Materials Research Science and Engineering Centers

Interdisciplinary materials research and education addressing fundamental problems in science and engineering that are important to society

The National Science Foundation Materials Research Science & Engineering Centers Program was established in 1994.

Materials Research Science and Engineering Centers are supported by the National Science Foundation (NSF) to undertake materials research of scope and complexity that would not be feasible under traditional funding of individual research projects.

THESE CENTERS:

- require outstanding research quality, intellectual breadth, interdisciplinarity, flexibility in responding to new research opportunities, support for research infrastructure, and foster the integration of research and education in the materials field;
- address fundamental, complex problems of intellectual and societal importance,
- contribute to national priorities by fostering active collaboration between academia and other sectors, and
- constitute a national network of university-based Centers in materials research.

Center Characteristics

The MRSECs constitute a spectrum of coordinated Centers of differing scientific breadth and administrative complexity that may address any area (or several areas) of materials research.

- Each MRSEC encompasses one or more **Interdisciplinary Research Groups (IRGs)**.
- Each IRG involves a group of faculty members, associated researchers and students addressing a major topic in materials research.
- In each IRG, sustained support for interactive effort by several participants with complementary backgrounds, skills, and knowledge is critical to progress.

Each MRSEC also incorporates most or all of the following activities to an extent commensurate with the size of the Center:

- Programs to stimulate interdisciplinary education, including research experiences for undergraduates accessible to students from other institutions, and the development of human resources (including support for under-represented groups).

- Active cooperation with industry, other institutions, and other sectors, including international collaborations, to stimulate and facilitate knowledge transfer among the participants and strengthen the links between university-based research and its application.

- Support for shared experimental facilities, properly equipped and maintained, and accessible to users from the Center and elsewhere.

Each MRSEC has the responsibility to manage and evaluate its own operation with respect to program administration, planning, content and direction.

NSF support is intended to promote optimal use of university resources and capabilities, and to provide maximum flexibility in setting research directions, developing cooperative activities, and responding quickly and effectively to new opportunities. To this end, NSF encourages MRSECs to include support for junior faculty, high-risk projects, and emerging areas of interdisciplinary materials research.

MRSEC Review and Awards

MRSECs are reviewed initially as pre-proposals, then by invitation as full proposals. See the latest MRSEC Proposal Solicitation (NSF 07-563) for details. NSF does not normally support more than one MRSEC based at any one institution. Awards range in size from about $1 million to $5 million per year and are made for an initial period of up to six years. Renewed NSF support will be awarded only on the basis of comprehensive, competitive merit review.

For more information: http://www.mrsec.org
http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5295

NSF Materials Research Science and Engineering Centers

University of Alabama - *Center for Materials for Information Science*
(Director: William H. Butler)
The Center investigates new materials with potential applications in information technology. It supports development of instructional materials for middle school students by teachers and MRSEC faculty, and a summer research program for faculty and students from Historically Black Colleges and Universities. The MRSEC is an integral part of MINT, the Center for Materials for Information Technology that serves as a resource for the information storage industry.

IRG 1 *Dynamics and Transport in Nanostructured Magnetic Materials (Leader: Arunava Gupta)*
Spin-transport through confined geometries; control of nanoscale magnetism through spin-polarized currents; investigation of magnetic oxides as candidates for spintronic devices.

IRG 2 *Materials for Information Storage Media (Leader: David Nikles)*
Dendrimer films for probe-based charge storage; fundamentals of substrate/dendrimer/ overlayer interactions; FePt nanoparticles for self-assemblying patterned magnetic recording media.

Brandeis University – Constraints and Frustration in Nano-Structures and Biomolecular Materials
(Director: Robert Meyer)
The Center studies the properties of materials occurring in biological systems, and in understanding the role of materials properties in the structure and function of cells and cellular components. Effects of constraints on biomaterials similar to those found in living cells can lead to new "emergent" properties; exploitation of these properties may lead to development of novel nano-structured biomaterials, and biomimetic materials such as "active matter" capable of moving on their own power, like living matter. The MRSEC offers an innovative program targeted to inner-city minority science undergraduates at Brandeis.

Brown University – *Micro- and Nanomechanics of Materials (Director: William A. Curtin)*
The Center investigates the mechanics in thin films and bulk materials through a combination of experimental and computer modeling techniques. The Center has a broad spectrum of educational and outreach programs, including the very successful BrownOut program that brings hands on demonstrations to local K-12 science and math classes.

IRG 1 *Stress in Thin Films and Small Scale Structures (Leader: Eric Chason)*
Focuses the growth and stability of surfaces or surface domains in nanostructured materials and the time evolution of stress during growth of thin films with non-epitaxial microstructures.

