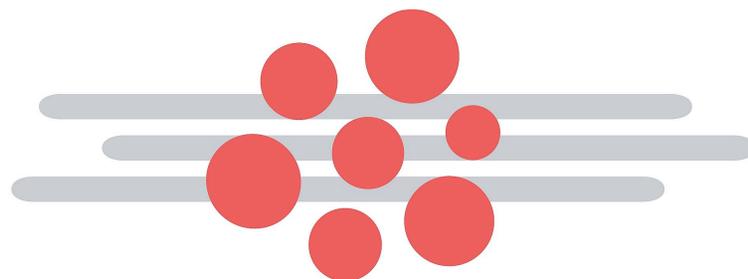


# Center for Functional Nanomaterials:

*A National Nanoscience User Center*

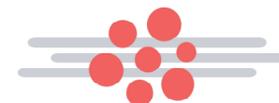
---



Center for Functional Nanomaterials  
Brookhaven National Laboratory

Robert Hwang

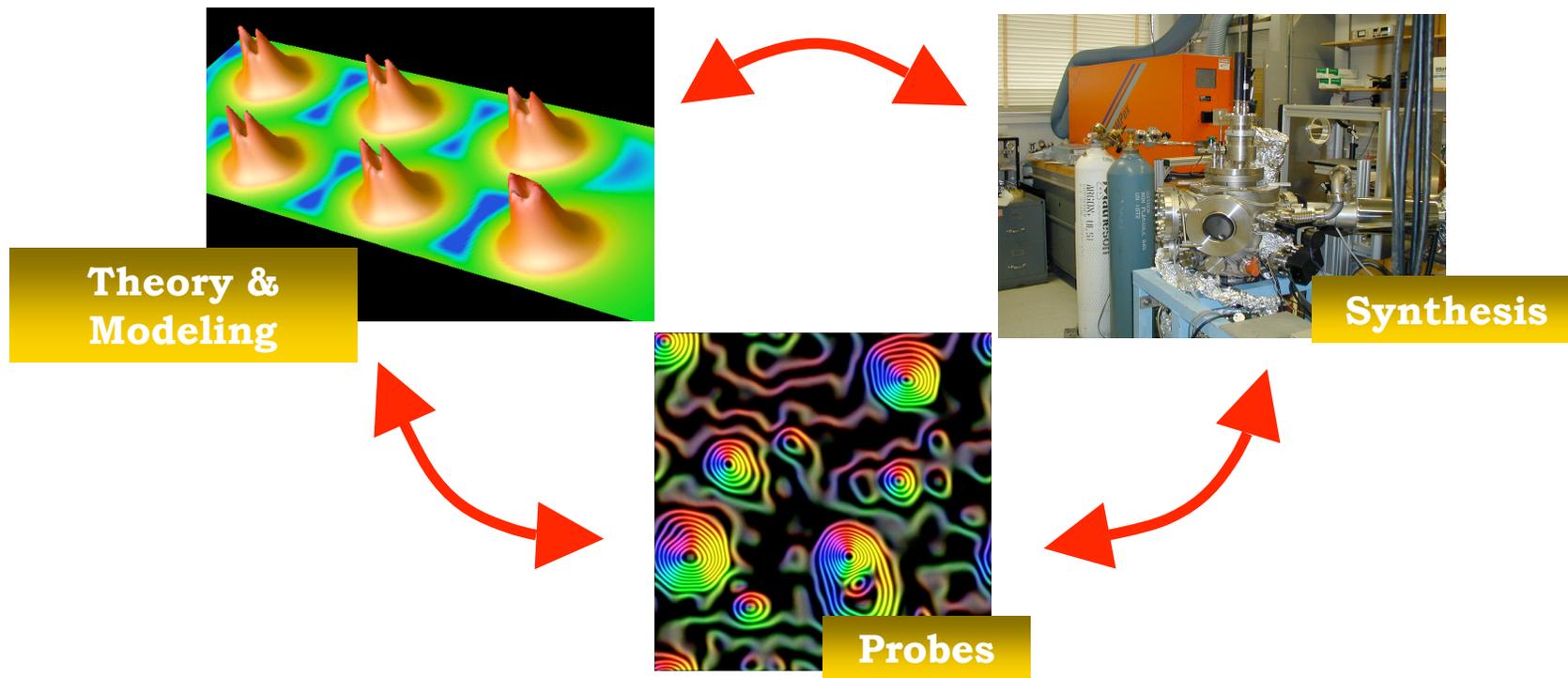
Brookhaven Science Associates  
U.S. Department of Energy



