SYMPOSIUM BB

Educating Tomorrow's Materials Scientists and Engineers

April 13 - 14, 2004

Chairs

Katherine C. Chen
Dept. of Materials Engineering
California Polytechnic State Univ
San Luis Obispo, CA 93407
805-756-6634

Michael L. Falk
Dept. of Materials Science & Engineering
University of Michigan
Ann Arbor, MI 48109-2136
734-615-8086

Trevor R. Finlayson
School of Physics and Materials Engineering
Monash University
Clayton, 3800 Australia
61-3-9905-3683

Wayne E. Jones
Institute for Materials Research
SUNY - Binghamton
Binghamton, NY 13902
607-777-2421

Luz J. Martinez-Miranda
Dept. of Materials Science & Engineering
University of Maryland
College Park, MD 20742-2115
301-405-0253

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* Invited paper

SESSION BB1: Learning Techniques and Nanotechnology in the Classroom
Chairs: Trevor Finlayson and Wayne Jones
Tuesday Morning, April 13, 2004
Room 2022 (Moscone West)

8:30 AM *BB1.1
Any Questions? Inquiry-Based Learning Taken Too Far: Pedagogical Lessons from Professorial Mistakes. Blair London, Materials Engineering, Cal Poly State University, San Luis Obispo, California.

Inquiry-based learning rests on the premise that students learn more by answering a series of questions on a certain topic rather than simply receiving information on that topic. It is the Socratic Method where the class sessions are based on questions for the students to answer instead of information for the instructor to present. But, what would happen if the questions were the responsibility of the students? This was the inquiry-based model used to teach several quarters of the Introductory Materials Engineering course, which is taught to a wide range of engineering majors. The goals were: (1) to inspire students to come to each class session prepared with questions that needed to be answered, and (2) to greatly increase the level of student participation in the class sessions. The method requires a high level of student preparation for the class sessions: reading the appropriate sections of the text, addressing specific learning objectives provided by the instructor, and solving homework problems suggested by the instructor. Data will be presented on the amount of preparation done by the students for the class sessions. The result of teaching the course this way for several different groups of engineering students was that it was not effective in increasing student motivation and learning. It was an extreme failure. The lessons learned from this failure; however, have proven invaluable in developing more effective teaching and learning methods for this course and other engineering classes. These lessons will be highlighted in the paper.

9:00 AM BB1.2
Crystals (A Freshman Seminar): An Exercise on Cooperative and Peer Learning. M.Krimo Bokreta and Jorge Juan Santiago-Aviles; Electrical and Systems Engineering, University of Pennsylvania, Philadelphia, Pennsylvania.

For the past half a decade we have been teaching a popular freshman seminar based on the subject matter of crystals. Simultaneously, we are giving them the opportunity to gain experience working in teams, doing formal oral presentations and writing reports. The underlying philosophy in this task is that students teach one each other far better than we can when they interact in small groups, in a carefully orchestrated atmosphere, and well guided. Our challenge has been to find the parameters that best exemplify that intellectually conducive atmosphere and level of guidance. We have found that dividing the group (usually about 20) in groups of four brings agility to the group logistics and minimize "defocusing" socialization. These are the teams of peer teachers. Each is responsible in carrying its own weight in the education of the team. They select their own "management" structure, as well as their agenda. Since the students will be utilizing the PP software, we will offer a workshop on the techniques for the un-initiated. The course itself starts with a month of lectures by the instructors and by visitors from other germane departments. The students organize visits to research labs on campus where research on crystalline materials is being performed, and invite researchers in the field to lecture the class. Each meeting period involves discussion of homework problems, where the groups informally present their findings. After this initial month the teams select a topic among a wide gamma of possibilities and clear the particular focus it wish to develop with the instructors. The selected themes tend to group in science, technology, as well the general "lore" of crystals. So the themes range from the growth of crystals in reduce gravity, through the economic aspects of synthetic diamonds, to the folklore of crystals in healing. The particular selection of a theme is not as important as the way they research the topic, develop it and present it. The teams first present a survey of their topic to the class. We evaluate the presentation in terms of intellectual content and delivery. The students not only receive our feedback but also that of their peers. They have the chance to incorporate the comments in a second report, three weeks after the first when they are supposed to focus more on the initial theme and select a part for a more in-depth study. A final oral (and written) reports are due at the end of the semester. Trough the semester the classroom atmosphere have been that of inquiry, acceptance of all points of view and the pursuit of diverse perspectives and points of view. The students seem to be able to take with them these attitudes and maintain them in their team meetings and discussions.

9:15 AM BB1.3
Nanotechnology Undergraduate Education at The University of Puerto Rico at Mayaguez: Active Learning Experiences in Nanotechnology for K to College Level Undergraduates. Emil Avier Hernandez[1], A. Odeh[1], J. Rosado[1], R. Rivera[1], A. Marin[1], Nerien Nerien[1], R. Garcia[1], S. P. Hernandez[1], J. Briano[1] and Miguel E. Castro[1]; [1]Chemical Imaging Center and Center for Chemical Sensor Development and Department of Chemistry, The University of Puerto Rico at Mayaguez, Mayaguez, USA, Puerto Rico; [2]Dupont Microelectronics, Manati, USA, Puerto Rico.

Active learning is an attractive mechanism for the introduction of nanotechnology to undergraduates. Active learning presents a unique environment for undergraduate education in nanotechnology based on a hands on approach to education. The methodology facilitates the processes of incorporating undergraduates into research activities associated with nanotechnology. We have adopted this education philosophy in our undergraduate education course at the University of Puerto Rico at Mayaguez. Active learning modules are created to introduce basic and fundamental concepts related to nanotechnology. A few examples of these modules include: (a) Introduction to nanotechnology: From the atom to the bulk to the nanoworld (b) Nanoparticle synthesis: synthesis and properties of gold colloids (c) Nanoparticle synthesis: synthesis and properties of quantum dots (d) Integrated nanoscaled science and engineering: photolithography using sunlight (e) Integrated nanoscaled science and engineering: magnetic properties of nanoparticles (f) Applications of nanotechnology to biophysical chemistry: gold colloids for surface enhanced Raman measurements. The active learning philosophy of motivating students to pursue their own interests has also resulted in new discoveries of the nanoscaled world performed by participating undergraduates. These new discoveries include new methods for the selective synthesis of silver nanowires and their manipulation for use as antennas, nanoscaled wiring circuits and membranes. We will present and discuss (1) the active learning modules discussed above and (2) provide strategies to motivate students to pursue their own goals in nanotechnology and (3) discuss strategies to adapt the active learning modules developed for undergraduate education to K-12 education.

