

EMERGING EDUCATION

An Education & Outreach Overview
of NSF's Materials Research
Science & Engineering Centers

Emerging Education:

An Education & Outreach Overview of NSF's Materials Research Science & Engineering Centers

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Editors



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UVA MRSEC Center for Nanoscopic Materials Design

&

The National Science Foundation

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Introduction

2004 marks the Ten Year Anniversary of the Materials Research Science & Engineering Centers of the National Science Foundation. These ground-breaking centers are located at universities across America. Each center has a unique, interdisciplinary focus in which research in materials science becomes an innovative force in the realms of knowledge and education. Developments and discoveries of each center contribute to the vast growth of technology in areas such as energy, transportation, biomaterials, microelectronics, optics and photonics, and information storage. As business and industry work to integrate this innovative research into the manufacturing of new technologies and materials, the MRSEC centers themselves work to innovate the field of education in America.

Using the model of interdisciplinary study and cutting edge scientific research, Education Directors at each NSF MRSEC explore new models for educating undergraduates, K-12 grade students, and the general public. Opportunities are created for teachers of every level to learn more about the discipline of materials research in order to expand and enhance classroom instruction. Information in this field has the potential to infuse education in such diverse subject areas as physics, biology, chemistry, engineering, mathematics, computer science, technology and society, and social studies. The Education & Outreach Programs at the twenty-eight centers develop new methods for improving the awareness and knowledge of students, teachers, parents, and the general public through such diverse activities as science museum exhibits, tours and workshops held at the MRSEC home institution, classroom visits to schools involving instruction and hands-on laboratory experience, summer camps and research opportunities, creation and distribution of teaching materials and kits, interactive websites, newspaper columns, and television programs.

On November 13-14, 2003 the Education Directors of all twenty-eight centers came together at the University of Virginia for a Director's Meeting, in order to share their approaches and successes in the field of Education & Outreach. Each center presented information on its activities through a combination of posters and short presentations. The Director's Meeting was the first national gathering of all Education Directors since the *Making Connections* Workshop sponsored by the University of California, Santa Barbara, October 21-23, 1998. The result of the 2003 Meeting was an inspiring introduction to the myriad of emerging developments across the spectrum of science and mathematics education in America. It is the goal of this publication to provide a much-needed resource guide to the Education and Outreach Programs of each current NSF MRSEC. As each center strives to expand and refine its efforts, such a reference provides information regarding activities already attempted at other centers as well as points of departure for the creation of entirely new programs and activities. It is also a way to track activities to their sources, so that the Education Directors from every center may be in closer contact for support, ideas, and potentially for future collaborative efforts between centers.

In order to foster easy-access to each center, a Contact Information section is included in this publication, listing current Center Directors, Education Directors, and web addresses for each center. An Overview Page of the Education and Outreach activities of each center follows, alphabetized by home institution of each MRSEC. The content of this publication was collected during the year following the November 2003 Directors Meeting. The synopsis of activities is meant to be a snap-shot introduction to the outreach initiatives of that center. The synopsis represents highlights of a center's work up to the 2003-2004 period of time. As each center grows and changes constantly, it is encouraged for users of this guide to visit the web-site of the center for the most current information, or to contact the Education Director or Center directly.

As implied by the title of this publication, the outreach efforts of America's MRSECs create a picture of Emerging Education in the field of materials science and engineering. This quick desk reference can serve as a tool for bringing these efforts together and for enabling easier information exchange while simultaneously inspiring the education and outreach efforts of the future.



The following is a complete list of MRSEC Center Directors and Education Directors.

University of Alabama

Center Director:	William Butler	wbutler@mint.ua.edu	205-348-2665
Education Director:	Martin Bakker	bakker@bama.ua.edu	205-348-9116
Web site URL:	http://bama.ua.edu/~mint/		

Brown University

Center Director:	W.A. Curtin	william_curtin@brown.edu	401-863-1418
Education Director:	Brian Sheldon	brian_sheldon@brown.edu	401-863-2866
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University of California, Santa Barbara

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Education Director:	Dorothy Pak	pak@mrl.ucsb.edu	805-893-5314
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California Institute of Technology

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Web site URL:	Robert deGroot	rdegroot@caltech.edu	626-395-3598
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Carnegie Mellon University

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Education Director:	Robert Suter	suter@andrew.cmu.edu	412-268-2982
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University of Chicago

Center Director:	Heinrich Jaeger	h-jaeger@uchicago.edu	773-702-6074
Education Director:	Eileen Sheu	e-sheu@uchicago.edu	773-834-9916
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University of Colorado, Boulder

Center Director:	Noel Clark	noel.clark@colorado.edu	303-492-6420
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Columbia University

Center Director:	Irving Herman	iph1@columbia.edu	212-854-4950
Education Director:	Alison Biuso	ab765@columbia.edu	212-854-3964
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Cornell University

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Education Director:	Nev Singhota	outreach@ccmr.cornell.edu	607-255-1486
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Harvard University

Center Director:	David Weitz	weitz@deas.harvard.edu	617-496-2842
Education Director:	Kathryn Hollar	hollar@deas.harvard.edu	617-496-7479
Web site URL:	http://www.mrsec.harvard.edu/		

Johns Hopkins University

Center Director:	Chia-Ling Chien	clc@eta.pha.jhu.edu	410-516-8092
Education Director:	Robert Cammarata	rcc@jhu.edu	410-516-5462
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University of Maryland

Center Director:	Ellen Williams	edw@physics.umd.edu	301-405-6156
Education Director:	Donna Hammer	dhammer@mrsec.umd.edu	301-405-8349
Web site URL:	http://mrsec.umd.edu/		

Massachusetts Institute of Technology

Center Director:	Michael Rubner	rubner@mit.edu	617-253-6701
Education Director:	Susan Rosevear	susang@mit.edu	617-253-0916
Web site URL:	http://web.mit.edu/cmse/www/		

University of Massachusetts, Amherst

Center Director:	Thomas Russell	russell@mail.pse.umass.edu	413-577-1516
Education Director:	Thomas Russell	russell@mail.pse.umass.edu	413-577-1516
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Michigan State University

Center Director:	Brage Golding	golding@pa.msu.edu	517-432-5500
Education Director:	Ann Kirchmeier	kirchmeier@pa.msu.edu	517-432-0159
Web site URL:	http://www.pa.msu.edu/csm/		

University of Minnesota

Center Director:	Mike Ward	wardx004@tc.umn.edu	612-625-3062
Education Director:	Frank Snowden	snowden@cems.umn.edu	612-626-0798
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Northwestern University

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Education Director:	Laura Ernst	l-ernst@northwestern.edu	847-491-3606
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**University of Oklahoma/
University of Arkansas**

Center Director:	Matthew Johnson	johnson@mail.nhn.ou.edu	405-325-3961
Education Director:	Caroline Hall	caroline@nhn.ou.edu	405-325-3961
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University of Pennsylvania

Center Director:	Michael Klein	klein@lrsm.upenn.edu	215-898-8571
Education Director:	Andrew McGhie	mcghie@lrsm.upenn.edu	215-898-6461
Web site URL:	http://www.lrsm.upenn.edu/		

Pennsylvania State University

Center Director:	Moses Chan	chan@phys.psu.edu	814-863-2622
Education Director:	Ronald Redwing	rdr10@psu.edu	814-863-0705
Web site URL:	http://www.mrsec.psu.edu/		

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Center Director:	Ravindra Bhatt	ravin@princeton.edu	609-258-2532
Education Director:	Daniel Steinberg	dsteinbe@princeton.edu	609-258-5598
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Education Director:	Sarah Morgan	sarah.morgan@usm.edu	601-266-5296
Web site URL:	http://www.usm.edu/mrsec/		

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Education Director:	Marni Goldman	mgoldman@stanford.edu	650-725-3351
Web site URL:	http://www.stanford.edu/group/CPIMA/		

SUNY Stony Brook – Thermal**Spray**

Center Director:	Sanjay Sampath	ssampath@ms.cc.sunysb.edu	631-632-8480
Education Director:	Lysa Russo	lrusso@notes.cc.sunysb.edu	631-632-4567
Web site URL:	http://www.stonybrook.edu/ctr		

SUNY Stony Brook – Garcia**Polymer**

Center Director:	Miriam Rafailovich	miriam.rafailovich@sunysb.edu	631-632-8483
Education Director:	Lourdes Collazo	lourdes.collazo@sunysb.edu	631-632-6097
Web site URL:	http://polymer.matscieng.sunysb.edu/		

University of Virginia

Center Director:	Robert Hull	hull@virginia.edu	434-982-5658
Education Director:	Carolyn Vallas	cv5d@virginia.edu	434-924-0614
Web site URL:	http://www.mrsec.virginia.edu/		

University of Wisconsin, Madison

Center Director:	Juan DePablo	depablo@engr.wisc.edu	608-262-7727
Education Director:	Wendy Crone	crone@engr.wisc.edu	608-262-8384
Web site URL:	http://www.mrsec.wisc.edu/index.php		

For Further Information:**Materials Research Science & Engineering Centers**

<http://www.mrsec.org>

The National Science Foundation

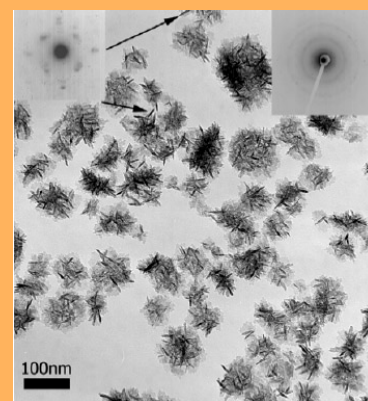
<http://www.nsf.gov/mps/dmr.mrsec.htm>





THE UNIVERSITY OF ALABAMA

Center for Materials for Information Technology



TEM image of acicular Co nanoparticles.

Educational Outreach

The MRSEC at Alabama collaborates with the Center for Communication and Educational Technology (CCET) on the development and broadcasting of the **"Integrated Science"** television program. This innovative science series is tailored for rural schools that lack the resources for a specialist science teacher. The curriculum focuses on teaching physics, chemistry, and biology in an integrated form throughout middle school. Approximately eighty thousand students in Alabama, the U.S. Southeast and other parts of North America currently take part in the program.

CCET/Integrated Science also hosts interested science teachers for eight weeks on the UA campus during the summer. The teachers work on a research project with a MRSEC faculty member while also working with a MRSEC/CCET software development team on the development of computer-based instructional materials. Currently, a suite of computer games based on the investigation of the **Periodic Table** is in development. While similar games exist for younger age groups, this program will customize the presentation for an older, middle-school audience. The games incorporate material about the elements, their structure, and predictions of chemical reactivity. Release is scheduled for Spring, 2005.



20 nm-high Co wires, directly transferred onto a dendrimer-modified silicon substrate by a patterned stamp.

HBCU Outreach

The MRSEC has provided support for two faculty from HBCUs: Prof. Justin Akujieze from Chicago State University (CSU) and Prof. Naidu Seetala from Grambling University. The goal of this program is to increase materials science at HBCUs by providing members of their faculty an opportunity to carry out research at the MRSEC, and by developing a supported research program at the HBCU.

Prof. Akujieze worked with MRSEC Prof. Gary Mankey during the summers of 2002 and 2003 growing magnetic materials by vapor deposition and characterizing the materials using Magneto-Optical Kerr Effect (MOKE) and neutron scattering at NIST. Akujieze is co-author of a manuscript in preparation for publication. Akujieze and Mankey have collaborated on a Partnership for Research and Education (PREM) proposal designed to garner support for magnetic characterization at CSU of materials prepared at the MRSEC in Alabama.

Prof. Seetala worked with Professors David Nikles and J. W. Harrell of the MRSEC during the summer of 2003 synthesizing and characterizing iron-platinum nano-particles. One outcome of this work has been the submission of a PREM proposal to expand the collaboration between the MRSEC and Grambling State University. In this proposal support is requested for a number of faculty from Grambling State to work at the MRSEC during the summer, as well as for the purchase of a Mossbauer spectrometer to enable sample characterization. This would compliment TEM and other studies at the MRSEC.



Brown University

Center for Advanced Materials Research

Providence, RI 02912

Brown MRSEC Outreach

Brown's MRSEC outreach program began in 1996, and builds upon four interrelated components: a teacher training institute, a classroom visits program, REUs for students from Brown and HBCUs, and a wonderful RET program.

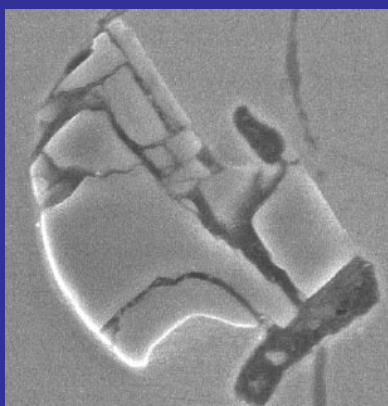
Classroom Visits Program

The focus of our program is to develop instructional modules that consist of demonstrations, in-class projects and problems, and homework assignments. Specially-trained Brown University undergraduates are paid to present the modules in area schools, grades K-12.