IRG 2 *Multiscale Mechanics of Complex Microstructures (Leader: Allan Bower)*
Focuses on the application of novel computational and experimental techniques to elucidate the mechanics of deformation and failure in complex multiphase and Nanoscale microstructures.

University of California at Santa Barbara - *MRSEC (Director: Craig Hawker)*
The Center investigates a wide range of materials including new semiconductors for microelectronics, novel nanostructures for high speed communication devices and advanced polymeric materials. Significant effort is devoted to successful K-12 and International Outreach programs. Active

collaborations exist with a variety of small to large companies. These activities have a direct benefit to the greater Santa Barbara community.

IRG 1 *Specific, Reversible and Programmable Bonding in Supra- and Macromolecular Materials (Co-Leaders: Luc Jaeger and Matt Tirrell)*
Identifies new experimental and computational methods for precisely controlling the structure and properties of materials based on directed and reversible interactions.

IRG 2 *Oxides as Semiconductors (Co-Leaders: Jim Speck and Chris Van de Walle)*
Focuses on the theory, growth, and application of ultra-pure binary oxides as new wide-band-gap semiconductors.

IRG 3 *Soft Cellular Materials (Co-Leaders: Gary Leal and Glenn Frederickson)*
Seeks to use tailor made/functionalized nanoparticles and block copolymers, in association with polymer blends, to develop new soft materials with precisely controlled cellular structures.

IRG 4 *Nanostructured Materials by Molecular Beam Epitaxy (Co-Leaders: Arthur Gossard and Elliot Brown)*
Examines the development of all-epitaxial metal/semiconductor nanocomposite systems for potential applications in high speed and Terahertz technology.

California Institute of Technology – *Center for the Science and Engineering of Materials (Director: Harry Atwater)*
The Center supports an interdisciplinary research program on advanced materials, as well as a wide range of educational activities, including outreach to minority communities in California both at the pre-college and college level, and development of pre-college instructional materials.

IRG 1 *Ferroelectric Photonic Materials (Leader: Kaushik Bhattacharya)*
Pursues the understanding of nonlinear optical interactions in ferroelectric photonic devices and the application of these interactions to make compact all optical switches and modulators.

IRG 2 *Patterns, Gradients, and Signals in Soft Biomaterials (Leader: David Tirrell)*
State of the art biosynthesis, micromechanical methods, rheological studies, cell biology, and theoretical and computational methods are combined to elucidate the interrelated roles of biochemical and biophysical factors in controlling cellular response to engineered biomaterials.

IRG 3 *Mechanics of Amorphous and Nanoscale Metal Composites and Foam Structures (Leader: William Johnson)*
This IRG combines materials synthesis and processing from the liquid and solid states, unique mechanical testing and characterization methods, atomistic molecular dynamics simulations, analytical theories, and finite element modeling, to design and create a new class of novel structural engineering materials.

Carnegie Mellon University – *MRSEC (Director: Gregory Rohrer)*
This MRSEC is dedicated to the understanding and control of interface dominated materials properties with emphasis on the study of grain boundary networks that determine the performance of many polycrystalline materials. The Center has extensive collaborations with industry and national laboratories, as well as important international collaborations.

University of Chicago - ***Materials Research Center (Director: Sidney Nagel)***
The MRSEC at the University of Chicago focuses on the manipulation of structural and dynamic properties of materials connected through hierarchies of length scales. Potential applications include the design of the next generation of functional materials, from cooperative spin systems and self-assembled nanostructures to bio-inorganic hybrid materials and biochips. The Center has a strong education outreach program from the K-12 level on up that emphasizes attracting and keeping women and minorities in science, and it fosters public science education through a partnership with the Midwest's premier science museum.

IRG 1 *Jamming and Slow Relaxation in Materials Far From Equilibrium (Co-Leaders Aaron Dinner and Heinrich Jaeger)*
Explores the factors that cause flowing systems to become jammed and therefore form a rigid material trapped far from equilibrium.

IRG 2 *Dynamic Transitions of Material Sheets (Thomas Witten and Wendy Zhang)*
This IRG focuses on the nonlinear interplay between a deformable boundary and imposed stresses, an outstanding issue in engineering and materials processing.

IRG 3 *Rational Design of Nanoparticle and Molecule-Based Functional Materials (Co-Leaders: Eric Isaacs and Steven Seibener)*
Aims to develop the tools needed to create a new class of materials based on the highly-diverse assortment of nanometer-sized particles that are now available.

IRG 4 *Macroscopic Quantum Coherence(Co-Leaders: Woowon Kang and Kathryn Levin)*
Attempts to establish quantum control of materials by addressing fundamental issues in quantum materials engineering. The control of associated complex quantum dynamics can be implemented into useful devices.