Center for Functional Nanomaterials  
Brookhaven National Laboratory

# Atomic-level tailoring of materials' response to achieve specific functionality

---

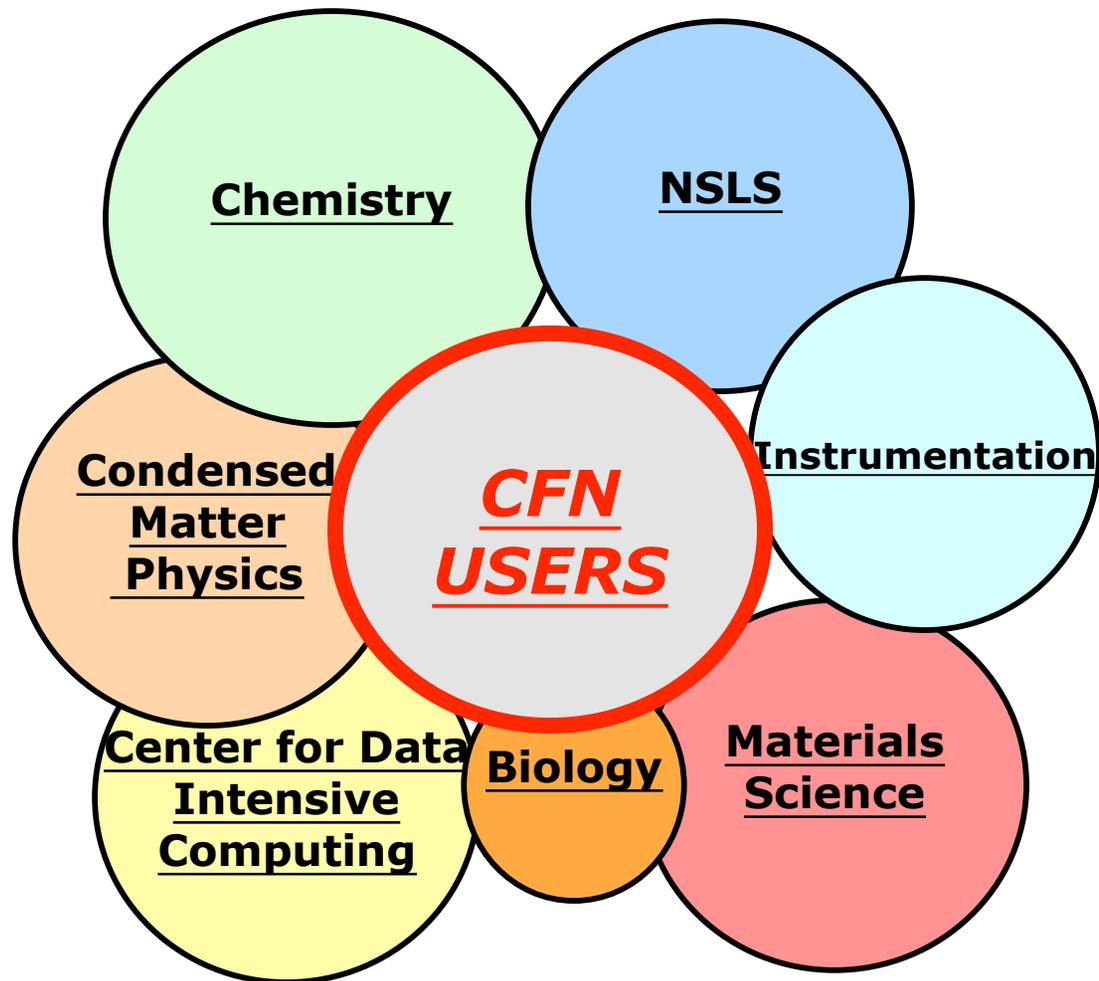


**New catalysts, New dielectrics, New organics**

*Explore and develop new materials' functionality based on the scientific understanding of nanoscale phenomena*

# CFN Interdisciplinary Approach to Nanoscience

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# Coordinated CFN Facilities

## Nano-Patterning

*John Warren*

*Chris Jacobsen (Stony Brook U.)*



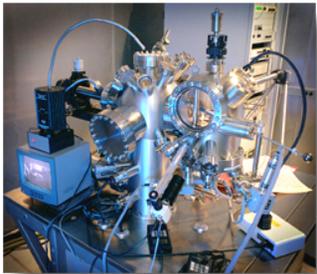
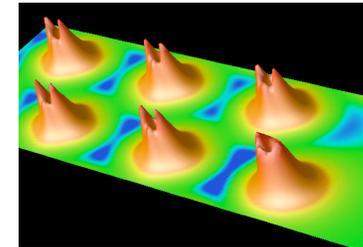
## Electron Microscopy