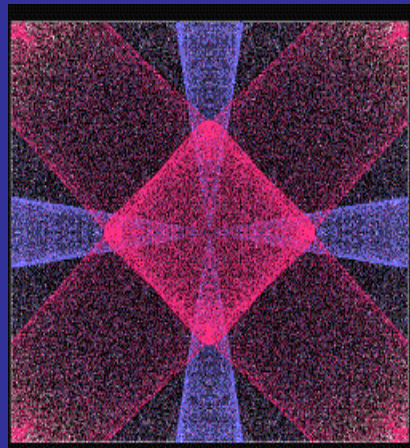
The module presentations utilize student participation through experiments, calculations, and discussions. All attempt to combine math, scientific computing, and science concepts with engineering applications.

The Classroom Visits Program has reached over 3400 students in the last 3 years alone, including 670 minority students. Several of the Brown undergraduate presenters have gone on to teaching careers as a result of their experiences in the program.

Brown Faculty also present these time-tested modules to primary and secondary school teachers enrolled in the annual teacher-training institute.



Ductile fracture in steel, nucleated by cracking of TiN inclusions.



Graph of phonons with a spatially directed flow of energy .

Teacher Training Institute & RET Program

The Teacher Training Institute is run with the help of the Brown-Based **Institute for Elementary and Secondary Education**. In recent years, attending teachers have payed only a nominal fee. Upon completion, participants receive continuing education credit.

Teachers may also enroll in the annual **RET** summer program, and work with Brown faculty on research and module development. The teachers are given lectures and weekly tours of research facilities throughout campus. Many choose to develop classroom teaching materials and kits for their own use. These modules are then used in our classroom visits program and are presented in future institutes.

REU Program

This program draws students from Brown University and HBCUs. Recruitment is aided by the Brown-based Leadership Alliance, a consortium of HBCUs, tribal colleges, and research universities. REU students work with a member of faculty on a research project. MRSEC faculty and the Leadership Alliance also organize seminars, social support, and leisure activities. We have now enrolled three outstanding REU participants from HBCUs in our PhD program in materials science.



Education Outreach Programs

MRL programs target K-12 and Community College teachers and students. Goals of the outreach programs include: improving teacher retention, providing professional development and generating curriculum resources to assist in meeting national and state standards for science teaching. MRL labs provide research experience for students and teachers whose home institutions do not have a research mandate.

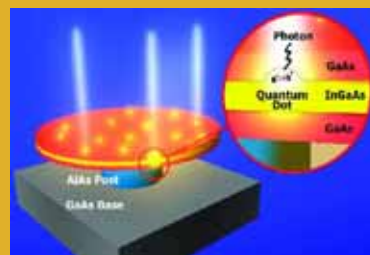
MRL is currently coordinating five different education programs. **UCSB ScienceLine** is an online "Ask a Scientist" program where students and teachers from K-12 schools can submit a science question and receive responses from one or more scientists. All questions and their responses can be viewed in a web-searchable database.

Our **Research Experience for Teachers (RET)** program brings secondary science teachers to the MRL for two summers. During the first summer, the participants participate in MRL laboratory research. During their second summer, they work collaboratively on projects that translate their research experience into new investigative projects for their classrooms.

Heirarchical supramolecular assembly of F-actin (blue) and cationic lipid bilayers (yellow) leading to 3-layer-tubule networks with applications in drug delivery and templating.



Beyond the Classroom was a 2000 – 2003 MRL initiative designed to support teachers using technology in their classrooms. Eighteen teachers in grades 5-12 developed curriculum projects focusing on student use of technology to enhance scientific investigation and communication skills. Each lesson supports the California State standards and the technology standards of the International Society for Technology in Education. Currently, the MRL hosts the program's web site containing detailed project descriptions for other teachers to use, as well as a *listserv* that enables teachers to discuss issues and innovations.



A quantum dot single-photon turnstile device: preparing the way for quantum cryptography.

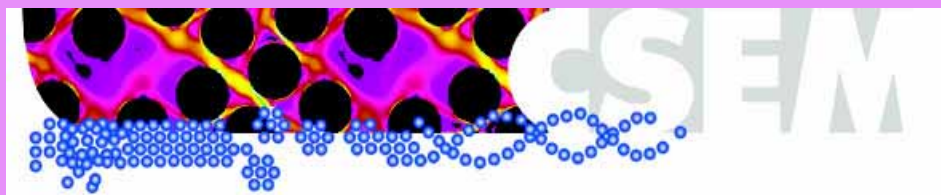
The **Research Interns in Science and Engineering (RISE)** program brings undergraduates from colleges and universities around the country to UCSB to complete ten-week summer research internships with MRL faculty. Internships during the academic year are also available for UCSB students.

Community College Interns in Materials Research (CCIMR) is a summer research internship opportunity for California Central Coast community college students. Students are matched with an MRL mentor to complete an eight-week laboratory research project. This program is run concurrently with the **INSET (Interns in Nanosystems Science, Engineering and Technology)** program administered by the California NanoSystems Institute at UCSB.

Technology Outreach Program

Our relationships with industry and national laboratories are at the heart of the MRL Technology Outreach Program. The goals of the Program include enhancing financial support of MRL research programs, soliciting funds for graduate support, stimulating interactions with industry and national labs, and developing employment opportunities for our students and post-docs. Our program activities range from one-on-one partnerships between faculty and industrial scientists to MRL-wide functions. Our annual **Materials Research Outreach Program** is designed to stimulate collaborative research between faculty groups at UCSB and industry scientists and engineers. Another recent initiative, the **Complex Fluids Design Consortium** brings together UCSB faculty with researchers from industry and national laboratories interested in the computational design and processing behavior of soft materials and complex fluids. Occasional **Focused Workshops** with companies or national labs are held to exchange research ideas and develop collaborations. Recent workshops have been held with Mitsubishi Chemical, LANL, and Amgen.

CENTER FOR THE SCIENCE AND ENGINEERING OF MATERIALS (CSEM)



California Institute of Technology

CSEM Outreach

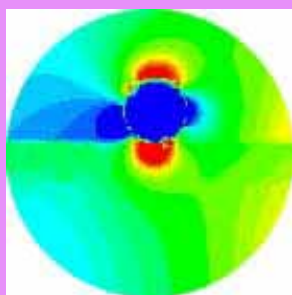
The four major outreach efforts of CSEM are the Materials Partnership with California State University at Los Angeles (CSULA), high school science experiences that engage under-represented minority students, development of hands-on science instructional materials for students in grades 7-10 with the partnership of the Caltech Precollege Science Initiative (CAPSI), and production of a ten-part television series about materials science and engineering entitled "Material World: The Properties of Matter" (currently in development).

CSEM has also taken a leadership role in the **NSF Research Center Educators Network (NRCEN)**, which fosters collaboration amongst educational outreach professionals in NSF centers (MRSEC, STC and ERC).

CSEM conducted further outreach activities with the Sally Ride Science Club, devoted to introducing middle-school girls to careers in science and engineering.



An additional Center resource is the partnership with outreach programs of the **American Chemical Society (ACS)**, which involves sponsorship of National Chemistry Week activities and a recent high school research and essay competition, Chemagination.



"Plasmon Printing": A new lithographic technique using ordinary visible light and conventional resist to print nanoscale features.



CSEM Fellows, 2003.



Sally Ride Science Festival.

CSEM-CSULA Materials Partnership

CSULA has an enrollment of greater than 80% under-represented minorities, and displays a growing level of faculty and student interest in materials science. The CSEM/CSULA Partnership has three main goals: faculty exchange between the two universities' seminar programs, purchase of instrumentation needed at CSULA for collaborative research with CSEM, and collaboration of CSEM and CSULA faculty in designing co-advised projects to involve CSULA undergraduates.

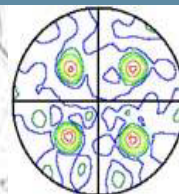
CSEM and Caltech-Wide Educational Outreach

CSEM is a founding member of the **Caltech Educational Outreach (CITEO)** Office, a new educational outreach resource for the Caltech community. CITEO facilitates, coordinates, and assesses Caltech's research-based educational outreach programs; provides personal assistance to faculty scholars, students, and staff within the Institute's six academic Divisions; and works to coordinate their educational outreach efforts with other groups on campus.

Recently, CITEO facilitated the formation of a community-based **Local Educators' Network (LEN)**. The LEN provides local educators with a primary role in the design and implementation of Institute-wide educational outreach programs.



Carnegie Mellon MRSEC



Education

Overview

The CMU MRSEC's education and human resource development activities are intended to impact a range of sectors within and external to the university and have three important components beyond graduate education: research experiences for undergraduates, a Partnership for Research and Education in Materials (PREM) with Florida A&M University (FAMU), and a summer program for Pittsburgh area science teachers.



Granular microstructure: the colors correspond to the local orientations of tungsten crystals.

Undergraduate Research

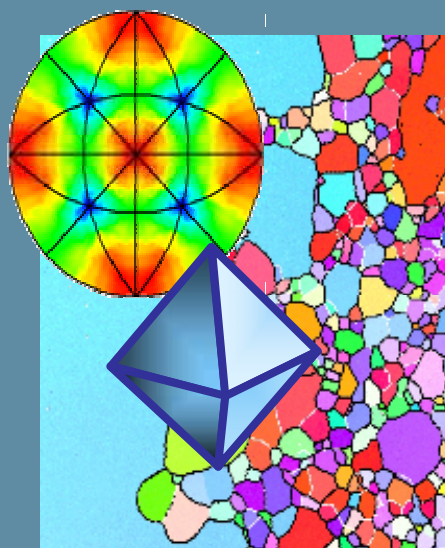
The goal of this program is to provide undergraduate science and engineering students with an experience that will encourage them to pursue a graduate degree in engineering, math, or science and to initiate the development of professional skills needed to succeed in these fields. Each student is assigned a faculty advisor and a graduate student mentor. This team decides on the goals and scope of the project to be conducted over a ten-week period. The student works most closely with the graduate student mentor, attends research group meetings, and reports to the faculty advisor. The idea is to provide a research experience that is similar to that of a typical graduate student.

The PREM Project

The Partnership for Research and Education in Materials (PREM) is a collaboration in which the CMU MRSEC has joined with Florida A&M University (FAMU) to advise graduate and undergraduate research and to teach classes via the internet. In this program, FAMU undergraduates spend the summer in the Research Experiences for Undergraduates program at CMU and then continue work on the same projects during the school year at FAMU. The project has had a successful record of encouraging under-represented minorities to pursue graduate degrees in science and engineering fields.

Program for Science Teachers

Our 7-12th grade curriculum development program provides summer support for teachers to develop materials-science-related educational units that are used during the school year. These units are shared with colleagues from their own schools and with other area schools via a web site.



Electron backscattered pattern mapping of the polycrystals of a commercial Al alloy (background): used here to construct a statistical picture of the crystallographic interface distribution (foreground).



An essential aspect of the University of Chicago MRSEC's mission is the integration of research with education and outreach. We have developed a multi-faceted approach to our programs that combines K-12 student and teacher enrichment, education activities geared toward our own academic community, and outreach to the general public. A selection of our current activities follows:

K-12 Student and Teacher Enrichment

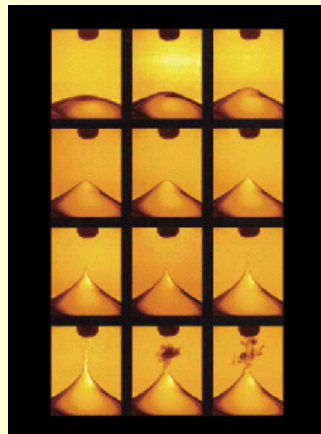
These programs include our Elementary School Demo Team; the Young Women's Leadership Charter School (YW LCS) high school internship program; and the Science and Technology Mentoring Program (STOMP), a science club for elementary school students in the surrounding South Side of Chicago. In addition, our Center collaborates with the University's Math Department in operating two acclaimed programs: the Young Scholars' Program (YSP) and the Seminars for Endorsement for Science and Mathematics Educators (SESAME) program for teachers.

The **YSP** annually hosts approximately 120 mathematically talented 7-12th graders for a four-week, tuition-free summer program that emphasizes academic enrichment. Students participate in interactive lectures, run computer simulations, and solve problems in small groups. Past topics include chaos and complexity, neural networks, geometry, hydrodynamics, and symmetry.

The **SESAME** program began in 1991 as a joint effort with the Chicago Public Schools to enhance the instruction of science and mathematics at the elementary and middle school levels through the professional development of teachers. By successfully completing a series of quarter-long, intensive, evening seminars, teachers can obtain a state endorsement in math or science. The MRSEC provides course components, materials, and instructors.

Research Opportunity Programs

Our research opportunity programs bring 23-25 students each year into the MRSEC laboratories to participate in forefront research. This group includes interns from our summer Research Experiences for Undergraduates (REU) program, undergraduates from the University of Chicago working on senior thesis projects, as well as outstanding local high school students. Over 75% of these students go on to pursue graduate studies in materials-related fields.



