

# Center for Functional Nanomaterials



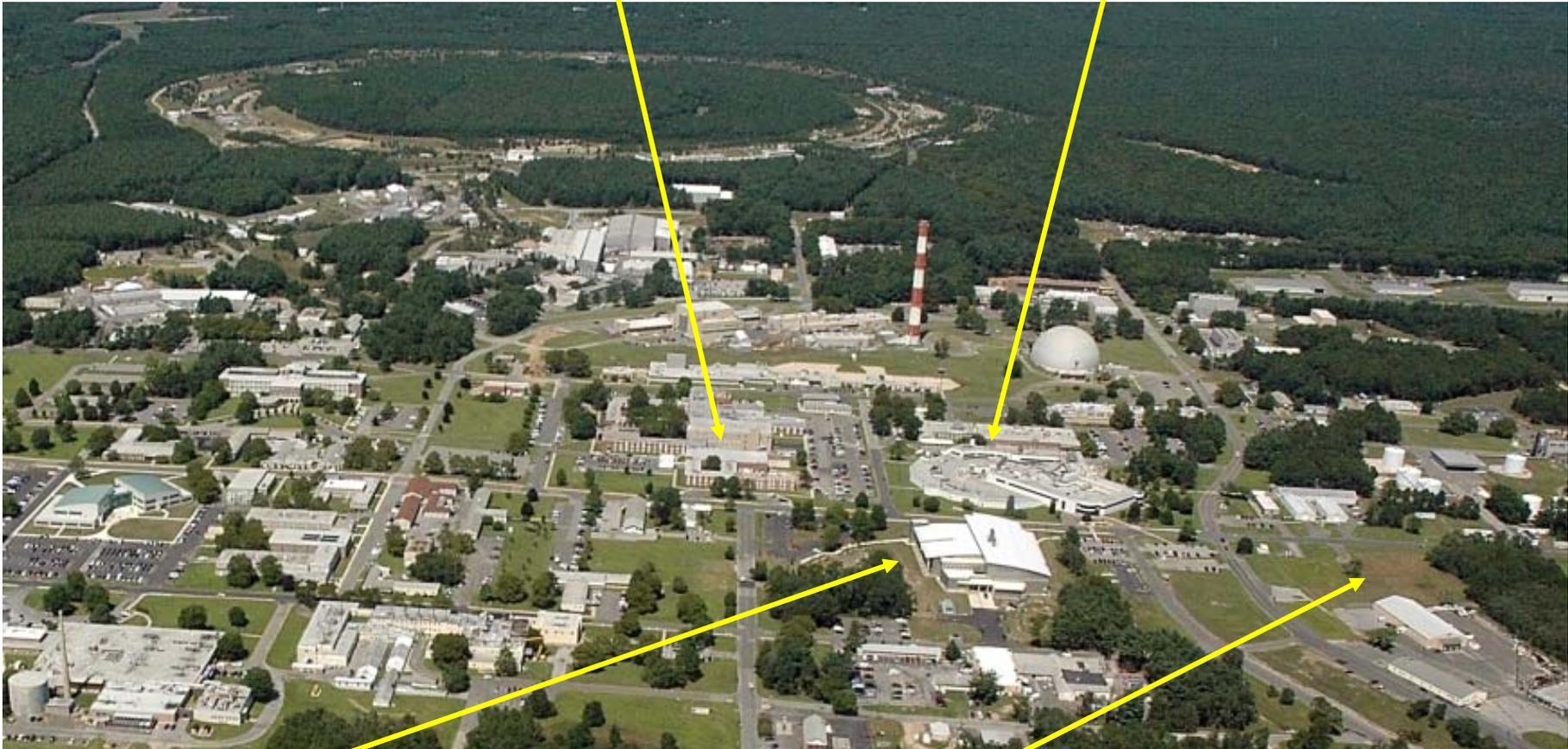
**Emilio Mendez**

BESAC Meeting  
July 24, 2008

# Major Facilities for Nanoscience at BNL

BlueGene

NSLS



CFN

NSLS-II  
(future)

# A User-oriented Nanoscience Research Center

Goal: To become a world-class hub of nanoscience research

## Staff-driven Research

Energy-related

- interf. & catalysis
- photovoltaics
- soft & bionanomat.

