The Thirty-Forth Annual Ross Tucker Award Recipients

David G. Garmire
Department of Electrical Engineering and Computer Sciences, University of California, Berkeley
Thesis Advisor:
Department of Materials Science and Engineering, Stanford University
Thesis Advisor:

The Tenth Annual EMS Undergraduate Award
San Jose State University  Stanford University

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The organizing committee would like to thank Greg Brown for webmastering.

The 36th Annual
ELECTRONIC MATERIALS SYMPOSIUM
A One-Day Symposium on Electronic Materials
Featuring Authorities Outstanding in their Fields

Network Meeting Center at Techmart
5201 Great America Parkway
Santa Clara, California
Friday, April 11, 2008
**PROGRAM**
Friday, April 11, 2007
Network Meeting Center at Techmart, Santa Clara

8:00  Registration

**MORNING SESSION**

**Session Chair:** Prof. Todd Weatherford
Naval Postgraduate School

8:30  Welcome Remarks and Introduction
Prof. Gamani Karunasiri, Naval Postgraduate School

8:40  "The Spin on Electronics!",
Dr. Stuart Parkin, IBM Fellow

9:25  "Imaging Charge Transport",
Prof. Nancy Haegel, Naval Postgraduate School

10:10 REFRESHMENTS (Vendor Exhibit Area)

10:40  "Concentrator Multi-junction Solar Cells",
Dr. Nasser H. Karam, VP., Spectrolab

11:25  "Materials Challenges for the IC Industry",
Dr. Paul Besser, AMD Fellow

12:10 LUNCHEON

1:10  Luncheon presentation: "Materials Science in Music"
Prof. Ronald Gronsky, U. C. Berkeley

**AFTERNOON SESSION**

**Session Chair:** Dr. Zhen Guo
Intel

1:55  "New Materials for Energy Conversion",
Dr. Jeffrey Urban, Lawrence Berkeley National Laboratory

2:40  34th Annual Ross Tucker Award
10th Annual EMS Undergraduate Scholarship

3:00  REFRESHMENTS (Vendor Exhibit Area)

3:30  "Surface Engineering of MEMS",
Prof. Roya Maboudian, U. C. Berkeley

4:15  "Energy Nanowire Materials",
Prof. Yi Cui, Stanford University

5:00  Closing remarks, Prof. Junqiao Wu,
U.C. Berkeley

5:10  HOSTED COCKTAIL PARTY

**VENDOR’S SHOW**

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**ELECTRONIC MATERIALS SYMPOSIUM**

**LIST OF VENDOR PARTICIPANTS**

We would like to give special thanks to this year’s vendors who provided the opportunity for many undergraduates to attend this conference through registration scholarships. Please take the time to stop by and visit the vendors’ booths during the breaks and cocktail party.

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**About the Cover:**
Transport image showing diffusion of minority carriers in a GaAs heterostructure. The motion of charge from the generation point is monitored by the light from its recombination.

* Cover image used with permission from Prof. Nancy Haegel from Naval Postgraduate School

**General Information:** The registration covers admission to the symposium sessions, abstracts of the symposium presentations, luncheon, a vendor’s exhibit, and a hosted cocktail hour following the symposium. The Electronic Materials Symposium Committee exists to promote the understanding of electronic materials within the industrial and academic communities of the San Francisco Bay area. This committee organizes the annual Electronic Materials Symposium, featuring presentations on advanced electronic, magnetic and optical materials processing, characterization and devices by outstanding speakers who have made significant contributions to their fields. Proceeds of the symposium are used to support electronic materials research and education in local universities.
The Spin on Electronics!

Dr. Stuart Parkin
IBM

Today, nearly all microelectronic devices are based on storing or flowing the electron’s charge. The electron also possesses a quantum mechanical property termed “spin” that gives rise to magnetism. Electrical current is comprised of “spin-up” and “spin-down” electrons, which behave as largely independent spin currents. The flow of these spin currents can be controlled in thin-film structures composed of atomically thin layers of conducting magnetic materials separated by non-magnetic conducting or insulating layers. The resistance of such devices, so-called spin-valves and magnetic tunneling junctions, respectively, can be varied by controlling the relative magnetic orientation of the magnetic layers, giving rise to magnetoresistance tailored for different applications. Recent advances in generating, manipulating and detecting spin-polarized electrons and electrical current make possible new classes of spin based sensor, memory and logic devices, generally referred to as the field of spintronics. In particular, the spin-valve is a key component of all magnetic hard-drisk drives manufactured today and enabled their nearly 1,000-fold increase in capacity over the past eight years. The magnetic tunnel junction allows for a novel, high performance random access memory which maintains its memory in the absence of electrical power. The respective strengths of these two major classes of digital data storage devices, namely the very low cost of disk drives and the high performance and reliability of solid state memories, may be combined in the future into a single spintronic memory. The Racetrack is a novel three dimensional technology developed at IBM, which uses nanosecond long pulses of spin-polarized current to move a series of magnetic domain walls along magnetic nanowires.