9:30 AM *BB1.4
Nanotechnology Education and Training. M. Meyyappan, NASA Ames Center for Nanotechnology, Moffett Field, California.

Nanotechnology is an enabling technology that will impact on various sectors: electronics/computing/data storage, materials and manufacturing, energy, transportation, health and medicine, national security, etc. As it is recognized the technology of the 21st Century, worldwide investment - both by government and private sector - is high in research activities. It is equally important now to invest in training of our future scientists and engineers. In this talk, I will outline my experience with the following: (1) A course on Introduction to Nanotechnology, at Santa Clara University, I taught in 2002 and 2003 for graduate and senior undergraduate students, (2) Summer undergraduate and high school student research programs in nanotechnology I have been running for the last five years, and (3) Webcasts on nanotechnology aimed at high school and community college students.

10:30 AM *BB1.5
Teaching Undergraduates Nanotechnology. Joe George Shapter, SOCPES, Flinders University, Bedford Park, South Australia, Australia.

Starting in 1998, Flinders University started down the path of offering a course in Nanotechnology (Bachelor of Science in Nanotechnology (Hons.)) with the first intake of students in 2000. That first intake will graduate this year. This presentation will outline some of the decisions made before and during the offering of the course and the positive and negative outcomes of some of those decisions. Further, it will discuss the impact of offering the degree on noneducational issues such as basic research and community involvement.

11:00 AM *BB1.6
Nanotechnology in the Undergraduate Program. Stan Whittingham, Materials Science & Engineering, SUNY at Binghamton, Binghamton, New York.

Nanotechnology is at the nexus of a broad range of disciplines including chemistry, physics, engineering, and biology. Yet, the study of this important area at the undergraduate level is not treated in a coherent manner throughout a student's career. It is through a coordinated learning environment that students can gain a better understanding of and appreciation for this area of science that is destined to lead the next generation of technological breakthroughs. An interdisciplinary team of faculty and students from Materials Science, Biology, Chemistry, Physics, ME, EE and education worked together over the summer of 2003 to create a series of nanotechnology modules for use in existing lower division undergraduate courses in science and engineering. These modules range from the initial synthesis of a new material through its complete characterization and built upon successful examples currently being used in the classroom and laboratory at Binghamton. This team also developed the foundations to implement a capstone nanotechnology experience in the form of a 2 credit independent course that could be taken as an elective by students in any discipline. Some examples of these modules will be described. This project was supported by the NUE initiative of the National Science Foundation.

11:30 AM BB1.7
Biomedical Nanoscience: Electrospinning Basic Concepts, Applications and Classroom Demonstration. Kristin J. Pawlowski[1], Gary E. Wnek[2,1] and Gary Bowlin[1,2]; [1]Biomedical Engineering, Virginia Commonwealth University, Richmond, Virginia; [2]Chemical Engineering, Virginia Commonwealth University, Richmond, Virginia.

Electrospinning is a rather old polymer processing technique that has been rediscovered of late. It allows for the easy creation of nano- to micro-fibers that when collected form a non-woven structure, and can be used to fabricate novel structures for various applications including tissue engineering scaffolds, clothing, drug delivery vehicles, and filtration media. Current research in our laboratories is focused on the processing of biopolymers to create materials with tailored properties/functions for tissue engineering scaffolds and other medical applications. This technology is revolutionizing the biomaterials and nanotechnology fields and has prompted us to incorporate the history, basic concepts, applications and basic examples in diverse courses such as Biomaterials, Tissue Engineering, Polymers in Medicine, and Senior Design. This Innovation of the Curriculum is timely and crucial for multiple reasons. There is a need for a systematic approach to course structure that ties historical concepts to new materials and ultimately to practical applications. Combining this with active learning in terms of open discussions and hands-on experiments will work to enhance learning outcomes at all levels. At the undergraduate and graduate levels in the courses mentioned, discussions of electrospinning make for an excellent classroom atmosphere that sparks open discussions and allows for the demonstration of an actual nanomaterial fabrication approach as a visual aid to the classroom. More importantly, it can be used at the high school level to demonstrate nanotechnology and it's applications to medicine, which will aid in sparking the interest of future generations of scientists and engineers. Fundamental issues of electrohydrodynamics are introduced at various levels, and the application examples are focused on natural polymers such as collagens, elastin and fibrinogen that have been pioneered in our laboratories. The applications of nano-fibrous, synthetic biodegradable polymers are also addressed. The innovation of the curriculum presents this technology and the remarkable biological interactions that occur with the novel biomaterials. These nanofibers create a new paradigm in terms of biocompatibility and forces the students to think "outside the box" and not rely on accepted theory based on materials composed of fibers two to three order of magnitude greater in diameter. Following this overview, a simple experiment that can be completed in a classroom at any level with minimal equipment is performed. This classroom demonstration, a complete step-by-step process, will be illustrated via a movie. In conclusion, the process of electrospinning of biopolymers has the potential to revolutionize many fields. This revolution must be and is being presented to the students at various levels of education in the classroom setting, as it is being developed, to allow the student to become future leaders in science and engineering.

11:45 AM BB1.8
DNET: The Drexel Nano Engineering Track.
Christopher Y. Li[1], Kishore Tenneti[1], Surya Kalidindi[1], Antonios Zavaliangos[1], Yury Gogotsi[1], Karl Sohlberg[2] and N John DiNardo[3]; [1]Materials Sci & Engin., Drexel University, Philadelphia, Pennsylvania; [2]Department of Chemistry, Drexel University, Philadelphia, Pennsylvania; [3]Department of Physics, Drexel University, Philadelphia, Pennsylvania.