University of Colorado - ***Liquid Crystal Materials Research Center (Director: Noel Clark)***
The Colorado Center advances basic liquid crystal and soft materials science and seeks enhanced capabilities for electro-optic, nonlinear optic, chemical and other applications of liquid crystals. Industrial interaction focuses on fostering of and collaboration with U.S. display and telecom industries. The Center operates a vigorous education outreach program featuring science shows for the K-12 audience, and "*Materials Science from CU*", a program of traveling physical science enrichment classes reaching about 8,000 Colorado K-12 students/year.

Colorado School of Mines – ***Renewable Energy Materials Research Science and Engineering Center (Director: Craig Taylor)***
This MRSEC focuses on transformative materials research and educational directions that would significantly impact emerging renewable energy technologies. A strategic partnership with scientists and engineers at the National Renewable Energy Laboratory allows sharing of students, research associates, equipment and facilities between the two organizations. In addition, the Center collaborates with companies that are actively involved in alternative energies.

IRG 1 *Materials for Next Generation Photovoltaics (Leader: Reuben Collins)*
This IRG aims to producing transformative changes in photovoltaic technology either through significant improvements in materials properties or the development of concepts for more efficient carrier generation and collection.

IRG 2 *Advanced Membranes for Energy Applications (Leader: Andrew Herring)*
Seeks to design novel transport membranes with highly optimized properties for electrochemical energy storage or conversion systems.

Columbia University – ***Center for Nanostructured Materials (Director: Irving P. Herman)***
Research in the Center addresses the science and technology of how nanoparticles of complex metal oxides can be combined to form useful films. Participants from several academic institutions and industrial concerns in the New York metropolitan area strengthen the Center's research and human resources. The MRSEC has a very active education and outreach effort, which includes research experiences for undergraduates and high school teachers. Visits to New York City high schools and middle schools introduce students to the world of materials through exciting demonstrations.

Cornell University – ***Cornell Center for Materials Research (Director: Melissa Hines)***
The major theme of Cornell MRSEC is Mastery of Materials at the Atomic and Molecular Level. New ways to synthesize, characterize and understand interfaces and surfaces at the atomic and molecular scales must continue to be invented and exploited to enable forefront discoveries in many fields. The center is aided in these tasks by extensive shared facilities on campus supported by a large interdisciplinary materials community extending well beyond specific MRSEC projects. The center supports an exceptionally strong education program for pre- K-12, undergraduate and graduate students and the public.

IRG 1 *Controlling Electrons at Interfaces (Co-Leaders: L. Hector Abruña and Dan Ralph)*
Develops an understanding and control of the electronic properties of interfaces that have major scientific and technological importance, so as to better manipulate electron and spin transport on and through the interfaces.

IRG 2 *Photonic Building Blocks from Multiscale Materials (Co-Leaders: Alex Gaeta and Ulrich Wiesner)*
This IRG will develop a novel class of fluorescent silica particles with potential applications in display, sensing, photonic, and imaging technologies. These particles will be integrated into a variety of 2D and 3D photonic structures to explore new concepts that control the flow of light and enhance light-matter interactions.

IRG 3 *Dynamics of Growth of Complex Materials (Co-Leaders: George Malliaras and David Muller)*
Investigates nonequilibrium growth processes for multilayer heterostructures of complex materials (e.g., multicomponent oxides, organic semiconductors) to enable growth with single layer precision.

IRG 4 *Atomic Membranes as Molecular Interfaces (Co-Leaders: Paul McEuen and Jiwoong Park)*
Investigates the mechanical, thermal, optical, and electronic properties of atomic membranes: mechanically robust, freestanding films of material as thin as a single atom. In addition, these membranes are studied as atomically thin interfaces between different environments, such as gas/vacuum or liquid/gas.

Georgia Institute of Technology – ***MRSEC: The Georgia Tech Laboratory for New Electronic Materials (Director: Dennis Hess)***
This Center addresses the need for new electronic materials and associated processes for applications in microelectronics, optics and sensors. The single Interdisciplinary Research Group on Graphene Science and Technology investigates fabrication and characterization approaches for the implementation of epitaxial graphene as an electronic material. The MRSEC has extensive collaborations with corporations, national laboratories and universities world-wide. Broad educational activities and outreach programs that integrate materials research into K-12, university and professional education are supported and fostered.

Harvard University - ***Materials Research Center (Director: David Weitz)***

This MRSEC supports a broad interdisciplinary research program that investigates the mechanical properties of crystalline and glassy materials at scales intermediate between atomistic and continuum, focuses on and exploits microfluidics to develop novel materials, and explores innovative ways to make stimuli-responsive active materials by self-assembly of soft materials. The MRSEC operates a broad education and outreach research program that includes summer research experiences for undergraduates and teachers, activities for K-12 students, and programs to enhance the participation of members of underrepresented groups in science and engineering at the graduate, postgraduate level, and faculty levels.