Energy Nanowire Materials: Batteries and Solar Cells

Prof. Yi Cui
Stanford University

Inorganic nanowires can support electron and photon transport along the length to a macroscopic distance while maintaining a large surface-to-volume ratio and facile strain relaxation without breaking during structure transformation. These properties are attractive for batteries and solar cells.

Dr. Stuart Parkin is an IBM Fellow and Manager of the Magnetoelectronics group at the IBM Almaden Research Center, San Jose, California and a consulting professor in the Department of Applied Physics at Stanford University. He is also director of the IBM–Stanford Spintronic Science and Applications Center, which was formed in 2004. He received his BA and PhD degrees from the University of Cambridge and joined IBM as a postdoctoral fellow in 1982, becoming a permanent member of the staff the following year. In 1999 he was named an IBM Fellow, IBM’s highest technical honor. Parkin’s research interests have included organic superconductors, high-temperature superconductors, and, for almost the past two decades, magnetic thin film structures and spintronic materials and devices for advanced sensor, memory, and logic applications. He is a Fellow of the Royal Society, the American Physical Society, the Institute of Physics (London), the Institute of Electrical and Electronics Engineers, the American Association for the Advancement of Science and the Materials Research Society. Parkin is the recipient of numerous honors, including the 2008 IEEE Daniel E. Noble Award, a Humboldt Research Award (2004), the 1999-2000 American Institute of Physics Prize for Industrial Applications of Physics, the European Physical Society’s Hewlett-Packard Eurfys袍sics Prize (1997), the American Physical Society’s International New Materials Prize (1994), the MRS Outstanding Young Investigator Award (1991) and the Charles Vernon Boys Prize from the Institute of Physics, London (1991). In 2001, he was named R&D Magazine’s first Innovator of the Year and in October 2007 was awarded the Economist Magazine’s “No Boundaries” Award for Innovation. In 2007 Parkin was named a Distinguished Visiting Professor at the National University of Singapore, a Visiting Chair Professor at the National Taiwan University, an Honorary Visiting Professor at University College London, The United Kingdom, and a Distinguished Research Chair Professor, National Yang Ming University of Science and Technology, Doulous, Taiwan. Parkin received an Honorary Doctorate from the University of Aachen, Germany in 2007 and will receive a second one from the Eindhoven University of Technology, The Netherlands in April 2008. Parkin has authored ~360 papers and has ~70 issued patents. Parkin can be reached at the IBM Almaden Research Center, 650 Harry Road, San Jose, CA 95128-6099, USA; phone: 408-927-2390; and e-mail: parkin@almaden.ibm.com.

Energy Nanowire Materials: Batteries and Solar Cells

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Inorganic nanowires can support electron and photon transport along the length to a macroscopic distance while maintaining a large surface-to-volume ratio and facile strain relaxation without breaking during structure transformation. These properties are attractive for batteries and solar cells.

Rechargeable batteries have been attractive for applications such as portable electronics, medical devices and electrical vehicles. My group has been exploring the nanowires of materials with displacement or alloying reactions with Li ions as Li-ion battery electrodes, which can provide much higher energy density than the intercalation materials although they can not be successfully used in the form of the bulk or particle due to large structure transformation and/or poor electrical conductivity. For battery anodes, Si nanowires directly grown on metal collector substrates have been shown to have a capacity more than 10 times higher than the carbon anode used in the existing technology. The Si nanowire electrodes have been shown to overcome the issues of 400% volume change during Li insertion and extraction, which cause pulverization and capacity fading in bulk Si electrodes.

I-III-VI semiconductors such as CuIn(Ca)Se₂ (CIGS) have been actively studied for solar cell applications, which has resulted in highest power efficiency close to 20% in polycrystalline thin film solar cells.

However, the materials property of CIGS is not well understood. Nanowires of CIGS provide well-defined nanodomains for studying the fundamental structure and property correlation. Here I will show our recent findings with nanowires, which provides better understanding towards improvement of CIGS solar cells.