Time-lapse photography of an electrohydrodynamic spout: the water is pulled by a charged electric diode into an infinitely sharp peak, known as a cusp structure, and then explodes into tiny droplets.

Management Laboratory

The Management Laboratory is a unique program which introduces MRSEC graduate students to business/industrial practices and culture. Interdisciplinary teams of graduate students from both the MRSEC and the Graduate School of Business work together for 10-week periods to solve industrial problems under the guidance of professional coaches. These problems involve technical and business aspects of industry processes, and are provided by companies who directly commission the studies from the Management Laboratory. Clients have included BASF, Roche Diagnostics, Ondeo-Nalco, Dow Chemicals, and Bulkmat Corp.

Museum Demo Team

The Museum Demo Team, one of several museum collaborations pioneered by our Center, provides a highly successful conduit to engage the general public, from children to adults, in hands-on, interactive exploration of materials science. Since 1997, the team's graduate students and postdocs have reached many thousands of museum visitors through their portfolio of approachable demonstrations, which include granular materials, ferrofluids, fiber optics, quantum dots, and non-Newtonian fluids, among others. The Demo Team primarily performs at the Chicago Museum of Science and Industry, located close to the U. Chicago campus and serving 2 million visitors annually. The team also makes appearances at the Adler Planetarium and SciTech Hands-on Museum.

Sights and Sounds of Science

This University-wide competition explores the question "where does science turn into art?" Designed to engage the arts and science community in dialogue, the S³ Project: Sights and Sounds of Science bridges materials science and the arts via musical compositions, sound collages, video, and animation, having MRSEC research as the theme. Winning entries are accessible on the MRSEC website.



Images from the S³ Project: Sights and Sounds of Science Competition



Ferroelectric Liquid Crystal Materials Research Center

an NSF MRSEC

Colorado
University of Colorado at Boulder



Thiol-ene polymer stabilized FLC at Smectic A phase, 30° C above clearing point.

Material Science From CU (MSFCU)

MSFCU is the Ferroelectric Liquid Crystal Materials Research Center's principal K-12 outreach activity. Conceived in 1998 and initiated with the onset of MRSEC funding, Center personnel design hands-on classes that teach physical science concepts using the current understanding of materials. Center faculty, staff, and students prototype these presentations in the classroom and train presenters who take the program statewide. MSFCU makes effective use of Center personnel and expertise, presenting classes to over 34,000 Colorado K-12 students in the past 5 years.

MSFCU has now expanded its scope to include MSFCU Traveling Kits, which are loaned for a 3-week period. A kit entitled "Ups and Downs: The Science behind Sports Equipment" is currently available. Each activity in the kit prepares students for a Design Project in which they construct a miniature golf-ball or invent a new sports product.

Liquid Crystal Wizards Show

The scientific concepts of light, polarization, and optics are explained through a number of experiments – such as the creation of a giant soap bubble - during the CU Wizards show "Liquid Crystals." This free, hour-long show combines physics, chemistry and engineering, and is intended primarily for students in grades 5-9. CU Wizards is an annual series that introduces topics in astronomy, chemistry and physics. Audience members see liquid crystals in action, through demonstrations & interaction with presenters.

Liquid crystals are gooey, organic materials that display properties of both the solid and liquid state, and that are sensitive to the polarization of light. The Wizards Show demonstrates the optical and electrical properties of liquid crystals and shows how they are used in today's high-tech society in items like laptop computers and digital watches to display information.

High School Honors Institute

The Institute is a four-day, intensive, campus-residential-experience program for juniors and seniors that introduces engineering to high-school students with a strong academic record who are interested in math and science. Participants attend classes in two CU engineering fields, attend curricular and extra-curricular activities, and explore career opportunities in the field. Students select which two fields they prefer for deeper classroom-study from the diverse areas of aerospace, chemical/biological, civil, environmental, architectural, electrical/computer, or mechanical engineering as well as applied math, engineering physics, and computer science.

Undergraduate Research Opportunity Program (UROP)

In addition to a **Research Experience for Undergraduates (REU)** program at the FLCMRC, the center extends financial support to CU undergraduates from all degree programs to fund innovative research projects. Students partner with faculty members to pursue their research; "research" for the program is defined as any scholarly or creative activity ranging from traditional science experimentation to the creation of new artistic works.

Liquid Crystal Science and Technology (LCSAT) Graduate Program

The Center offers a limited number of Graduate Fellowships each year in its Graduate Training Program, which focuses on interdisciplinary education and training in the field of liquid crystals. The goal of the program is to prepare graduates for careers in the field by generating collaborative research projects. Opportunities include a one-semester laboratory rotation, mentored teaching opportunities, and a three-month industrial partnership.

MHOBOW, a new material, shown here as a single chiral domain, which exhibits layers ordered in polar and antiferroelectric fashion in the absence of any applied field.





Education, Human Resources & Outreach Programs

The Materials Research Science and Engineering Center (MRSEC) at Columbia University, called the Center for Nanostructured Materials, was first established in 1998 and renewed in 2002. One central goal for our Center is to be a focus for education and outreach within the New York metropolitan area. Our education and outreach activities are highlighted by summer research opportunities and curriculum enhancement in NYC schools.

A **High School Visitation Program** brings the Columbia University MRSEC to NYC public schools to promote materials science and engineering. One goal is to foster the interests of K-12 students in science by showing them the marvels of materials science and engineering and describing the relevance of science to quality of life. Another objective is to improve the retention of a diverse student body on track for careers in science and technology.

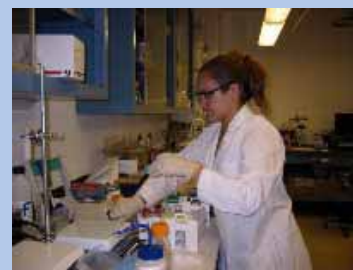
Materials science is explained through exciting, hands-on demonstrations incorporating "every day" objects. During a typical visit, an Education Outreach team of 2-3 graduate-student volunteers address 4-6 science classes, with a total of 100-150 students involved per visit.

A new extension of the Columbia MRSEC High School Visitation Program is the **Ron McNair Curriculum Integration To Interactively Engage Students (CITIES) Program**, started in 2003. This is a pilot program, creating a partnership between the Columbia MRSEC and the NYC Department of Education, Instructional Region 10. The aim of this new collaboration is to enhance student performance within the structure of the New York State Regents curriculum.



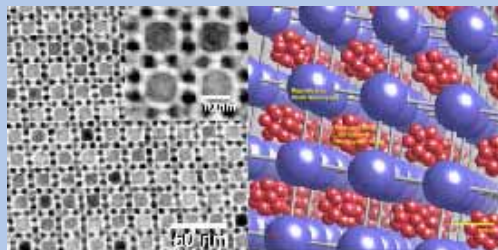
A graduate-student volunteer interacts with NYC high school students during a classroom visit.

An REU student working in the lab.



Research Experiences for Undergraduates

This 10-week program brings 12 students each summer to conduct research with MRSEC and other materials faculty. We actively recruit students from colleges that provide little or no research opportunities for their undergraduates, as well as women and under-represented minority-students. Participants receive a stipend, campus housing, and a reasonable student-travel allowance. Students in MRSEC and related REU programs are clustered in Columbia housing to enable formation of ties with a larger group of approximately 30 REU students. Participants visit industrial and government research laboratories and attend a weekly seminar series describing the diverse areas in materials science and engineering.



The first assembly of magnetic and semiconducting nanoparticles: TEM of ordered-array maghemite (left); schematic of nanocrystals (right) showing gamma-Fe₂O₃ in blue and PbSe in red.

Research Experiences for Teachers

This program enables four K-12 teachers from NYC public high schools to conduct 8 weeks of research with MRSEC and materials faculty over 2 consecutive summers. RET teachers are paid a generous stipend and their schools receive classroom funds to be used as each RET participant chooses. They receive free AOL and can receive educational credit if registered with Columbia University's Teachers College. The RET program is run in conjunction with Columbia University Summer Research Program for NYC Science Teachers, which has enriched the program with career development training for the teachers and supplemental support obtained from private foundations. RET teachers also evaluate new MRSEC education outreach programs.

Outreach to Teachers: The Materials Science Workshop

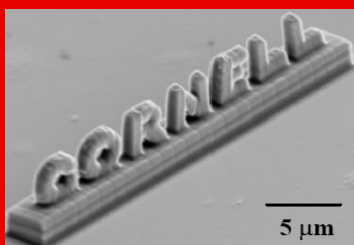
This day-long workshop for K-12 teachers builds on curriculum developed by Professor Arthur Ellis in *Teaching General Chemistry: A Materials Science Companion*. The workshop involves faculty, staff, and graduate students from Chemistry and Chemical Biology, Textiles & Apparel, Chemical Engineering, and Materials Science & Engineering. Developed in 1996, the program has now reached over 200 area teachers. Participants spend most of the day involved in hands-on demonstrations that they can take back into the classroom.

A morning overview session elucidates the impact of materials science on society and the need to incorporate materials science into grade-school science curricula. This is followed by small-group laboratory work, dealing with the science of polymers. Polymers analyzed include breathable fabrics such as Gore-Tex, performance fibers used in medicine, sports, and industry, as well as demonstration of the ways in which common chemicals such as glue and borax, or the addition of polymeric materials to water, can be used to introduce polymers to students.

The afternoon session incorporates experiments and demonstrations dealing with non-polymeric materials. Non-polymeric materials presented include crystalline structures and nickel-titanium wires; other demonstration studied explore the properties of superconductors, explanation of the applications of thermodynamics using crystal structure models, building a circuit by wiring together light-emitting diodes (LEDs), and minting gold and silver coins through an oxidation-reduction process.

At the conclusion of the workshop, the teachers are provided with a complete set of materials to perform the experiments with their students in class. They also have access to order additional supplies for these labs in the future. A follow-up session of collaborative work to integrate this curriculum into the New York State Science Standard is currently being planned. The success of the workshop has led to a waiting list of thirty teachers, with plans to expand the program from once every two years to annually, and to invite past participants to return to share how they have integrated materials science into their lesson plans.

Acrylate 3D fabrication system prepared by two-photon lithography.



Community Outreach: The Ask a Scientist Column

CCMR's most successful outlet to the general public is the **Ask a Scientist** column in the Ithaca Journal. In this column, scientists and engineers answer questions primarily from K-12 students. Both the scientist and the student are featured in the article. The column first appeared on September 17, 1998. Professor Neil Ashcroft, then director of CCMR, answered the first question, "What is Jupiter made of?"

Over 250 questions have been answered and published in the past five years. The questions are answered by scientists from across disciplines and across the upstate New York region, from science education advocate Bill Nye, to Nobel Prize winning physicist David Lee. Based on CCMR's model, Binghamton University now coordinates an *Ask a Scientist* column in the Binghamton Press & Sun paper.

Ask a Scientist reaches more than 81,000 readers in Central New York. All current and past questions are available to students and the general public through exploration on the web at <http://www.ccmr.cornell.edu/education/ask/>, bringing this forum to an even wider variety of people.

Other Outreach Offerings

CCMR's **Educational Programs Office (EPO)** collaborates with teachers and the community to provide high-quality science education to K-12 students through numerous programs. To this end, faculty, postdoctoral associates, graduate students, undergraduates, and staff have developed and enhanced hands-on science lessons for classroom use.

In the past year, we have offered 50 separate educational outreach programs reaching approximately 60 undergraduates, 2,500 K-12 students, 475 parents of school children, 290 schoolteachers, and 81,000 upstate New York newspaper readers.

Additional educational opportunities include: a **Research Experience for Undergraduates**; a **Research Experience for Teachers I & II**; a **Microworld Festival** workshop for the introduction and demonstration of microscopes to elementary- and middle-school teachers; and a **Professional Development** collaboration with teachers to address science curriculum requirements in New York State.

Harvard University



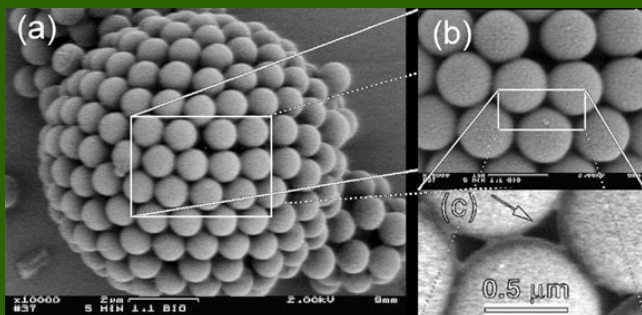
Materials Research Science and Engineering Center

Educational Activities

The education and research programs of the Harvard University MRSEC actively promote diversity, strong interconnections among the activities, and the development of a sense of community which extends beyond the research activities of the Center. The program goals are:

- Bring the excitement of scientific inquiry to pre-college students through collaboration with faculty towards development of new methods for teaching science, through direct research experience, and through demonstration of the value of interdisciplinary teamwork.
- Promote career advancement for a diverse group of tomorrow's materials scientists and engineers.
- Involve participants from various educational and community programs as mentors and collaborators, providing interconnections for every stage of development as a scientist.

