Center for Integrated Nanotechnologies

Sandia National Laboratories • Los Alamos National Laboratory

Scientific Thrust Areas

- Center capabilities and expertise
- Building blocks for multidisciplinary projects
- Developed with input from1st User Workshop

Core Research Programs

- Joint laboratory nanoscience programs
- Build capabilities and expertise of CINT scientific staff

"One scientific community focused on nanoscience integration"

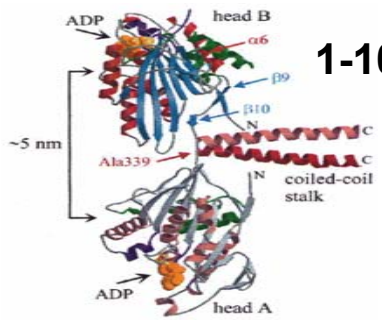
CINT Scientific Thrust Areas

- **Nano-bio-micro Interfaces**

  » **Import biological principles and functions into artificial biomimetic nano- and micro-systems**

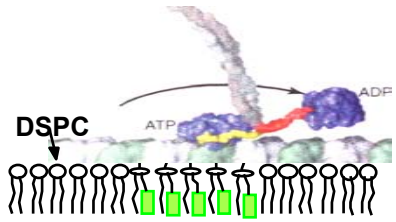
Bruce Bunker (bcbunke@sandia.gov)

Andy Shreve (shreve@lanl.gov)



1-10 nm

motor proteins:
molecular biology & genetic engineering



Aggregated receptors

10 -100 nm

biomimetic interfaces:
complexation chemistry, molecular modeling, & self-assembly

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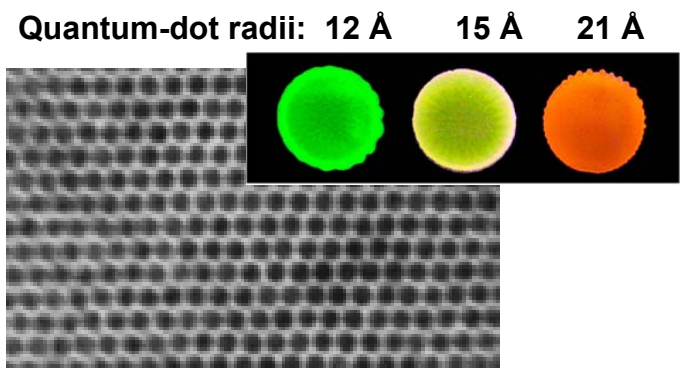
CINT Scientific Thrust Areas

- **Nanophotonics and Nanoelectronics**

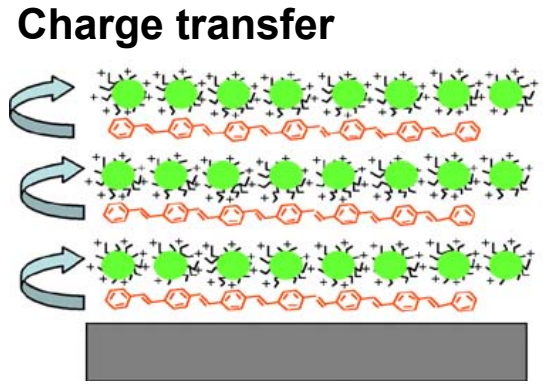
  » **Control of electronic and photonic properties of nanostructured materials**

Victor Klimov (klimov@lanl.gov)

Jerry Simmons (jsimmon@sandia.gov)



Tunable electronic spectra in Q-dot solids



Organic/inorganic hybrid structures

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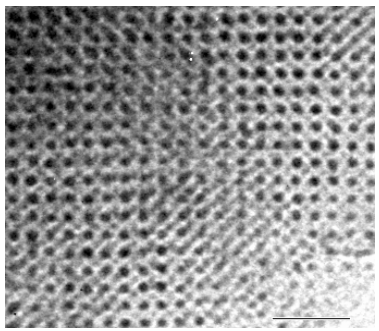
CINT Scientific Thrust Areas

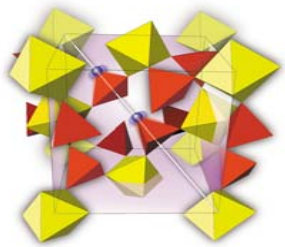
- **Complex Functional Nanomaterials**
  - » **Nanoscale materials synthesis, assembly, interfacial science, self-assembly processes and structure-function characterization**

Duane Dimos (dbdimos@sandia.gov)
Toni Taylor (ttaylor@lanl.gov)