Professor Yi Cui went to University of Science and Technology of China, where he received a Bachelor’s degree in Chemistry in 1998. He attended graduate school from 1998 to 2002 at Harvard University, where he worked under supervision of Professor Charles M. Lieber. His Ph.D thesis concerned semiconductor nanowires for nanotechnology including synthesis, nanoelectronics and nanosensor applications. After that, he went on to work as a Miller Postdoctoral Fellow with Professor Paul Alivisatos at University of California, Berkeley and Ernest Orlando Lawrence Berkeley National Laboratory. His postdoctoral work was mainly on electronics and assembly using colloidal nanocrystals. In 2005, he joined the faculty in Department of Materials Science and Engineering at Stanford University. His current research is focused on nanomaterials synthesis, electronic properties, solar cells, battery, memory and sensor devices. He has received MDA Innovators Award (2007), Terman Fellowship (2005), the Technology Review World Top Young Innovator Award (2004), Miller Research Fellowship (2003), Distinguished Graduate Student Award in Nanotechnology (Foresight Institute, 2002), Gold Medal of Graduate Student Award (Material Research Society, 2001).
Imaging Transport: Monitoring the Motion of Charge through the Detection of Light

Prof. Nancy Haegel
Naval Postgraduate School

The ability to rapidly image phenomena at an appropriate scale of resolution often provides transformational insight into our understanding of the world. This has been true when the phenomena of interest are relatively distant (e.g., the telescope in astronomy), relatively small (e.g., scanning and transmission electron microscopes) or otherwise invisible to the human eye (e.g., infrared imaging for night vision). The ability to see what otherwise could only be assumed or inferred often challenges idealized assumptions or leads to the discovery of new phenomena.

In this talk, a technique to “image transport” by monitoring the motion of charge via the recombination emission of light will be described. Transport imaging combines the potential resolution of near field optics with the charge generation control of a scanning electron microscope (SEM). Although the technique builds upon standard cathodoluminescence, it is significantly different, since it maintains the spatial information of the emitted light. This allows for a direct spatially resolved measure of minority carrier diffusion length, mobility-lifetime products under applied fields or contact resistance - important parameters that are often difficult to measure directly on individual devices.

Results will be presented illustrating minority carrier drift behavior in heavily doped heterostructures, single-shot contact-free measurements of minority carrier diffusion in solar cell materials, observation of anisotropic diffusion in ordered ternary alloys and localized mapping of the transport effects of radiative damage.

This approach can also be used for highly resolved spatial mapping of local field variations. In many ways, the technique is an optical Haynes-Shockley experiment, but with the high spatial resolution and flexibility provided by e-beam generation to match the needs of today’s materials and devices.

For spatial imaging beyond the diffraction limit, a near field scanning optical microscope (NSOM) has also been introduced for transport imaging of nanostructures. On-going work to extend transport imaging to 50 to 100 nm resolution for the measurement of carrier diffusion and drift in nanostructures will be described.

Nancy M. Haegel is a Professor of Physics at the Naval Postgraduate School in Monterey, CA. She received her BS degree in Metallurgical Engineering and Materials Science from the University of Notre Dame and a PhD in Materials Science from the University of California, Berkeley. She was a post-doctoral scientist at Siemens Research Laboratories in Erlangen, Germany before joining the faculty in the Department of Materials Science and Engineering at UCLA in 1987. Prior to her appointment at NPS, Dr. Haegel was Professor of Physics at Fairfield University in Fairfield, Connecticut. She was awarded the 2004 American Physical Society Prize to a Faculty Member for Research in an Undergraduate Institution for her work at Fairfield. She is currently a member of the Board of Trustees of the University of Notre Dame and a member of the APS Committee on the Status of Women in Physics. She is the author of ~95 publications. Her research interests are in imaging transport, transport in high resistivity materials, far-infrared detectors and the characterization of new materials. In younger days, she was a recipient of the Ross Tucker Award, awarded at the EMS Symposium.

Surface Engineering of MEMS

Prof. Roya Maboudian
U. C. Berkeley

Given the large surface area-to-volume ratios of many micro-nanoelectromechanical systems, interfacial forces dominate over gravity and other body forces. As a consequence, adhesion, friction, and wear are prevalent problems in many M/NEMS devices. Viewed differently, MEMS technology provides us with an opportunity to study tribology in the mesoscopic length scale.

This presentation will discuss the use of several microinstruments in conjunction with various surface characterization techniques to gain insights into the origin of these interactions, and to manipulate them by utilizing various surface modifications.

