Overview and needs for electron microscopy at CFN

Lihua Zhang

E. Sutter, J. Wall and Y. Zhu

Center for Functional Nanomaterials
Brookhaven National Laboratory

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Center for Functional Nanomaterials
Brookhaven National Laboratory

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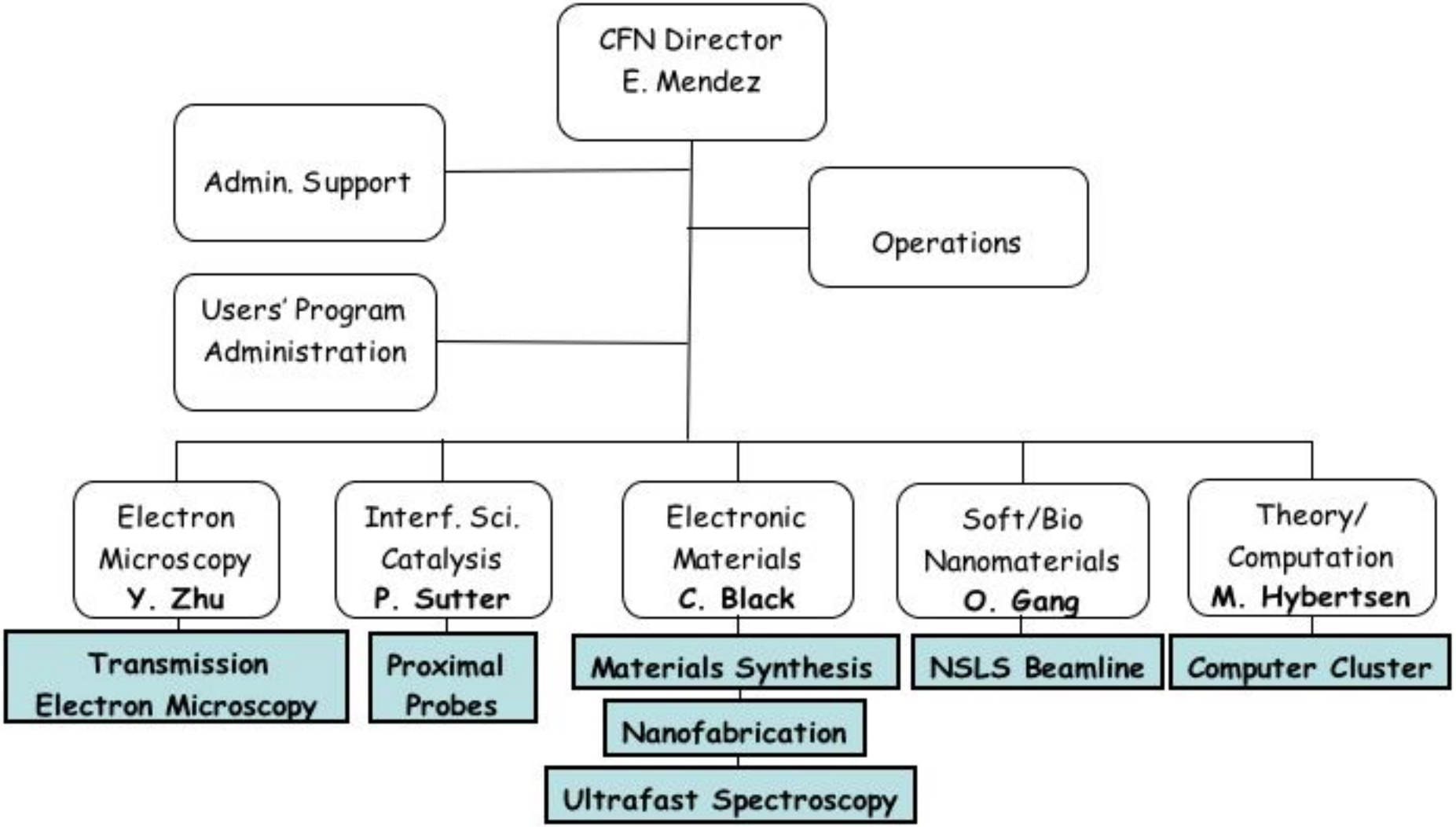
Outline