*Yimei Zhu*



## Theory & Computation

*Jim Davenport*

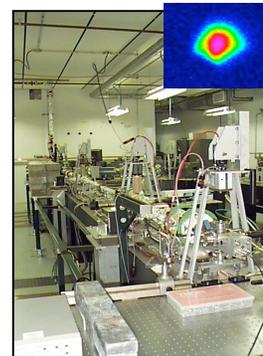


## Proximal Probes

*Jan Hrbek, Mike White*



## NSLS *Ron Pindak*



## Ultra-fast Optical Sources

*Brian Sheehy*

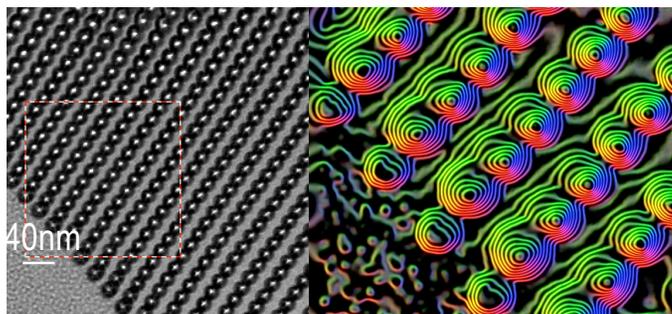


## Materials Synthesis

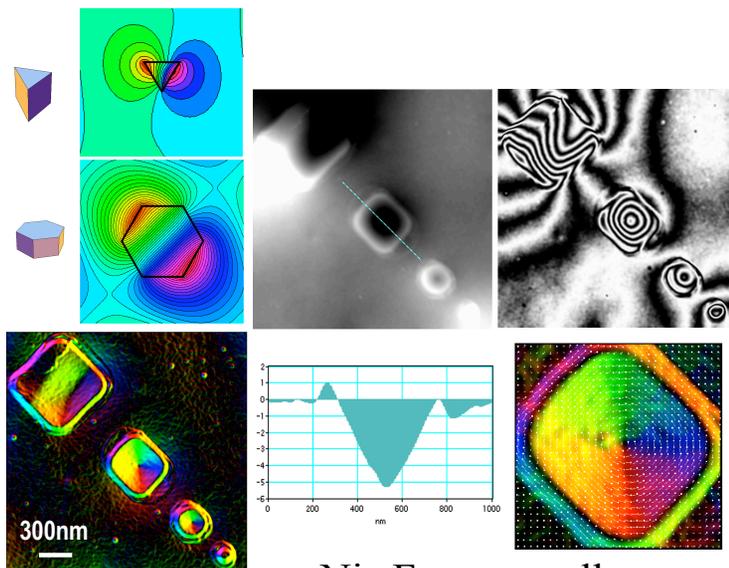
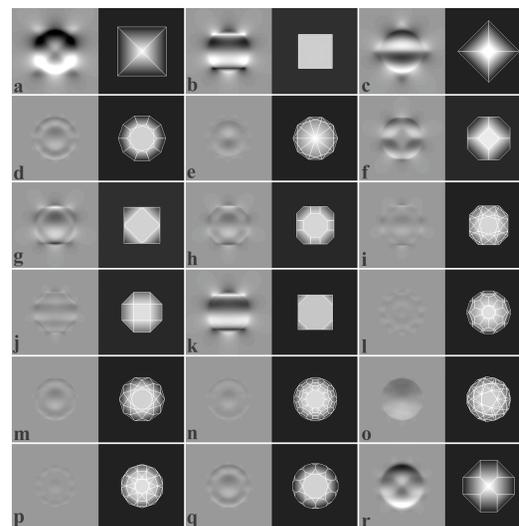
*Tom Vogt,  
Arnie Moodenbaugh*

Brookhaven Science Associates  
U.S. Department of Energy

# Electron Microscopy and Nanopatterning



TEM lithography and patterning of Ni-dot array



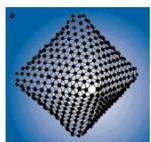
$\text{Ni}_{20}\text{Fe}_{80}$  permalloy

Artificially structured nano magnetic particles: calculation

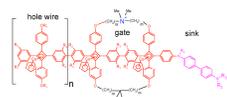


# Scientific Thrusts

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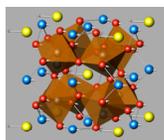
Catalysis on the Nanoscale - [Mike White](#)



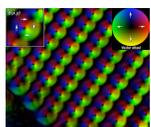
Charge Transfer on the Nanoscale - [Carol Creutz](#)



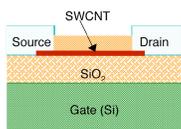
Nanostructured Organic Films - [Ben Ocko](#)



Nanoscale Correlated Oxides - [Peter Johnson](#), [Doon Gibbs](#)



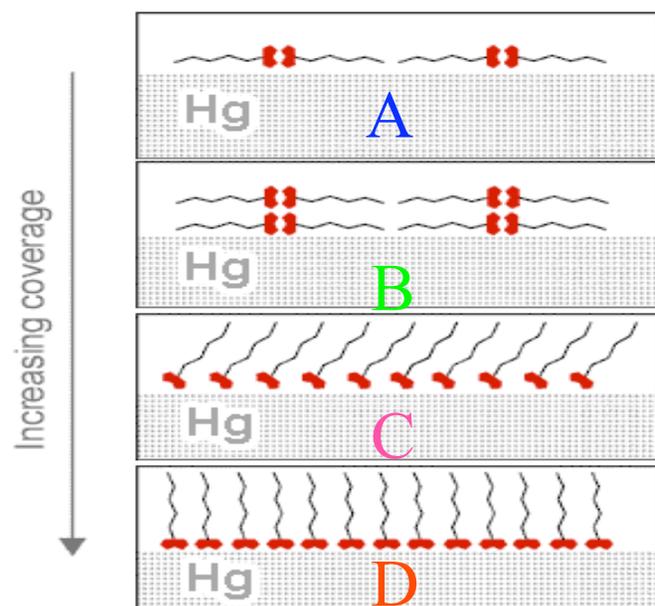
Magnetic Nanoassemblies - [Laura Lewis](#)



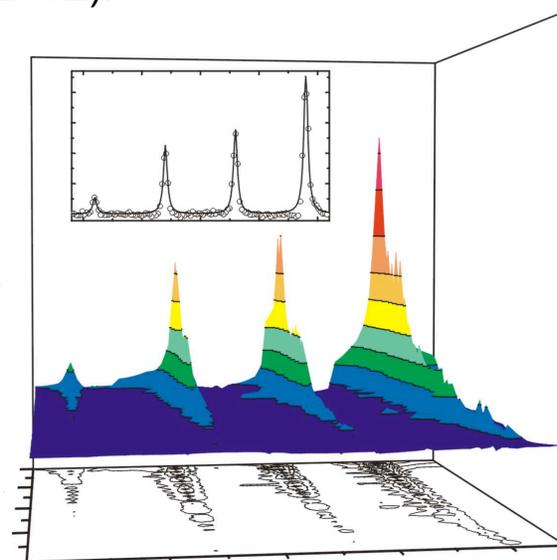
Applications of Nanoscience - [Jim Misewich](#)

# NSLS Investigation of Organic Molecular Self-assembly

H. Kraack, B. Ocko, P. Pershan, E. Sloutskin, and M. Deutsch "Structure of a Langmuir Film on a Liquid Metal Surface", *Science* **87**, 1404 (2002).