IRG 1 *Micromechanics (Leader: Frans Spaepen)*
The goal of this IRG is to investigate the mechanisms of dislocations and failures in Crystals and glasses, investigate the complex rheology of concentrated particle suspensions, reexamine solid friction, and study the mechanical properties of fiber networks.

IRG 2 *Droplet Templated Materials (Leader: Michael Brenner)*
The goal of this IRG is to use droplet-based microfluidic techniques to fabricate new materials.

IRG 3 *Active Soft Materials (Leader: George Whitesides)*
The goal of the IRG is to develop new materials and new components for use in 'soft systems', such as soft robotics, foldable motors, and muscle-like actuators.

Johns Hopkins University - ***MRSEC (Director: Chia-Ling Chien)***

The Center conducts fundamental research on nanostructures that exhibit enhanced magneto-electronic properties due to the intricate structure of the entities and the interplay of the constituent materials. Topics of interest include highly spin polarized materials, materials with high magnetocrystalline anisotropy, spin interconnects/injection and lateral devices, and novel nanostructures including spintronic devices. The MRSEC has active collaborations with industrial partners, particularly those in magnetic recording, national labs and research institutions. Educational outreach is aimed at undergraduates, high school teachers and students, middle school students, and local communities.

University of Maryland, College Park - ***Center for Oxide Thin Films, Probes and Surfaces (Director: Ellen Williams)***

The Maryland MRSEC carries out nationally recognized fundamental research on surfaces and interfaces of materials with potential impact on the next generation of opto- and nano-electronic devices, and on complex oxides with potential applications in memory, switches and sensors. The research is closely integrated with a continuing educational outreach program that has a direct impact on the education of a diverse population of K – 12 students and teachers.

IRG 1 *Low-Dimensional Interfaces (Leader: Ellen Williams)*
The goal of this research program is to understand and exploit the special statistical and low-dimensional characteristics of junctions between ultra-thin films of electro-optic and nano-electronic materials to create novel device properties.

IRG 2 *Multifunctional Magnetic Oxides (Leader: Dennis Drew)*
This IRG uses state of the art growth techniques, a comprehensive range of characterization tools and advanced theoretical analysis to understand the fundamental processes in multiferroic magnetic oxides, and develops and tests device concepts for their exploitation.

University of Massachusetts-Amherst - ***Center for Polymer Science and Engineering***
(Director: Thomas Russell)

The MRSEC supports a broad interdisciplinary program in the area of polymer science and engineering. Sub-IRG initiatives focus on *Polymer Surfaces for Bacterial Control* and *Amphiphilic Polyelectrolytes*. The Center has strong ties to industry through its industrial affiliates program, maintains effective education and outreach programs with emphasis on undergraduate, K-12 and teacher education and strong links to near-by women's colleges, and has an active international program with centers in Korea and Europe.

IRG 1 *Directed Polymer-Based Assemblies (Co-Leader: Thomas Russell and Thomas McCarthy)*
Explores hierarchically ordered polymer systems based on nanoscopic elements and nanoconfinement relevant to functional nanodevices.

IRG 2 *Polymer Surface Instabilities (Co-Leaders: Alfred Crosby and Jonathan Rothstein)*
Looks to elastic instabilities to control polymer surface morphology, arranging structures resulting from instabilities into hierarchies and exploiting instability dynamics to generate rapid and selective response.

Massachusetts Institute of Technology - ***Center for Materials Science and Engineering***
(Director: Michael Rubner)

The MRSEC supports a broad-based interdisciplinary research program with emphasis on micro- and nanostructured materials in the areas of photonics, polymer assemblies, and improved batteries. Sub-IRG sized initiatives focus on *Engineering Living Cells via Nanomaterials* and *New States of Frustrated and Correlated Materials*. The Center has a strong education program directed toward graduate students, undergraduates, middle and high school students and K-12 teachers. Emphasis is placed on including underrepresented minorities in these programs. The Center operates widely accessible shared facilities and has an effective industrial outreach program.

IRG 1 *Design of Nanomaterials for Electrochemical Energy Storage and Conversion (Co-Leaders: Yang Shao-Horn and Gerd Ceder)*
Seeks to accurately model, predict, and determine how thermodynamics, phase behavior, and kinetics are modified at the nanoscale, and will use the resultant knowledge to design materials with energy and power-delivery capabilities far superior to those currently available.

IRG II *Mechanomutable Heteronanomaterials (Co-Leaders: Christine Ortiz and Robert Cohen)*
Develops new dynamically tunable multicomponent heterogeneous nanostructured systems with an emphasis on mechanical behavior, both theoretical and experimental.