The emerging field of Nanoscale Science, Engineering and Technology (NSET) has become an extremely active and vital area of research extending into almost every facet of engineering and science. The need to educate young students about NSET by incorporating its aspects into curriculum at several levels is essential because the preparation of future faculty, researchers and professionals is critical to the progress of the NSET field. Early exposure of NSET to undergraduate students is anticipated to play a pivotal role in recruiting highly qualified professionals for industry and in preparing future faculty and researchers for graduate education. Focusing on early undergraduate education in NSET, the newly launched Drexel Nano Engineering Track (DNET) program at Drexel University addresses the urgent need for early NSET education at the University level. The primary objective of the DNET program is to expose freshmen and sophomores in Drexel's College of Engineering to basic concepts in NSET. It is envisioned that the career decisions of a large fraction of students will be directed as they learn the vocabulary of NSET and see potential engineering applications. The proposed DNET program, together with the existing Nanotechnology Institute and Drexel/Upenn IGERT program that focus on the NSET research and graduate education, will offer a stream of NSET education from college to graduate school at Drexel University. The current DNET program activities include 1) update/modify seven freshmen/sophomore courses and three introductory engineering laboratories to infuse NSET into early undergraduate curriculum 2) coupled with The IGERT program, organize Nano-frontier seminar series on scientific and societal impacts of NSET geared towards undergraduate 3) launch DNET web for information dissemination, performance assessment and outreach activities. At this introductory level, the intent is to familiarize engineering students with NSET concepts and terminology that they can relate to forefront science and technology going on worldwide. Because of the size of the established tDEC program, this initiative will reach a remarkably large body of students immediately. Over 700 students are/will be enrolled in NSET-revised freshmen courses, and they will progress to NSET-revised sophomore courses the next year. Six faculty members (five PIs and one Senior Investigator) are involved in the curriculum revision. In addition, approximately fifteen faculty members with research interests in the area of NSET will potentially serve as mentors for some of these students to guide them through various freshman design projects involving NSET.

SESSION BB2: Computational Materials Science & Engineering
Chair: Michael Falk
Tuesday Afternoon, April 13, 2004
Room 2022 (Moscone West)

1:30 PM *BB2.1
Introduction to Modeling and Simulation: a Multidisciplinary Approach to Computational Materials Education.
Adam Clayton Powell and Sidney Yip; Materials Science and Engineering, MIT, Cambridge, Massachusetts.

Introduction to Modeling and Simulation, first taught in Spring 2002, is a broad overview of computation for processing-structure-property relationships. This subject draws lecturing faculty from the departments of Materials Science and Engineering, Nuclear Engineering, Applied Mathematics, Civil and Environmental Engineering, Health Sciences and Technology and Chemical Engineering, with undergraduate and graduate student representation from a similar diversity of backgrounds. Lectures cover modeling methodologies with assignments spanning lengthscales from electronic structure of simple molecules, to percolation clusters, to Ising models, to finite difference modeling of heat conduction and phase change. Students also work on term projects as individuals or in pairs. This talk will focus on experiences in managing the diverse backgrounds of students and faculty, both in terms of differences in approach between departments, and also varying mathematical and computational backgrounds of their students. It will also introduce new opportunities for enhancing computational materials education via MatDL.org, the Materials Digital Library.

2:00 PM BB2.2
Materials Digital Library: Enabling Laboratory Experience in a Large Freshman Class. Donald R Sadoway[1] and Laura M. Bartolo[2]; [1]Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts; [2]College of Arts and Sciences, Kent State University, Kent, Ohio.

Providing meaningful laboratory experience in large introductory undergraduate science courses is effectively impossible owing to limitations of resources, i.e., facilities and staff. A recent ABET/Sloan Foundation colloquy posed the question: to what extent does a remote laboratory experience accomplish the goals of educational laboratories? Of 13 learning objectives identified only 3 require in situ physical interaction. With access to data acquired in the laboratory by others and stored in an addressable archive students should be able to perform exercises that teach most of what is to be learned in a traditional laboratory subject. This paper examines the effort to design a virtual laboratory to accompany a large materials-centered freshman chemistry class at MIT (625 students in Fall 2003). The plan is to make use of data available in the Materials Digital Library, MatDL.org (For details about MatDL see the paper by Laura Bartolo.). Success would have widespread significance as the results are scalable and not confined to materials chemistry.

2:15 PM BB2.3
The Materials Digital Library and the NSF National Science Digital Library Program. Laura Bartolo[1], James A. Warren[2], Vinod Tewary[3], Sharon C. Glotzer[4], Adam C. Powell[5], Donald R. Sadoway[5], Javed I. Khan[6] and Kenneth M. Anderson[7]; [1]College of Arts and Sciences, Kent State University, Kent, Ohio; [2]Materials

Science and Engineering Laboratory, National Institute of Standards and Technology, Gathersburg, Maryland; [3]Materials Reliability Division, National Institute of Standards and Technology, Boulder, Colorado; [4]Departments of Chemical Engineering; and Materials Science and Engineering, University of Michigan, Ann Arbor, Michigan; [5]Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts; [6]Department of Computer Science, Kent State University, Kent, Ohio; [7]Department of Computer Science, University of Colorado, Boulder, Colorado.

