where each atom sits in its local environment, visualize what each atom is doing, and use theory and computation to understand why each atom behaves in its specific way. They are now beginning to apply this expertise and information to create materials with improved functions and properties.

Contributing to this progress, CNMS researchers have:

- Built freestanding, three-dimensional metallic structures with features as small as a few nanometers, akin to nanoscale 3D printing of tiny designs, such as nanoscale antennas, cages for single cells, or connections for the smallest electronic circuits
- Visualized magnetic properties at the atomic scale, taking the guesswork out of the design of new devices, especially for electronics and sensors
- Obtained chemical information at length scales ranging from single atoms to whole devices, revealing what nanomaterials are made of, what limits the performance of solar cells, or how batteries degrade
- Applied high-performance computing to shed light on the meaning of data obtained using neutrons, photons, and electrons to provide a more complete understanding of structure, properties, and behavior, enabling the development of materials for future applications and products
- Designed nanoscale materials including new polymers for solar energy harvesting, catalysts for converting carbon dioxide to liquid fuels, and ionic conductors for better batteries by combining theory, simulation, and precision techniques for imaging and synthesis



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