Interrelated MRSEC educational programs target students from K-12th grade through the post-doctoral level. MRSEC faculty and graduate students are involved in a minimum of one outreach activity. Programs include an early awareness program for Cambridge Public School seventh-graders aimed at science careers and pathways to college; community and public programs such as science academies, science fairs, and museum symposiums; a special **Holiday Lecture** for children and parents, including historical discussions and current Center research; a **Research Experience for Teachers (RET)** and **Undergraduates (REU)** summer activity; innovative academic courses created by Center faculty for undergraduate & graduate students; and distinguished Women and Minority Center Postdoctoral Fellowships.



SEM image of colloidosome, showing the pores that control permeability.

Cross-Program Collaboration

In past summers, RET and REU participants working together with faculty mentors have developed educational activities for the larger community in addition to their technical work. For example, area high school physics teacher Meghan Walkbran worked as an RET participant with Prof. Howard Stone to create a **Holiday Lecture**, "Scratching the Science of Surfaces." This Lecture, modeled after the Christmas Lectures initiated by Michael Faraday at the Royal Society, was advertised to 'Children of all Ages' throughout the Boston area, including the network of science teachers in the public schools systems who collaborate with the MRSEC for science fairs. Roughly 80 children and parents attended the lecture, which featured historical figures such as Benjamin Franklin.

Another instance of cross-program collaboration is the co-development of in-class activities by RET and REU participants, in which an RET teacher develops a classroom activity related to his or her summer research, and invites an undergraduate to the classroom to talk about his or her related REU experience. This provides K-12 students with accessible role models who can inspire them towards a future in science.

REU participants often become co-authors of published papers based on their summer research, and present at national and regional conferences; over 30 such presentations and publications have been made since 1998. Follow-up with REU students includes guidance on career and graduate school choices long after the summer program is over.

The REU is run in conjunction with the Nanoscale Science and Engineering Center based at Harvard, and is also supported by Harvard's Division of Engineering and Applied Sciences, which allows students to form a larger REU network (approximately 30 participants per year) and become familiar with research areas that are outside the scope of an individual summer project.

Focus on Diversity

As part of the MRSEC's diversity outreach effort, the Center has cultivated relationships with faculty at the University of Puerto Rico System and Historically Black Colleges and Universities through recruiting visits and national conferences. These off-campus efforts and on-campus follow-up activities have contributed to a growing diversity among students of our REU program. We have approximately doubled our percentage of women participants - from 31% in 2001 to 58% in 2003 - and of underrepresented minorities participants - from 21% to 48%.





JOHNS HOPKINS UNIVERSITY

Outreach Overview

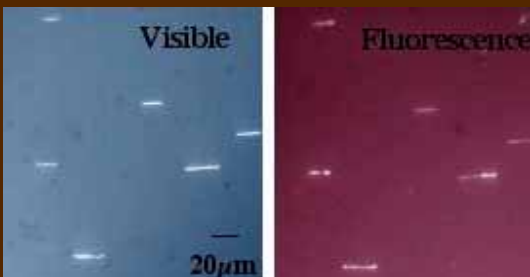
The outreach programs run by the JHU MRSEC are designed to introduce the participants to current materials research. The programs for teachers also provide assistance for curriculum development and access to the educational resources of the JHU MRSEC. Administration and organization of these programs is carried out with the assistance of the Johns Hopkins University Center for Talented Youth (CTY).

Current Outreach Programs

- Research Experience for Undergraduates (REU)
- High School Student Summer Internships
- High School Teacher Summer Internships
- Research Experience for Teachers (RET)

Research Experience for Undergraduates (REU):

Each summer, the Materials Science Research and Engineering Center provides support for at least six undergraduates to spend approximately ten weeks doing actual materials research in one of the laboratories of the JHU MRSEC, either at Johns Hopkins or at Brown University. Under the guidance of the MRSEC faculty in physics, materials science, and engineering, students conduct research in such areas as nanowire structures, nanoparticle self-assembly, half-metallic ferromagnets, spin-valve structures, and nanocrystalline metals and alloys.



Electrodeposited magnetic Ni nanowires, displaying strong fluorescence.

High School Teacher Summer Internships

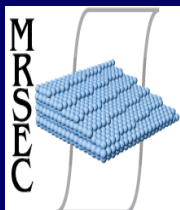
This one-week program offers high school teachers the opportunity to enhance their scientific knowledge, develop new classroom and laboratory projects, and make use of the educational resources of the JHU MRSEC. Each summer, seven physics and chemistry teachers from area high schools are selected to participate in this internship. This program consists of eight three-hour, hands-on sessions on topics such as scanning electron microscopy, transmission electron microscopy, crystallography and x-ray diffraction, microelectronics, optical and e-beam lithography, and phosphors for display technology. Additional materials and demonstration kits are provided for the teachers to develop projects for their students. As a result of this interaction, several previous high school teacher interns have brought their science classes to JHU for field trips. Members of the JHU MRSEC have also gone to various high schools to give lectures, perform demonstrations, and serve as judges at science fairs.



A group of teachers with the Summer Internships Program work in the lab.

High School Student Summer Internships

This one-month program provides high school students with in-depth exposure to a research environment. Each year in July, select high school students work as paid interns in MRSEC laboratories. Participants are introduced to research in advanced materials, nanotechnology in particular, and have the opportunity to participate in a multidisciplinary research program emphasizing the development of small-scale structures for applications in fields ranging from fundamental physics to electronic devices. Students also have the opportunity to attend informal seminars on the latest developments in advanced materials research. At the end of the internship, each student prepares a written final report, and gives an oral presentation describing his or her results.



NATIONAL SCIENCE FOUNDATION



Materials Research Science and Engineering Center

University of Maryland MRSEC

Committed to Excellence in Education Outreach

UMD MRSEC education programs target the highly diverse public schools in UMD's surrounding Prince George's County and neighboring Montgomery County, as well as home-schooling families from around the region. The MRSEC employs a successful service-learning approach, in which MRSEC research personnel (graduate students, post-docs, and faculty) all contribute service hours to the education programs. In addition, volunteers from participating departments allow us to reach more students each year.

MRSEC-AIP Student Science Conference

Now in its eighth year, the MRSEC-AIP Student Science Conference is designed for a middle-school level and draws students from diverse backgrounds. As co-host, the American Institute of Physics Education Division provides conference facilities, luncheon, and the conference-day, hands-on science workshop. The conference program is guided by three objectives: 1) to improve students' abilities in and perceptions of science, 2) to improve students' research presentation skills, and 3) to involve families and the community in science education.

To accomplish these objectives four components have been developed: 1) MRSEC researchers are trained to work with students to help transform their science fair projects into scientific presentations, 2) students and mentors participate in a workshop on public speaking, 3) three one-on-one mentoring sessions with MRSEC researchers are held at UMD for students to complete and practice their presentations, and 4) the conference day includes activities and discussion for families and the community.



STM image of
single-atom steps -
a complex non-
equilibrium structure
- created by an
external electric field.



Roller Coaster Workshop

The Roller Coaster Workshop is a multidisciplinary program including physics, engineering, and math. The Workshop curriculum effectively integrates hands-on learning and the application of science. The program targets under-represented high school students who are considering careers in science and engineering. The curriculum includes history, physics, design, computer modeling, G-force, and presentation skills. The computer modeling of a roller coaster and a construction project, in which the students are separated into teams to design and build a roller coaster using K'nex, compliments the lesson plans. The roller coasters are judged according to specific, preset criteria derived from the lesson plans and the activities of the workshop. During the presentations, the students must show justification for the design, as well as competence in the physics and engineering behind the design, based on the specific, pre-set criteria.

Summer Camp Programs and Workshops

Summer camps offered by the MRSEC include: Physics Summer Girls Program; Science, Engineering, and You!; Math for Physics Workshop; Aeronautics & the Age of Flight Camp; The Materials of Sports; and Engineering Design Camp. Workshops offered include Science Education Workshops for Researchers, Teacher Workshops, and Home-schooling Workshops.



Water droplets on a super-hydrophobic surface mimic the water-repellence of the lotus leaf.

The Center for Materials Science and Engineering (CMSE) at MIT offers a broad range of educational outreach programs, including:

- Science and Engineering Program for Middle School Students
- Science teacher workshops
- Research Experience for Teachers (MRET)
- Science Teachers Enrichment Program (STEP)
- Summer Research Internship Program (REU)
- Minority Graduate Research Assistantships

Three of these are highlighted here.

Science and Engineering Program for Middle School Students

Since 1991, CMSE has operated this program for seventh- and eighth-grade students from Cambridge public schools. The objectives of the program are to familiarize the students with materials science and engineering, to demonstrate that science and engineering are fun and interesting, to introduce students to a college environment, and to expose them to some of the exciting resources at MIT. The program consists of a one-week experience for twelve students from each school, the majority of whom are females or members of minority groups. The science teachers from the two schools consult with CMSE on the program content and attend with their students. While at MIT, students explore materials science and engineering through a variety of hands-on activities, including glassblowing, metal casting, electric circuit design, motor construction and a design contest. The students learn firsthand about different materials, how their properties can be manipulated, and how they are used in designing products. These projects are developed and presented by MIT faculty, staff, students, and postdoctoral associates. Each weekly program concludes with the design competition, to which the families of the participants are invited.



3-D photonic crystals use light as a carrier of information in micro devices.

Professional Development Programs for Teachers

Participants of the **Materials Research Experience for Teachers (MRET)** program include high school and middle school science teachers, who spend seven weeks at the MIT MRSEC collaborating on research, touring the Shared Experimental Facilities to learn how the equipment is used, and attending weekly meetings to share ideas about how to incorporate their research into their teaching curricula. The summer session concludes with a poster presentation on their research at a joint event with CMSE's REU students. Participants are encouraged to return the following summer to create classroom materials based on their areas of research. Teaching modules resulting from this work include a unit on the metric system, another on the physics and engineering of a dc motor, and a third on the fabrication of light-emitting thin-film devices. The teachers have shared the results of their MRET experience with their colleagues in workshops at professional meetings and in a paper published in the *Journal of Chemical Education* (November 2004, Vol. 81, No. 11, p. 1620).



CMSE's **Science Teacher Enrichment Program (STEP)** is designed to deepen the teachers' content knowledge in areas related to the state learning standards. The current program consists of a week-long summer class entitled "Dustbusting by Design," in which teachers design and build motors to meet the performance requirements of a hand-held vacuum. Faculty lead discussions about the science and technology of the magnet, battery, and polymer materials included in a dust buster. For the first four days of the program, the teachers are joined by 40 eleventh-grade girls who participate in the design-and-build lab as part of the **Women in Technology Program** at MIT. The final day of the teachers' program is devoted to brainstorming ideas to convert the week's experience into classroom engineering modules that address state learning standards. STEPs to address other content areas are under development.

MRSEC

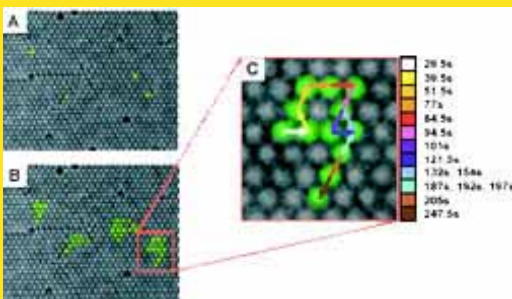
University of Massachusetts Amherst

Overview

The MRSEC at the University of Massachusetts is committed to interdisciplinary education in polymer science and engineering. This commitment to excellence in education extends beyond the University of Massachusetts. Strong educational and research ties with Smith and Mount Holyoke (two nearby women's colleges), Howard University (a traditionally African American institution), and Harvey Mudd College are well-established.

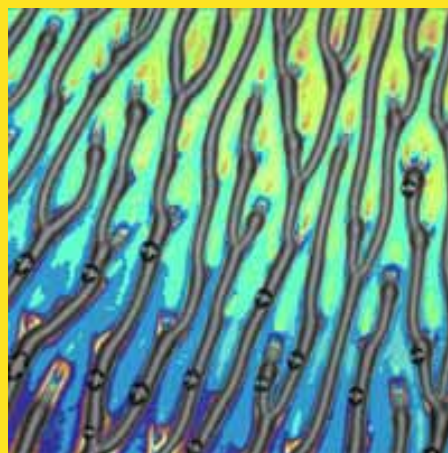
Two highly successful K-12 educational programs developed by MRSEC-supported graduate students continue to excel and expand. The Center continues a very successful **Research Experience for Teachers (RET)** program. The Center's popular **Research Experience for Undergraduates (REU)** program has been augmented by students working in nanotechnology and in biopolymer physics with support from other sources.