Self-Assembly to form 3-D nanostructures

Unique functionality is often due to complex crystal structures



Nanometer Unit Cell- ZrW_2O_8

Underconstrained lattice – leading to Negative Thermal Expansion

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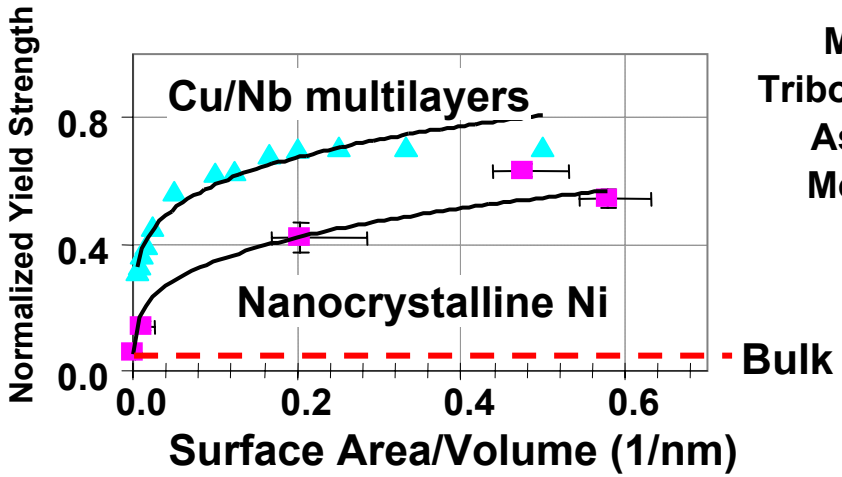
CINT Scientific Thrust Areas

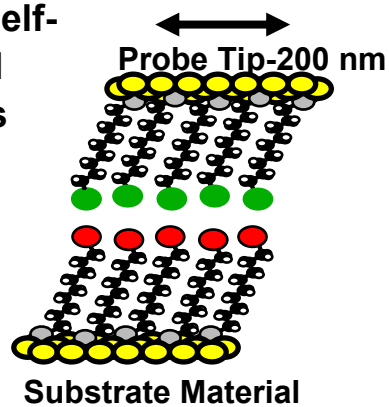
- **Nanomechanics**
  - » **Mechanical behavior of nanostructured materials and devices**

Mike Nastasi (nasty@lanl.gov)
Charles Barbour (jcbarbo@sandia.gov)



New Deformation Mechanisms for High Interface/ Volume Ratio

Molecular Tribology of Self-Assembled Monolayers



New Tools: Interfacial Force Microscope

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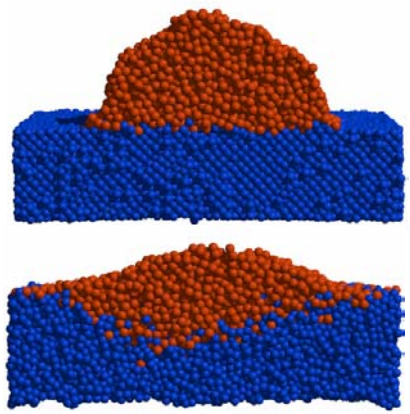
CINT Scientific Thrust Areas

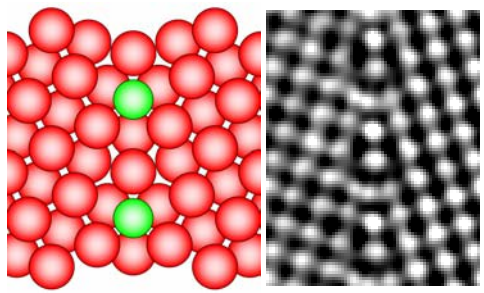
- **Theory and Simulation**

  » **Capabilities and expertise in theory, modeling and simulation of nano- and meso-scale materials**

Eliot Fang (hefang@sandia.gov)
Tony Redondo (redondo@lanl.gov)



Wetting Phenomena



Impurity Segregation at GB

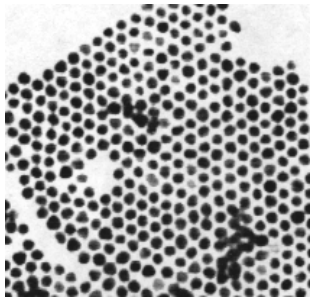
Science Programs – Key Challenges

- **Integration of top-down fabrication with bottom-up assembly to create new classes of functional materials**
- **Control of optical and electronic energy transfer coupled across multiple length scales**
- **Coupling of mechanical forces across nano, micro and larger length scales, including control of fluidic transport**
- **Integration of biological and synthetic materials, and control of the interface between biological and non-biological components**

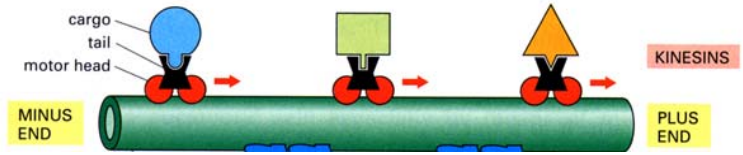
Science Programs Built to Address Challenges

- **Integrate teams across disciplines and thrust areas**
- **Support the capabilities that are available for users at jump-start**
- **Examples of scientific directions users can interact with**
- **Also see poster session**

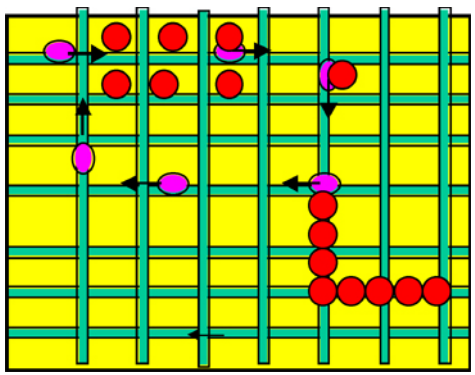
Assembly and Actuation of Nanomaterials Using Active Biomolecules