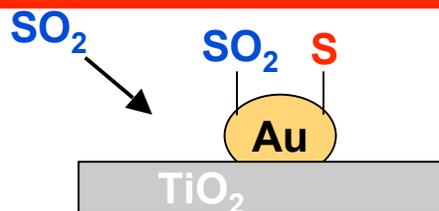
Phases of Stearic acid on the mercury surface which form with increasing coverage



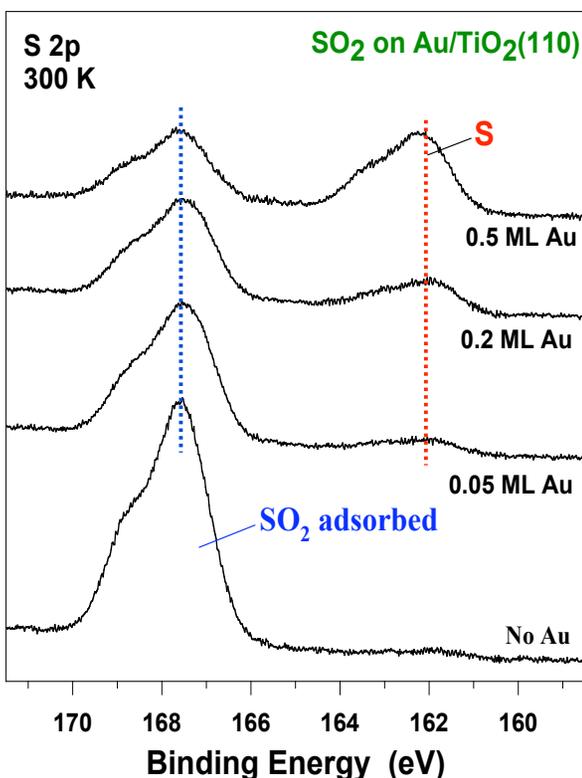
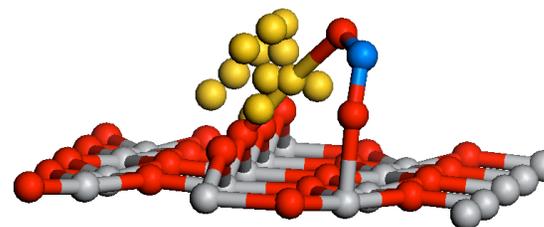
GID X-ray diffraction from lying down phase (A). The 52.4 Å spacing (two molecules) is 2.5 Å longer than the bulk phases.

# NanoCatalysis Research: 3D Nanoparticles

Supported metal nanoparticles can exhibit reactivity not characteristic of the bulk metal or support



Calculations show that  $\text{SO}_2$  binds to both Au particle and  $\text{TiO}_2$  support



Brookhaven Science Associates  
U.S. Department of Energy

Au particle size  
3-5 nm  
2-3 nm  
> 1 nm

Au nanoparticles supported on  $\text{TiO}_2$  are extremely reactive towards  $\text{SO}_2$ .

**Au/ $\text{TiO}_2$  catalyst is 7-10 times more active than commercial catalyst.**

Bulk metallic Au and  $\text{TiO}_2$  exhibit a low reactivity for the dissociation of  $\text{SO}_2$ .

# Center for Functional Nanomaterials



**Specialized Laboratories**  
**NSLS and Instrumentation Division**  
**User and CFN scientist space**  
**High interaction cross-section**

**Brookhaven Science Associates**  
**U.S. Department of Energy**

## Materials Synthesis

Wet Chem, MBE, PLD, e-beam dep.

## Nanopatterning

JEOL 9300 FS: e-beam patterning,  
Resist process & develop.

Deep Reactive Ion Etch, Ion Beam Patterning

## Ultrafast Optical Sources

SFG, DFG, XUV/SXR THz Microscopy,  
Laser-Electron Accelerator Facility (LEAF)

## Electron Microscopy

High Res. TEM, Scanning Auger, SEM,  
Electron Holography, STEM, EELS

## Proximal Probes

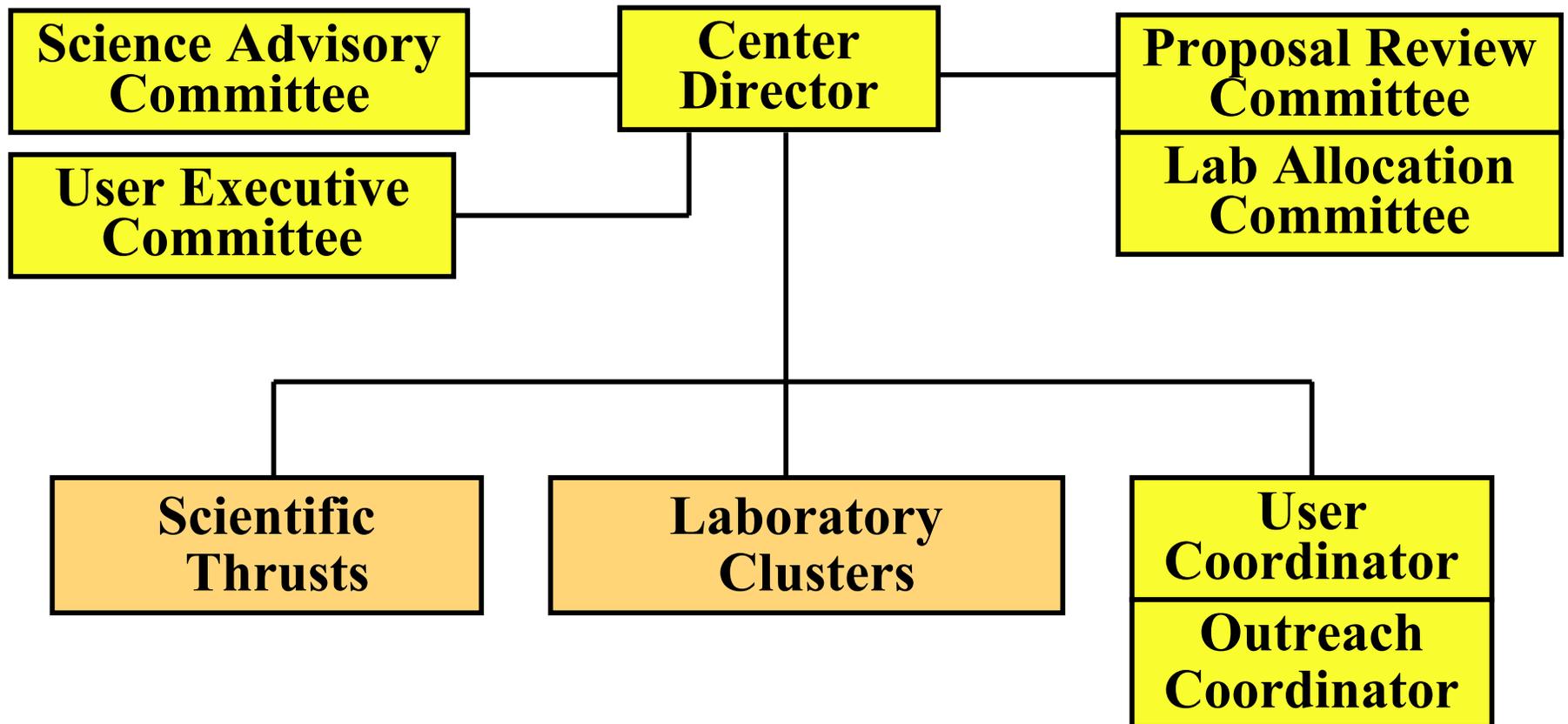
UHV-SPM, NSOM, IR microscope,  
Env. SPM, LEEM, SPLEEM