IRG III *Multimaterial Multifunctional Nano-Structured Fibers (Co-Leaders: Yoel Fink and Marin Soljačić)*
Explores the design, fabrication, characterization, and physical phenomena of a new class of multicomponent nanoscale fiber materials containing conductors, semiconductors (glassy and crystalline) and insulators.

University of Minnesota – ***Materials Research Science and Engineering Center***
(Director: Timothy P. Lodge).

Research in the Center is organized into four research groups on microstructured polymers, crystalline organic semiconductors, and magnetic heterostructures. The Center benefits from extensive materials synthesis and characterization facilities and supports a strong education outreach program to four-year colleges with emphasis on the Native American community in the region.

IRG 1 *Engineered Multiblock Polymers (Leader: Marc Hillmyer)*

This IRG will establish strategies to functionalize blocks with compromising self-assembly; design mechanically robust multi-block architectures; and develop advanced advance coating and extrusion processes.

IRG 2 *Organic Optoelectronic interfaces (Leader: C. Daniel Frisbie)*
The goal of the IRG is to determine crucial structure-property relationships at organic optoelectronic interfaces to improve performance of organic field effect transistors and organic photovoltaic devices.

IRG 3 *Magnetic Heterostructures (Leader: Paul A. Crowell)*
This IRG focuses on the fundamental understanding of spin transport and dynamics, both in bulk and at interfaces.

IRG 4 *Nanoparticle-based Materials (Leader: Uwe Kortshagen)*
This IRG explores the fundamental optoelectronic properties of environmentally benign nanoparticle based materials for luminescent and photovoltaic applications.

University of Nebraska- *Quantum and Spin Phenomena in Nanomagnetic Structures*
(Director: Evgeny Tsymbal)
The Center supports an interdisciplinary research program on nanomagnetism with an emphasis on the study of interactions between magnetic dots or clusters and spin transport across nanocontacts and interfaces. The research involves strong collaborations with industry as well as international partners. The Center's educational outreach efforts include research experiences for teachers and for faculty-student teams from predominantly undergraduate institutions.

IRG 1 *Nanoscale Magnetism: Structure, Materials, and Phenomena (Leader: David Sellmyer)*
Focuses on synthesizing and studying novel magnetic clusters including alloys, compounds, core-shell, and two-phase structures; and interactions and dynamics in novel nanomagnetic structures produced by self-assembly on surfaces..

IRG 2 *Magnetoelectric Interfaces and Spin Transport (Leader: Christian Binek)*
This IRG will employ the electron spin in a synergistic combination with novel nanoscale magnetic, magnetoelectric, ferroelectric, and piezoelectric structures to yield new spin dependent properties and unique functionalities.

New York University – *Semantophoretic Assemblies (Director: Michael Ward)*
The Center focuses on fabrication of innovative materials – from the colloidal to macroscopic scale – based on colloidal or microscopic particles equipped with self-contained information that directs assembly, either through shape or chemical interactions. Potential applications include among others ceramic composite dental and medical materials as well as photonic materials. The Center takes advantage of its location to develop curriculum content for K-12 education and communities in New York City, reaching substantial numbers of minority students. The Center offers symposia in conjunction with the New York Academy of Sciences and operates an Industrial Partners Program as well as International Partner Workshops to significantly expand the impact of the MRSEC beyond NYU.

Northwestern University - *Materials Research Science & Engineering Center*
(Director: Monica Olvera de la Cruz)
The Center supports an interdisciplinary research program on materials with an emphasis on the nanoscale. The Center features a strong pre-college education program, including the widely disseminated Materials World Modules (MWM), as well as outstanding undergraduate and graduate educational opportunities. The science teachers who participate in the summer research program represent middle schools, high schools and community colleges and many actively collaborate with the Center throughout the school year.

IRG 1 *Synergistic Linear and Nonlinear Phenomena in Multifunctional Oxide Ceramic Systems (Co-Leaders: Vinayak Dravid and Bruce Wessels)*
Studies and exploits the unique attributes of oxide materials that result simultaneously in two or more functionalities (electronic, photonic, and magnetic).

IRG 2 *Novel Processing Methods for Nanostructured Polymer Blends, Composites, and Supramolecular Structures (Leader: Ken Shull)*
Studies the roles of non-equilibrium mechanical forces and equilibrium thermodynamics on the nanoscale structure and macroscale properties of polymer blends and composites resulting from gradient copolymerization, thermoreversible gelcasting, and solid-state shear pulverization.