- Overview of CFN
- CFN user program
- TEM facilities at CFN
- Needs for TEM facilities at CFN

Overview of CFN and CFN user program

Organization Chart and Facilities Management



The CFN Project at a Glance

2008

2007

2006

2005

← Operations Review (5/7-9/08)

← READY for OPERATIONS

CD-4b Passed (3/21/08)

← Last equipment received

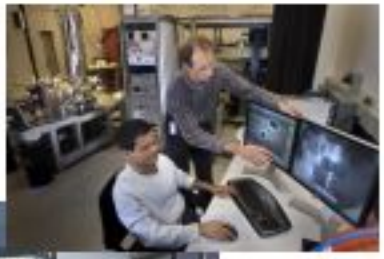
Green Building: Silver

← Ribbon-cutting (05/21/07)

← First equipment received

CD-4a Passed (03/13/07)

← Construction Starts (CD-3)



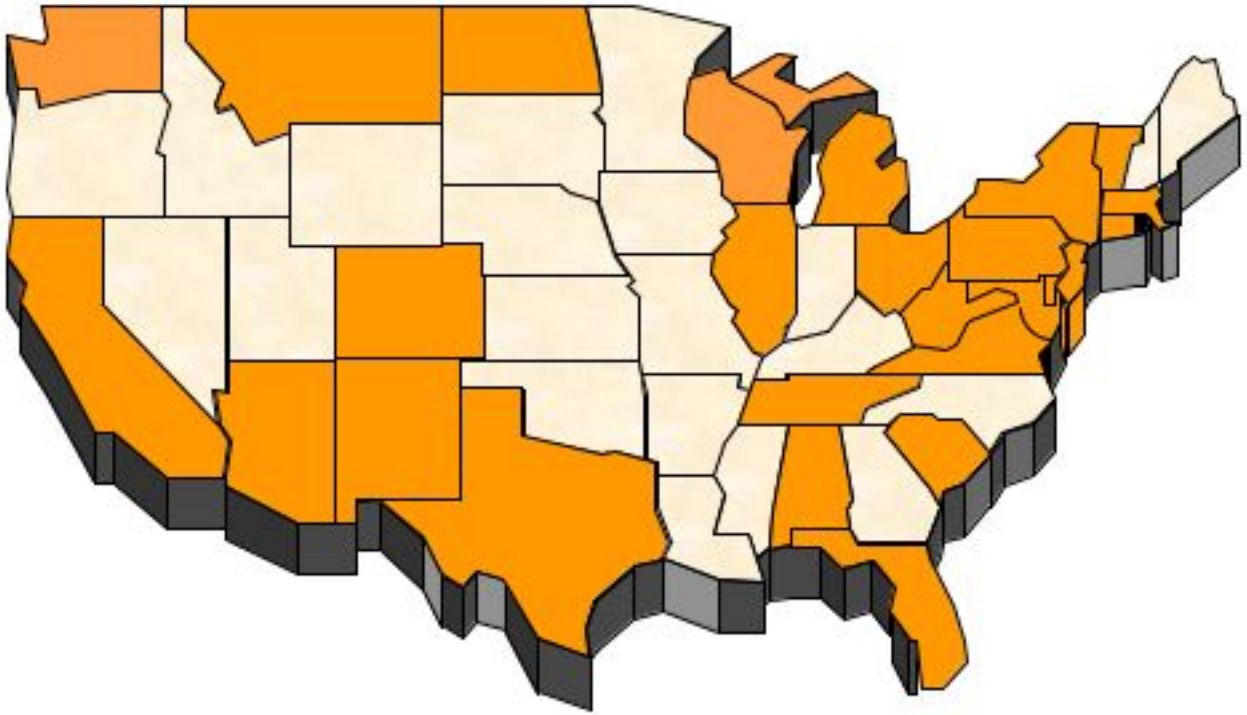
CFN User Program

CFN Goal: To become a resource for the nanoscience community of the Northeastern US and beyond