MRSEC support contributes to the **Northeast Complex Fluids Workshop** and the **New England Workshop in Chemistry**; both workshops regularly stimulate inter-institutional collaborations. The Center continues support of inter-MRSEC collaborations through its **Spring Workshop on Long Interactions in Polymer Technologies**.



Microscopic visualization of 7.25 kbp DNA diffusional trajectories in an array of spherical cavities. A) Still frame of 4 DNA molecules trapped in a single cavity, B) over 500 consecutive frames of the same molecules, C) expanded image of path taken by one molecule.

Image (below) from the MRSEC **VISUAL** program, which frames images from center research along with a simple text description. **VISUAL** images have now been featured in Nikon Exhibits, in the New Jersey Science Museum, the Franklin Medical Center, and by the American Optical Society and the American Chemical Society.



Special Courses and Visiting Guests

Center-sponsored visits, ranging from weeks to months, bring distinguished scientists to UMASS for the presentation of lectures and participation in collaborative research. Past visiting scientists include Edward D. T. Atkins of the University of Bristol, Seung Hyun Kim of Seoul National University, and Hong Qi Xiang of Kyushu University, who participated in IRG-I research. Atkins continues to be involved in graduate-student education at the Center by delivering general lectures on the use of x-ray diffraction on polymers, and active involvement in the research efforts of the MRSEC. The Center also supported a visit by Jae Jho of Seoul National University to perform research on the use of copolymers to spatially organize nanoparicles.



Center for Michigan State University Sensor Materials

A National Science Foundation
Materials Research Science and Engineering Center

Science Theater

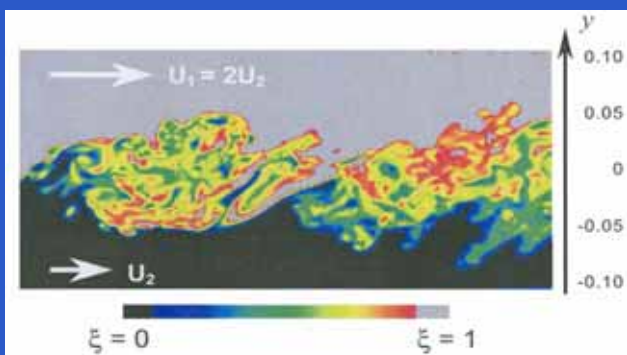
The Michigan State University CSM promotes and provides support for the education outreach efforts of Science Theater, a Michigan State University student-run organization. Through this program, undergraduate and graduate students from MSU, including many of the CSM graduate students, teach science to K-12 students through in-school demonstrations. In 2000, Science Theater presented science shows at 20 schools, reaching more than one thousand students. The CSM is working with Science Theater to publish a two-volume set of tested classroom demonstrations that emphasize scientific methodologies and principles.

Sensing our World

CSM offers two sessions per year of this week-long summer camp for seventh- and eighth-grade students about science and sensors. The camps are conducted in association with the **Capital Area Science and Math Center (CASM)**, a Lansing area association of K-12 science and math teachers.

Science Day at the Mall

This annual event brings faculty, staff, and students from the CSM MRSEC together with an audience of 6,000 - 9,000 people for explanation and demonstration of the operating principles of simple sensors used in the home and outdoors. The event is particularly well-attended by elementary-school children and their parents.



Instantaneous concentration field in a two-stream mixing layer.

Research Experience for Teachers (RET)

The CSM RET program offers high school teachers pragmatic research experience in understanding materials through projects involving synthesis and characterization. RET participants work with Center faculty and their graduate students and postdoctoral associates. The MRSEC provides access to shared facilities, training in their use, and involves participants in active rolls during MRSEC group meetings.

Research Experience for Undergraduates (REU)

CSM contributes to two MSU REU sites, through the Departments of Chemistry and Physics. CSM provides financial support and active mentoring of REU students in their area of research. This collaboration has been a growth resource for both REU programs.

Additional Outreach Activities

The Center has developed ties to small colleges in the Great Lakes region. The annual **Great Lakes College Chemistry Conference (GLCCC)** brings research-active juniors and seniors to MSU for a one-day spring symposium that showcases their efforts in the lab. An important part of the program is a series of faculty-led workshops that exposes students and their faculty advisors to a broad range of chemical and materials research topics. The CSM faculty and staff offer workshops at the GLCCC conference.

The Center provides support for the College of Natural Science's **Drew Enrichment Science Laboratory (Drew Program)**, which offers intensive supplemental classroom and research opportunities for minority undergraduates. The program, named after the eminent African-American scientist Dr. Charles R. Drew, is designed for gifted minority students who are interested in pursuing careers in science-related fields. The Center provides financial support for graduate assistants in chemistry for the Drew-TAC (tutorial assistance in chemistry) program.



UNIVERSITY OF MINNESOTA

Materials Research Science and Engineering Center

Education & Outreach

The University of Minnesota (UMN) MRSEC operates a multi-faceted Education and Outreach program that engages students from the kindergarten to the undergraduate level, as well as college faculty and high school teachers. At the heart of the Education and Outreach initiative is its summer research programs, which provide participants with opportunities that augment their traditional curriculum and increase their understanding of materials science and engineering. These programs are based on the premise that materials science and engineering stands at the nexus of the three core disciplines - biology, chemistry, and physics - which comprise the foundational science curriculum at the high school and collegiate level.

Summer Research Opportunities

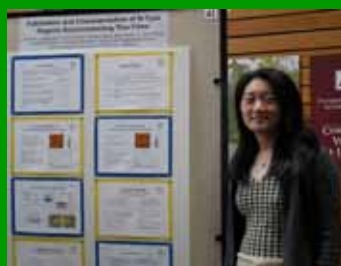
The UMN MRSEC **College Faculty-Student Teams** bring faculty and accompanying undergraduates from four-year and tribal colleges to UMN each summer in order to enhance their undergraduate-based research efforts and provide fresh exposure to specific areas of materials research.

The UMN MRSEC also offers **Native American Undergraduate Fellowships** which are designed to increase the awareness and raise self-expectations of Native American students who are not accompanied by a faculty member from their home institution.

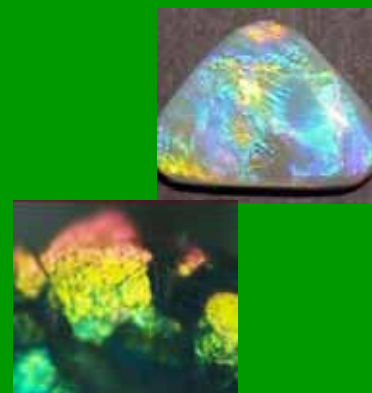
The **Research Experiences for Undergraduates** program draws undergraduates from a national base of four-year colleges and universities to perform MRSEC research. REU participants frequently collaborate with the Faculty-Student Teams.

A **Research Experiences for Teachers** program provides high school teachers with a forum for the development of a standards-based curriculum element that consists of a concept, a demonstration, and a specific lesson or set of lessons related to a materials science and engineering topic.

Summer program participant showcases her research at the UMN Institute of Technology Summer Undergraduate Research Expo.



Inverse Opal Photonic Crystals: formed from uniformly-sized polymer spheres, these inorganic solid replicas have uniformly spaced macropores & large periodicities resulting in peculiar optical properties.



Summer research participants perform research in the Interdisciplinary Research Groups or in one of the various UMN MRSEC Seed groups.

The UMN MRSEC summer programs are greatly enriched by connections to key organizations such as the American Indian Higher Education Consortium, the American Indian Science and Engineering Society, the Midwestern Association of Chemistry Teachers in Liberal Arts Colleges, the Florida A&M Life-Gets-Better Scholarship program, and specific Historically Black Colleges & Universities and Hispanic Serving Institutions.



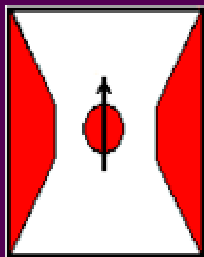
An REU participant works on his summer project: Construction and Characterization of Organic Thin-Film Transistors.

K-12 Outreach

The UMN MRSEC engages K-12 students through activities such as Physics Force, which consists of K-12 teachers and UMN faculty who convey scientific principles through entertaining performances.

Industrial Outreach

Undergraduates participating in a UMN MRSEC summer research program may also participate in our Summer Internship Feeder program through which they are connected with industrial internship opportunities the summer following their research experience.



Materials Research Science and Engineering Center



MRSEC

Q-SPINS: Quantum and Spin Phenomena in Nanomagnetic Structures

Research Experience for Teachers

Each summer, two high school or middle school teachers are invited to participate in a MRSEC research program. A summer stipend is provided. In addition to the summer experience, MRSEC graduate students and faculty then visit the teachers' classes during the following school year to demonstrate and explain the impact of materials research on the lives of the students.

Undergraduates in Research

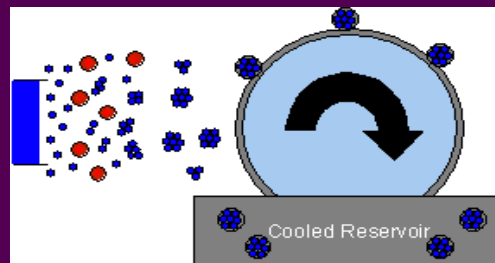
Our summer 2003 program involved twelve undergraduate students directly in MRSEC research. The majors of our student participants included physics, chemistry, biology, chemical engineering, computer engineering, and electrical engineering.

Minority Student Recruitment

We actively recruit students from low-income and under-represented minority groups to participate in MRSEC research. The Office of Multicultural Affairs and the Office of Graduate Studies assist MRSEC faculty members in arranging recruiting trips to institutions with large populations of under-represented groups. NU has reciprocal exchange agreements with Grambling State University, Alcorn State University, and New Mexico Highlands, among others. A recent MRSEC visit to Florida A&M University in Tallahassee yielded discussion of possible collaborations, including reciprocal visits, exchanges, and recruitment of their undergraduates to our graduate program. FAMU is an HBCU that has a significant number of African-American students who are enrolled in the joint FAMU/FSU Engineering College, studying materials-related topics.

Left: a bundle of magnetic Fe_3O_4 nanotubes.

Right: possible types of spin structures that may be created.



A new system for depositing nanoscale magnetic particles directly into a liquid, designed jointly by RET & REU participants.

Research Experiences for Undergraduates

Each summer faculty members at four-year institutions are invited to work with their students on a materials research project (two pairs per year), with the goal of providing a research experience which will benefit both the participants and the MRSEC projects involved. The professor/student pair can continue to expand on MRSEC-related research at their home institutions upon their return, thus enriching not only the participants but also the home institution.

The summer stipend for the professor is 1/9th of his/her academic year salary per month for up to two full months of commitment to the MRSEC project. The student participant receives \$350/week plus room and board for up to 10 weeks of commitment to the project.

Women in Science Program

One MRSEC faculty member and two MRSEC students contributed to the Women in Science Program sponsored by UNL's Center for Science, Math and Computer Education. This 1.5-day program brings approximately 100 female high-school students (and their science teachers) from Nebraska and neighboring states to our campus to interact with women scientists and to make them aware of the opportunities that exist for women in science. The primary function of this event was to encourage participants to pursue careers in science or mathematics, especially through the University of Nebraska.

Northwestern University

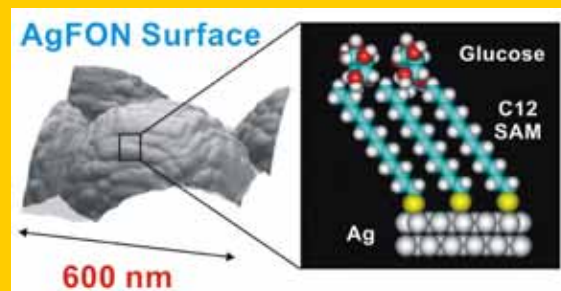


NU-MRSEC Synergism: MWM/REST

The NSF-funded **Materials World Modules (MWM)** Program at Northwestern University's Materials Research Science & Engineering Center (NU-MRSEC) has produced a series of interdisciplinary modules based on topics in materials science including Composites, Ceramics, Concrete, Biosensors, Biodegradable Materials, Smart Sensors, Polymers, Food Packaging, and Sports Materials.

The modules are designed to enhance the scientific literacy of students in middle and high school science, technology, and math classes and have been used by over 9,000 students in schools nationwide. MWM is based on principles of inquiry and design and emphasizes active, hands-on learning. Most importantly, MWM provides middle and high school students of all ability levels with opportunities to apply what they learn in the classroom to real-world problems, while also helping their teachers to meet the National Science Education Standards.

An outstanding example of the success of this program is 2002 participant Neil Schmidgall, an 11-12th-grade honors physics teacher at Glenbrook South High School (Glenview, IL). While participating in the summer **REST (Research Experience for Science Teachers)** program at Northwestern University, Neil contributed to the atomic force and scanning tunneling microscopy research of Dr. Mark Hersam and collaborated with the MWM team on the development of 15 high school physics investigations that relate to mechanical and electrical resonance. Two of these activities were later used in the MWM Module on Nanotechnology, with credit shared with Schmidgall. Since his initial involvement, Neil has field tested the Nanotechnology Module with 21 Engineering Physics students and given valuable feedback to the NU module developers.