## Theory & Computation

LAPW, Plane Wave Pseudo Potl., Quantum Chem.,  
QMC, MD, and SMP computing

# Operating Structure of the CFN

---



# Accessing the CFN

---



*One proposal accesses the CFN and the NSLS*

# CFN Workshops and Outreach

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## ■ General Nanoscience Workshops:

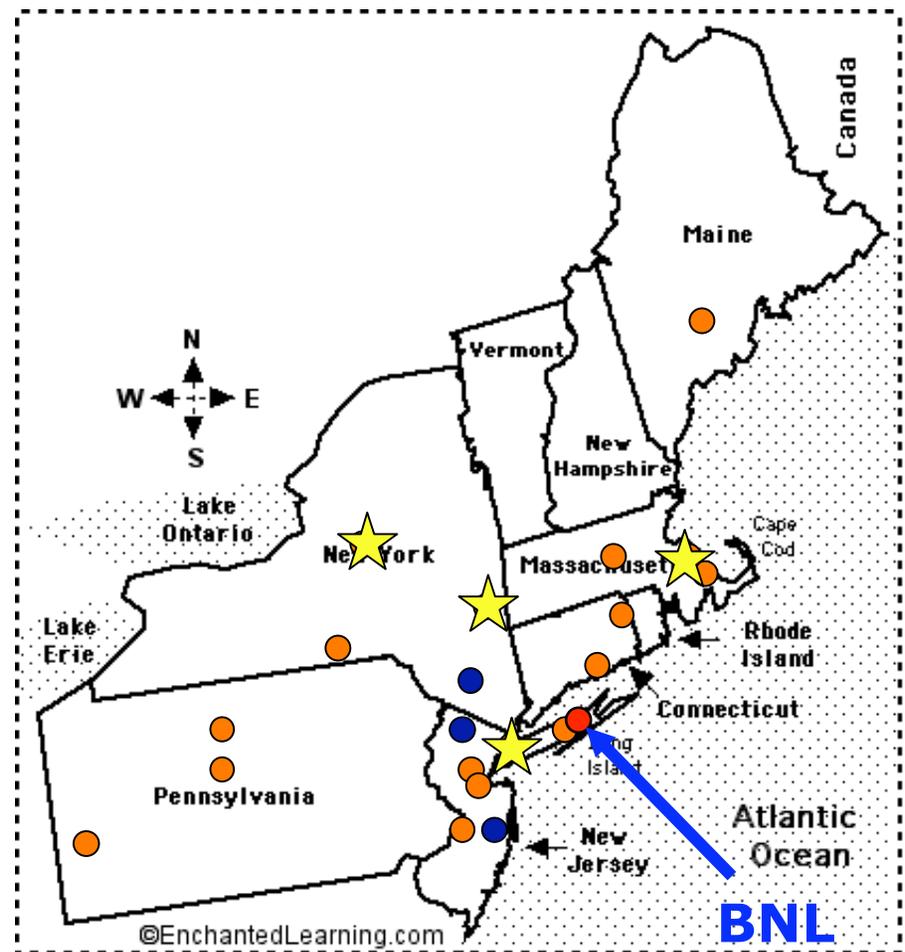
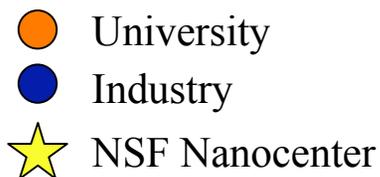
- December 2000, “The Frontier: A Workshop on Nanoscience and Technology”
- March 2002, “Planning Workshop for the CFN”

## ■ Topical Nanoscience Workshops :

- January 2001, 8<sup>th</sup> Joint MMM-Intermag Conference Symposia/Evening Tutorial: “[Magnetic Nanotechnology in the Next Decade](#)”
- May 2001, “NSLS User Meeting Workshop on: Applications of Synchrotron Radiation in Nanoscience and Technology”
- October 2001, DOE Center for Excellence in Synthesis and Processing (CESP): [Nanocomposite Magnets](#), Annual Meeting
- January 2002, “[Charge Transfer on the Nanoscale](#),” Chemical Sciences sponsored workshop,
- April 2002, “Workshop on Frontiers in Synchrotron Research on [Soft Matter and Biomaterials](#)”
- September 2002, EPENS, “International Workshop on [Electron-Phonon Effect](#) in Nanosystems”,
- October 2002, CESP [Nanomagnetic](#) Materials Workshop
- October 2002, “International Meeting on Low Energy Electrodynamics in Solids”
- January 2003, “Workshop on Frontiers in Synchrotron X-Ray Microbeam Diffraction”
- March-April 2003, INTERMAG03 conference
- May 2003, LI Business Network Workshop
- May 2003, Workshops at the NSLS Users Meeting
- August 2003, Quantum Field Theory of Nanoscale Systems