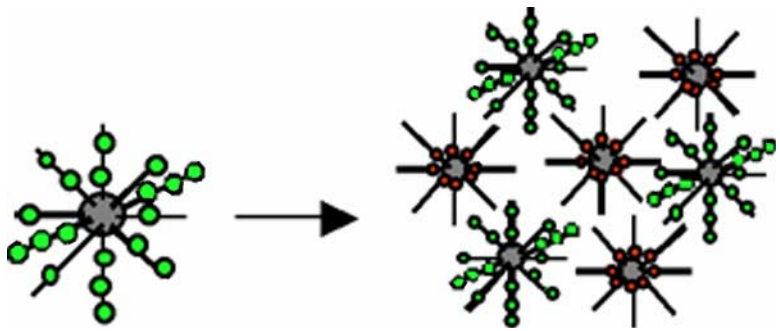
Nanoparticles



Motor Proteins



Nanowires with Programmable Interconnects



Tunable QD Arrays

- Nano-Bio-Micro Interfaces
- Nanophotonics/Nanoelectronics
- Complex Functional Nanomaterials
- Nanomechanics

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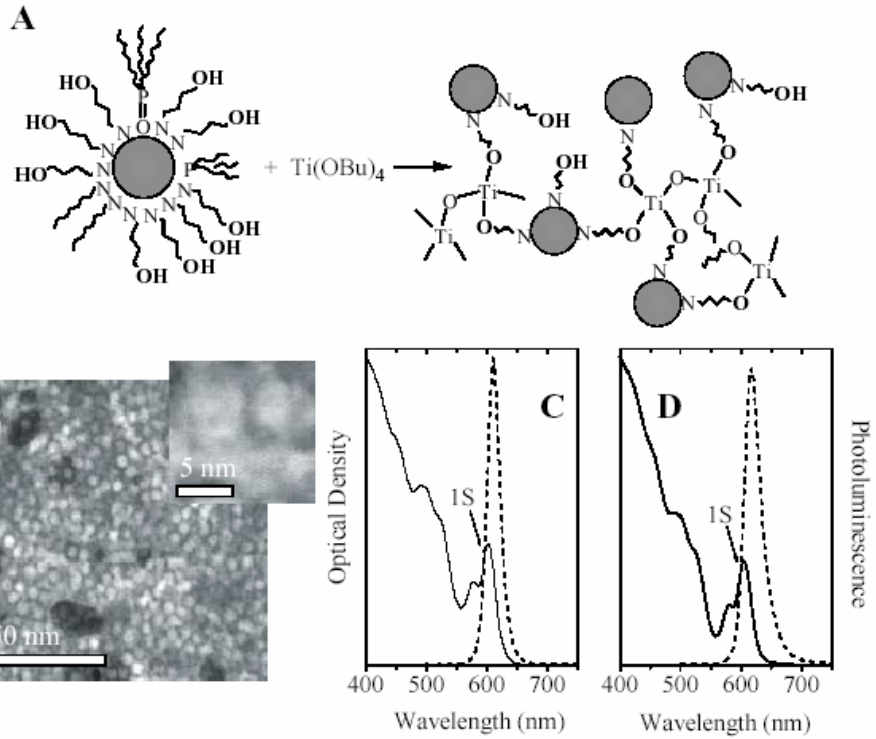
Quantum-dot Nanocomposite Materials For Non-linear Optics and Lasing

■ Partial surface exchange followed by a reaction with a titania precursor

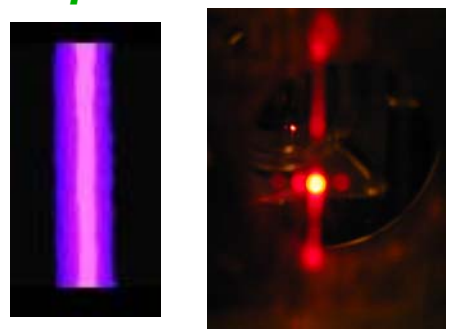


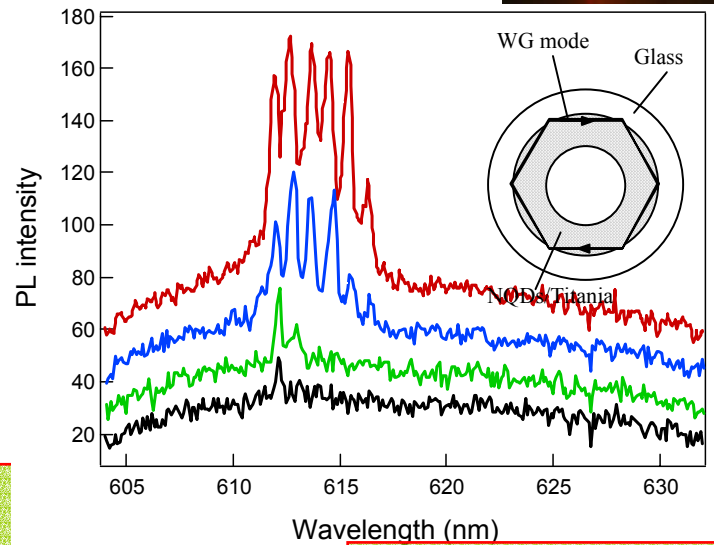
Filling factor: 15 - 20%, n = 2.1
Modal gain: 100 - 200 cm^{-1}