Professor Roya Maboudian is a professor of chemical engineering, and associate director of the Center of Integrated Nanomechanical Systems (COINS) at the University of California, Berkeley. She received her B.S. degree in Electrical Engineering from the Catholic University of America, Washington, DC, and her M.S. and Ph.D. degrees in Applied Physics from the California Institute of Technology. Prof. Maboudian's research interest is in the surface and materials engineering of micro/nanosystems. She and her group have investigated the tribological issues in micro/nanoelectromechanical systems and designed surface processes to reduce adhesion and friction in MEMS. In addition, they have developed novel schemes to integrate SiC and diamond-like carbon films into MEMS technology. More recently, they have been exploring methods to selectively grow a variety of nano-structures and integrating them with other micro/nanocomponents. Prof. Maboudian has authored and co-authored over 120 peer-reviewed scientific papers. She is the recipient of several awards, including the Presidential Early Career Award for Scientists and Engineers from the White House, the DOE Defense Program Early Career Award for Scientists and Engineers, NSF Young Investigator award, and the Beckman Young Investigator award.
**Single Molecules as Electronic Components?**

*Dr. Jeffrey Urban*

*Lawrence Berkeley National Laboratory*

The ability to synthesize nanoscale inorganic solids of desired size, shape, and chemical composition provides a rich family of building blocks for the assembly of new solid thin films and devices.

Furthermore, the formation of composites integrating quantum dots into a continuous phase of bulk semiconductor or polymer can provide another route toward engineering desired electronic and/or thermal properties.

The bulk of this talk will focus on the electronic and thermal properties of thin-film quantum dot solids, quantum dot/semiconductor composites, and quantum dot/polymer phases. Complementing these experimental paths is a related effort to gain more insight into the fundamental mechanisms of charge dynamics in strongly confined systems.

These processes of charge separation and transport in strongly confined systems are essential to energy conversion technologies yet incompletely understood. Here I will present our initial efforts into using theoretical tools to carefully investigate charge dynamics in test systems in inorganic nanostructures.

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**Challenges and Opportunities in Concentrator Multijunction Solar cell Development for Low-cost Energy Generation**

*Dr. Nasser. Karam*

*Spectrolab*

- Solar cell efficiency and its impact on terrestrial energy cost
- Challenges to achieving high efficiency Multijunction solar cells
- Pathways for high efficiency Multijunction solar cells
- Opportunities for higher efficiency solar cells
- Snap shot on Current status on concentrating solar cell production

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**Dr. Jeffrey Urban** is a Staff Scientist at Lawrence Berkeley National Laboratory working at the Molecular Foundry. His specific research focus is on the development, characterization, and measurement of new materials for energy conversion and their incorporation into test devices. His most recent work has been in the area of thermoelectrics materials development and characterization, having developed novel binary nanocrystal assemblies exhibiting synergistic enhancements in the electrical conductivity which simultaneously possess very low thermal conductivity. Dr. Urban received his PhD in Physical Chemistry in 2004 from Harvard University working with Professor Hongkun Park. He then carried out postdoctoral studies with Professor Christopher Murray at the University of Pennsylvania and the IBM T.J. Watson Research Center.

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**Dr. Nasser H. Karam** is Vice President of Advanced Technology Products and is responsible for Boeing - Spectrolab’s internally and externally funded Research and Development. He has over twenty years experience in the field semiconductor materials research, photovoltaic and Optoelectronic devices. He received the B.S. degree in Materials Engineering from The American University in Cairo in 1980, and Ph.D. degree in Materials Engineering from North Carolina State University in 1984. He is actively involved in the development of advanced Space solar cells for satellites, as well as terrestrial concentrating solar cells, and other Optoelectronic devices. In 2001-2002, Dr. Karam and his Advanced Technology Products Team won the “R&D 100” and the “Scientific American 50” awards for contributions in the field of terrestrial energy generation and demonstration of concentrating terrestrial photovoltaic cell with 34% efficiency. Recently Dr. Karam’s group at Spectrolab demonstrated the world record of 40.7% efficient terrestrial solar cell under concentration; the team has been recognized with “R&D 100” award for this accomplishment in 2007. Dr. Karam is a five-time winner of the Hughes and Boeing Technical Excellence awards and a recipient of the Hughes Electronics Chairman’s Award. In 2004 Dr. Karam was inducted in the Space Technology Hall of Fame along with colleagues from Boeing-Spectrolab, and the Air Force for their contributions to the development of Multijunction Space solar cells. Spectrolab is in production with the most efficient solar cell in the world at an average efficiency of 28.3% AM0 and expects to introduce a 30% average AM0 efficiency cell in 2007. Dr. Karam has over one hundred and fifty publications and holds ten patents in the fields of compound semiconductor materials and devices research.
Materials Challenges for the IC Industry

