



Materials Research @ PENN

FUNDING FOR SHARED EXPERIMENTAL FACILITIES

Arjun G. Yodh, MRSEC Director

Laboratory for Research on the Structure of Matter (LRSM)

“Collaboratory” for Interdisciplinary Materials Research @ Penn



LRSM is host for MRSEC.

~60-Year, sustained, comprehensive Center garners University support.



LRSM Missions

New Materials

(Ideas)

Discovery & Innovation through
Collaborative Interdisciplinary Research

Expertise & Leadership

(New Knowledge)

Synthesis, Characterization & Modeling

Tools

(State-of-the-art Infrastructure)

Shared Facilities – *In-house* & *National Labs*

People (Diversity)

(Competitive S&E Workforce)

LRSM, Academe, Government & Industry

Outreach

(Partnerships)

Local, Regional, National & International

Translation & Transformation

(Society)

National Laboratories / Facilities

- LRSM participated in creation of several national facilities over the years.
 - Neutrons at NIST, X-Rays at Brookhaven and APS
- In addition, MRSEC faculty contributed to their design and raised substantial \$\$ support for beamline operation.

Paradigm Shift at National Labs:
Universities are less 'financially' involved in facility operation.



December 22, 2004

Professor Michael Klein
University of Pennsylvania
3231 Walnut Street
Philadelphia, PA 19104-6202

Dear Professor Klein:

We here at the NIST Center for Neutron Research (NCNR) are highly enthusiastic about the great success we have had over the past decade in our many collaborations with your Laboratory for Research on the Structure of Matter (LRSM), including our extensive joint work with your NSF MRSEC program. Our efforts with you and other key professors and staff at Penn have resulted in highly productive, high impact research accomplishments in areas ranging from nanoscience to biological research and modeling.

Your plan for a new emphasis in your MRSEC proposal is a well thought out and exciting multidisciplinary approach. The themes and research plan in the four Individual Research Groups exploring new frontiers in "soft matter" resonate very well with our research priorities here at the NCNR and the fifth IRG on novel functional oxides is directly in line with the plans of our Condensed Matter Physics team. We very much look forward to continued strong collaborations with the Penn MRSEC in a number of areas. I would note that our recent instrumentation developments here at the NCNR in high resolution neutron spectroscopy, small angle neutron scattering and reflectivity and next generation crystal spectrometry can make major contributions to your research efforts in areas such as networks and structured gels, cylindrical assemblies, synthetic membrane and oxide-based materials.

Beyond the prospects of joint research opportunities, we are also very impressed with your MRSEC's educational outreach program and your plan to engage your students and post-docs from many disciplines in research on complex materials within the different IRG's. As you know we strongly encourage the participation of students, with an emphasis on diversity, in the use of state-of-the-art research capabilities here at the NCNR and hold annual training workshops which we hope will attract many of your students and post-docs.

Again we hope you are successful in your latest MRSEC proposal and look forward to working closely with you and your Penn colleagues in the years to come.

Sincerely,

Patrick D. Gallagher
Patrick D. Gallagher
Director, NCNR

Los Alamos
NATIONAL LABORATORY

Office of the Associate Laboratory Director
for Basic Energy Sciences

BROOKHAVEN
NATIONAL LABORATORY

Professor Michael L. Klein
Director, LRSM
Laboratory for Research
on the Structure of Matter
University of Pennsylvania
3231 Walnut Street
Philadelphia PA 19104-6202

Dear Professor Klein,

It is a pleasure to express our broad support of The University of Pennsylvania's NSF MRSEC programs, and to unequivocally state our commitment to continuing, indeed expanding, our ongoing scientific relationship. As the Associate Laboratory Director of Basic Energy Sciences at Brookhaven National Laboratory (BNL), I speak for the Materials Science, Chemistry and Condensed Matter Physics Divisions, as well as for the newly created Center for Functional Nanomaterials—one of five action is to begin this spring.