The NSF National Science Digital Library Program (NSDL) is a premier collective portal of authoritative scientific resources supporting education and research. As a key component of the cyberinfrastructure, the NSDL provides a strong foundation for novel team based learning environments. With funding from NSF, the Materials Digital Library (MatDL) is a collaborative project being developed by the National Institute of Standards and Technology's Materials Science and Engineering Laboratory (NIST/MSEL), and the materials science departments at MIT and the University of Michigan (U-M), with Kent State University (KSU) providing the materials science informatics (matinformatics) backbone and University of Colorado-Boulder (UC-Boulder) supporting workflow technology. As a part of the NSDL program, MatDL is geared towards the interface of materials science information and its cognate disciplines. Initial content of MatDL will begin with resources selected from NIST/MSEL. MSEL is committed to providing existing and ongoing content of their recent research, such as online publications, presentations, and materials data from the Combinatorial Methods Center (NCMC), the Polymers Division, and the Nanomaterials Informatics project. Students and faculty in three types of MSE courses at MIT and U-M use and contribute to MatDL utilizing domain-specific authoring tools. In MatDL, KSU and UC-Boulder information and computer scientists are currently working with materials scientists at NIST/MSEL, MIT, and U-M to build distributed peer-to-peer submission, editing, annotation, and access tools to help students, teachers, and researchers accurately describe the digital resources they generate. This presentation will describe the NSDL program, the MatDL infrastructure and NIST/MSEL content, and materials science authoring tools. See also abstracts by SC Glotzer, AC Powell, and DR Sadoway for details about the MSE curriculum. Given the central and interdisciplinary role of materials science in science and engineering, MatDL aims to resonate across the cognate disciplines of biological sciences, chemistry, mathematics, and physics. The goal of MatDL is to expand its founding partnership with a call for additional participants in order to facilitate the flow of digital knowledge from laboratories where the most recent research discoveries are taking place, to the classrooms where new scientists are being trained.

2:30 PM BB2.4
Teaching computational materials science for nanoscale science and engineering. Sharon C Glotzer, Chemical Engineering and Materials Science and Engineering, University of Michigan, Ann Arbor, Michigan.

We describe the development of a graduate level course designed to teach computational materials science and its application to nanoscale science and engineering. The aim of this course is to provide the student with an understanding of the strategies, methods, capabilities, and limitations of computer simulation as it pertains to the modeling and simulation of soft materials at the nanoscale. Students completing the course learn to (i) appreciate the role of computer simulation in modern research and development, and understand the relationship between theory, simulation and experiment; (ii) assess the relevance and quality of molecular and mesoscale simulation studies reported in the literature; (iii) judge which simulation models and methods are useful for describing processes and phenomena on different length and time scales; (iv) ascertain which, if any, simulation methods are relevant to their research, and if so, how to develop or find codes and how to use them; and (v) understand the workings and limitations of commercial molecular and mesoscale simulation software. Simulation methods are taught in the context of physical phenomena of soft matter, in particular as applied to current problems in nanoscience and engineering. In this way, students gain a deeper understanding of the behavior of soft materials and their potential application to nanotechnology. The course is taught in a state-of-the-art computational laboratory and students work in teams at Mac G4 workstations to carry out simulation labs during class. Results from simulation labs are contributed to MatDL, a new web-based digital materials library described elsewhere in this session.

3:15 PM *BB2.5
Educational Software for Materials Processing and Kinetics. Suzanne Mohney[1], Gary L. Gray[2], Andrew J. Miller[2] and Tom Yurick[2]; [1]Department of Materials Science and Engineering, The Pennsylvania State University, University Park, Pennsylvania; [2]Department of Engineering Science and Mechanics, The Pennsylvania State University, University Park, Pennsylvania.

We have developed and tested three programs that expose students to modeling in materials processing and kinetics. The first program allows students to solve two dimensional heat transfer and diffusion problems in MATLAB using the finite difference technique. Either steady-state or time-dependent problems can be solved. The program provides a graphical user interface for defining problems, as well as several ways to plot and visualize solutions. Second, we created an atomistic simulation of diffusion, from which students can generate data to discover, on their own, the outcome of many random walks. This program was developed using the software package Macromedia Director. The third computer-based learning tool we created allows students to observe the development of microstructure during the deposition of thin films. It relies on molecular dynamics simulations using Leonard-Jones interparticle potentials, and students access it through an interactive web page. Student response to all the programs has been documented, and the first two programs have been made available to instructors outside our university. We will describe the use and evaluation of the computer-based courseware, and information on how to obtain materials for use at other institutions will also be provided.

3:45 PM BB2.6
AtomLab: A tool for teaching materials science and simulation on the atomic scale. Michael L. Falk, Materials Science and Engineering, University of Michigan, Ann Arbor, Michigan.

AtomLab is new open-source software based on the MatLab platform that allows students and researchers to design and execute atomic scale simulation of materials systems ranging from metallic crystals to semiconductors and biomolecules. The strength of AtomLab is that the user can engage in simulation at a variety of levels of sophistication ranging from using the program as a black box to customizing every aspect of the simulation. Because the code is built on the MatLab platform it is easy to write and debug plug-in routines using the MatLab programming language. In addition higher level functions for data visualization and data processing are included in the MatLab package and can be easily applied to simulation output. This presentation will focus on use of AtomLab in an educational context to enhance learning on the graduate and undergraduate level.

4:00 PM *BB2.7
An Innovative Laboratory Facility for Undergraduate MSE Majors. R. Gibala and J. W. Jones; Materials Science & Engineering, University of Michigan, Ann Arbor, Michigan.

The Department of Materials Science and Engineering at the University of Michigan has recently developed 6000 sq. ft. of modern laboratory and computational space to serve a central role in undergraduate courses in the MSE curriculum. A full complement of hands-on experiments on most classes of materials (metals, ceramics, polymers, composites, electronic materials) is easily accommodated in junior-year MSE lab courses. Computational and experimental space is also available for use in other more traditional lecture-style courses and for group projects. The new space allows for more effective team-based activities, a more natural infusion of computation and modeling into lab experiments, a more complete use of computational facilities in all of the curriculum, and educational partnerships outside the curriculum. The program specifics and future plans will be presented.

4:30 PM BB2.8
A New MSE Curriculm. David Roylance, Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.

The MSE Department at MIT has developed a new undergraduate curriculum, and has implemented it for Sophomores in the 2003-2004 academic year. The Junior and Senior year curricula will be implemented as the current Sophomores advance. In addition to major core topic additions such as biomaterials and computational modeling, the new curriculum features a novel mixing of laboratory and lecture hours. This permits students to experience hands-on applications of materials in the laboratory immediately after covering the associated theory in lecture. The curriculum was developed in consultation with both students and our external community (Visiting Committee, ABET, alumni), and it required construction of substantial new laboratory facilities. It also required a novel approach to scheduling, in which some loss of flexibility was accepted to gain coherence and relevance of topics.