SERS (surface-enhanced Raman spectroscopy) of a Glucose Biosensor, towards development of optical glucose testing in the treatment of diabetes.

NU-MRSEC REU Program

The Northwestern University **Research Experience for Undergraduates (REU)** Program hosts undergraduate science majors from around the country for a 9-week, intensive program, in which participants engage in hands-on materials research, learn the latest scientific and technological developments, experience a graduate-level research environment, and network with other students and professors in their field. The participants conduct research full-time and present their information in both oral and written format at the program's conclusion. They receive a weekly stipend for their participation.

The REU program was initiated in 1987, and has become increasingly competitive and diverse. The average GPA of undergraduates attending the program is now 3.8 or higher, and the percentage of minority participants has increased. By 2004, 50% of participants were under-represented minorities and 46% were women. Former participants have gone on to co-author journal articles on their research topics, to attend graduate school in materials science, and to work professionally in the field.

Center for Semiconductor Physics in Nanostructures



O *the university of* **OKLAHOMA** **UNIVERSITY OF ARKANSAS**

The Center for Semiconductor Physics in Nanostructures (C-SPIN) is a co-located center at the University of Oklahoma (OU) in Norman, Oklahoma, and the University of Arkansas (UA) in Fayetteville, Arkansas. Given the different communities and programs existing at the two campuses, our outreach efforts are localized. The UA component of C-SPIN focuses their outreach on two programs: the BEST robotics competitions and a MRSEC-funded program called KIDS: K-12 *I Do Science*. At OU, the primary emphases of educational outreach have been through the OU RET program and a local, after-school science club called SeeS. The BEST Competition and the SeeS Program will be discussed in further detail here.



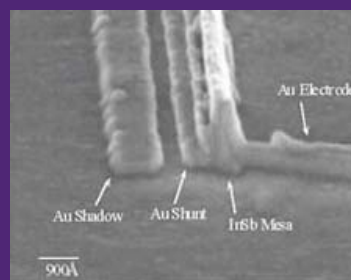
BEST Robotics Competition:

BEST (Boosting Engineering, Science, and Technology) is a technology contest for high school and junior high students that simulates real world experiences in a sports-like robotics competition. Student teams are given the task of designing, building, testing and reworking a robot in a six-week time frame using only specified materials. The robot must function competitively against other robots on the game field, accomplishing hypothetical world-saving tasks. The limited time frame and materials simulates the time-to-market and budget constraints of the real world of business. Additionally, students record their activities and strategies and develop a plan to educate the public about engineering and technology, which simulates project management and marketing responsibilities. The BEST Award is given to the most well-produced project. The Robotics Award is given to the team whose robot wins on the field on game day.



BEST student teams send their robots in to battle on game day.

The BEST competition features 20 local teams of approximately 20 students each. C-SPIN graduate students serve as judges for the BEST Award and prepare the playing field for game day. There is now a Texas BEST regional competition in addition to the one hosted at UA. A resource book for coaches is in development, which will explain the basic scientific principles used in developing the robots.



Read-head mesa etched in an InSb quantum-well structure.

Sooner Elementary Engineering and Science:



This innovative, informal education program is a voluntary, after-school learning experience open to all children at an elementary site, pre-kindergarten through 5th-grade. Hands-on, inquiry-based experiments are led by university faculty and student volunteers, aimed at teaching 3 to 4 words or key concepts on a specific topic each month, with some “flashback” activities to reinforce earlier lessons. The activities span the physical sciences, mathematics, and engineering. Curricula presented to date include the areas of aeronautics, weather, environment, logic, static and DC electricity, and other topics from chemistry and physics.

The elementary students leave each month with a summary handout of the topics taught, in addition to a list of further resources that their parents can obtain from local education stores. In addition to C-SPIN, financial support has been provided by the elementary schools' PTAs and the Norman School District Foundation. Currently, lessons compiled and developed by the C-SPIN high school and middle school RET fellows is being adapted to the elementary science level for use in SeeS modules. SeeS materials are available on-line for parents or teachers at other schools to use.



Local Outreach Programs

The LRSUM summer **Research Experience for Undergraduates** began in 1989 and enrollment to date is 366 students, approximately 40% of whom were minorities, 42% were women, for a combined 57% from under-represented groups. The program involves a 10-week experience comprised of collaboration on LRSUM faculty research, a lecture series, facility and campus tours, and a final presentation of research in both oral and written form.

The **Research Experience for Teachers** annually hosts five high school science teachers for a six-week summer program, consisting of collaborative research, lectures, tours, and a final presentation of research results in oral and written forms.

More than 20% of past RET participants have joined the Penn Science Teachers Institute to obtain a **Master of Chemistry Education (MCE)**. The program is jointly funded by Penn, NSF, and local industry to cover all tuition beyond a school district's Tuition Reimbursement Plan. The LRSUM works closely with this Institute, which has also introduced a **Masters in Integrated Science Education** for middle school teachers.

Outreach to the Philadelphia Schools

The **Penn Summer Science Initiative (PSSI)** accepts 24 high school juniors for a free, four-week lecture/laboratory course in the study of materials science. Student participants experience formal lectures, lab research, discussion groups, computer instructional labs, tours, and generate weekly lab reports.

The **Enrichment Courses for High School Science Teachers Program** began in 1994, and these combination lecture/demonstration courses have now grown to a year-long series of monthly presentation sessions by LRSUM faculty, some of which additionally incorporate tours of related research facilities. The course is entitled 'Advanced Material: Synthesis, Characterization, and Properties,' and involves approximately twenty teachers per year.

Outreach to the Wider World

Recent **Collaboration with Southern Africa** has involved visits from Southern African faculty members of the National University of Lesotho (NUL) and the University of North West (UNW), South Africa. A 2003 visit brought 3 NUL faculty and one UNW faculty for a month-long collaboration; the NUL faculty returned in summer 2004 for two further months of research collaboration, with another UNW visit scheduled for 2005.

A previous CIRE relationship with Puerto Rico has now evolved into an NSF **PREM (Partnership for Research and Education in Materials)** grant for further collaboration with ten faculty from three different University of Puerto Rico (UPR) campuses.

Video conferencing enhances information exchange between Penn and UPR research groups. The goal of the program is to facilitate greater minority outreach, while improving both equipment and curriculum for the home institutions of Puerto Rico. Penn faculty exchange has also been arranged with the National Institute for Materials Science, Japan.



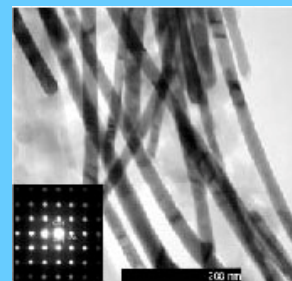
Video conference images from the LRSUM **Telepresence** presentation 'Blood Cells: Biological and Artificial.'

Telepresence

Penn's **Telepresence** program for the local Philadelphia School District uses video-conferencing to bring LRSUM presentations in real time into 7-12th grade classrooms via the school district's cable TV network. The goal of this program is to generate greater awareness of new equipment and techniques in the study of science by utilizing LRSUM's advanced equipment and facilities to explore topics related to students' science classroom curriculum. Topics covered explore a diverse range of subject areas, including chemistry, physics, earth science, biological science, and environmental science.



MRSEC Center for Nanoscale Science



TEM image of 40 nm single-crystal nanowires.

Outreach to General Audiences

The Penn State MRSEC offers a variety of outreach resources in the field of materials science. For K-12 teachers we have programs for bringing cutting-edge research into their classrooms via classroom demonstrations, summer fellowships, and summer workshops. Summer programs for middle- and high-school students are designed to increase interest in science, sharpen problem-solving skills and build self-esteem; attendance includes females and members of under-represented minority groups. Additionally, a number of undergraduate programs, both during the summer and the school year, provide students with opportunities to participate in frontier materials physics and materials engineering research.



Collaboration with the Franklin Institute

Since January 2000, students, faculty, and staff have been working in close collaboration with museum program directors and trainers at Philadelphia's nationally-renowned science museum, The Franklin Institute. Our efforts have resulted in a 60-minute cart-based interactive exploration titled *Materials Matter: It's a Nanoworld After All*. The show includes demonstrations and macro-scale models, and explores the "micro" mechanisms behind the unusual and surprising "macro" behavior of materials such as aerogels, shape-memory alloys, polymers, electronic ink, and zeolites.

In November of 2002, the *Materials Matter* show was distributed to 22 (roughly equal numbers of small, medium and large) science museums nationwide, reaching a potential audience of 2 million school-aged visitors in 2003. Each museum was provided with sufficient materials and supplies to support the exhibit for a year and a half. MRSEC faculty and staff also present the show locally for classroom visits, visits from school groups, summer camps, and workshops which target women and under-represented minorities. A second museum show is currently in development, entitled *Our Bodies: The Ultimate Nanotechnology Factory*.

Collaboration with PBS

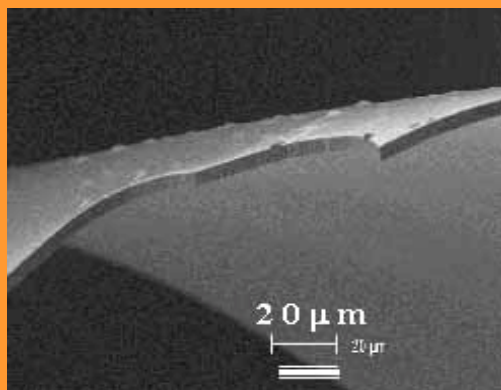
MRSEC faculty and students also contribute to the PBS show *What's In The News*, an award-winning multi-media instructional television series which uses current events as a springboard for teaching 4th-7th grade social studies curriculum through exploration of history, geography, government, world cultures, science, and language arts. Weekly 15-minute television programs are combined with computer-based resources to provide a comprehensive and challenging instructional tool, reaching a potential audience of 5.7 million students. For example, the MRSEC created a segment for the Earth Day 2003 show on new photo-degrading six-pack rings which serve to protect wildlife from strangulation.

A previous MRSEC-PBS collaborative feature, *"It's a Small, Small World,"* explores the implications of nanotechnology on computing, medicine, and society. Upcoming projects include a segment on forensic science, featuring the use of electron microscopes in the analysis of synthetic and natural fibers; and a segment on nanotechnology as art, highlighting the images captured and the tools used in the observation of phenomena on the nanoscale level.





Princeton Center for Complex Materials



Biomimetic synthesis of CaCO_3 thin film.

The Princeton University Materials Academy (P.U.M.A.)

Princeton University Materials Academy (P.U.M.A.) is a program committed to improving the science education of under-represented high school students in Trenton, NJ and the surrounding districts. P.U.M.A. brings 30-50 high school students to the labs of the Princeton Center for Complex Materials (PCCM) for 2-3 weeks every summer to teach them about science and engineering.

Students learn through hands-on, inquiry-based activities, labs modeled after actual PCCM research experiments currently in progress, and lectures by faculty members and lead teachers. Topics covered include nanotechnology, cancer research and materials science.

P.U.M.A. students are given access to university scientists and labs, where they can operate a scanning electron microscope or learn about cutting-edge science concepts such as BioMEMS (microscopic machines used in living organisms, including humans).

Many P.U.M.A. students choose to return to the program for a second and third year. Their progress is tracked during college and throughout their careers.

Science Curriculum Support Project (SCSP)

In collaboration with $\mathbf{E} = mc^2$ (an NSF-funded teacher-enhancement project), PCCM researchers work with elementary and middle school teachers to develop sources of inquiry-based learning where textbooks are supplemented by commercially-developed experimental kits. The investigative teams study currently available kits in order to identify and remove design flaws, equipment problems, and conceptual errors.

PCCM faculty and local teachers also work to develop background materials explaining the basic scientific principles of the kits, and create practical suggestions for the implementation of kits as teaching tools. New background manuals created in this effort and first-hand accounts of teacher's experience with the kits are placed on PCCM's web site for easy access by teachers nationwide. Participating teachers have reported that "graduates" from elementary school classes that have used SCSP-improved kits opt to pursue elective middle school science courses at rates far greater than students in courses that have not benefited from the SCSP. Due to parent and teacher demand, SCSP now includes the new middle school kits in its program.

As a side benefit, the lead teachers and faculty who develop these materials are now "experts," qualified to train other teachers. Dozens of teachers have now benefited from SCSP teacher-training programs.

List of Current Outreach Offerings

K-12:	Princeton University Materials Academy
Undergrad.:	Research Experience for Undergraduates
Teachers:	Research Experience for Teachers
Educators:	Science Curriculum Support Project
Public:	Liberty Science Center Collaboration
	Science & Engineering Expo



MRSEC faculty and students demonstrate properties of polymers in the **Strange Matter** exhibition at Liberty Science Center.