# CFN Outreach Environment

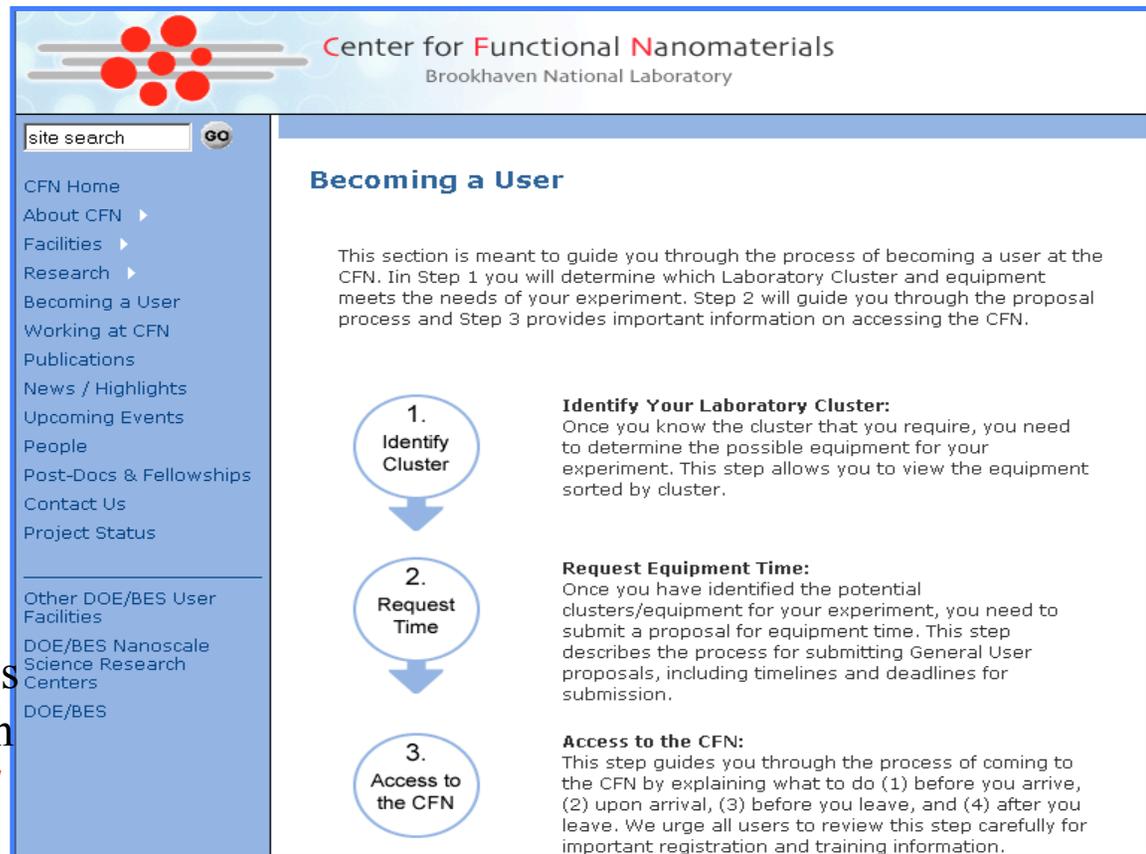
- Premier **user** center for interdisciplinary research on new functional nanomaterials: important for basic science and industry
- Catalyst for powerful new approach to materials research: national laboratories, universities, industries combined!



Brookhaven Science Associates  
U.S. Department of Energy

# CFN Jumpstart

- *March, 2003 - Call for proposals*
- Access to leveraged nanoscience capability
  - Advanced electron microscopy
  - National synchrotron light source
  - E-beam lithography for nanofabrication
  - Proximal Probe
  - Materials Synthesis
  - Ultra-fast optical probes
  - Theory & computation
- *October 2003, 1st annual "CFN Users Meetings"*
- [www.cfn.bnl.gov](http://www.cfn.bnl.gov)



The screenshot shows the website for the Center for Functional Nanomaterials at Brookhaven National Laboratory. The page is titled "Becoming a User" and provides a guide for new users. It includes a navigation menu on the left with links such as "CFN Home", "About CFN", "Facilities", "Research", "Becoming a User", "Working at CFN", "Publications", "News / Highlights", "Upcoming Events", "People", "Post-Docs & Fellowships", "Contact Us", and "Project Status". Below the navigation menu are links for "Other DOE/BES User Facilities", "DOE/BES Nanoscale Science Research Centers", and "DOE/BES". The main content area features a three-step process: 1. Identify Your Laboratory Cluster, 2. Request Equipment Time, and 3. Access to the CFN. Each step is accompanied by a brief description of the process.

Center for Functional Nanomaterials  
Brookhaven National Laboratory

site search  GO

CFN Home  
About CFN ▶  
Facilities ▶  
Research ▶  
Becoming a User  
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Publications  
News / Highlights  
Upcoming Events  
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Post-Docs & Fellowships  
Contact Us  
Project Status

Other DOE/BES User Facilities  
DOE/BES Nanoscale Science Research Centers  
DOE/BES

## Becoming a User

This section is meant to guide you through the process of becoming a user at the CFN. In Step 1 you will determine which Laboratory Cluster and equipment meets the needs of your experiment. Step 2 will guide you through the proposal process and Step 3 provides important information on accessing the CFN.