4:45 PM BB2.9
Goniometry of direct lattice vectors supporting student's comprehension of core concepts of geometrical-structural crystallography. Peter Moeck[1], Armando Acha[1], Krishnan

Padmanabhan[1], Mukes Kapilashrami[4,1], Wentao Qin[2] and Phillip B. Fraundorf[3]; [1]Department of Physics, Portland State University, Portland, Oregon; [2]PMCL/DDL/SPS, MD EL622, Motorola, Tempe, AZ 85284, Arizona; [3]Physics and Astronomy and Center for Molecular Electronics, University of Missouri, St. Louis, Missouri; [4]Department of Materials Science, The Royal Institute of Technology, Stockholm, Sweden.

A novel approach to quantitative crystallographic analyses of nano-crystals in a transmission electron microscope (TEM) [1], which is conceptually similar to the classic mineralogical crystallometry method, is described. We plan to develop this approach further into computer controlled nano-crystallography methods that will utilize the three degrees of freedom that a double-tilt rotation specimen holder provides for orienting crystals inside a TEM. As a first step towards this goal, software will be developed (and will become freely accessible from the project's web site [2]) that enables visualizing the operation of this goniometer in a quantitative manner. Both the stereographic and cyclographic projections will be employed for this purpose. Aided by simulations employing this software, core concepts of geometrical-structural crystallography could in the future be taught in materials science classes or acquired by the students individually at home without access to a TEM. Representations of cubic and hexagonal densest packings of identical diameter spheres and the corresponding optimal goniometer adjustment protocols in TEM that lead for these crystal models to the identification of their crystal lattice will be incorporated in this software. As the technique of convergent beam electron diffraction is no longer available for crystals in the size range of a few nanometers, one may consider crystallometry to have "come full circle" and use its basic concept in a modified form again not only in research, but also in the education of future nano-materials scientists. [1] W. Qin and P. Fraundorf, Ultramicroscopy 94 (2003) 245 [2] http://www.physics.pdx.edu/ pmoeck/goniometry.htm

SESSION BB3: Investing in the Future: K-12, undergrad research, and projects
Chair: Luz Martinez-Miranda
Wednesday Morning, April 14, 2004
Room 2022 (Moscone West)

8:30 AM *BB3.1
Science and Engineering Graduate Teaching Fellows in the Classroom: Connecting University Research and Resources to the K-12 Community. Donna Hammer, MRSEC, University of Maryland, College Park, Maryland.

University-based education outreach efforts in the areas of science and engineering are continuing to grow and be refined as their success stories rapidly increase. As we have learned, effective outreach to K-12 schools and the broader community requires extensive understanding of the K-12 educational system, making a long-term commitment to support and enhance the existing curriculum, training researchers, and meeting our own goals of integrating the excitement of new science and technology into the classroom. The University of Maryland (UMD) MRSEC Graduate Teaching Fellows Program is making strides to accomplish these objectives. This presentation will discuss the infrastructure of the UMD GK-12 Program. Emphasis will be placed on the importance of developing viable partnerships, integrating research-based concepts into the curriculum, and training research volunteers and Fellows to develop the necessary skills to take advantage of their research background and to refine their teaching and communication skills within the scope of education outreach.

9:00 AM BB3.2
Incorporating Biomaterials into the High School Curriculum: An Exothermic Reaction Ready to Happen. Deepa Srikantaiah, MRSEC, University of Maryland, College Park, Maryland.

Working as a GK-12 Fellow has given me an opportunity to work with public schools and homeschooling families on two levels: 1) to support K-12 learning as a resource to teachers and students, and 2) to share exciting research in science and engineering. In this presentation, I will discuss inquiry-based and hands-on biomaterials units for high school. Implemented at local high schools, the biomaterials lessons have been effective as a learning tool in the biotechnology units of the broader engineering curriculum or divided into single lessons in physics, chemistry, and biology classes. The lessons are also used as a biomaterials curriculum for our homeschooling science and engineering program. Sample topics include DNA Extraction, Tissue Engineering, Crystal Structures, and Bone Structures and Composites.

9:15 AM BB3.3
Impact study of the Implementation of Material Science and Engineering Modules at the Third through Fifth Grade Level. Souheil Zekri[1], LaNetra Clayton[2], Emily Ferguson[3], Geoffrey Okogbaa[4], Ashok Kumar[1,6], Tapas Das[5], Grisselle Centeno[5] and Louis Martin-Vega[7]; [1]Mechanical Engineering, University of South Florida, Tampa, Florida; [2]Chemistry, University of South Florida, Tampa, Florida; [3]Biology, University of South Florida, Tampa, Florida; [4]Institute on Black Life, University of South Florida, Tampa, Florida; [5]Industrial Engineering, University of South Florida, Tampa, Florida; [6]Nanomaterials and Nanomanufacturing Research Center, University of South Florida, Tampa, Florida; [7]College of Engineering, University of South Florida, Tampa.

An impact study of the implementation of newly developed material science and engineering modules is being conducted as part of an NSF GK-12 Fellows grant at the University of South Florida (USF). The USF/NSF STARS GK-12 project focuses on K-5 students, specifically, the 3-5 grade band. The objective is to engage graduate and senior level undergraduate students (or Fellows) in the challenge of infusing engineering and science principles in such cutting edge areas as nanotechnology, optics, and advanced manufacturing into the elementary school environment. The USF/GK-12 partnership involves five area elementary schools, two of which predominantly serve minority students, two in suburban schools, and a private school. The science curriculum in Hillsborough County, Florida is based on the State of Florida Sunshine State Standards for Science instruction. The State Standards are divided into seven major topics, one being named The Nature of Matter. The state adopted standards offer limited introductory information on the nature of materials and their differences based on objectives, also called benchmarks that are specific in content. Enhanced modules for materials science and engineering have been developed by the Fellows. The purpose of the enhancement modules is to create or heighten awareness in elementary school students (specifically, grades three through five) regarding the science of materials and engineering. As part of this activity, the students are introduced to modern developments in materials science and engineering through hands-on experiments, presentations, and field trips to the material research related laboratories at the university. The enhancement module offers information ranging from basic definitions to the wonders of newly developed materials and nanotechnology. A series of presentations prepared by the GK-12 Fellows, primarily involved with material science research, are offered to the participating schools. In addition, students also visit laboratories that conduct research in different material science and engineering fields such as microelectronics (i.e. clean room, metrology), Biomaterials, nanotechnology, geotechnics, corrosion, etc. The assessment part of the study will be in the form of formative and summative evaluations using questionnaires and other instruments to generate pre and post assessment data.