The University of Southern Mississippi

Materials Research Science Engineering Center

CENTER FOR RESPONSE-DRIVEN POLYMERIC FILMS

at The University of Southern Mississippi



The Macrogalleria

The Macrogalleria is an interactive, Internet-based, educational program about polymers. This award-winning web site features resources and activities for teachers and students of all levels (K-12 through college undergraduate). The web site includes an "Internet Mall," where students shop to learn about scientific and industrial aspects of polymers, and laboratory activities for teachers which can be used in the classroom. Further creation of dynamic web sites and web-based activities building upon Center findings is in progress.

Research Experience for Undergraduates

The REU is a ten-week experience that focuses on providing undergraduates the opportunity to conduct interdisciplinary research in response-driven polymeric films. Participants work with faculty mentors from polymer science, biology, chemistry, biochemistry, and physics. The program includes field trips to polymer and chemical industry sites,, professional development, and a seminar series presented by industrial and academic scientists. Other REU group-activities for students, such as a Ropes Course experience, work to develop team building, leadership, and group problem solving skills.

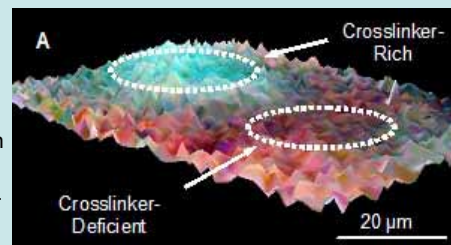
The 2003 program included thirty-two students from fifteen colleges and universities across the country; the 2004 program included twenty undergraduates and two outstanding high school students.



REU students on a team building Ropes Course exercise.



Visiting students receive an overview lecture about polymer science.



Chemically heterogeneous surfaces and phase separation at 100 nm levels in polyurethanes.

SCIENCE

In 2003 we launched Science Courses for Integration and Enhancing New Curriculum in Education (**SCIENCE**) for high school students, a program designed to encourage careers in science through hands-on, scientific discovery and relating science to everyday life. During this day-long experience, mornings are spent in vocabulary-study and reading, and afternoons are spent in laboratory experiments ranging from recycling plastics to DNA isolation. Responses from students have been overwhelmingly positive. Teachers participating in the workshop develop hands-on activities and lessons to take back to their classrooms.

Campus Visits Program

Each year, more than 500 Southern Mississippi elementary, middle, and high school students come to USM for tours of the MRSEC. Each group receives an overview presentation about polymer science as well as a hands-on laboratory experience through activities and demonstrations led by MRSEC graduate students.



MRSEC researchers present an inside view of polymer science research.



Center on Polymer Interfaces and Macromolecular Assemblies



A Stanford University/IBM Almaden/UC Davis/UC Berkeley Partnership

CPIMA's Education activities are targeted at students of all levels (elementary to graduate), as well as the general public. CPIMA education programs are designed to include all people, with a special emphasis on women, minorities, the disabled, and the economically disadvantaged. All efforts are designed to promote science education, with a particular emphasis on polymers.

Summer Undergraduate Research Experience (SURE-REU)

Each summer, CPIMA provides a diverse group of 24 undergraduates in the physical sciences and engineering with a ten-week research opportunity to help them decide whether to pursue graduate studies. Applications are especially encouraged from students of community colleges and primarily-undergraduate institutions as well as from women, minorities and the disabled. A partnership with the AAAS Entry Point helps recruit disabled students to the program. The SURE program allows students to work on independent research projects involving direct interaction with research scientists, post-doctoral scholars, and graduate students at Stanford University, IBM Almaden, UC Berkeley, UC Davis, or a CPIMA Industrial or International Affiliate. Students participate in a number of SURE activities including a Graduate School Workshop, Career Day and the CPIMA Forum where they present their summer research in a poster.

Community College Program

CPIMA has formed a partnership with Sacramento City College. Each summer one faculty member and 2-3 students work on independent research projects at UC Davis for ten weeks. The students participate in the SURE activities. Programs are currently being developed with the faculty at SCC to help the students prepare for their summer internships during the academic year.

Research Experiences for Teachers (RET)

K-12 science teachers participate in an 8-week RET program. The teachers work on independent research projects in a scientific laboratory at Stanford University. Participants interact directly with research scientists, post-doctoral scholars, and graduate students. The program culminates with a poster presentation at the CPIMA Forum and the development of an education transfer plan to integrate their experience into their teaching.



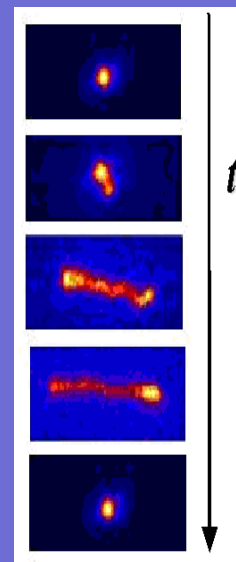
(Left) Young visitors learn how nylon is made on Community Day.

(Center) Girls make slime at SUCCESS summer science camp.

(Right) Students show off their 2004 Eastside School Science Fair project.

Eastside College Preparatory School

CPIMA has established a partnership with Eastside College Preparatory School, a non-profit school serving a 100% minority 6th -12th grade student population in East Palo Alto, CA. Reciprocal visits involve Stanford Nano-fabrication Facility and CPIMA Shared Facility lab tours for high school chemistry classes and classroom visits to Eastside for presentation of talks and demos on rubber, nylon and slime. In 2002-2003, CPIMA worked with Eastside to establish an annual middle school science fair. Groups of students are paired with mentors from Stanford for guidance on their projects. The groups meet weekly, beginning in October until the science fair is held at the end of April.



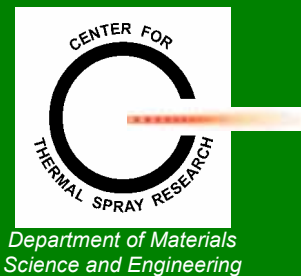
DNA tumbling in shear flow.

Exploratorium Museum Project

CPIMA has partnered with the Teacher Institute at the Exploratorium (a San Francisco science museum) to bring the research being conducted at CPIMA to the public and to high school classrooms. Two high school chemistry teachers have developed an exhibit consisting of a physical model of a protein folding based upon CPIMA investigators V. Pande's and W. Swopes' work on computer modeling of protein folding. An accompanying interactive PowerPoint presentation allows visitors to explore various areas of the subject in greater depth. The teachers have also developed a "snack" version of the model that can be constructed in a classroom as well as some lesson plans and PowerPoint presentations on general aspects of the chemistry and biology of protein folding for high school teachers. This work was funded in part by a Dreyfus Foundation grant.

Other Activities

CPIMA co-organized a week long SUCCESS science camp for underprivileged 6th-7th grade girls in 2003. The girls spent half a day learning about materials science and polymers. CPIMA participates annually in Stanford's Community Day. CPIMA's Education Director has co-organized two national RET conferences and has been on the planning committee for two NSF Research Centers Educators Network meetings.



CENTER FOR THERMAL SPRAY RESEARCH (CTSR)

Educational Outreach

The thermal spray industry generates \$2-4 billion annually in applications ranging from aircraft to automotive. The CTSR MRSEC center works to improve understanding of the processing, microstructures, and properties of thermal spray coatings and the materials science of layered and non-equilibrium processed materials in order to penetrate into newer, more advanced engineering applications. The goal of the Center is to achieve "prime reliant thermal spray coatings and functional surfaces".

The educational outreach component of the center seeks to raise the level of awareness and understanding of this technology in business & industry as well as with middle- and high-school students.

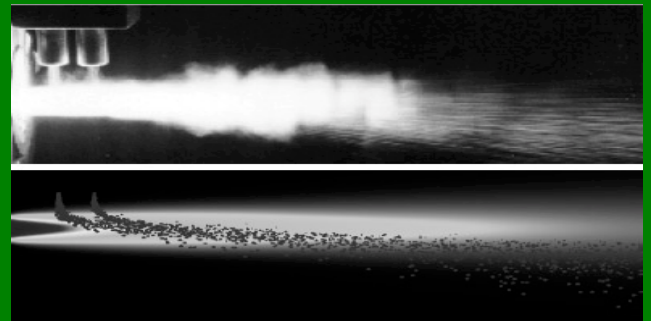


A visiting student on a field trip to the center receiving hands-on lab training.

Consortium on Thermal Spray Technology

Through the Consortium, over a dozen of the industry's leading coating-specifiers, applicators, and suppliers are brought together to exchange ideas and concepts regarding the future of thermal spray, and to be introduced to innovations in the understanding of thermal spray overlays. For example, a previous Consortium focused on training attendees in the use and benefits of process-mapping. The result has been regular implementation of this technology by these leaders in industry.

The Consortium offers on-site training classes and inspires the development of research projects targeted to meet the specific needs and goals of industry partners. Annual workshops are held to reach the widest possible international range of businesses.



2-D Plasma jet flow and flame/particle interaction.

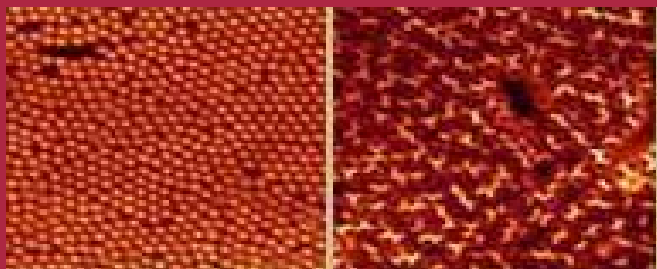
Pre-College Student Outreach

The pre-college outreach programs target middle and high school students for camps, day-long field trips featuring hands-on laboratory classes for student groups, and a Women in Science and Engineering day, as well as extended research internships which occur during the school year and the summer.

During the hands-on laboratory classes, senior staff members and graduate students introduce material and allow students to gain further research independence on the topic. The research topics are geared to satisfy school science-class requirements or to prepare the students for national scientific competitions such as Intel and Westinghouse. Specific initiatives have targeted under-represented minority groups for exposure to materials science and engineering.

Jet plume from a plasma spray torch.





Con-focal image of a patterned surface with adsorbed DNA prior to surface electrophoresis.

Research Scholar Program for High School Students

The RSP is an intense seven-week summer experience held annually at **SUNY Stony Brook**. The program began in 1997 with 8 students, and has grown to 58 students in 2003. Students work closely with faculty and staff as part of focused research teams and are taught to make original contributions of interest to the scientific community. They are encouraged to enter national competitions, to publish in refereed scientific journals, and to present their results at national conferences.

During the program, students attend a series of colloquia, a weekly journal club, and numerous training sessions addressing experimental techniques and data analysis. Students become familiar with a large set of open research questions of interest to the Center, and are able to choose a research direction early in the summer, joining the research team in that area.

At the close of the session the students deliver short talks on their research project. Twenty-six of the 2003 participants are Siemens-Westinghouse semifinalists, with past participants winning the First Place Siemens-Westinghouse project (2001), and the Second Place project (2002).

The Garcia Center Open House

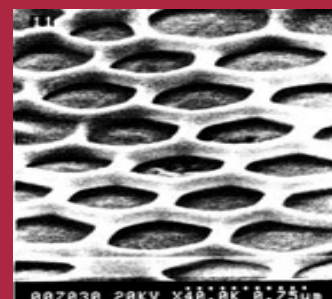
The Open House is a full-day activity held each December at **Queens College** in New York City, attended by approximately 400 high school students. Students divide into groups of approximately twenty-five, and move through a series of eight undergraduate laboratories, which are set up with three to four hands-on demonstrations per lab.

Faculty and graduate students in each lab direct student participation in short polymer-related experiments, addressing topics such as rheology, birefringence, liquid nitrogen, diaper absorption, foams, spinning, and fibers. Students and teachers receive handouts accompanying each demonstration.

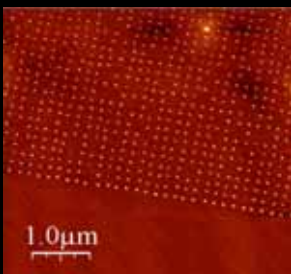
When not in the experimental labs, students are taken on a tour of the Science Building research laboratories. They also attend auditorium presentations providing a description of available research programs and talks by past participants of the Research Scholars Program, a poster session and industrial-partner exhibit, and a presentation from the National Plastics Center and Museum.

Keynote speakers at the Open Houses have included Albert Hoser (CEO, Westinghouse), Ellen Baker (NASA astronaut), and Dennis Pfeiffer (Exxon-Mobil). Teachers meet during lunch with an RET participant to learn more about high school research programs and resources.

Scanning electron microscopy image of regular honey-cob-shaped carbon mesoscopic network.



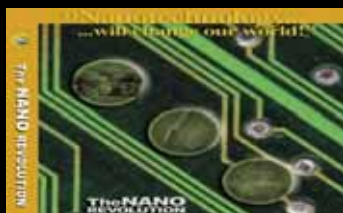
Center for Nanoscopic Materials Design



Focused ion beam surface templating of epitaxial nucleation: Ge/Si (100).