- 1. Identify Cluster**  
**Identify Your Laboratory Cluster:**  
Once you know the cluster that you require, you need to determine the possible equipment for your experiment. This step allows you to view the equipment sorted by cluster.
- 2. Request Time**  
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**Access to the CFN:**  
This step guides you through the process of coming to the CFN by explaining what to do (1) before you arrive, (2) upon arrival, (3) before you leave, and (4) after you leave. We urge all users to review this step carefully for important registration and training information.

# CFN User Program

---

- *Call for proposals in March 2003*
- *October 2003, 1st annual “CFN Users Meeting”*
- *[www.cfn.bnl.gov](http://www.cfn.bnl.gov)*
- *Bob Hwang - [hwangr@bnl.gov](mailto:hwangr@bnl.gov)*

# Coordinated Laboratory Facilities

---

Nanopatterning - [John Warren, Chris Jacobsen \(Stony Brook U.\)](#)

Materials Synthesis - [Tom Vogt](#)

Electron Microscopy - [Yimei Zhu](#)

National Synchrotron Light Source - [Ron Pindak](#)

Ultrafast Optical Sources - [Brian Sheehy](#)

Proximal Probes - [Jan Hrbek, Mike White](#)

Theory & Computation - [Jim Davenport](#)

# CFN Summary

---

- Scientific and Project Management in place
- Enthusiastic commitment of scientific/technical staff across BES
- Strong local interest in northeast from industry and universities
- Strong nanoscience capability in place

We are ready and anxious to go.

# CFN Central BNL Location

---



Brookhaven Science Associates  
U.S. Department of Energy

18

# Science Advisory Committee (SAC)

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## Science Advisory Committee Members:

**Paul Fleury, Dean, [Yale University](#)**

**Wayne Goodman, Department of Chemistry, [Texas A&M University](#)**

**Sam Bader, Materials Science Division, [Argonne National Laboratory](#)**

**Giacinto Scoles, Department of Chemistry, [Princeton University](#)**

**Frans Spaepen, Division of Engineering and Applied Science, [Harvard University](#)**

**Edwin L. Thomas, Department of Materials Science and Engineering, [MIT](#)**

\* **James Yardley, Department of Chemical Engineering, [Columbia University](#)**

**Rudolf Ludeke, [IBM Watson Research Laboratory](#)**

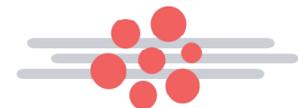
\* **Om Nalamasu, [Rensselaer Polytechnic Institute](#)  
UEC Chair**

\* **NSF Nanocenter Directors**

**DOE Nanocenter Director**

**Brookhaven Science Associates**

**U.S. Department of Energy**

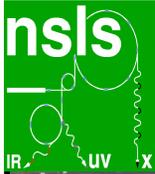


# Integration with Other Nanocenters

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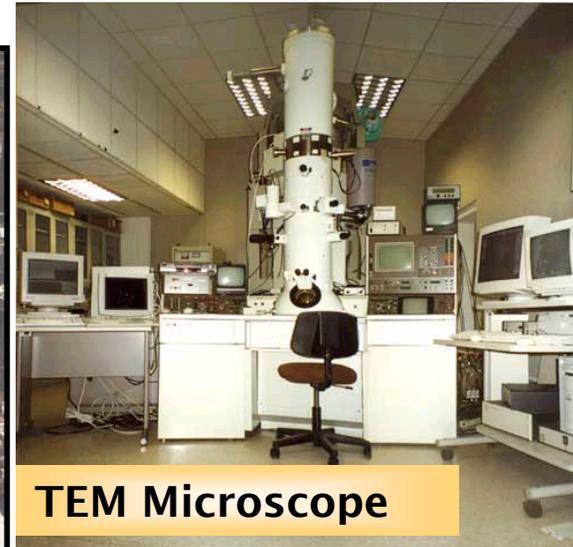
- There are 4 NSF nanocenters in the Northeast region (*Columbia, RPI, Harvard, and Cornell*). Their user programs are smaller in scope – need major CFN instrumentation; provide CFN focused science collaborations
- Representatives of **all** of the regional NSF nanocenters gave talks at the BNL Nanoscience Workshop
- A number of collaborative projects have been initiated with the Columbia Nanocenter (*Osgood, O'Brien, Millis, Nuckols, Brus, Flynn*) – just the beginning ... talk on NSLS nanoscience techniques scheduled for April. Exchange visits with the RPI Nanocenter are being planned. Visits to other nanocenters will follow.
- The Directors of **both** the Columbia (*Jim Yardley*) and RPI (*Om Nalamasu*) Nanocenters are members of the CFN SAC.
- BNL and ANL collaboration on nanopatterning at *Lucent* - the *Lucent* e-beam writer will be used in *jump-start phase* of their user programs
- BNL and 4 other DOE labs have a collaboration (TEAM) to develop an aberration-free electron microscope

# Existing Materials Probes at Brookhaven National Laboratory



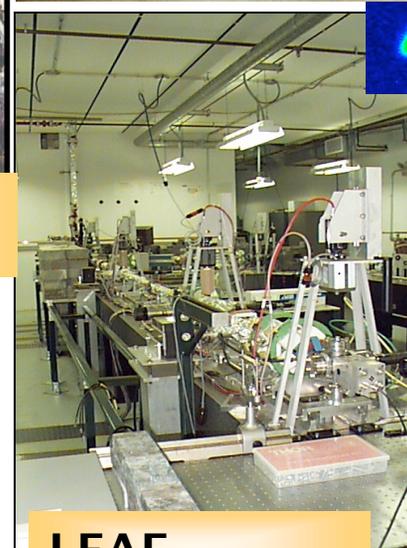
**NSLS**

**Ex: Structure of nanoparticles  
>80 x-ray, UV, IR beamlines**



**TEM Microscope**

**Ex: Electron holography**



**LEAF**

**Ex: picosecond charge flow in molecular wires  
(Laser Electron Accelerator Facility)**

**Brookhaven Science Associates  
U.S. Department of Energy**

# CFN Involvement in Organization of Nanoscience Workshops

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- March 2002, “Planning Workshop for the CFN”