9:30 AM *BB3.4
Realistic roles for research scientists in k-12 education. Fiona Margaret Goodchild, California Nanosystems Institute, UCSB, Santa Barbara, California.

This presentation will discuss how scientists at university based institutions may interact with students and teachers in k-12 schools. The speaker will identify several different programs and partnerships that currently operate and will discuss the variety of roles that scientist may play as mentors, curriculum designers and collaborators with teachers. While scientists need to recognize the constraints that may limit their contribution, they can bring a distinctive approach to partnerships that cross between the boundaries of the campus and the community.

10:30 AM BB3.5
A Way to Get Students Interested in Materials Science: Research Presentations for the K-16 Group. Luz J. Martinez-Miranda, Materials Science and Eng., University of Maryland, College Park, Maryland.

The GK-12 program involves students doing a masters or a Ph. D. in science and engineering working with a science teacher to develop demonstrations and laboratories which will bring the excitement of science into the schools. They work for an entire semester with the same group in school. We expect that the teachers will be able to carry on these demonstrations after the GK-12 students have left. Another aspect we want to bring to the students is the excitement of doing research in the field, and that what they are learning may be helpful in doing this research. As part of their work, we ask the GK-12 participants to prepare a research presentation for their schools. They have to present it in language that the students will understand, and with the material that the students have learned. doing this, the students learn how to explain their research in much better terms and the K-12 students are exposed to real research and new approaches that nonetheless are based in the lessons they are learning. Similarly, for our undergraduate students, we want them to associate what they do in class, especially the laboratory class with the research they may be working in as part of a university, a laboratory or an industry. We have organized a series of presentations in the laboratory class that relates to what they are learning but ask them how they will apply this knowledge to the research at hand. They usually present in groups, so they are supposed to get together with their partners and look into the literature. This activity fulfills ABET's requirement that the students be able to present their work orally.

10:45 AM BB3.6
Models for Successful Undergraduate Research in Materials Science. Colin Inglefield and Adam Johnston; Department of Physics, Weber State University, Ogden, Utah.

Research has become a point of much greater emphasis in the undergraduate science experience in recent years. However, there is not universal agreement upon what constitutes a successful undergraduate research program. For instance, how should the scholarly value of the research be balanced and prioritized with the educational value for the undergraduate? A model for a successful program based principally on student ownership of projects will be discussed. This approach is an attempt to give undergraduate students the most holistic research experience possible, by involving them in all stages of a research project in a limited amount of time. Measures of success, both in terms of research goals and impact on students, will be presented. These will include an assessment of the educational value of the research experience for undergraduates, specifically in terms of their understanding of the nature of science, based on interviews with the students before and after their research experiences.

11:00 AM BB3.7
Incorporating Diverse Majors and Backgrounds in Materials Science Research Experience for Undergraduates (REU) Sites. David F. Bahr and M. Grant Norton; Mechanical and Materials Engineering, Washington State University, Pullman, Washington.

Since 1999 we have had a National Science Foundation REU site at Washington State University. The focus of the research activities of our REU site is "Characterization of Advanced Materials". To date we have had almost 60 undergraduate participants from 21 different schools/colleges, from 15 different states, and in 9 different majors. The majority of the students have not been materials science and engineering majors. Each year we include several freshmen and sophomores in our program, as it is during these formative years that students are statistically most likely to leave an engineering or science discipline. We will demonstrate that the REU is a successful method of involving these students in research, and greatly improves retention in science and engineering. The initial target population for our REU program was primarily students from schools in the Pacific Northwest and Rocky Mountain states that do not have access to the modern instrumentation that is needed for materials research. Over the five years of our program the number and popularity of REU programs has increased nationally and we have attracted students from throughout the United States. In this presentation we will discuss how we run our REU site and the type of projects that the students are involved in, particularly through presentations of example projects for freshmen and sophomores. Our meters for success include our ability to attract students from underrepresented groups in science and engineering (50% women), the percentage of participants that go on to graduate school (approaching 90%), and the number of publications and student presentations resulting from REU projects.

11:15 AM BB3.8
Nanotechnology Summer Undergraduate Research Intern Program: Comprehensive Introduction to Life as a Researcher. Michael R. Melloch and Joanne Lax; School of Electrical and Computer Engineering, Purdue University, West Lafayette, Indiana.

We have implemented a summer undergraduate research intern (SURI) program whose purpose is to give the undergraduates as real a picture as possible of what it is like to be a research scientist and what will be encountered in graduate school. Our first SURI class, summer of 2003, consisted of a diverse group of 18 students from 9 different universities. Each student joined an ongoing cross-disciplinary research project team comprised of faculty and graduate students who have been working on research projects throughout the year. Coordinated with the students' research project was a technical writing/presentation course. The first task for the students was to write a literature review for their research project. The culmination of the students' research and the technical writing/presentation course was a one-day conference at the end of their program where all the SURIs presented the results of their summer research. The SURIs wrote abstracts for their conference presentation just as is done for consideration for presentation at a professional conference. The SURIs' abstracts and powerpoint presentations are "published" on our center's website. This posting of the abstracts and powerpoint presentations on a web site simulated the issues involved with submitting work for publication. In order for the SURIs to experience the environment of an actual scientific meeting before their end-of-summer conference, we held a two-day workshop on "Molecular Conduction" at which we had 100 attendees from industry, academia, and government agencies. The day before the Molecular Conduction Workshop we held a series of tutorials to prepare the SURIs for the presentations and discussions that occurred at the workshop. Throughout the summer we also held a series of professional development seminars/discussion sessions for the SURIs on topics such as scientific ethics, teamwork, project planning, and how to choose and apply to graduate schools. Every week one of the faculty members in our nanotechnology center presented a seminar on their research. This exposed the SURIs to a wide variety of research programs on nanotechnology and the typical seminar environment encountered at research institutions. This program was very intense, but in the end-of-program survey the SURIs were unanimous in strongly agreeing they were glad they chose to participate. Our SURI program is supported by NASA under award no. NCC 2-1363 and by NSF under award no. EEC-0228390.