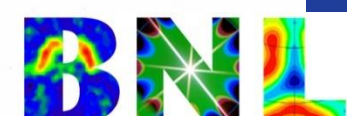
The Center for Nanophase Materials Sciences at Oak Ridge National Laboratory is a collaborative nanoscience user research facility for the synthesis, characterization, theory modeling simulation, and design of nanoscale materials. It is one of five Nanoscale Science Research Centers currently being established by the Office of Science, U.S. Department of Energy.

Partnerships with LRSM will continue to flourish and top, for example, involving our soft matter/bio Nanomaterials, and involving our newly developing productive relationships as these clearly benefit our institutional goals, but more broadly advance the nation's scientific interests, both for the research that is carried out and for the students they train.

Sincerely,

David M. P. Brown

LAWRENCE LIVERMORE NATIONAL LABORATORY
Science in the National Interest



Still advise but primary participation phasing out



Major Shared Experimental Facilities (In-House)

- **Multi-angle X-Ray** (Heiney & Winey)
- **Property Measurement Facility** (Kikkawa)
 - Thermal/electrical transport, magnetometry, optics
- **Materials Characterization @ Singh Center for Nanotechnology** (Yates)
 - SEM, TEM, FIB, Ion-scattering
- **Optical Imaging and Micromanipulation** (Yodh)
 - Confocal microscopes, laser tweezers, scattering
- **Multifunctional Scanning Probe/Confocal-Raman** (Carpick)
- **Rheology Center** (Janmey, Arratia, & Winey)
- **Computing** (Riggleman & Liu)
- **Quattrone Nanofabrication Facility @ Singh Center** (Clay)
- **Polymer Characterization Facility** (McGhie)



Departmental Facilities
(NMR, Mass Spectrometry,
single-crystal X-Ray).



Singh Center for Nanotechnology (2013)



**Sophisticated equipment too expensive for
individuals to purchase & maintain.**

These SEFs are Important!

- Enable state-of-art IRG/Seed research
- Educate undergrads, PhDs, Post-docs
- Create qualitatively different channels to local academe & industry
- Facilitate community outreach (PREM, REU, PSSI, RET,...)

A “glue” needed to bind LRSM community.

Challenges (\$)

- **Getting an SEF Off-The-Ground**
- **Sustaining Support for SEF Staff**
- **SEF Equipment Maintenance**
- **SEF Equipment Upgrades (MRIs)**
- **SEF Space (Renovations)**

FOUR EXAMPLES

- **Property Measurement Facility (Kikkawa)**
 - Thermal/electrical transport, magnetometry, optics
- **Multi-angle X-Ray (Heiney & Winey)**
- **Computing (Riggleman & Liu)**
- **Materials Characterization @ Singh Center for Nanotechnology (Yates)**
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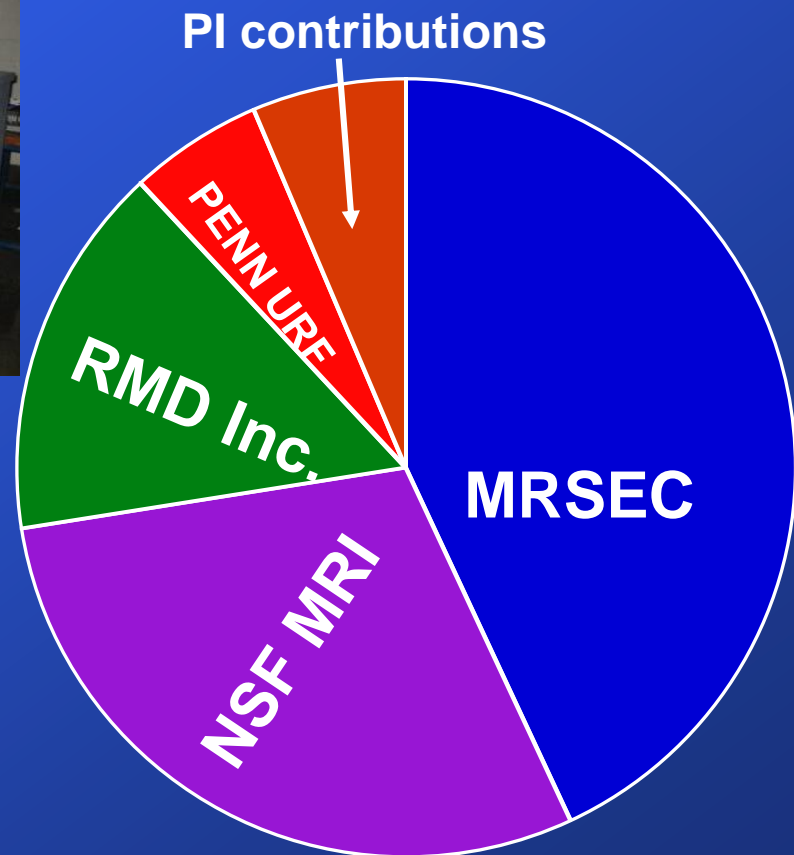
Property Measurement SEF (2001-09)

