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Sandia National Laboratories

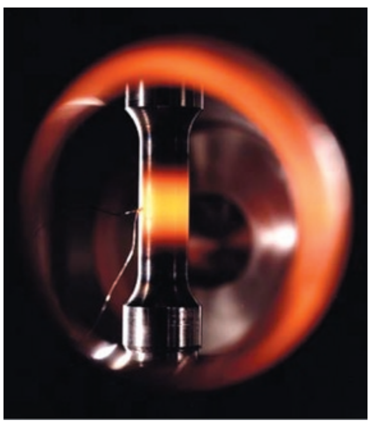
Fact Sheet

Mechanics of Materials Department

Physical and Engineering Sciences Center

Predicting Material Behavior

When it comes to national security, material performance is critical. Conventional weapons, the nuclear deterrent, counterterrorism detection and response systems, core infrastructure such as communications and energy supply…all our vital security technologies depend on reliable performance by their constituent materials, often in harsh service environments.



High-temperature tri-axial material testing

Through experiment and analysis, Sandia's Mechanics of Materials Department studies material behavior under wide-ranging environmental and loading conditions. We work with metals, alloys, and organics—often unique materials newly developed by our sister organizations—as well as geomaterials and biological tissues.

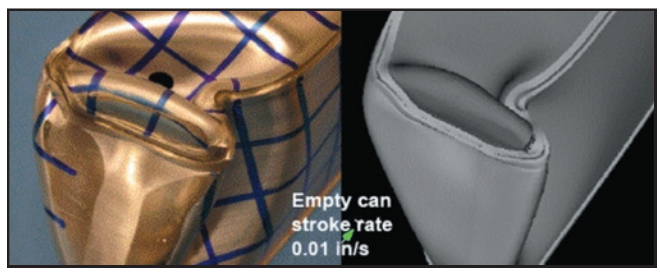
We cover the entire discovery-to-validation spectrum, developing high-resolution models to describe our observations and validating these models in tests that replicate service conditions. Our multiphysics models solve complex problems coupling chemical, electrical, thermal, and mechanical behavior to yield accurate, detailed results. Simulations range from atomic to macroscale; we devote special effort to multiscale models that describe both atomic and continuum behavior.

Our multidisciplinary team—of physicists, materials scientists, applied mechanicians, and software engineers—collaborates readily with industry, academia, and government agencies, efficiently leveraging national resources to achieve our research goals.

Current Areas of Technical Focus

Fracture and failure

- Brittle fracture
  - Cohesive surface modeling
  - High-rate fracture and crack propagation
- Ductile fracture
  - Short cracks
  - In-situ scanning electron microscope (SEM) fracture testing
- Plasticity/crystal plasticity and damage
  - Evolving Microstructural Model of Inelasticity (EMMI) development
  - Deformation-induced microstructural evolution (e.g., recrystallization)
  - Nonlocal continuum theories
  - Environmental effects



Crush of a steel can: Comparison of Evolving Microstructural Model of Inelasticity (EMMI) calculations and experimental observations

- Soft material mechanics
  - Foams
  - Polymers
  - Composite materials
  - Biological tissues and cells

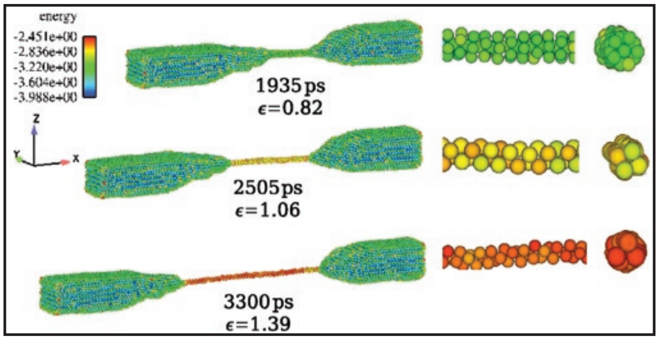
Micro/nano systems: multiscale capabilities development

- Friction and contact
- General continuum theories
- Size effect
  - Atomic simulations
  - Atomic-continuum coupling

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Modeling and simulation using high-performance computing

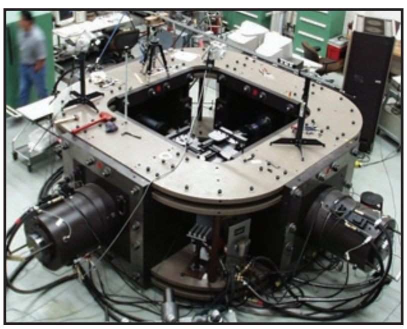
- Parallel finite element code development
- Mesh-free code development
- Molecular dynamics



Molecular dynamics simulation of nanobridges formation: Stretching gold nanowires to various, specific levels of strain results in tailored multishell structures

Experimental diagnostics

- High-strain-rate experiments
- Unconventional materials (e.g., foams, polymers)
- Multi-axial thermal-mechanical response
- Micro and nano experimental mechanics
- Structural dynamics



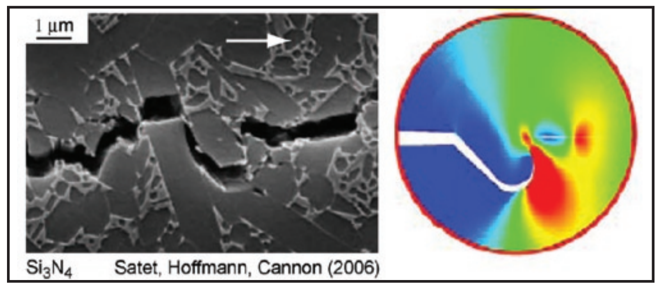
In-plane, half-million-pound bi-axial tension compression

Experimental and Computing Facilities

Our work is possible thanks to ready access to state-of-the-art laboratories and extensive computing resources, including some of the world's fastest high-performance computers.

Materials mechanics and micromechanics laboratories

- 15 MTS test frames, mostly servo-hydraulic, 2 electromechanically driven
  - Capacities ranging from 2 million pounds to 1-μN, 1-μm load/displacement resolution
  - Uni-axial and multi-axial (in-plane bi-axial, axial/torsional bi-axial, axial/torsional/internal pressure tri-axial)
  - Quasi-static to high rate
  - High and low temperature
  - Vibration, fatigue, creep
- 2 Hopkinson bar test systems at very high strain rates (1000/s–5000/s)
  - Low-impedance Hopkinson bar for soft materials (foams, polymers, fabrics)
  - Hopkinson bar for engineering materials (aluminum, steel, other alloys)
- Gas gun
- Diagnostics
  - Laser displacement/strain measures
  - Digital image correlation for field strain measurement
  - Laser vibrometer and micro-motion analyzer
  - High-speed cameras (up to 2 million frames per second)



Micromechanical grain bridging in structural ceramics

  - High-speed, high-resolution thermal imaging camera

Computing resources

- Individual and networked workstations
- Leading world-class massively parallel high-performance computers (e.g., Sandia/Cray ASC-Red Storm, ASC Blue/Gen machines at Lawrence Livermore and ASC/Q machine at Los Alamos National Laboratory)
- Massively parallel distributed computing clusters
- State-of-the-art distributed visualization systems

Learn more at: http://public.ca.sandia.gov/8700

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