Characteristics

- **Free access to facilities and expertise for non-proprietary research**
  academia, companies, national laboratories
- **Based on peer-reviewed proposals** (266 proposals by 04/30/2008)
- **Three proposal cycles per year**
  regular access, rapid access
- **Suitable to a wide range of users' needs**
  from straightforward, one-time measurements
  to complex, extended experiments

Where CFN proposals come from



69.8% Universities
20.8% National Labs
8.7% Foreign 0.7% Others

Canada
France
Germany
Hungary
Israel
Italy
Thailand
United Kingdom

Alabama - 1
Arizona - 3
California - 2
Colorado - 4
Connecticut - 9
Delaware - 7
Florida - 1
Illinois - 2
Massachusetts - 4
Maryland - 4
Michigan - 3
Montana - 2
North Dakota - 2
New Jersey - 19
New Mexico - 3
New York - 150
Ohio - 2
Pennsylvania - 8
S. Carolina - 7
Tennessee - 2
Texas - 3
Virginia - 1
Vermont - 3
Washington - 1
Wisconsin - 1
West Virginia - 1

Overview and needs for electron microscopy at CFN

Overview of TEM facility at CFN

JEOL 2100F
Analytical TEM/STEM

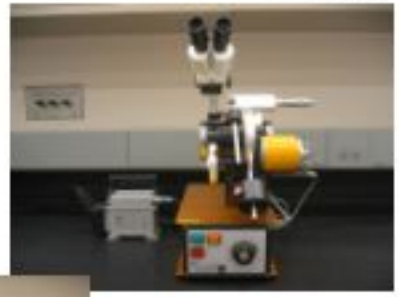
Hitachi HD-2700
STEM

FEI Titan 80-300
E-TEM

Installation finished Feb. 2008.

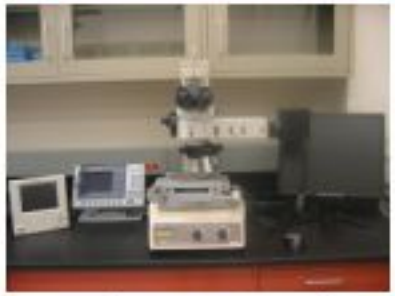
Overview of TEM facility at CFN

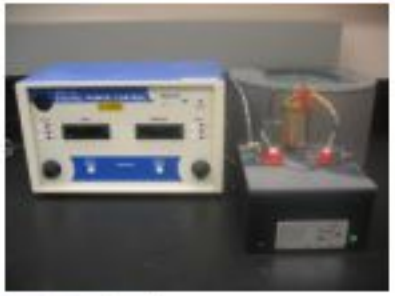
Cutting



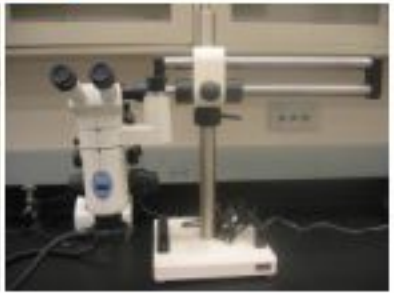
Polishing

Dimpling

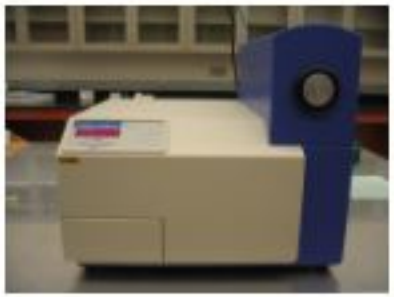




Measuring



Ion Milling



Jet Polishing

Plasma Cleaning

Research goals and approaches

Research goals:

- Emphasis will be on catalysis, nanoelectronics and nanostructured materials

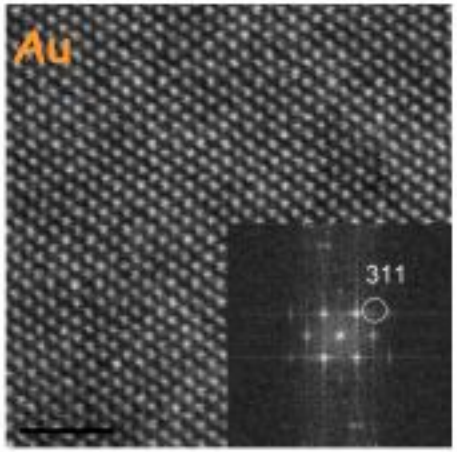
Approaches:

- Quantitative microscopy emphasizing on spectroscopy imaging and in-situ microscopy
- Coupling experiments with calculations
- Coupling users' science with our own research projects

Resources :

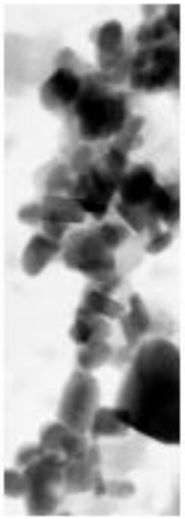
The workhorse instrument : JEOL JEM2100F

- Analytical TEM/STEM
- Energy dispersive x-ray spectroscopy
- Various stages for in-situ experiments
- 0.2nm spatial resolution
- ±40° stage tilt



STEM

BF



DF

$LiCoO_2$

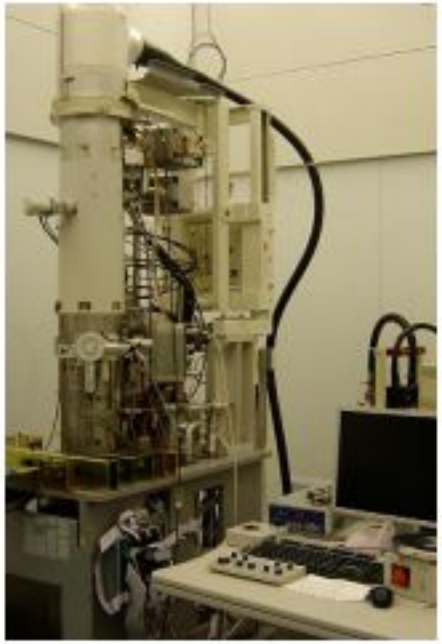
Clare Grey, Stony Brook

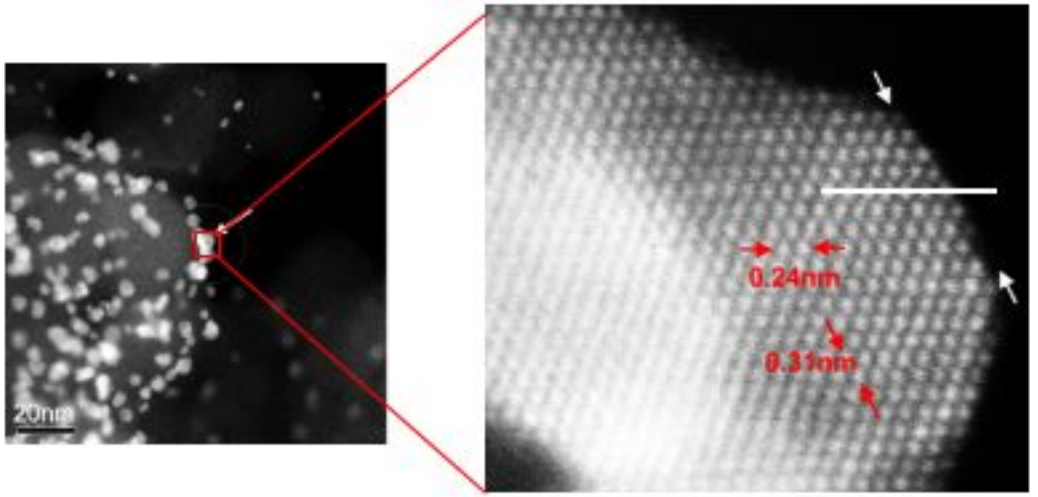
Resources :