## User-driven Research

- training
- expert support
- collaborations

## FACILITIES

Technique and Tool Development

## Mission

To contribute to the solution of the country's critical challenges by

- 1) Discovering, understanding, and exploiting energy-related nanomaterials
- 2) Enabling the community of external users develop their top-quality nanoscience projects

$$\left[ \begin{array}{l} \text{high concentration} \\ \text{of state-of-the-art} \\ \text{nanoscience tools} \end{array} \right] + \left[ \begin{array}{l} \text{top scientists} \\ \text{in nanoscience} \end{array} \right] = \text{UNIQUE FACILITY}$$

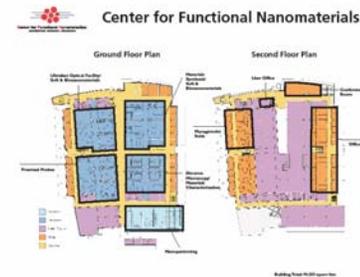
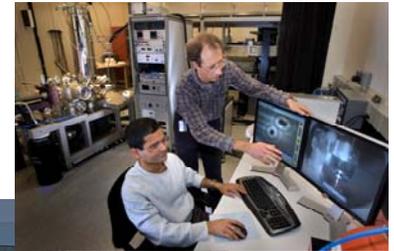
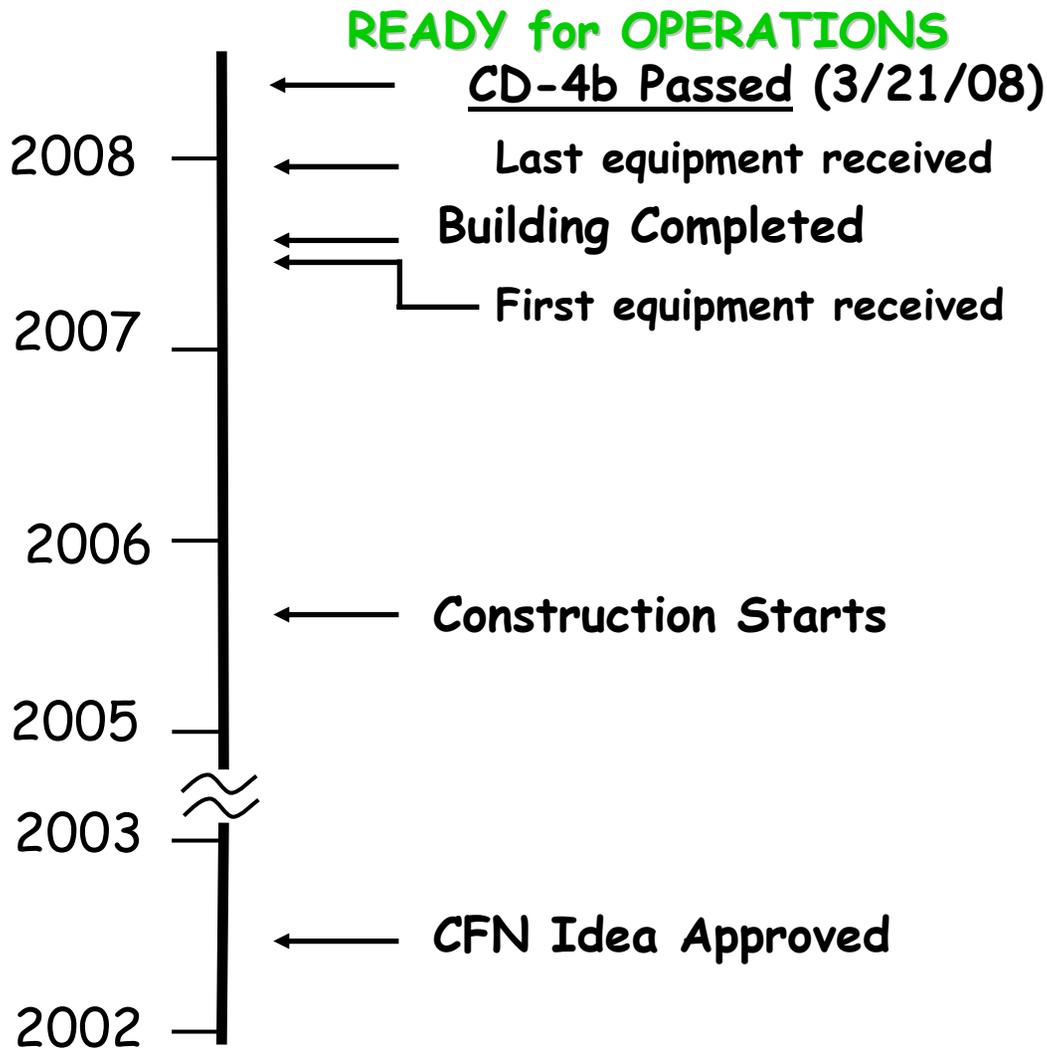