11:30 AM BB3.9
Shape Memory Alloys for Classroom Demonstrations, Laboratories, and Student Projects. Katherine C. Chen[1], Wendy C. Crone[2] and Eric J. Voss[3]; [1]Materials Engineering, California Polytechnic State University, San Luis Obispo, California; [2]Engineering Physics, University of Wisconsin, Madison, Wisconsin; [3]Chemistry, Southern Illinois University, Edwardsville, Illinois.

Shape memory alloys (SMAs) are unique materials that effectively capture the attention of students due to their dramatic phase transformations. The transition between the austenite and martensite phase is activated by temperature or stress, and is utilized in a wide variety of biomedical, aerospace, automotive and other applications. SMAs can also be incorporated into a variety of courses under topics such as phase transformations, kinetics, constitutive relations, and smart materials. In addition, the concepts can be presented at different levels of knowledge, appropriate to the learning objectives of the particular audience. Several different activities using NiTi shape memory alloys are to be presented. An apparatus has been created for classroom demonstrations that uses NiTi wire and an overhead projector to illustrate the actuation abilities of SMAs. Next, an innovative experiment assists the visualization of the latent heat of transformation during loading by using a liquid crystal paint. Another laboratory exercise involves the use of phase diagrams and time-temperature-transformation (TTT) diagrams to develop the appropriate heat treatments to change NiTi wire from superelastic into shape memory behavior. Differential scanning calorimetry (DSC) and tensile tests are utilized to characterize the materials. Lastly, an activity that uses an inexpensive training jig allows students to shape set a piece of NiTi wire into any desired shape. Students have employed their ability to shape set NiTi wire to create a student-run project and fundraiser. The multiple educational aspects of the shape memory alloy activities will be discussed.

11:45 AM BB3.10
An Unconventional Leaning Strategy - Innovative Design Competition using High Temperature Superconductor for Magnetic Levitation. In-Gann Chen[1], M. D. Shieh[2], Jun-Fu Huang[3], Hong-Yi Tang[4], Ching-Wei Tang[5] and Maw-Kuen Wu[6]; [1]Materials Science and Engineering, National Cheng Kung Unicersity, Tainan, Taiwan; [2]Industrial Design, National Cheng-Kung Univ., Tainan, Taiwan; [3]National Science and Technology Museum, Kaohsiung, Taiwan; [4]Applied Chemistry, National Chi-Nan Univ., Puli, Taiwan; [5]Science Education, National Science Council, Taipei, Taiwan; [6]Institute of Physics, Academia Sinica, Taipei, Taiwan.

We have conducted an experiment since 2000 to implement a new learning strategy on high school students (10-12 grades) with the title of Innovative Design Competition using High Temperature Superconductor for Magnetic Levitation. We use the unique levitation/suspension phenomenon of superconductor/permanent magnet (which were shown in public media frequently) to inspire interested students to form teams to explore potential applications of HTS with innovative ideals. In order to implement this experiment, we have: 1. Offer a free training workshop on HTS materials and creative thinking to interested students. Prof. M.K. Wu, one of the inventors of the HTS in 1987 together with Prof. Paul C.W. Chu, closely watched this program with frequent encouragement to the students. 2. Create and manage a web-site (www.HiTcWorld.org) which provides fundamental information of superconductors, discussion area, and updated news of the competition. 3. Provide high flux trapping HTS materials (i.e. top-seeded melt-textured Y-Ba-Cu-O materials, which are not available in market and were made in our lab.) and Nb-B-Fe permanent magnet to the finalist that allow them to finish their demonstration model. 4. Form a group of interested faculties from physics, chemistry, and materials science department over different demographic area of Taiwan. These faculties offer consultation and

access to liquid nitrogen to participated students. We have attracted over thousand of students each year to involve in this competition with enthusiastic returns. We believe that this unconventional learning experience will not only attract more students to major in materials science related program but also inspire their creativity in leaning and group-work skills. Supported by NSC-91-2511-S-006-007-X3, TAIWAN
a Corresponding author. E-mail address: ingann@mail.ncku.edu.tw

SESSION BB4: Innovating the Curriculum
Chairs: Katherine Chen and Luz Martinez-Miranda
Wednesday Afternoon, April 14, 2004
Room 2022 (Moscone West)

1:30 PM *BB4.1
New Laboratory Curriculum for Undergraduate Materials Chemistry. Scott R. J. Oliver, Department of Chemistry, SUNY at Binghamton, Binghamton, New York.

As materials chemistry continues to rapidly expand, the undergraduate experience requires much development in order to expose students to this technologically important area. This presentation will focus on a set of experiments created for the senior undergraduate laboratory course in inorganic and materials chemistry at SUNY-Binghamton (http://chemistry.binghamton.edu/OLIVER/Chem445). The first is based on the synthesis and characterization of ZSM-5, an open-framework zeolite, which the students calcine and convert to the acid catalyst form. In addition to powder X-ray diffraction and carrying out a catalytic isomerization, the students use the equipment in the laboratory of the presenter, namely TGA-MS and physisorption/chemisorption analysis. These methods confirm the microporosity, stability and catalytic activity of the zeolite that the students have prepared. The same set of equipment can be used for our WO3 intercalation experiment. Finally, a module developed for our polymer synthesis experiment will be described, where the students synthesize a high molecular weight polymer and test its mechanical properties, as revealed through stress-strain curves.

2:00 PM BB4.2
A General Education Course on Materials. Grant Norton and David Bahr; School of Mechanical and Materials Engineering, Washington State University, Pullman, Washington.