IRG 3 *Molecular Plasmonics: Fundamentals, New Tools, and Devices (Leader: Rick Van Duyne)*
Studies nanoparticles that act as plasmonic switches and develops nanoscale optical characterization tools for investigating conductor-molecule-conductor junctions that lie at the heart of molecule based electronics.

IRG 4 *Hybrid Organic-Inorganic Nanoelectronic Materials from Molecules to Printable Thin Films (Co-Leaders: Tobin Marks and Lincoln Lauhorn)*
This research enables novel technological advances in the area of hybrid organic/inorganic nanoelectronic materials by improving fundamental understanding and optimizing processing efficiency across multiple length-scales.

Ohio State University – *Center for Emergent Materials (Director: Nitin Padture)*

This Center performs integrated research on emergent materials and phenomena creating new paradigms in computing and information storage. The research activities focus on a new understanding of electron-spin injection and transport, and the synthesis and exploitation of multifunctional properties of innovative double perovskite heterostructures. An important component of the education program is an interactive, constructionist approach to address the nature and cognitive cause of the misconception of materials science concepts.

IRG 1 *Towards Spin-Preserving, Heterogeneous Spin Networks (Co-Leaders: P. Christopher Hammel and Ezekiel Johnston-Halperin)*
This IRG is laying the foundation for spin-preserving networks for next generation information processing through the study of spin injection/extraction and transport.

IRG 2 *Double Perovskite Interfaces and Heterostructures (Co-Leaders: Leonard Brillson and Patrick Woodward)*
Develops theoretical tools, routes to fabrication, and studies interfacial phenomena in highly ordered epitaxial films of half-metallic double perovskite

University of Oklahoma/University of Arkansas – *Center for Semiconductor Physics in Nanostructures (Director: Matthew Johnson)*

The Center, a collaboration between the Universities of Oklahoma and of Arkansas, supports an interdisciplinary research program on semiconductor nanostructure science and applications. The Center is engaged in a number of educational activities from the graduate to the middle school level, including support for workshops for middle and high school science teachers.

IRG 1 *Nanostructures – Growth and Characterization (Leader: Greg Salamo)*

Control over semiconductor and ferroelectric materials growth will yield systems that give new insight into the collective interactions between individual quantum dots, wires and rings, and will provide the basis for new optical and electronic materials.

IRG 2 *Nanoscale Interface Studies (Leader: Michael Santos)*
Explores the unique properties of narrow bandgap semiconductor materials to address nanoscale electronic devices that exploit quantum mechanical effects for higher speed operation, denser memory with increased functionality.

University of Pennsylvania - *Laboratory for Research on the Structure of Matter (Director: Michael Klein)*

The MRSEC integrates the design, synthesis, characterization, theory & modeling of materials ranging from hybrid macro-molecules and de novo proteins, with architectures & functions inspired by nature, to nano- and micro-structured hard & soft materials with unique properties. Potential practical outcomes are in the areas of drug delivery, energy transduction, electronics, sensors, and cellular probes. The MRSEC sustains an array of education and human resources development programs, whose impact will range from K-12 students and their teachers to undergraduates and faculty at minority serving institutions.

IRG 1 *Filamentous Networks and Structured Gels (Co-Leaders: Shu Yang and Arjun Yodh)*
Explores the properties of filamentous networks with a goal to design & synthesize responsive network materials.

IRG 2 *Functional Cylindrical Assemblies (Co-Leaders: Dennis Discher and Andrea Liu)*
Synthesizes semi-flexible, functional cylinders, composed of dendrimer-based polymers & self-assembling block copolymers with the aim of understanding the fundamental properties if diverse macromolecule-based cylinders.

IRG 3 *Designed Programmable Membranes (Co-Leaders William DeGrado and Daniel Hammer)*
Biological and bio-inspired synthetic approaches will be used to design highly stable membrane bilayers and integrate into them functional components such as ion channels, pH sensing receptors, and signal transducers.

IRG 4 *De Novo Synthetic Protein Modules for Light-Capture & Catalysis (Co-Leaders: Kent Blasie and Leslie Dutton)*
Draws on the rich biological resource of atomic-level structures and functional mechanisms to guide design & synthesis of novel proteins as modular nano-scale materials. These self-assembling modules will be constructed to couple light energy to conservative oxidative and reductive catalysis.

IRG 5 *Oxide-based Hierarchical Interfacial Materials (Co-Leaders: James Kikkawa and I-Wei Chen)*
Studies the interfaces within ordered alloys of bulk perovskite phases, layered superlattices, oxide-metal hybrids, and between oxide surfaces and molecular adsorbates.