# Outline

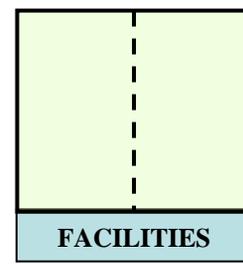
- CFN Timeline
- Major Facilities
- User Mission
- Scientific Mission
- Staff
- Interactions of the CFN with Other DOE Facilities
- Engaging the Science Community
- Challenges



# The CFN Project at a Glance



# Facilities



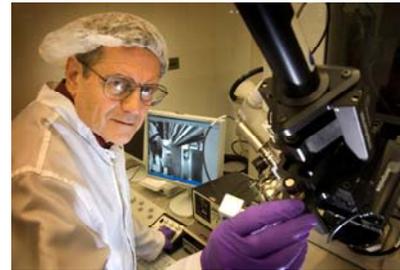
TEM



## Characteristics

- **State-of-the-art** nanoscience-research equipment
- **Comprehensive** suite of tools
- **Balance** between equipment requiring straightforward training with equipment demanding extensive training and expert knowledge

Materials Synthesis  
Nanofabrication  
Trans. Elect. Microscopy  
Proximal Probes  
Ultrafast Spectroscopy  
NSLS Beamline(s)  
Computer Cluster



Dual-beam FIB



SEM



CVD Reactor

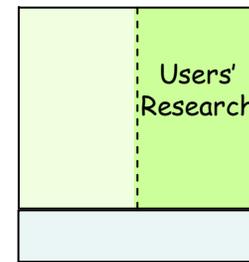


Low-T Nanoprobe



# User Program

---

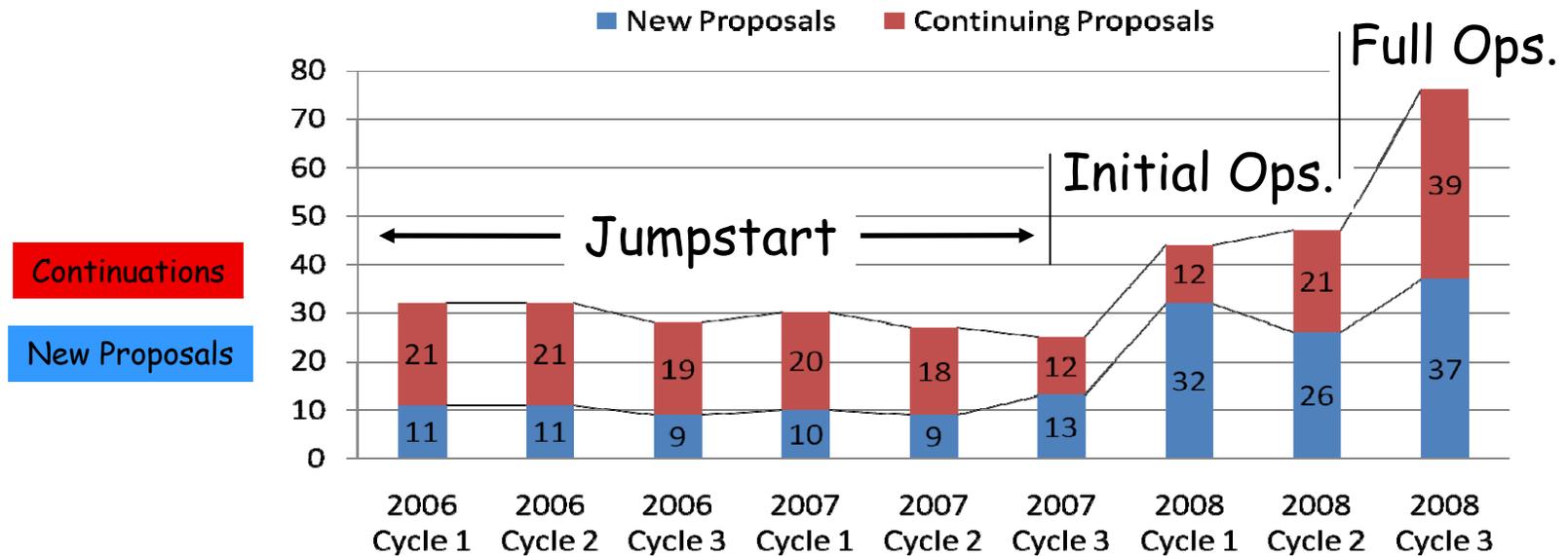


**CFN Goal:** To become a resource for the nanoscience community of the Northeastern US and beyond

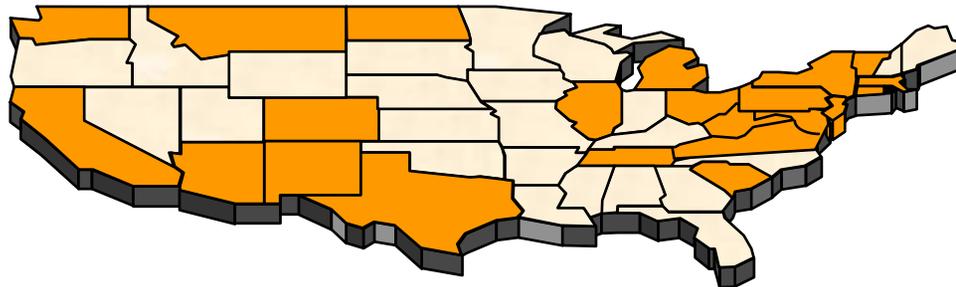