Pd(core)-Pt(shell) nanoparticle for fuel-cell applications

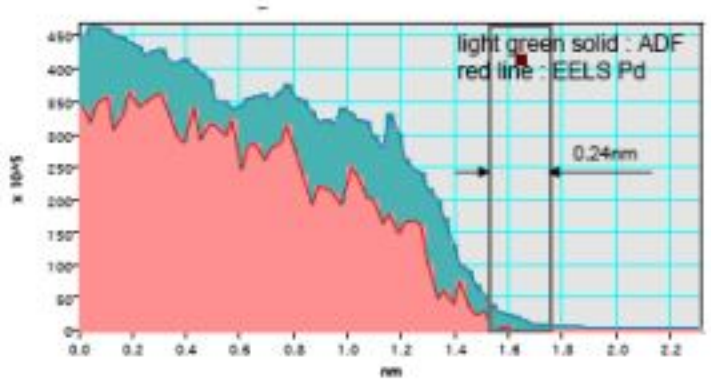
collaboration with J. Wang, Chemistry

The dedicated instrument :
Hitachi HD2700C STEM





- dedicated STEM
- probe corrector
- cold FEG
- Enfina EELS
- electron diffraction
- 5-detectors
- 1A probe size

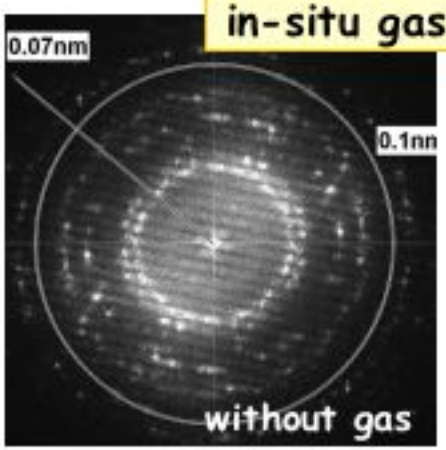


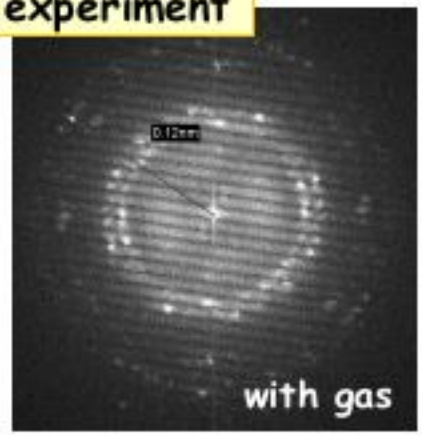
Resources :

The dedicated instrument :
FEI Titan environment TEM

- imaging corrector
- in-situ gas reaction
- EELS/chemical mapping
- Lorentz microscopy
- holography
- tomography

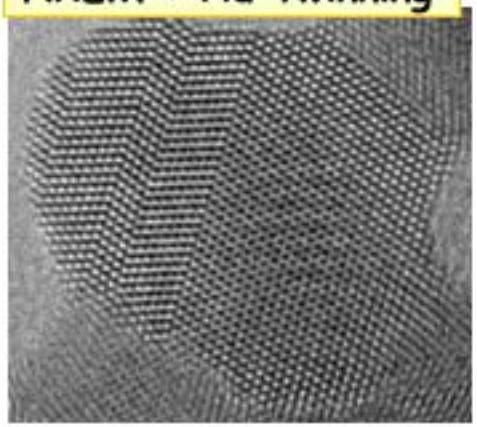
in-situ gas experiment

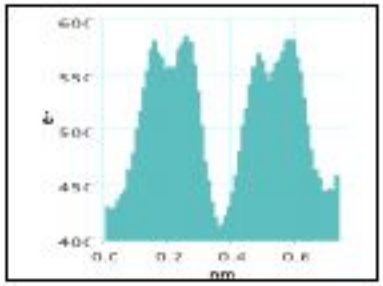




HREM : Si d_{112}~0.78A

HREM : Au twinning





Needs for electron microscopy at CFN

Facility and staffing

- Energy filter for JEOL 2100F
- Computer lab for simulations
- Scientist for FEI Titan
- Technician for sample prep lab