M. A. Petruska, A. V. Malko, P. M. Voyles, and V. I. Klimov, *Adv. Mater.* **15**, 610 (2003)

■ Sol-gel composites are readily combined with photonic structures

Q-dot Microring Laser





A. V. Malko *et al.*, *Appl. Phys. Lett.* **81**, 1303 (2002)

- **Nanophotonics/Nanoelectronics**
- **Complex Functional Nanomaterials**

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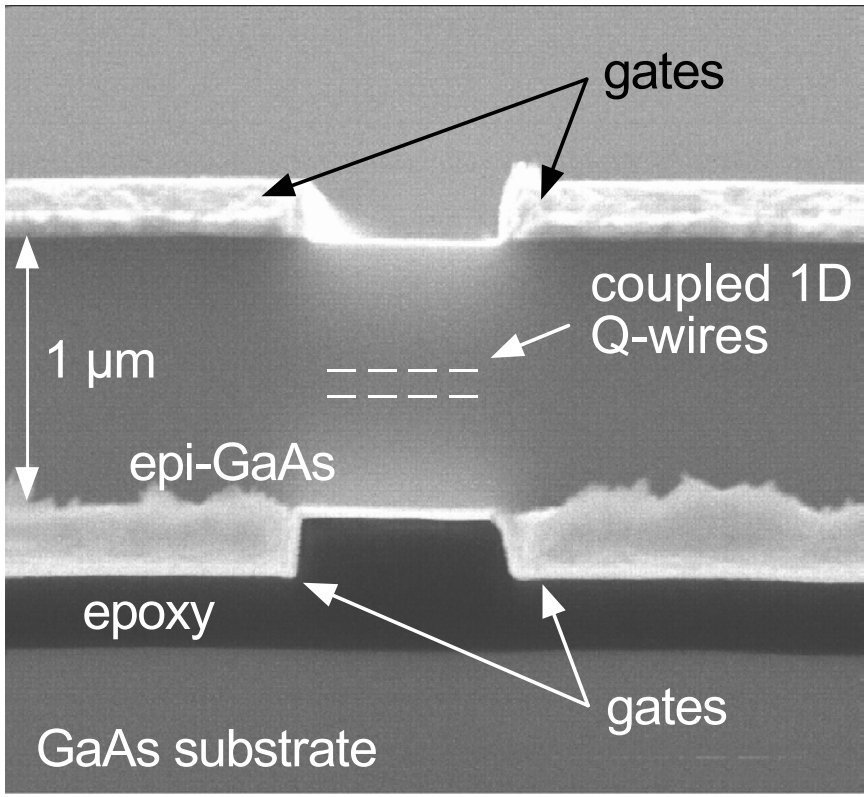
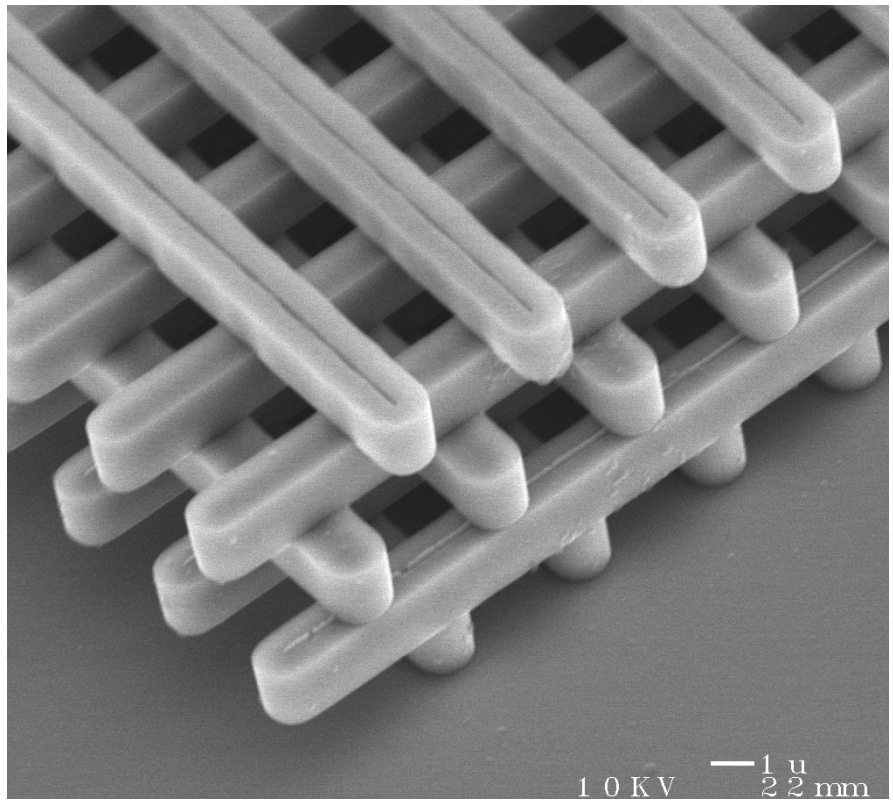
Fabricated Electronic and Photonic Architectures



Correlated states in coupled Q-wires



Tunable photon states in photonic structures

- **Nanophotonics/Nanoelectronics**
- **Nanomechanics**
- **Theory and Simulation**