## **Characteristics**

- **Free access to facilities and expertise** for non-proprietary research  
academia, companies, national laboratories
- Based on **peer-reviewed proposals**
- **Three proposal cycles per year**  
regular access, rapid access
- **Full-cost recovery for proprietary work**
- **Suitable to a wide range of users' needs**  
from straightforward, one-time measurements  
to complex, extended experiments

# Evolution of User Proposals



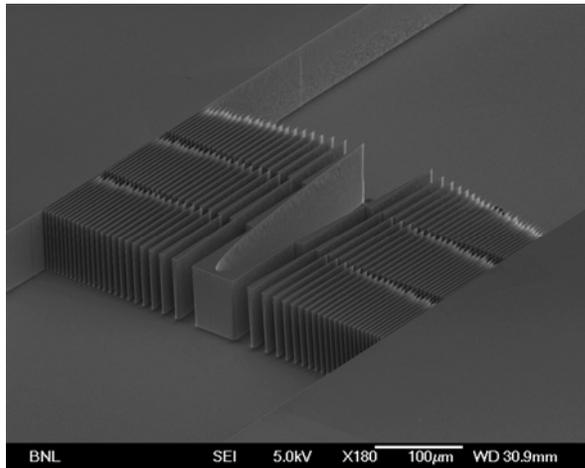
306 proposals received so far



# Examples of User Projects

## Fabrication of Kinoform Lenses for Hard X-ray Focusing

K. Evans-Lutterodt (NSLS/BNL)  
and A. Stein (CFN)

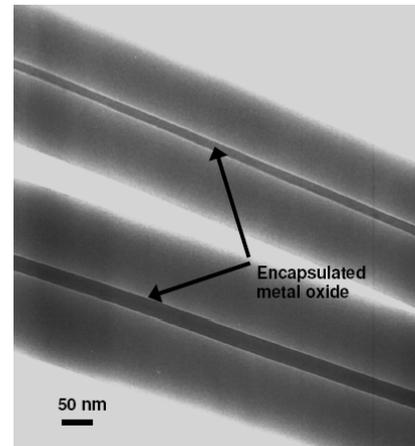


Lenses fabricated using electron beam lithography and deep silicon etching.

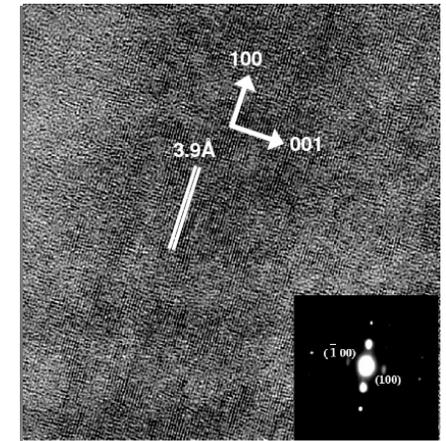
K. Evans-Lutterodt et al. Phys. Rev. Lett. **99**, 134801 (2007)