- Established ~2001 (Kikkawa / Chen) for **TRANSPORT, SUSCEPTIBILITY, & SPECTROSCOPY** to meet a research need in our IRG-5 (Complex Oxides)



- State-of-the-art capabilities

- Low temp (2K)
- High B (9T)

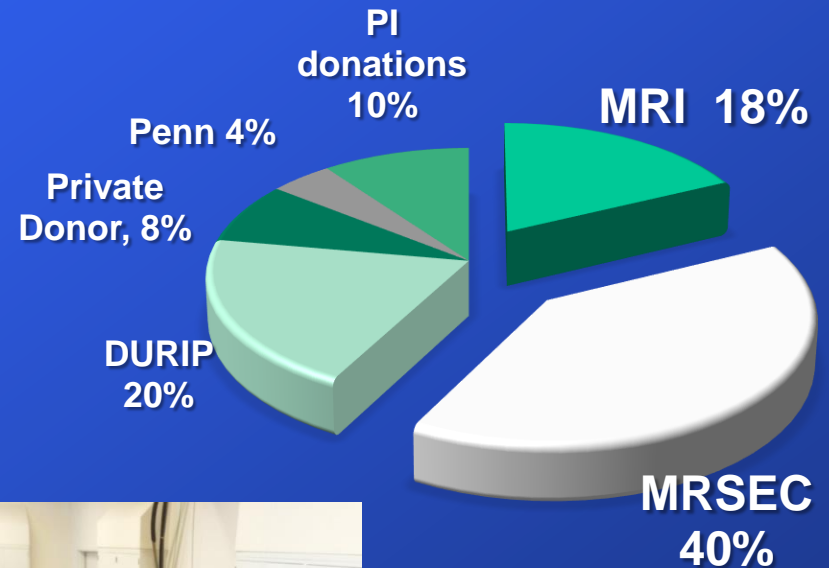


By 2009, ~\$720k equipment acquired, ~75% NSF support + \$20k annual maintenance

Property Measurement SEF (2017)

- **An evolution Toward Increasingly Broad Access**

- LRSM-MRSEC → PENN At-Large → Outreach (PREM)....
- Free except consumable supplies
- Training, data interpretation, *remote interface!*
- Since inception: 85 major users, >60 publications, 15 PhDs
- Oxide IRG finished in 2011, but equipment is broadly useful to other (new) IRGs in MRSEC !

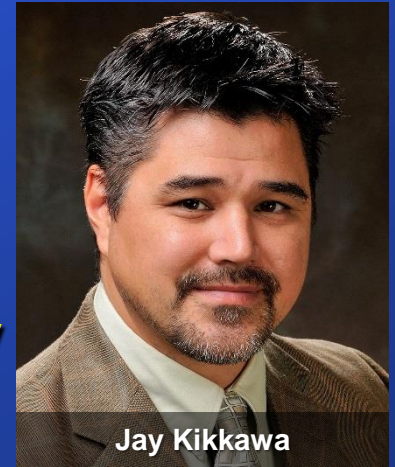


**~\$1.2M equipment
nearly 60% NSF
support
+ \$40k annual
maintenance**

**Recent: \$160k NSF,
He Reliquification**

Keys to Success

- **Facility PI, Kikkawa, “runs” the SEF** (**instrumentation and working facility is crucial for his own research).
- **“Above average” yearly budget**
- **Continued major equipment from NSF (MRI, liquid-He); facilitated by MRSEC and MRSEC-matching...**



Future Challenge – Difficult for usage to grow much more without additional supervisory staff/post-docs.