Remote Operation of electron microscopes

Remote Access for Targeted Simulations

- Applications that address recurrent needs
  Tool to interpret TEM images and data
- Web-enabled data entry, execution and display of results
- Accessible remotely to badged users

Remote Training

- Web-based videos with operational procedures
- Online operation manuals/instructions

Our needs from the TEAM instrument

- **Better spatial resolution**

  Atomic structure, defect, interface from high-index orientation

- **Better energy resolution**

  Spatially resolved spectroscopy, spectroscopy imaging

- **In-situ measurements**

  structural evolution and physical response under various environments, such as change in temperature, electric and magnetic field, mechanical stress

- BNL scientists are eager to have access, including remote access, to TEAM instruments
- We have been working with TEAM scientists to evaluate STEM performance on the TEAM instruments
- We are evaluating the pros and cons of aberration corrected JEOL, Hitachi, FEI microscopes at BNL

Summary

- User-oriented research center striving to become world- class resource
- **In full operations** since March 21, 2008
- Blooming high-quality User Program and enthusiastic staff **ready to train/help/work with users**
- **State-of-the-art equipment** for advanced nanoscience research
- **Comprehensive** suite of tools for TEM sample prep
- Planned **facilities enhancement and staffing**
- Need **remote access** to TEAM instruments


BNL
Brookhaven
National Laboratory
OPERATED BY BROOKHAVEN SCIENCE ASSOCIATES UNDER CONTRACT WITH THE UNITED STATES DEPARTMENT OF ENERGY

Thank you

Distribution of User Projects

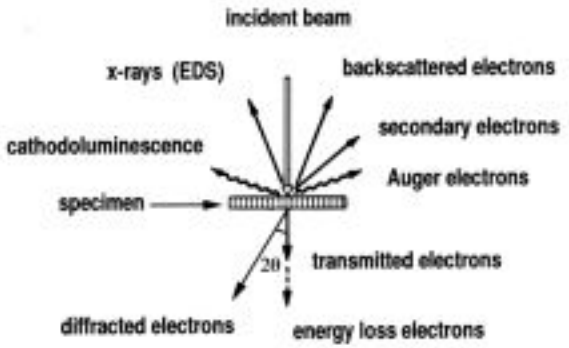
266 proposals received and reviewed (4/30/08)

Facility	# of Proposals Reviewed	# of Proposals Approved	Approval Rate
Electron Microscopy	90	66	73%
Nanofabrication	72	70	96%
Materials Synthesis	39	38	97%
NSLS	32	23	72%
Proximal Probes	20	17	85%
Theory & Computation	8	8	100%
Optical Spectroscopy	5	5	100%
TOTAL	266	227	85%

Scientific directions

Electron Scattering Science :

quantitative electron microscopy



Research areas and questions to answer:

Local atomic arrangement – how atoms are arranged ?

- nanocrystallography (electron diffraction)
- displacement measurement (HREM, geometric phase analysis)
- diffractive imaging (aperiodic objects)

Chemical nature - what are the chemical species, bonding states and associated field ?

- chemical mapping (spectroscopy imaging, EELS+EDX)
- electrostatic and magnetic potential mapping (holography & phase retrieval)

Functional response –what is structure-property response under various environments ?

- in situ microscopy : variation in temperature, gas, and field

Scientific directions

II. Application Science :

To understand the origin of microscopic properties and the role of individual atoms in materials

A) Catalysis
- Water-gas-shift reaction
- Nanoscale liquid-solid transition & particle phase diagram
- TiO_2 for solar energy conversion

B) Nanostructured materials
- Structure of multi-wall CNTs and molecule-encapsulated CNTs
- Strain & field mapping in nanoparticles and devices
- Understanding toxicity of nanoobjects

Summary

- Knowledge of structure and chemistry at the atomic scale is a prerequisite for advances in modern materials science and nanotechnology.

- Advanced electron microscopy can provide such knowledge that will enable us not only to understand, but also to control the physical and chemical behavior of nanostructured materials.

- Our objective in microscopy focuses on identifying nanoscale structure-property relationships of energy related materials by employing state-of-the-art instruments.

- We emphasize technique development that will enhance our facility capabilities for our own research as well as your users'.