## Electrospun Single Crystal MoO<sub>3</sub> Nanowires for Sensing Probes

P. Gouma, K. Kalyanad., and A. Bishop  
(Stony Brook University)



TEM image of a as-spun polymer-metal oxide nanocomposite



HRTEM image of a MoO<sub>3</sub> nanowire on a Si<sub>3</sub>N<sub>4</sub> grid, showing growth direction

P. Gouma et al., J. Mater. Res. 21, 2904 (2006)

# Scientific Mission



## Scientific Themes

- electronic materials / photovoltaics
- interface science & catalysis
- soft & biomaterials

## Cross-cutting Programs

- electron microscopy
- theory and computation

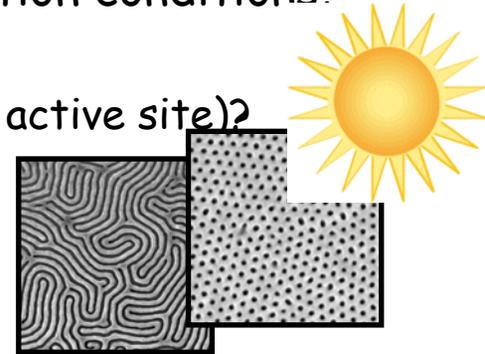
- are relevant to the energy challenge
- address important scientific questions
- are synergistic with BNL's core programs
- take advantage of BNL facilities



# Basic Questions Being Addressed

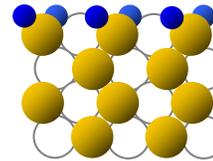
## Scientific Questions

- What is the active phase in a catalysis system under reaction conditions? (time, pressure, temperature)
- What determines reactivity ( $S/V$  ratio, electronic structure, active site)?
- How can photovoltaic physical processes be optimized? (light collection, exciton diffusion and recombination)
- How to better capture the solar spectrum?
- How to assemble nano-objects in large well-ordered 3D structures?
- How does addressable recognition compete with non-specific interactions?



## Approach

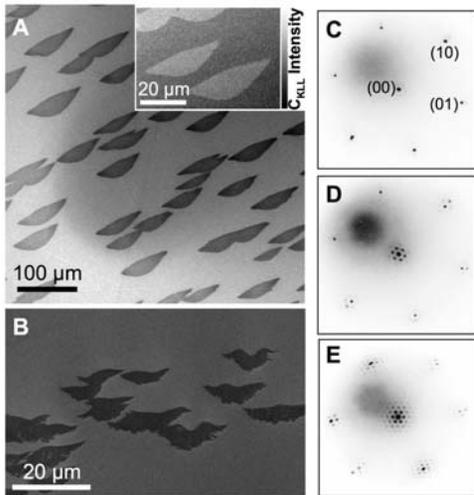
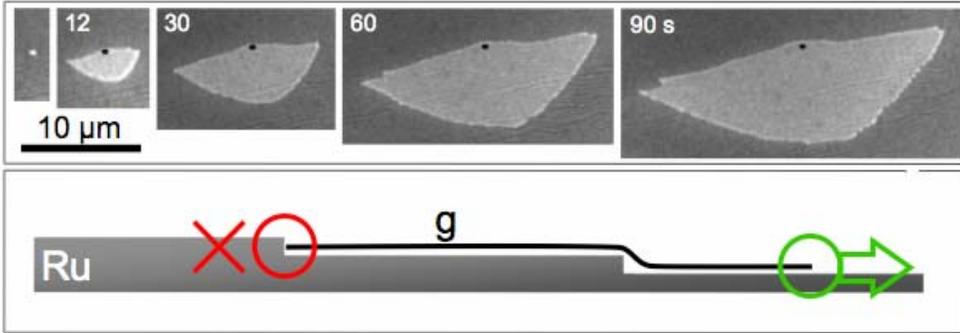
- *Atomic-scale precision* in model systems
- *In-situ* observation of dynamic processes. under reaction conditions
- Nanostructured PV devices based on low-cost (organic) materials
- Assembly methods for large-area patterning at nm length scales
- Exploitation of properties of DNA and proteins
- Development of new techniques and tools