Multi-Angle X-Ray SEF

- **Successful SEF, affects research in most IRGs.**
- **MRSEC pays Yearly Service Contract**
- **Excellent Outreach Efforts.**

MAX Facility

STRUCTURAL TOOLS
@ the LRSM

A one-day workshop highlighting research tools available at Penn's Laboratory for Research on the Structure of Matter and the Penn Regional Nanotechnology Facility, including X-ray Diffraction, Electron Microscopy, and Ion Scattering. Open to faculty and staff at primarily undergraduate institutions in the Delaware Valley whose research projects may benefit from reduced-rate access to LRSM structural facilities.

Wednesday, January 6, 2010
9:30 AM – 4:30 PM
Laboratory for Research on the Structure of Matter
University of Pennsylvania
3231 Walnut Street
Philadelphia, PA 19104
USA

Presenters:
Dr. Paul Heiney
Professor of Physics
Dr. Karen Winey
Professor of Materials Science and Engineering
Dr. Russell Composto
Professor of Materials Science and Engineering
Dr. Christopher Murray
Helford Perry University Professor of Inorganic, Microscale and Materials Chemistry
Dr. Douglas Yates
Technical Director, Penn Regional Nanotechnology Facility

Program will include:
• Short pedagogical talks describing instrumental capabilities
• Hands-on tours of the facilities including demonstration of sample preparation techniques
• Opportunity to discuss potential research projects with Penn faculty and staff
• Lunch and continental breakfast

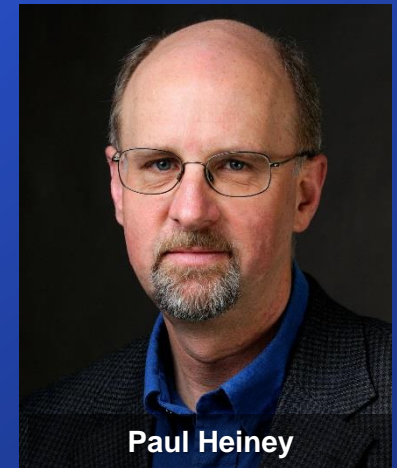
The program is **free**, but pre-registration is **required** at:
www.lrs.m.upenn.edu/events/st09
Contact Paul Heiney, heiney@sas.upenn.edu

NSF-DMR-05-20020
MRSEC Penn

- **All users charged for supplies. For MRSEC Users this is the only charge. Higher rates charged for OUTSIDE academic & industry (even higher).**

How do we “break even” every year?

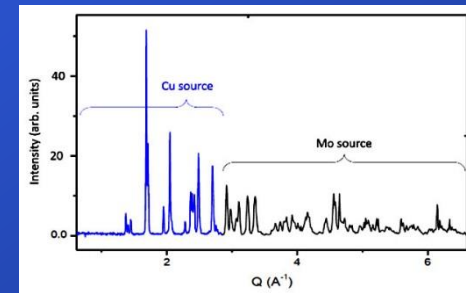
- **Zero Cost for Staff !**
- **One of the SEF Directors (Heiney)**
 - carries out routine maintenance
 - carries out all training/supervision
 - at NO COST.



Challenge – Possible major additional SEF staff cost when Heiney retires (>5 years).

X-Ray SEF: Other Recent Challenges

- Equipment Upgrade (MRI – Success)
- ***Building Renovation for new Equipment !



MRI Matching \$\$ solicited over 2-year period from School of Arts & Sciences, **School of Engineering & Applied Sciences**, and Provost.

LRSM provides match for MRI, *but not for renovations (SAS, SEAS, Provost).*

Another Strategy for MRSEC SEF Investment

Computing Shared “Experimental” Facility

- 54 computational nodes
- Condo model purchase
- MRSEC owns >590 of the cores

MRSEC Investment ~\$250k,
leveraged by Penn Startups
(Srolovitz, Shenoy)

*Partial funding computing
support staff (yearly \$).