## ■ Topical Nanoscience Workshops :

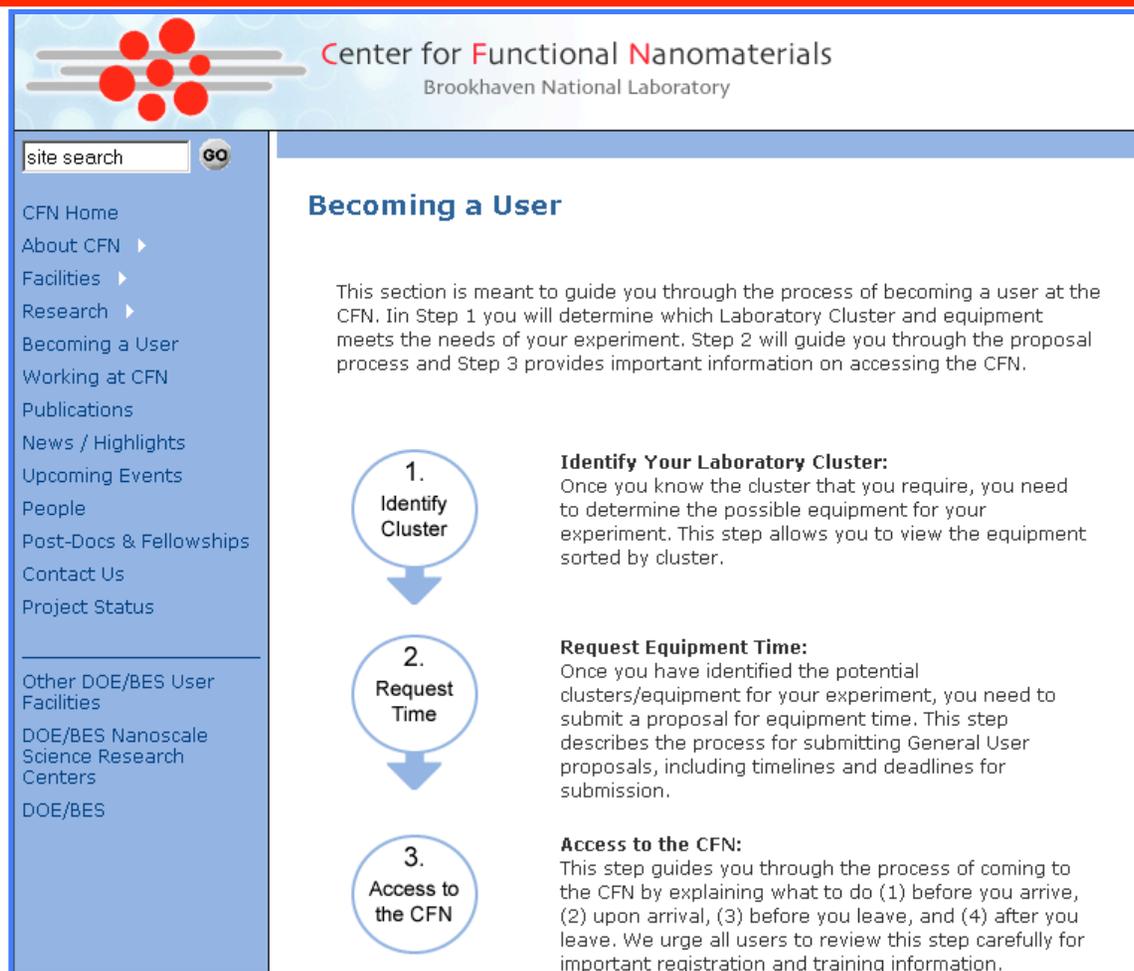
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- March-April 2003, INTERMAG03 conference
- May 2003, LI Business Network Workshop
- May 2003, Workshops at the NSLS Users Meeting
- August 2003, Quantum Field Through Nanoscale Systems

# Highlights of CFN Jumpstart Proposal

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- Provides a User Coordinator and the *infrastructure* to effectively run a User Program including a User Meeting
- Provides support for the *key hires* that are crucial to staffing the CFN.
- Provides post-doc support for specific Laboratory Facilities and Thrusts that have existing capabilities that can be brought *on-line* for Users in 2003.

# Becoming a CFN User – *www.cfn.bnl.gov*



The screenshot shows the website header with the CFN logo and name. A search bar is present. A left sidebar contains navigation links. The main content area is titled 'Becoming a User' and contains an introductory paragraph and three numbered steps with descriptions.

Center for Functional Nanomaterials  
Brookhaven National Laboratory

site search  GO

CFN Home  
About CFN ▶  
Facilities ▶  
Research ▶  
Becoming a User  
Working at CFN  
Publications  
News / Highlights  
Upcoming Events  
People  
Post-Docs & Fellowships  
Contact Us  
Project Status

Other DOE/BES User Facilities  
DOE/BES Nanoscale Science Research Centers  
DOE/BES

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# Planning Workshop for the CFN

## March 8-9, 2002

---

- **Overwhelming excitement and interest**
- **435 registered participants from >83 institutions**

### **NSF Nanocenters**

Columbia (Yardley)

RPI (Ajayan)

Cornell (Buhrman)

Harvard (Narayanamurti)

### **New Visions**

Craighead (Cornell)

### **Thrust Areas Science Visions**

George Sawatzky (UBC)

Ted Madey (Rutgers)

John Miller (BNL)

Ami Berkowitz (UCSD)

Tom Russell (UMass)/Ben Chu (USB)

Randy Isaac (IBM)/John Rogers (Lucent)