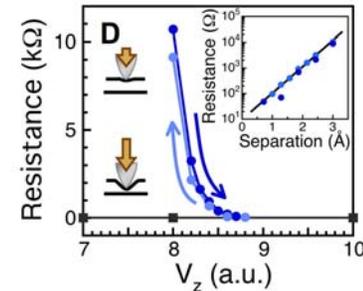
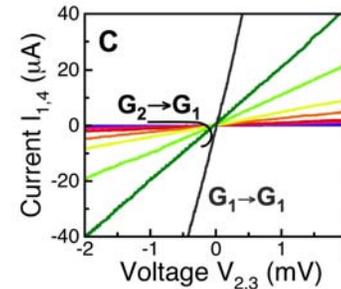
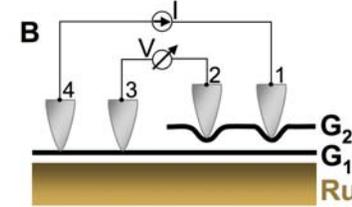
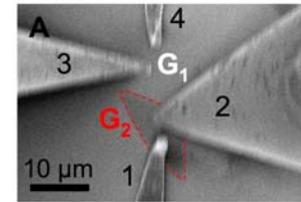
# Epitaxial Graphene on Ru

## Epitaxial Graphene on Transition Metals: from Catalyst Template to Electronic Material?

(P. Sutter et al., Nature Mat.7, 406 2008)



Original goal  
develop moiré template for  
bottom-up synthesis of  
metal nanoparticles



Potential pathway to epitaxy of large-area  
device quality graphene

- nature of graphene/Ru interface?
- influence of substrate on electronic structure?
- decoupling of additional graphene layers?
- electronic transport in graphene/Ru?



# Recent Scientific Accomplishments

2007-08

> 40 papers in high-impact journals

3 Nature (1 cover)

1 Science

1 PNAS

2 PRL

2 APL

6 Nanoletters

3 JACS

9 invention disclosures

BNL inventor of the year

Sci.Am 50 Award 2007

LETTERS

Dispensing and surface-induced crystallization of zeptolitre liquid metal-alloy drops

PETER W. SUTTER AND ELI A. SUTTER\*

Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, New York 11973, USA  
\*p.sutter@bnl.gov

Activity of  $\text{CeO}_x$  and  $\text{TiO}_x$  Nanoparticles Grown on Au(111) in the Water-Gas Shift Reaction

J. A. Rodriguez,<sup>1\*</sup> S. Ma,<sup>2</sup> P. Liu,<sup>2</sup> J. Hrbek,<sup>2</sup> J. Evans,<sup>3</sup> M. Pérez<sup>3</sup>

PRL 99, 134801 (2007)

PHYSICAL REVIEW LETTERS

week ending  
28 SEPTEMBER 2007

Using Compound Kinoform Hard-X-Ray Lenses to Exceed the Critical Angle Limit

K. Evans-Lutterodt,<sup>\*</sup> A. Stein, J. M. Ablett, and N. Bozovic<sup>†</sup>  
Brookhaven National Laboratory, Upton, New York 11973, USA

A. Taylor and D. M. Tennant<sup>‡</sup>

Lucent Technologies, 600 Mountain Avenue, Murray Hill, New Jersey 07974, USA  
(Received 9 January 2007; published 28 September 2007)