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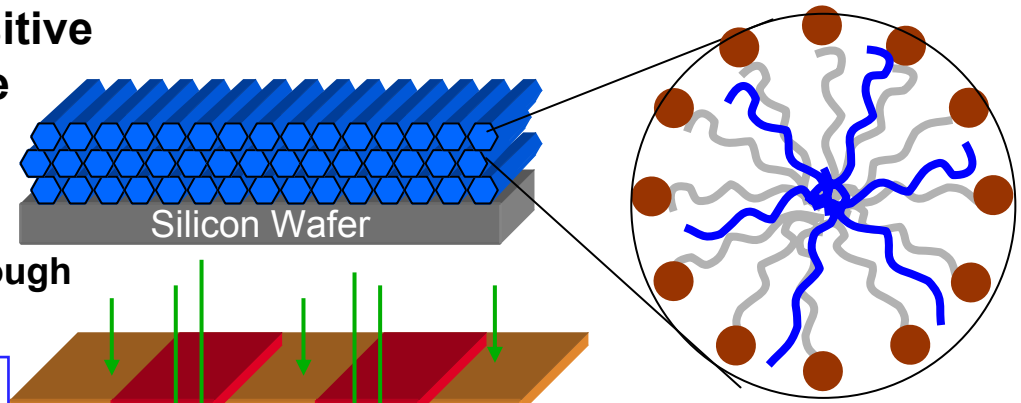
Thin-Film Self-Assembly of Nanostructured and Composite Materials

Self assembly of photosensitive silica/surfactant mesophase containing a photoacid generator (PAG)



incorporation of the PAG in the micelle

Selective UV exposure through mask

- **Nano-bio-micro Interfaces**
- **Complex Functional Nanomaterials**
- **Theory and Simulation**

Compartmentalized production of acid

Selective etching of unexposed mesostructure

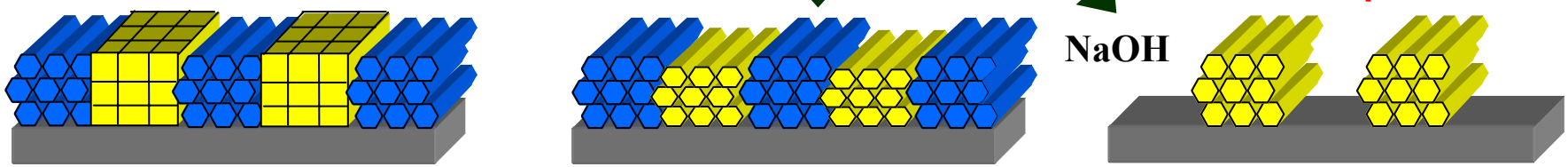
(Doshi et al., Science, 2000)

Heat treatment

T > 125 °C

NaOH

Patterned Thin Film Mesophase



Nanostructural Lithography

J. Brinker, D. Doshi

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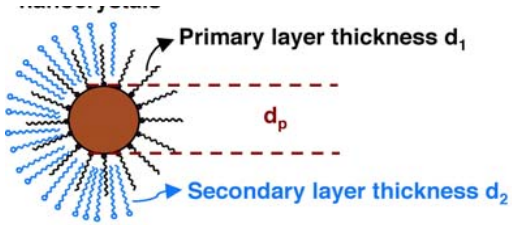
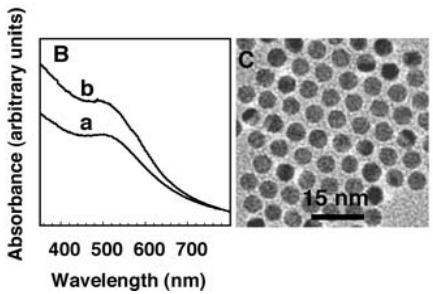
Processing Methods for Nanomaterials

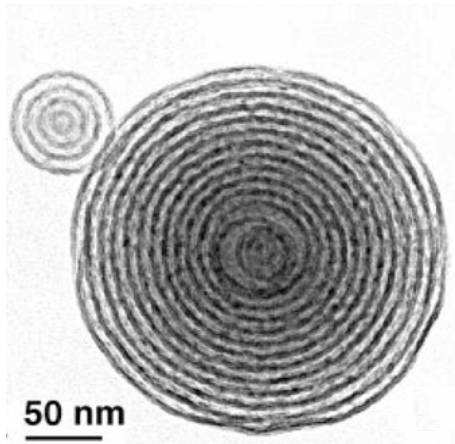
Race to develop new materials/applications - What will be the bottom line in a few years?

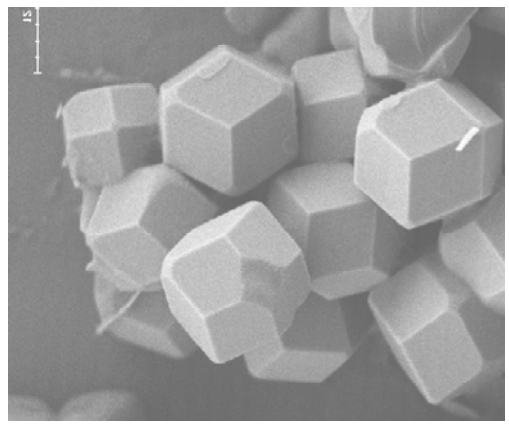
- **Scalability?**
- **Reliability?**
- **Quality control?**
- **Functionality?**

- **Complex Functional Nanomaterials**
- **Nanomechanics**
- **Theory and Simulation**









J. Liu, J. Voigt, T. Boyle, J. Brinker

Challenge: Science-based, predictive, robust, scalable processing of nanomaterials