Penn State University – *Center for Nanoscale Science (Director: Tom Mallouk)*

The MRSEC supports a broad range of materials research encompassing studies and applications of biological and synthetic molecular motors, collective electronic and spintronic phenomena in restricted geometries, materials for the management of electromagnetic radiation, and multiferroics. The Center partners with the Penn State node of the National Nanofabrication Users Network enabling the fabrication and characterization of nanoscale condensed matter systems. The Center supports a full range of education activities ranging from the graduate level to K-12 teachers and students and education programs for the public. In partnership with the Franklin Institute Science

Museum in Philadelphia the Penn State MRSEC created and sponsored a show called " Materials Matter" that is being exhibited currently on a weekly basis in 23 science museums nationwide.

IRG 1 *Molecular and nanoscale motors (Leader: Vin Crespi)*
Generates new physical regimes of autonomous powered nano and microscale elements, inspired by the complex dynamical interplay of nanoscale machines that comprise living systems.

IRG 2 *Charge and Spin Transport in Quasi-1D Nanowires (Leader: Moses Chan)*
This IRG brings together complementary expertise to explore these new phenomena and to ascertain their promise for, and potential barriers to, device applications. Specifically, the focus will be on the physics of superconducting, magnetic and metallic nanowires in the quasi-1D limit, and on spin-dependent transport in semiconductor nanowires.

IRG 3 *Electromagnetically-coupled Nanostructures(Leader:Theresa Mayer)*
Accesses new physical regimes and enables new technologies by directing the spatial organization and integration of metals, semiconductors, and dielectrics in geometrically sophisticated patterns both within the extreme-aspect-ratio pores of microstructured optical fibers and on planar substrates.

IRG 4 *Strain-enabled Multiferroics (Leader: Darrell Schlom)*
Investigates the impact of strain on the coupling of ferroic order parameters within a single material with the aim of finding new functionalities that can displace existing technologies or make new applications possible.

Princeton University - *Center for Complex Materials (Director: Richard Register)*
The Center pursues a common theme of synthesizing and characterizing materials at the nano-, meso- and microscale. The Center has a strong outreach program to pre-college students and teachers and to local museums. Industrial and national laboratory interactions also play an important role.

IRG A *Electronic Materials with Triangular Lattice and Dirac Excitations (Co-Leaders: Robert. Cava and N. Phuan Ong)*
This IRG synthesizes and explores correlated electron phenomena in triangular-lattice oxides and "Dirac materials" (graphene, Bi, Bi1-xSbx, □-Sn and PbSnTe) to understand the superior thermoelectric performance seen in NaxCoO2 and Bi1-xSbx at low temperatures, as well suggest novel electronics applications.

IRG B *Design and Control of Buried Active Molecular Materials Interfaces (Co-Leaders Antoine Kahn and Yueh-Lin (Lynn) Loo)*
Pursues a multidisciplinary investigation of fundamental electronic, chemical and structural properties and applications of molecular interfaces and systems formed by "non-traditional" methods, such as stamping, printing, lamination and laser-induced deposition.

IRG C *Integrated Self-assembled Nanostructures (Co-Leaders: A.Z. (Thanos) Panagiotopoulos and Richard Register)*
Focuses on integrating self-assembling nanoscale building blocks, such as large organic molecules, inorganic nanoparticles, and block copolymer nanodomains into spatially defined structures of macroscopic dimensions for applications as diverse as electron emitter arrays and photovoltaic cells.

IRG D *Quantum Control in Semiconductor Nanostructures (Co-Leaders: Ali Yazdani and Jason Petta)*

Combines the synthesis of nanostructured materials with the development of novel techniques to create new materials systems with functionality that is derived from control of quantum degrees of freedom.

The University of Southern Mississippi – *Center for Response-Driven Polymeric Films (Director: Marek W. Urban)*

This Center focuses on interdisciplinary research on thin polymeric films and organic coatings. Research, with strong international collaborations, addresses fundamental aspects of "smart" coatings that will be critical to many disciplines. The Center supports high school and undergraduate summer research educational activities with the emphasis on hands-on experience as well as distance learning with web-based tutorials and new laboratory courses. Industrial component also plays an important role and numerous projects conducted within the Center have strong industrial relevance.

IRG 1 *Design and Synthesis of Response Driven Macromolecules (Leader: Sabine Heinhorst)*
This IRG is concerned with design, synthesis, and understanding of molecular processes in biomaterials, self-assembling amphipatic protein films, film formation of membrane forming proteins, synthesis of water-soluble and liquid crystalline polymers as well as colloidal dispersions that mimic biosystems or exhibit stimuli-responsive characteristics.

IRG 2 *Responsive Films and Film Formation (Leader: Charles E. Hoyle)*
This IRG focuses on the fundamental aspects and molecular level processes leading to film formation as well as chemico-physical and environmental conditions responsible for the formation of stimuli-responsive "smart" polymeric films and coatings. Another significant component is the development of novel spectroscopic, morphological, and rheological characterization techniques that will enable better understanding of stimuli-responsive polymeric coatings.