Dr. Paul Besser
AMD

The highest performing microprocessors require the most advanced technologies. Improving performance is much more than just shrinking the dimensions: it requires novel materials innovations. In this presentation, the novel materials innovations necessary to enhance performance, improve reliability and enable technology scaling will be highlighted. The challenges with implementing materials innovations are tremendous and advanced planning and coordination are required between the research, development, manufacturing and design community to guarantee that these innovations can be inserted into the process technology, product designs and manufacturing process seamlessly, reliably, with high yield and low cost. This talk will explore whether novel materials innovations such as rare earth silicides, copper metallurgy, ultra-low-K dielectrics, metal gates and high K gate dielectrics provide performance enhancement, improve reliability or enable technology scaling.

Materials in Music

Prof. Ronald Gronsky,
U. C. Berkeley

The design, selection, synthesis, processing, evaluation, replacement, remediation and repair of materials used in engineering applications has traditionally been the mission of the discipline known as materials science and engineering, with a goal to meet or exceed all performance specifications. In this pre-entation, the protocols of materials science & engineering are applied to musical instruments. Based upon accepted performance criteria firmly rooted in acoustics, the role of the internal structure is examined and compared to distinguish tonal response across the normal range of the human auditory recept-ion. Examples are drawn from popular musical artists, several instruments in the woodwind, brass, and string families, and results obtained during experiments performed by over three dozen Berkeley under-graduate students.

Dr. Paul Besser is an AMD Fellow in the Technology Research Group at Advanced Micro Devices, Inc. in Sunnyvale, CA. Paul graduated with honors from North Carolina State University (1988) and earned his M.S. (1990) and Ph. D. (1993) from Stanford University in Materials Science and Engineering. Since joining AMD in 1993, Paul has researched materials issues and their influence on product performance, yield and reliability. He has developed metallization stacks for Al interconnects, developed advanced silicides, correlated metal microstructure to reliability and measured stress and stress migration in Al and Cu interconnects. Paul researched silicides at IMEC (Belgium, 1997), developed technology in the AMD-Motorola Alliance (Austin, 1999-2001), developed a stress migration methodology for AMD (Germany, 2004) and researched silicides and contact metallurgy at IBM’s TJ Watson Research Facility (Yorktown, 2006). Paul holds >150 U.S. patents and has co-authored >75 research publications. Paul is a member of the MS&E Advisory Board at Stanford University and on the Scientific Advisory Board at Intermolecular, Inc. He is currently researching contact metallurgy, Cu capping materials and stress effects in ultra-fine Cu interconnects fabricated in low K dielectrics.

Professor Ron Gronsky received his BS in Metallurgical Engineering from the University of Pittsburgh in 1972 (Magna Cum Laude), and his MS and PhD in Engineering from the University of California, Berkeley, in 1974 and 1977, respectively.

Following a two-year post-doctoral appointment, he was named Principal Investigator in charge of the Atomic Resolution Microscope project and the establishment of the National Center for Electron Microscopy within the Lawrence Berkeley National Laboratory. He ran several programs at the Lab, entering senior management in 1988 as Deputy Associate Laboratory Director for Energy Sciences, overseeing four Laboratory Divisions. In the same year he accepted full-time appointment to the faculty of the Department of Materials Science and Mineral Engineering on campus, soon relinquishing his management position at the Lab to become Chair of the Department of Materials Science and Mineral Engineering from 1990 through 1996. He later served several years as Chair of the faculty of the College of Engineering, and a full term as Chair of the Berkeley Division of the Academic Senate. He is a recipient of the Robert Lansing Hardy Gold Medal from TMS, the Burton Medal from the Electron Microscopy Society of America, and the Bradley Stoughton Award from ASM. In 1983, he was named one of “America's 100 Brightest Scientists Under 40” by Science Digest Magazine. In 1992 he was elected a Fellow of ASM, International, and in 1995, a “Distinguished Alumnus” of the University of Pittsburgh. In 2001 he was awarded Berkeley’s coveted Distinguished Teaching Award.

Dr. Gronsky’s research contributions span the study of nanostructured materials, aerospace alloys, biomaterials, catalysts, and electronic materials and devices. He is author or co-author of over 325 technical publications. In his spare time, he enjoys poetry, performance cars, and playing electric blues guitar.