



Center for Nanophase Materials Sciences

The Center for Nanophase Materials Sciences (CNMS) at Oak Ridge National Laboratory (ORNL) integrates nanoscale science with neutron science; synthesis science; and theory, modeling, and simulation. Operating as a national user facility, the CNMS supports a multidisciplinary environment for research to understand nanoscale materials and phenomena.

Scientific Themes

CNMS research focuses on understanding, designing, and controlling the dynamics, spatial chemistry, and energetics underlying functionality and properties of nanoscale materials, systems, and architectures.

Origins of Functionality at the Nanoscale

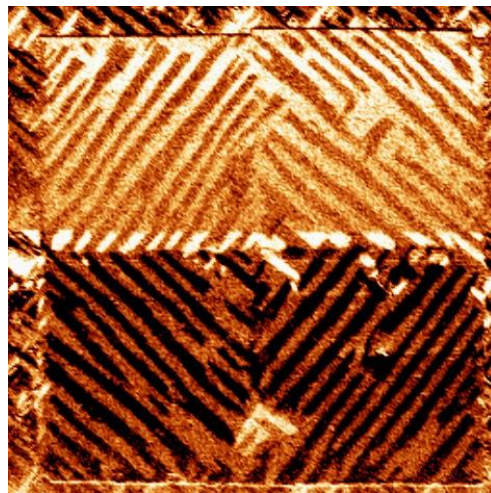
- Developing instrumentation and techniques to image and understand the functionality of nanoscale materials and interacting assemblies
- Research on optoelectronic, ferroelectric, electronic transport, and catalytic phenomena at the nanoscale
- Understand energy transfer at nanoscale interfaces

Functional Polymer Architectures

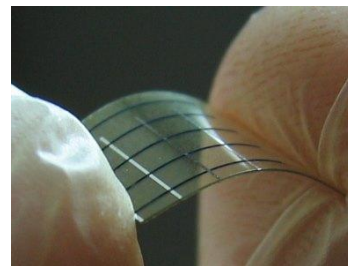
- Advancing our fundamental understanding of the links between polymer structure, property and function that are controlled by weak intermolecular interactions and interfacial phenomena
- Understanding the role of macromolecular topology in self-assembly
- Rooted in controlled synthesis of well-defined polymers and bio-inspired polymers, and in rigorous nanoscale characterization

Understanding Emergent Behavior

- Builds on strong theoretical effort, focusing on understanding the emergence of collective behavior
- Developing and applying multiscale methods to understand and predict emergent properties at the nanoscale, such as high - T_c superconductivity and quantum transport
- Understanding functionality that emerges in fluctuation-rich nanoscale assemblies, with focus on nano-bio systems

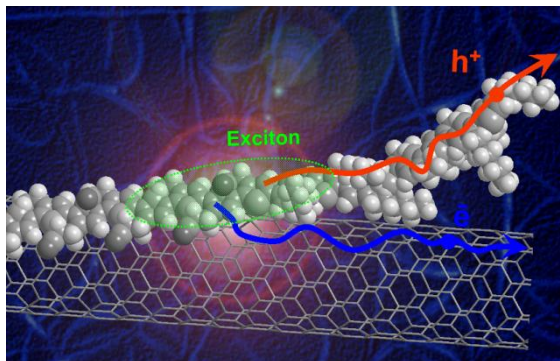


Ferroelastic domains in ultrathin BiFeO₃ films fabricated to explore a predicted vortex state. Achieved through motion-induced tip field symmetry breaking of a scanning probe.



A flexible plastic cross-point memory device based on a network of Cu-TCNQ nanowires

Synthesis and processing of hybrid systems including well-defined interfaces and architectures to test and model





Coupling ultrafast with ultrasmall

Research Capabilities

The CNMS is housed in a beautiful facility on the Chestnut Ridge Campus of ORNL, co-located with the Spallation Neutron Source. It is equipped with a wide range of specialized tools for synthesis, characterization, and fabrication of novel nanoscale materials and assemblies, including the integration of hard and soft materials. CNMS encompasses expertise and instrumentation for user research in a broad range of disciplines selected to address forefront research in nanoscience and nanotechnology.

- **Macromolecular Nanomaterials:** Synthesis and molecular level characterization of small molecule building blocks, polymers, and polymer-modified interfaces, including biologically inspired systems, deuterated molecules and polymers for neutron scattering studies.
- **Multiscale Functionality:** Synthesis and characterization of inorganic and hybrid nanomaterials and assemblies with emphasis on functional performance for energy applications. Evolution of atomic-level and nanoscale structure and dynamics with varying environments; electron microscopy and laser spectroscopy at high resolution; neutron and x-ray characterization. Specialized laser, chemical, and CVD synthesis of catalysts, carbon nanostructures, oxide hetero-structures, and related structures.
- **Scanning Probes:** Imaging of functionality and dynamics in nanostructures including magnetic domains, electro-mechanics, energetics, chemical reactions and local phase transitions, mesoscale and quantum electrical transport, electronic, structural and spin phases, electro-optical interactions and photovoltaics.
- **Nanomaterials Theory Institute:** Multiscale modeling, nanomaterials design, virtual synthesis and characterization using ultrascale computing capabilities.
- **Nanofabrication Research Laboratory:** Controlled synthesis and directed assembly of nanomaterials in a Class 1000 cleanroom environment; chemical and biological functionalization of nanoscale materials.

Many user projects take advantage of multiple capabilities in tackling research to understand complex nanoscale phenomena. In addition, CNMS has partnerships with other ORNL user programs enabling CNMS users to access these facilities. The CNMS Nanomaterials Theory Institute provides collaborative workspaces, visualization equipment, and high-speed connections to the ultrascale computing facilities of the National Center for Computational Sciences. The intense neutron beams from the Spallation Neutron Source and from the recently upgraded High Flux Isotope Reactor afford unique and expanding opportunities for fundamental studies of the structure and dynamics of nanomaterials. The CNMS also provides a gateway to sub-angstrom electron microscopy, atom probe, and other capabilities in the Shared Research Equipment user program.

User Program

The CNMS user program provides access to equipment and technical expertise for nanoscale research that defines the state of the art. The program is open to users from academia, the private sector, and research institutes worldwide. Users join a vibrant research community that brings together ORNL research staff, technical support staff, students, postdoctoral fellows, and collaborating guest scientists. The program accommodates both short-term and long-term collaborative research partners. Access is obtained through a brief peer-reviewed proposal with no charge for users who intend to publish their results. Access is available on a cost-recovery basis for research that is not intended for publication. Prospective users are encouraged to consult CNMS staff members to learn more about the Center's science and capabilities.

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