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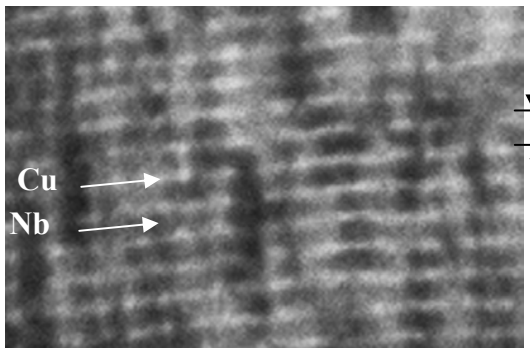
Mechanical Behavior of Nanomaterials and Nanostructures

- **Mechanical properties of nanostructured materials**

- Complex Functional Nanomaterials
- Nanomechanics
- Theory and Simulation

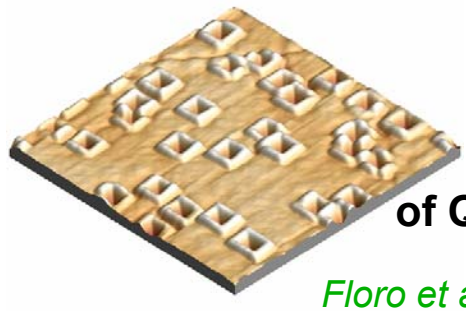


Nanostructures Providing Extreme Strengths

Misra et al., LANL

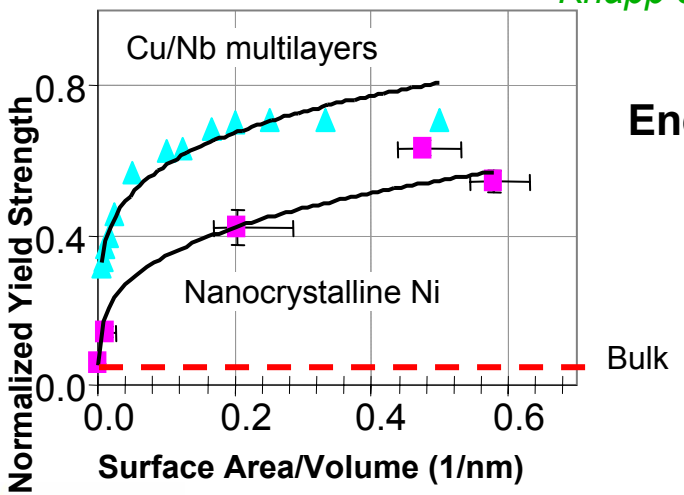
Knapp et al., SNL

roperties nostructures

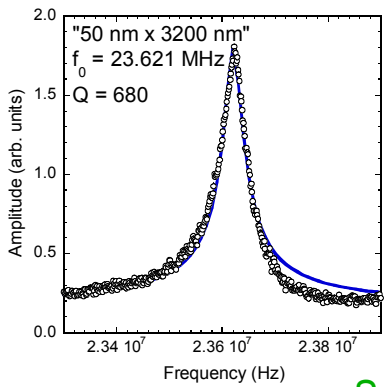


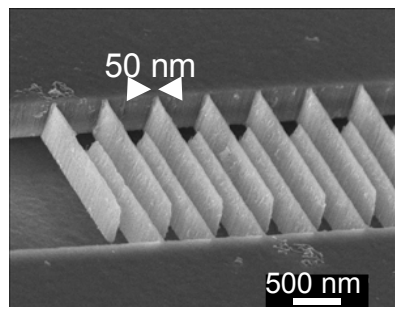
Strain-layer Self-assembly of Quantum Dot Molecule

Floro et al., SNL



Energy Dissipation in Nanomechanical Oscillators





Sullivan et al., SNL

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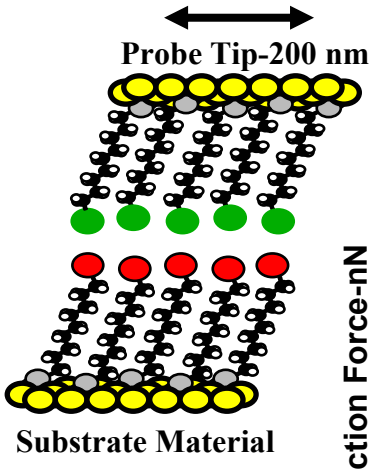
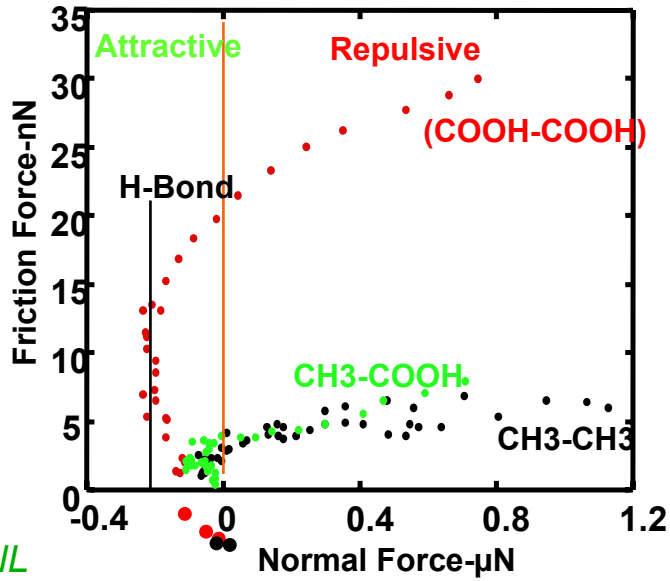
Surface & Interface Properties, New Techniques and Modeling