Stanford University / IBM-Almaden / University of California-Davis / UC Berkeley - *Center for Polymer Interfaces and Macromolecular Assemblies (Director: Curtis Frank)*

The Center is a partnership between Stanford University, UC Davis, UC Berkeley and the IBM Almaden Research Laboratory. Research, with strong international collaborations, focused in the areas of nanostructured and interfacial molecular and biomolecular materials with potential applications in nanotemplating, photovoltaics, catalysis, and artificial membranes. The Center supports undergraduate summer research activities in academic and industrial settings as well as in science museum projects with plans to increase the participation of physically disabled students. The K-12 programs for teachers and students include partnerships with area schools.

IRG 1 *Synthesis and Application of Nanostructured Materials (Co-Leaders: Jim Hedrick and Bob Waymouth)*
This IRG aims to develop new synthetic and theoretical methodology for the preparation and study of functional macromolecules with unparalleled architectural control.

IRG 2 *Structure and Dynamics of Polymeric and Biomolecular Materials at Interfaces (Co-Leaders: Marjorie Longo and Eric Shaqfeh).*
IRG-2 focuses on the fabrication and in-situ observation of dynamic interfaces. Emphasis is placed on microfluidic and nanofluidic molecular processing of materials. Although inspiration often comes from biomolecular systems such as phospholipid membranes or DNA assemblies, the applications are broad and include lubrication, emulsion stability, and polymer processing.

IRG 3 *Directed Nano-assemblies and Interfaces for Advanced Electronics: (Co-Leaders: Zhenan Bao and J. Campbell Scott).*

This IRG focuses on the control and characterization of interfacial charge transport in directed nanoassemblies. This research is motivated by basic issues that relate to the performance of organic electronic devices, including photovoltaics, field-effect transistors, biological sensors, and memory elements.

University of Washington – *Genetically Engineered Materials Science and Engineering Center (Director: Mehmet Sarikaya)*

This MRSEC supports innovative research and education that integrates modern molecular biology with state of the art chemical synthesis to construct hybrid materials exhibiting properties that cannot be achieved through either traditional biological or chemical routes. The center is developing coordinated activities in graduate and *undergraduate* education and outreach, establish an international network of laboratories sharing a common interest in molecular biomimetics, and partner with industry and national laboratories to translate fundamental discoveries into new products realities. The MRSEC conducts a unique outreach program to Native Americans in the Seattle area.

University of Wisconsin-Madison - *Nanostructured Materials and Interfaces (Director: Juan DePablo)*

The Center carries out research on the synthesis, characterization, and exploitation of nanostructured interfaces over a wide array of applications, including ultrathin silicon electronics, contacts between organic and traditional semiconductors, and cell substrates for the control of stem cell differentiation. The center supports a vibrant education and outreach program aimed at K-12 students and teachers, college-level learners, and the public. As part of its educational initiative, the Center actively produces instructional materials for integrating materials science and engineering into pre-college, college, and graduate curricula that are currently in use throughout the world.

IRG 1 *Silicon Based Nanomembrane Materials (Co-Leaders: Max Lagally and Robert Blick)*
Explores the science and technology of membranes so thin that the thinness determines the structure and topography, and creates unique electronic, mechanical, chemical, and defect properties. Ultra-thin silicon and strain engineering allow a vision of a new field of investigation – fundamental studies of extremely thin semiconductor membranes – with potentially significant technological outcomes.

IRG 2 *Functional Organic-Inorganic Electronic Interfaces (Co-Leaders: Tom Kuech and Robert Hamers)*
Design, fabricate, and characterize interfaces between inorganic materials and organic molecular structures in order to achieve a high level of control over their structural and electronic properties, critical to a broad spectrum of applications from sensing to lighting.

IRG 3 *Nanostructured Interfaces to Biology (Co-Leaders: Nick Abbott and Paul Bertics)*
Designs polymeric and liquid-crystalline materials that provide both spatial and temporal control over the chemical functionality and physical properties of interfaces of synthetic materials presented to biological systems, including proteins, viruses and human embryonic stem cells.

Yale University – *Center for Research on Interface Structure and Phenomena (Director: John Tully)*

This Center addresses the electronic, magnetic and chemical properties of complex oxides and their interfaces, along with possible applications in areas such as magnetic storage, "spintronics", chemical sensing and electronic devices. The Center partners with Southern Connecticut State University in their education and outreach activities in the New Haven area.

For additional information:

- Visit http://www.mrsec.org, or the web sites of the individual Centers;
  Visit http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5295

- Contact one of the NSF Program Directors:

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- Contact the Center Director (information below)

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