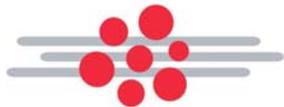
doi:10.1038/nature06560

nature

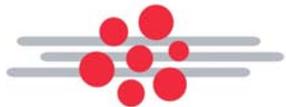
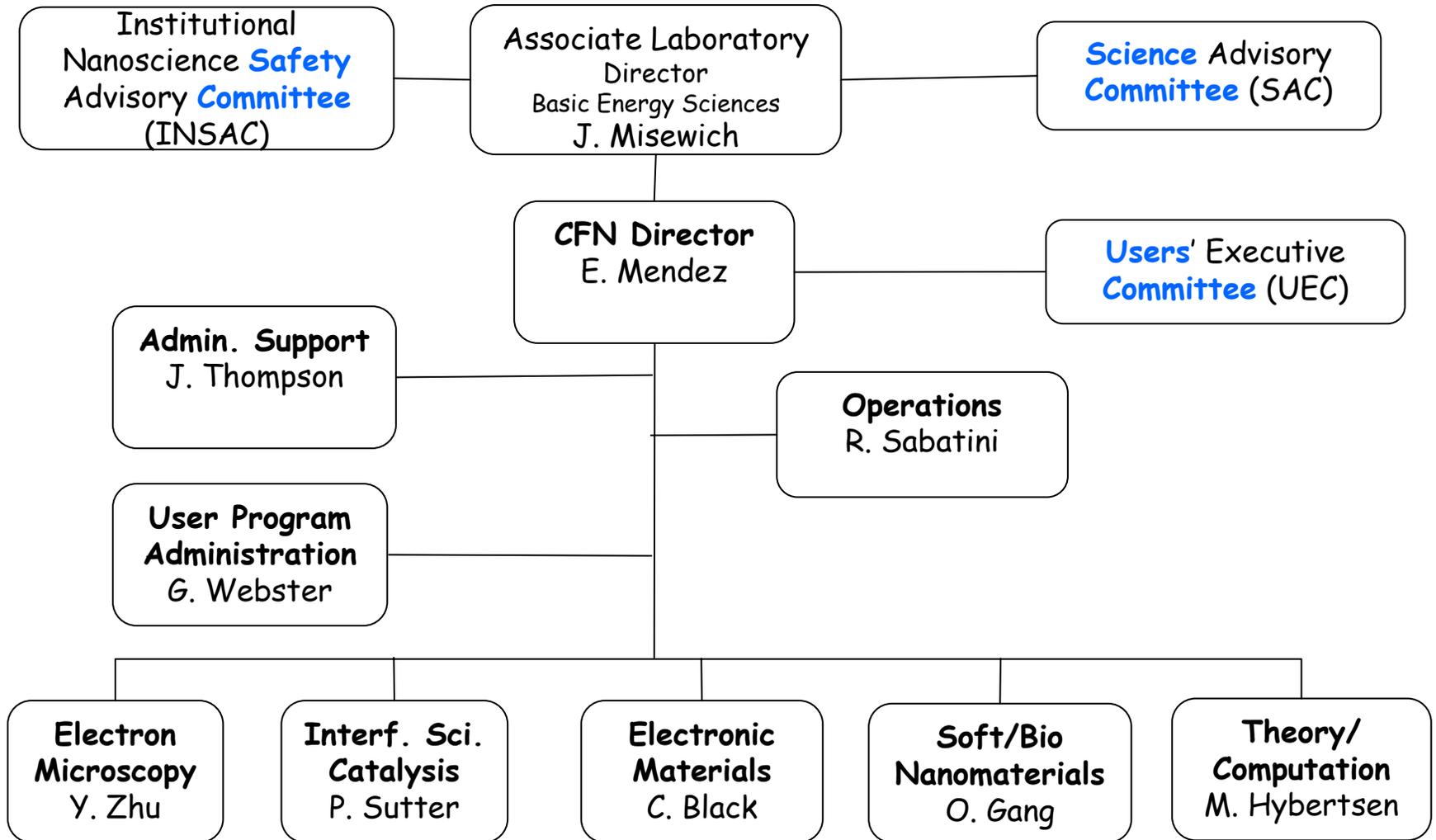
LETTERS

DNA-guided crystallization of colloidal nanoparticles

Dmytro Nykypanchuk<sup>1\*</sup>, Mathew M. Maye<sup>1\*</sup>, Daniel van der Lelie<sup>2</sup> & Oleg Gang<sup>3</sup>