- Mechanical properties derived from surface and interface effects
- Techniques for in-situ mechanical measurement and modeling

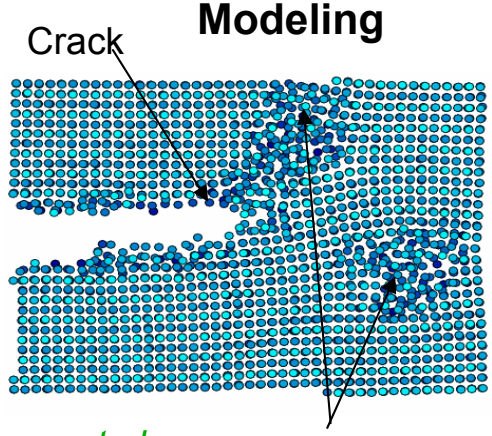


Molecular Level Adhesion and Friction



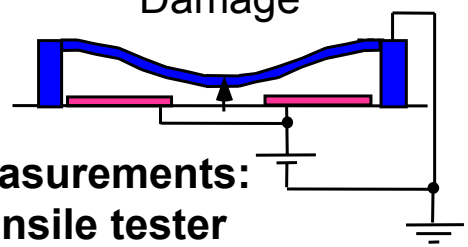
Houston et al., SNL

Deformation Modeling



Swadener et al., LANL

Radiation Damage



In-situ Measurements: MEMS tensile tester

Hearne, de Boer, et al., SNL

- Nano-bio-micro Interfaces
- Complex Functional Nanomaterials
- Nanomechanics
- Theory and Simulation

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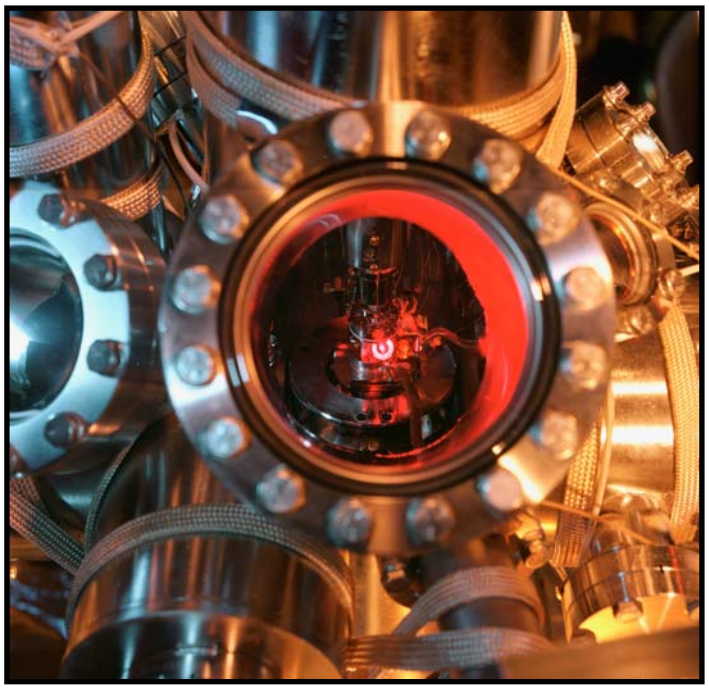
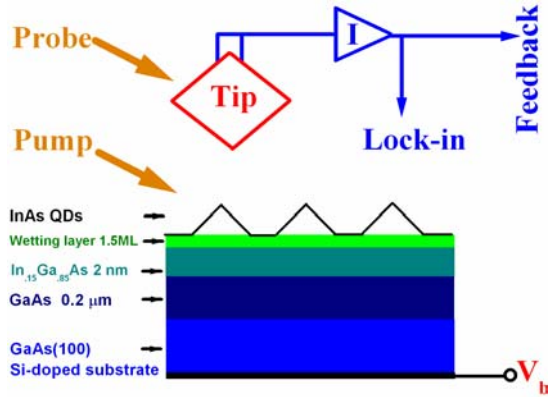
Capability Development: Ultrafast STM

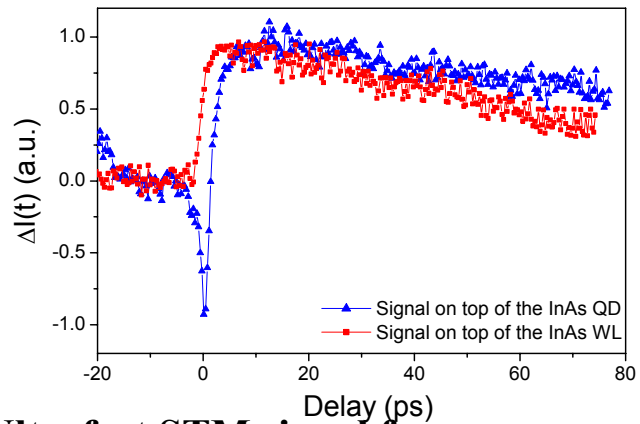
Spatial and temporal atomic-scale imaging of real space processes and excitations with 20 nm/2 ps resolution.