The importance of increasing the knowledge and awareness of all students, as citizens in a society increasingly dependent upon science and technology, to areas of science and engineering is of paramount importance. For more than two decades materials science has been highlighted by federal agencies such as the National Science Foundation as one of the key areas for support in both research and education. To increase the awareness of materials among the general student population at Washington State University we developed a new course, MSE 440 Materials: The Foundations of Society and Technology. This course is taught as a Tier III course in the General Education Program and to date almost 100 students from majors as different as construction management, history, communications, and entrepreneurship have successfully completed the course. In this presentation we will describe why we developed the course, how we teach it, student response, and our plans for the future. Our future plans include completion of a textbook for the course and the development of instructor materials that will enable other institutions to adopt and implement similar courses.

2:15 PM BB4.3
Implementation of Paul Revere: Tough as Nails, an Integrated Project-Based Course on Materials Science and History of Technology. Jonathan Stolk and Robert Martello; Franklin W. Olin College of Engineering, Needham, Massachusetts.

Olin College sophomores participate in integrated course blocks that merge technical content with business, arts, humanities, and social sciences, allowing students to work on engineering projects that have broader implications than the purely technical. In this paper, we present $PaulRevere : ToughasNails$, a multidisciplinary course block that combines an introductory materials science course with a history of technology course and a large scale project. In $PaulRevere : ToughasNails$, students explore connections between historical and technological materials science developments through an examination of Paul Revere's metallurgical work. Student teams examine alloy systems and fabrication techniques familiar to Paul Revere, they design experiments to answer a historical question of importance to Revere and to shed light on materials processing-microstructure-property relationships, and they investigate the political, social, economic, and environmental elements that contributed to Revere's decisions. Although centered on Revere's metallurgical work, the $PaulRevere : ToughasNails$ course block also includes smaller hands-on projects that provide experiences in modern laboratory techniques, application of historical research skills, and an opportunity to explore a contemporary materials science topic of technological and historical significance through a self-designed program of research, experimentation, and analysis of the relevant social, environmental, political, and economic aspects of the topic. Throughout the semester, student teams learn fundamental principles of materials science and historical analysis, synthesize and apply multidisciplinary content in a project setting, design experiments, practice contextual thinking, and develop their communication skills through writing assignments, presentations, and student-directed classroom discussions. The explicit, strong linkages among technical, non-technical, and hands-on aspects of the course improve learning of traditional topics, help drive interdisciplinary thinking, and lead to a high level of student satisfaction and motivation throughout the semester.

2:30 PM BB4.4
Teaching Corporate Culture: An Engineer's Survival Guide. Richard Savage, Materials Engineering, Cal Poly State University, San Luis Obispo, California.

The transition from new engineering graduate to successful member of corporate America is a difficult journey. Often the skills required are not part of a student's traditional undergraduate education. At Cal Poly, we have integrated a new course into our existing Senior Project curriculum which enables students to develop the professional skills necessary to become an effective member of any corporation. Key skills such as communication, problem solving and project management are practiced through active learning techniques. These as well as other topics studied are required for ABET certification. The new course investigates the mission and values that are at the foundation of any corporation's culture. It challenges students to evaluate their own personal leadership potential. Organization structures along with the roles and responsibilities of Engineering, Marketing, Sales, Operations, Finance and Executive management are studied along with the interdisciplinary nature of engineering and technology. The rigors and metrics of a typical product development methodology are explored along with the concepts of program management and the protection of intellectual property. Business models are studied which enable the students to evaluate the impact of engineering on a company's financial success. Moreover, the students learn that they are members of a global community with environmental and social responsibilities. The impact of technology on society can be profound and students are challenged to consider difficult ethical issues as well as exciting opportunities.

2:45 PM *BB4.5
Curricula For A Sustainable Future: A proposal for integrating environmental concepts into our curricula. Linda Vanasupa[1] and Frank G. Splitt[2]; [1]Materials Engineering, California Polytechnic State University, San Luis Obispo, California; [2]Northwestern University, Evanston, Illinois.

The global scientific community recognizes the critical need for industries to develop and practice manufacturing techniques that minimize harm to our environment. In the National Science Board's report Environmental Science and Engineering for the 21st Century, the National Science Foundation was urged to promote "Environmental research, education, and scientific assessment [as] one of NSF's higher priorities." Although there are a number of independent efforts to fold environmental issues in existing undergraduate curricula, no dominant paradigm has emerged as a means of including these concepts. One of the difficulties in adjusting our materials science and engineering (MSE) curricula is the problem of how and what to include in an already full curriculum. In this paper, we propose a path for integrating environmental and sustainability concepts within the framework of the performance-structure-processing-properties paradigm. We will suggest learning outcomes for each year of the MSE curriculum and offer examples.

3:30 PM BB4.6
An Approach to the Teaching of Functional Materials for Materials Science and Engineering Undergraduate Courses. Trevor Roy Finlayson and Barry Charles Muddle; School of Physics and Materials Engineering, Monash University, Clayton, Victoria, Australia.

Traditional materials science and engineering texts have, for the most part, focussed on instructing the undergraduate student on the physical properties of materials and providing a significant knowledge base from which, subsequently, to consider materials applications. With the increasing demand for professional materials scientists and engineers to embrace all classes of materials, in their everyday applications, it is increasingly important for undergraduate teaching to increase the awareness of students to applications through a focus

on functionality rather than just providing a thorough knowledge and understanding of material properties. This has become even more important in the area of "nanostructured" materials where functional devices are designed at the material fabrication stage. In this paper, recent experiences in the teaching of functional materials for electronic, thermal and transducer applications, to a second level undergraduate student group, comprising both "science" and "engineering" students will be outlined and some initial outcomes from the assessment of the group discussed.

3:45 PM ***BB4.7**
A Look at the Senior Design Project in Materials Science and Engineering Curricula. Emily L Allen, Chemical and Materials Engineering, San Jose State University, San Jose, California.

ABET 2000 requires accredited undergraduate programs to have a "curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints." In the disciplines of Materials Science and Engineering, which sit on the cusp of engineering and science, the line between research and design projects is not always clearly delineated. A look at how some U.S. programs handle their senior design courses will be presented. Early results indicate that in the programs surveyed, there is a mixture of team projects and individual projects, research and design projects, industry-based and faculty-driven projects. This examination may be used initiate a conversation as to whether there is or ought to be any commonality to senior design projects in the field.

4:15 PM
PANEL DISCUSSION ON MS&E EDUCATION