# Organization Chart



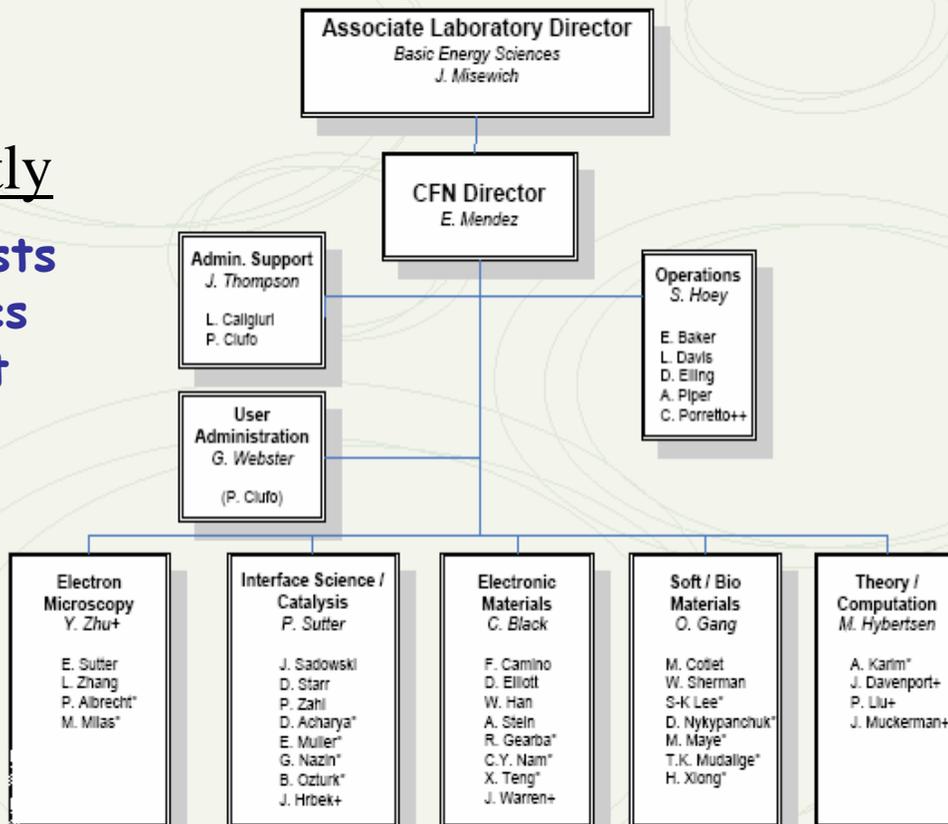
# Center for Functional Nanomaterials Organization Chart

Currently

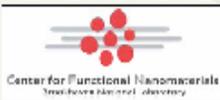
19 scientists  
6 postdocs  
10 support

CFN funded  
2010 Goal

30 scientific staff  
12 postdocs  
13 support



\* Postdoc Fellow  
+ Joint Appointment  
++QA Representative



Approved  
Emilio Mendez  
Chairman, Center for Functional Nanomaterials  
May 1, 2008

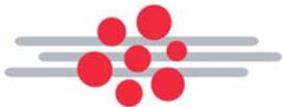


# CFN Staffing Plan

---

## Immediate

- Management
  - Associate Director, User & External Programs
- Scientific Staff
  - Electron microscopy ⇒
  - Ultrafast spectroscopy ⇒
  - Organic materials synthesis ⇒
  - Materials processing ⇒
  - Soft-matter theory
  - NSLS endstation
- Technical & Admin. Support
  - Materials preparation
  - Information technology ⇒
  - User program



# Interaction with other DOE Facilities and NSRCs

---

- National Synchrotron Light Source (NSLS) at BNL
  - CFN-owned/maintained endstation for small-angle x-ray scattering
  - CFN-owned LEEM/PEEM facility at NSLS beamline
  - Contribution to NSLS's users' catalysis consortium with high-p. XPS
  - Synchron. proposal cycles and (planned) coordinated proposal system
  - Integration of CFN's stockroom with NSLS's
- NSLS II
  - Participation in planning of catalysis beamline, and (probably) others
- Other NSRCs
  - Visits to NSRCs for familiarization with other facilities
  - Exchange of ideas and experiences with NSRC directors
    - monthly phone calls, BESAC meetings
  - Coordination of acquisition of new instrumentation
  - Development of common *Approach to Nanomaterials ES&H*

# Engaging the Scientific Community

## - Workshops

Bio-inspired Assembly (Users' Meeting '07)

Electrical Nanoprobes (Users' Meeting '08)

Electron Microscopy (11/07)

Nanoscience for High-Tech Industry (11/07)



## - Visits / Lectures

Stony Brook, U. Conn., Cornell,  
Delaware, Penn, Columbia, IBM

## - Participation in Stony Brook U.

Advanced Energy Center



## - Focused Collaborations & Energy Frontier Research Centers catalysis, photovoltaics

## - International (institutional) Collaborations INL (Portugal), KIST (Korea)

# Challenges

---

- Hiring Finding top science candidates with optimum profile for a user-oriented research center
- Facilities Completing suite of instruments for state-of-the-art facility
- Budget Planning in uncertain times
- User Program Managing growth of user base  
Attracting industrial users

# Summary

---

- **User**-oriented **research** center striving to become world-class resource
- Uniqueness from **synergy** between advanced equipment and expert staff
- In full operations since March 21, 2008
- Staff's research focused on **energy**-related materials & processes
  - photovoltaics
  - interface science & catalysis
  - soft & bio nanomaterials
- Blooming high-quality **User Program**
- Thriving **Research Program**
- Planned **facilities enhancement**
- **Staffing plan** well under way