- **Complex Functional Nanomaterials**
- **Theory and Simulation**

Relaxation dynamics in InAs/GaAs SAQDs





Ultrafast STM signal from InGaAs SAQD: permits investigation of single quantum dot photoconductivity

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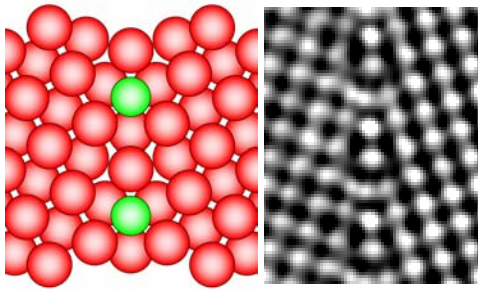
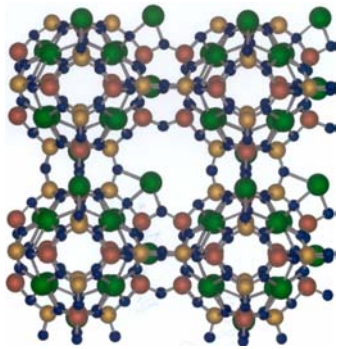
Atomistic and Mesoscopic Approaches for Theory and Simulation

Impurity Segregation at GB

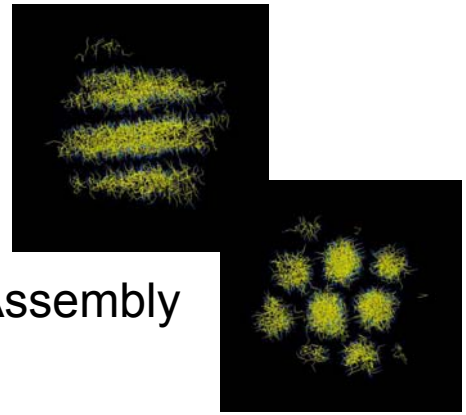


Calculated Exp: HRTEM

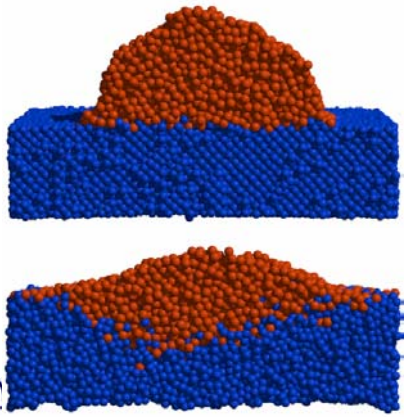


Quantum & Atomistic

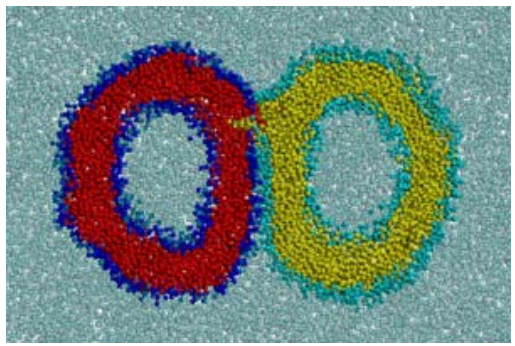
Self Assembly



Nanodroplet at Different Temperatures

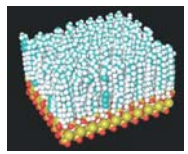


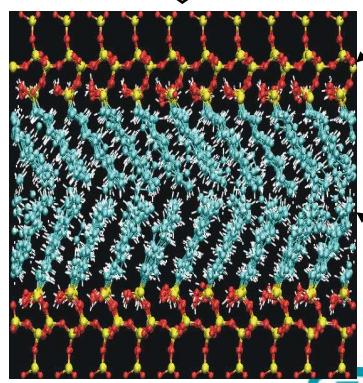
Membrane Fusion



Fusing liposomes

Reliability of MEMS Coating





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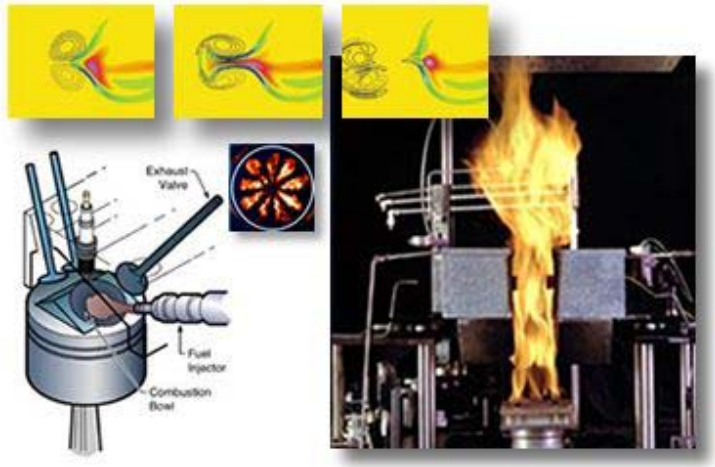
CINT Connections to National User Facilities

Los Alamos Neutron Science Center
(http://lansce.lanl.gov/)



Combustion Research Facility
(http://www.ca.sandia.gov/CRF/)

National High Magnetic Field Laboratory
(http:/www.lanl.gov/mst/nhmfl/)

Additional connections to national laboratory facilities through gateway operations

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User Workshop Poster Session

- **Thirty posters representing ongoing science and thrust area capabilities**
- **Posters representing national user facilities, library resources and overall CINT program**
- **Opportunity to discuss science and develop connections with laboratory scientists (poster presenters and others)**