**SEAS pays for space &
power (\$35K/year)



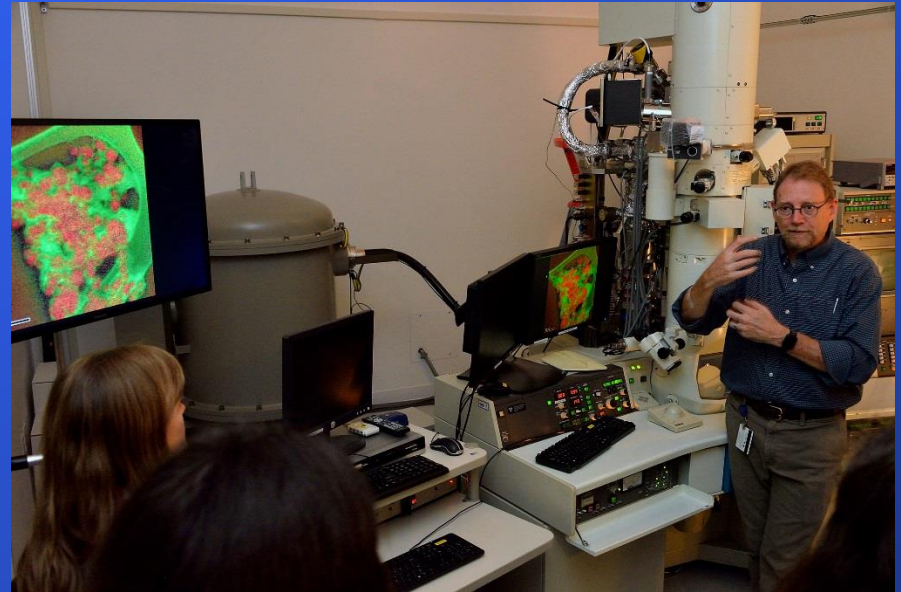
Computing Facility

Opportunity to participate in SEAS, SAS hiring processes.

Electron Microscopy (& More)



Doug Yates



- Critical for research of many faculty.
- Expensive (equipment, staff, service, space)
- MRSEC Support (~\$100K/year)

Many \$\$ problems over years, but situation has improved

Why the Improvement? (1) Singh Building



- ~10,000 sq-ft cleanroom; cleanliness increased from class 10,000 to facility with local space for class 100 & 1000 work.
- Isolation from vibrational/acoustic, and electromagnetic noise.
- Consolidation of TEMs, SEMs, Focused Ion Beam, Scanning Probe facilities, and improved wet-lab processing.

University Investment in Physical Plant

(2) New Hires and (3) Local Champions



Mark Allen, Director, Singh
Center for Nanotechnology



Eric Stach, MSE
Electron Microscopy Expert

**“Coordinated”
Faculty Recruiting**



Maria Drndic, Physics
& Astronomy



Chris Murray,
Chemistry/MSE

Internal Pressure for EM

KEYS TO SUCCESS

- **Intellectual Guidance & Major Start-up Support** (Eric Stach)
- **MRI Matching for New Microscopy Equipment** (LRSM, SEAS, SAS)
- **SEAS now supports dedicated staff as a line-item in their budget** (NEW...lasting?).
- **Previously unmet need for Electron Microscopy for Soft/Bio Materials coming soon....**



TESCAN S8000G
focused ion beam /
scanning electron
microscope.

SEFs Are Important!

- Many hundreds of students & researchers at all levels use SEFs.
- MRSEC students generally use SEFs at no cost, except supplies.

Funding (Matching, Operating \$\$)

- All SEFs received “injection” of support for MRI or related grant.
- Many SEFs receive modest MRSEC funding (~\$20K/yr).
- A few SEFs require more substantial support from LRSM & other University (SEAS, SAS) sources. **Lobby Admin – case by case.**
- X-Ray & Electron Microscopy SEFs charge non-MRSEC users charged to recover costs (\$30-70/hr for educational institutions, \$200-300/hr for industrial institutions). **Valuable, not enough.**
- Critical to be aware of **University missions/hiring/start-up-commitments** and to shape/utilize these efforts for materials.