Educational Outreach

The goal of the Outreach activities of the UVA MRSEC is to ensure the center's impact both within and beyond the nanoscience community. All Center members play an active role in our education programs. Outreach efforts target middle school and high school students and teachers, as well as students at the undergraduate, graduate, and post-doctorate levels. The center supports a number of **Graduate Students and Post-docs**, who participate in center research, outreach work, and industrial partnerships. Collaborative efforts have created **Research Partnerships** with key nanotechnology research groups around the world, including IBM, Sandia National Labs, Pacific Northwest National Labs, UC Irvine, Notre Dame, North Carolina State University, and the Fritz-Haber Institute of Germany. A recently-funded **NSF International Progress Grant** further strengthens the center's European partnerships through joint research with the University of Lund, Sweden.



The NANO Revolution DVD

This new digital video developed by the Center delivers an introductory overview of nanotechnology for middle and high school students and the general public. The program builds a foundational understanding of materials research and its applications in nanotechnology, presented in simple terms, in order to engage a wider audience. Plans are underway to make this video available for viewing via the center's web-site.

The UVA Virtual Lab

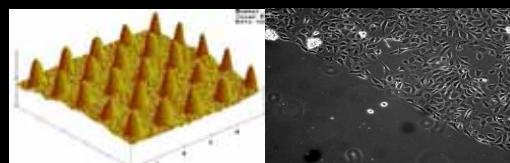
Resources from the Center have contributed to the continued development of a multimedia web site that uses software tools of the computer gaming industry to show young students the inner workings of advanced science and engineering research (and production) tools. The web site content is constructed at a level accessible to students, teachers, parents, and the general public and is designed to give unparalleled insight into the inner workings of advanced technologies. The Virtual Lab is available through the MRSEC web-site, and offers guided multimedia tours of nano- and related technologies, allowing visitors to customize their tours with selections from an extensive Table of Contents. Tours include UVA lab sites and a virtual integrated circuits-manufacturing facility; topics available for exploration include microelectronics, nanoscience, semiconductor science, scientific instruments, fields, and circuits.



Views from the **Virtual Lab**: (Left) Electrons emitted from a heated tungsten filament being focused by an electromagnet; (Center) room level view of an atomic force microscope (AFM); (Right) the inner workings of an AFM.

Summer Research Experience for Undergraduates

During four years of activity this program has introduced nearly fifty undergraduates to nanotechnology-related research. Thirty of the participants have been women or other under-represented minorities. For each of the last two summers, students participating in our REU program have taken a two-credit course that explores the broader impact of **The Societal and Ethical Dimensions of Nanotechnology**.



(Left) AFM image of an APS-B stamp; (Right) Endothelial cells growing on a region printed with rhodamine-FN, but not on an adjacent, non-printed region coated with PEG.



Materials Research Science and Engineering Center on Nanostructured Materials and Interfaces



Overview

One of the core goals of the UW-Madison MRSEC is the creation of instructional materials on nanoscale science and technology for use in K-12 and undergraduate science and engineering curricula. Course content, demonstrations, and laboratory experiments have been developed around the themes of nanoparticles, nanoporous materials, nanoarchitectures, self-assembly, and surface reconstruction.

Collectively, these topics illustrate the importance of surface effects, the limitations of scaling laws, and the onset of quantum effects as nanoscale dimensions are approached. They also demonstrate the tools and techniques required for nanoscale studies, including scanning probe microscopies, lithographic and contact printing techniques, and mechanical, electrical, optical, and magnetic characterization of materials and devices.

These materials have been shared with K-12 teachers and college educators in numerous workshops to encourage the materials' use in a variety of science, mathematics, engineering, and technology courses. Several instructional kits and a suite of web-based support materials have been created to make specialized instructional materials readily accessible and affordable for teachers around the world.



The Laboratory Manual for Nanoscale Science and Technology

This resource presents a set of experiments (currently 10, with more in development) that are unique for both the content topic area and the video-based-presentation format utilized. Experiments are broken into steps with short text descriptions and accompanying videos of the procedure or manipulation. The manual has been used in both high-school and college-level laboratories and as virtual experiments when laboratory equipment was not available or a student's disability prevented a hands-on laboratory experience. The website resource has been cited and commended by *Science* NetWatch and The American Chemical Society's *Chemistry* website in the 'Quick Hits' section.

Additional Instructional Resources

The **Nanoworld Cineplex**, available online, contains movies of experiments and demonstrations that can be brought into classrooms and laboratories. The web-based nature of these materials makes them accessible to people around the world. Consequently, the Cineplex provides a valuable resource for teachers.

Numerous kits, software programs, teaching modules, and articles about nanotechnology have also been created. These are disseminated through the Institute for Chemical Education and various education journals. Kits available include the *Exploring the Nanoworld Kit*, the *DNA Optical Transform Kit*, and the *LED Color Strip Kit*, among others. To date, over 7,900 kits have been sold. The *Exploring the Nanoworld Kit* was featured in an article in *Muse*, a magazine published by the Smithsonian for 8-14 year-olds, and was highlighted as a learning tool by *eWeek* magazine.



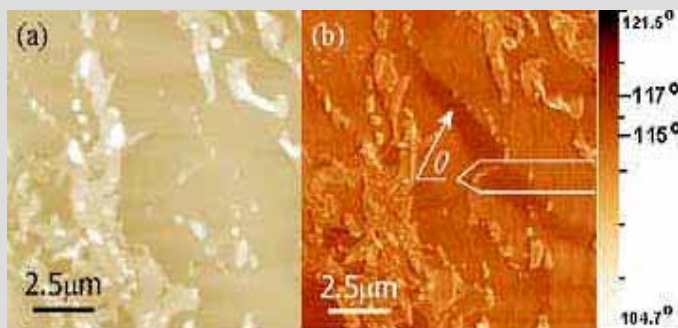
Materials Research Science and Engineering Center

Internships in Public Science Education: Making the Nanoworld Comprehensible

The **IPSE award**, funded by the Office of Multidisciplinary Activities of the Directorate for Mathematics and Physical Sciences, involves a partnership between the UW MRSEC and the Discovery World (DW) science museum in Milwaukee. The award strives to bring cutting-edge research on advanced materials and nanoscale science and engineering into the museum and K-12 classrooms. The goals of the IPSE program are:

- To educate the public and student populations about nanoscale technology through hands-on, interactive activities.
- To provide future leaders with the tools to share scientific knowledge with diverse audiences.
- To foster imagination, interest, and enthusiasm in science, technology, engineering, and entrepreneurship, especially as they relate to advanced and nanoscale materials.
- To provide a deeper understanding of scientific practices and the connections among scientists, engineers, and society.

A diverse group of IPSE interns collaborates with UW MRSEC researchers, DW personnel, and local K-12 educators to expand the interns' knowledge of advanced materials and nanotechnology, to enhance their communication skills, and to develop exciting grade-appropriate activities for classroom and museum settings. Initial projects expanded upon existing MRSEC-created education products and covered such topics as lithography, carbon nanotubes, and Giant Magnetoresistance (GMR).



Tapping mode AFM images of polydiacetylene monolayer film:
(a) topography, (b) phase imaging.



(Left) An IPSE intern synthesizing ferrofluid during a Professional Development Day at UW; (Right) An IPSE intern leading table-top demonstrations at Discovery World.

More recent projects have expanded content areas to include current research themes of ferrofluids, liquid crystal sensors, and the societal implications of nanotechnology. DW also links IPSE participants and MRSEC graduate students with middle- and high-school students to provide information on scientific themes and career development related to materials science and engineering.

To date, over 30 graduate and undergraduate students have participated as interns from majors such as chemistry, physics, biomedical engineering, chemical engineering, food science, psychology, computer science, journalism, and history of science. Following their IPSE experience, several former interns have continued in science education, through career paths such as working at NASA Television, writing about health and science for a local newspaper, and earning their teaching certification.

Since its inception, IPSE has impacted over six-thousand people through publications and presentations that highlight science and nanotechnology and inspire the imagination, interest, and enthusiasm of future scientists and engineers. Program results have been disseminated through meetings and publications of professional disciplinary and pan-disciplinary organizations, workshops for regional K-12 teachers, and a workshop held in partnership with the Association for Science-Technology Centers (ASTC). Activities and resources for teachers have also been made available on the IPSE website.

The UW-DW IPSE program can serve as a model for the professional development of students interested in science and technology, providing them with rich opportunities for sharing their scientific knowledge and enthusiasm with pre-college and museum audiences. This enhances the communication skills of IPSE participants while also sharing exciting research developments with the public, K-12 teachers, and students of all ages.

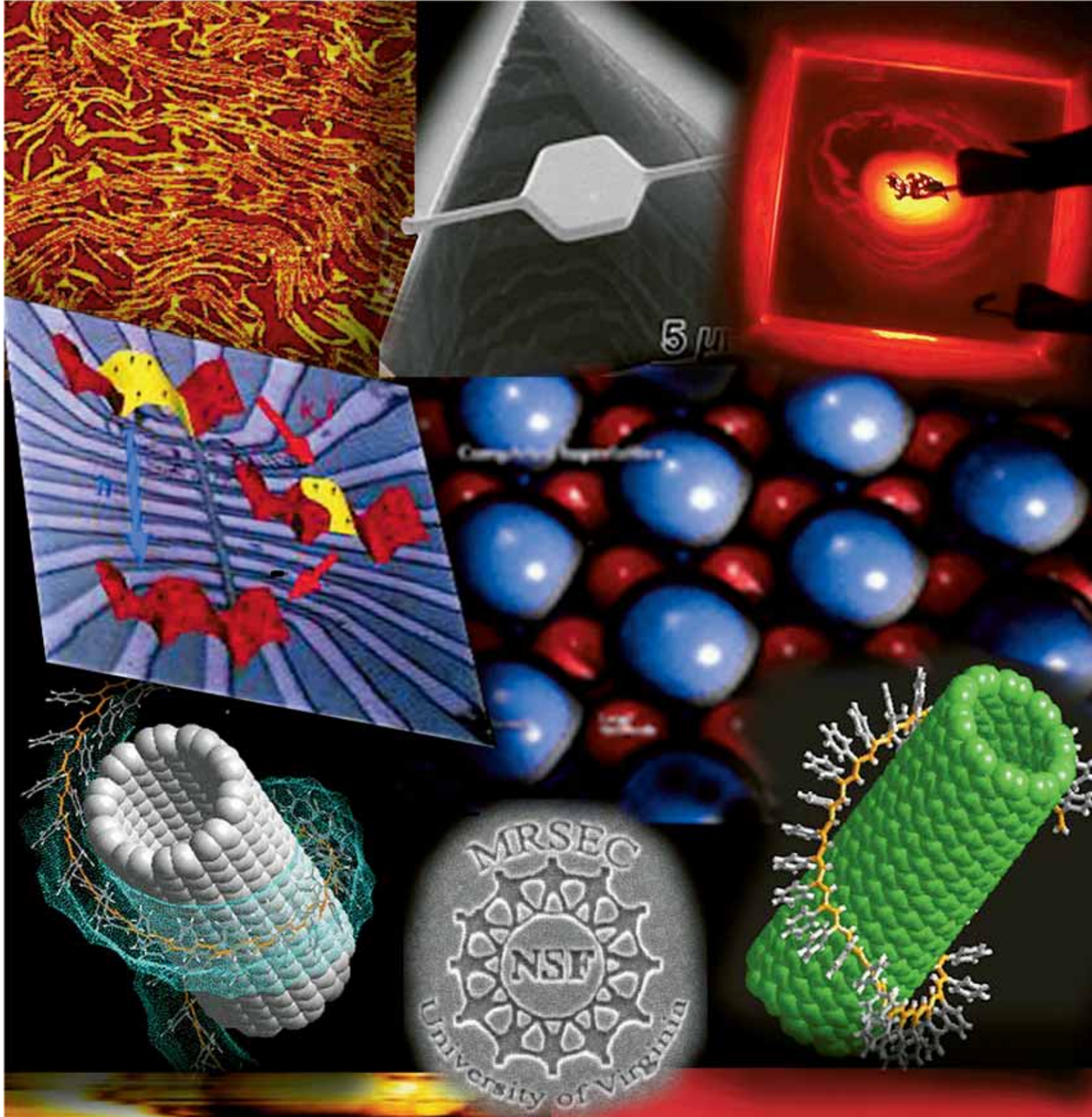


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We would like to thank the following institutions for allowing the use of their research images on the cover of this publication: **Front Cover** (from left to right and top to bottom): Princeton University; SUNY, Stony Brook; University of Maryland; University of Colorado, Boulder; University of Virginia; University of Wisconsin, Madison; University of Massachusetts, Amherst; Michigan State University; University of Chicago. **Back Cover** (left to right and top to bottom): CPIMA of Stanford, UC Davis, UC Berkeley, and IBM Almaden; Cornell University; University of Wisconsin, Madison; University of Chicago; Columbia University; Princeton University; University of Virginia; University of Maryland; Michigan State University. **Title Page**: Northwestern University. Please contact the institution to learn more about an individual image.





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