Sensors and Sensing in Harsh Environments: Setting the Research Agenda

SPRING 2012 CONFERENCE

Stanford University Energy and Environment Affiliates Program

MAY 9, 2012

MACKENZIE ROOM
JEN-HSUN HUANG ENGINEERING CENTER
STANFORD UNIVERSITY
The internet of things
Sensors are becoming ubiquitous and are invading every aspect of our lives, the environment, and industry. As a result of low-cost microelectronics and low-power radios, the cost of adding a sensor to virtually anything is virtually zero. These sensors are producing vast quantities of data, and creating huge opportunities and major challenges.

One area remains particularly challenging—sensors and sensing in harsh environments. Innovations are needed in order to fully exploit applications such as oil and gas exploration, environmental monitoring particularly in oceans and saline lakes, industrial process control, and sensing in the human body.

This conference addresses three aspects of sensors and sensing in harsh environments: hardware, software, and applications. Speakers, panelists, student posters, and informal discussions will address needs and developments in sensors, environmentally robust materials, sensor networks, data analytics for big data, and specific applications in diverse fields.

Setting the research agenda
This is an emerging field; it is not yet mature. Throughout the conference we will focus on where this field should go in the future. What are the important applications for sensors and sensing in harsh environments? What are the major challenges and opportunities in sensors and sensor networks? What breakthroughs are needed? What existing capabilities are not being fully exploited?
# AGENDA

## SPRING 2012 CONFERENCE

**WEDNESDAY, MAY 9, 2012**

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<td>8:00 am</td>
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| 9:00 am | **Steve Eglash**, Executive Director, Energy and Environment Affiliates Program  
Welcome and Introduction |
| 9:10 am | **Jeff Koseff**, Director, Woods Institute for the Environment, Professor, Civil and Environmental Engineering  
Overview and Results from Pre-conference Survey |
|        | Moderator: **Jeff Koseff**, Director, Woods Institute for the Environment, Professor, Civil and Environmental Engineering |
| 9:30 am | **Zhenan Bao**, Associate Professor, Chemical Engineering  
Skin-inspired Flexible Sensor Sheets for Touch, Chemical, and Biological Species |
| 9:55 am | **Stephen Monismith**, Department Chair and Professor, Civil and Environmental Engineering  
Observing the Nearshore Coastal Ocean: Opportunities and Challenges |
| 10:20 am | Break                                                                 |
|        | Moderator: **Ram Rajagopal**, Assistant Professor, Civil and Environmental Engineering |
| 10:35 am | **Andy Brayshaw**, VP Emerging Science and Promotion, BP America  
Corporate Overview: An Oil Industry Perspective |
| 10:50 am | **Michael Mahoney**, Research Associate, Mathematics  
Large-scale Data Analytics for Sensor Networks |
| 11:15 am | Student Poster Oral Preview Presentations                         |
| 12:00 pm | Lunch and Poster Viewing                                         |
| 1:30 pm | **Steve Eglash**, Executive Director, Energy and Environment Affiliates Program  
Energy and Environment Affiliates Program Overview |
|        | Moderator: **Stacey Bent**, Director, TomKat Center for Sustainable Energy, Professor, Chemical Engineering |
| 1:45 pm | **Chris Scholin**, President and CEO, Monterey Bay Aquarium Research Institute  
Next-generation Ocean Observatories |
| 2:10 pm | **Ronald Hanson**, Professor, Mechanical Engineering  
Laser Absorption Sensors for Energy Systems |
| 2:35 pm | **Yang Liu**, Ph.D. Candidate, Energy Resources Engineering  
Interpreting Pressure and Flow Rate Data from Permanent Downhole Gauges |
| 3:00 pm | Break                                                                 |
|        | Moderator: **Franklin M. ("Lynn") Orr, Jr.**, Director, Precourt Institute for Energy, Professor, Energy Resources Engineering |
| 3:15 pm | **Debbie Senesky**, Assistant Professor, Aeronautics and Astronautics  
Sensor Technology for Extreme Harsh Environments |
| 3:40 pm | **Greg Asner**, Professor, Carnegie Institution  
Remote Sensing of Tropical Forests |
| 4:05 pm | Panel Discussion: Setting the Research Agenda (**Steve Eglash**, Moderator)  
**Ram Rajagopal**, Assistant Professor, Civil and Environmental Engineering  
**David Shimbo**, Director, BP Chief Technology Office  
**Henry Swartzlander**, Unit Manager Process Automation, Chevron Energy Technology Company  
**Jack Wenstrand**, Director, University Relations and External Research, Agilent |
| 5:00 pm | Wine and cheese reception                                          |
The Energy and Environment Affiliates Program is a partnership between member industrial firms and Stanford University. The program supports advanced research, policy study, outreach, and education across a broad range of issues at the intersection of energy and environmental science, technology, and policy.

The Affiliates Program is primarily about establishing a relationship and the exchange of ideas. Member companies come from a wide range of industries, including building and construction, communications, computer, consumer electronics, instrument, legal, engineered materials, oil and gas, semiconductor, semiconductor equipment, solar, utilities, and venture capital.

Companies benefit from access to emerging technology, out-of-the-box thinking, and innovative problem solving. Stanford benefits from exposure to practical real-world problems, constraints, and opportunities.

PROGRAM SCOPE

The scope of the Affiliates Program is broad and encompasses basic physics, chemistry, and materials science; natural resources and biological systems; complex engineered systems, such as sustainable buildings and the electric power grid; and societal aspects, such as human behavior, regulatory issues, and public policy.

In addressing these topics, the Affiliates Program balances broad coverage of interdisciplinary topics with in-depth treatment of specific focus areas that evolve over time in response to the interests of program members and Stanford faculty. Current focus areas include solar photovoltaic, advanced materials for energy applications, smart grid, sensors and sensing in extreme environments, freshwater, oceans, natural capital, and the built environment.

The Affiliates Program works closely with leading energy and environment research organizations across the Stanford campus, including the Precourt Institute for Energy, the Woods Institute for the Environment, the Geballe Laboratory for Advanced Materials, and many others.

The Stanford Energy and Environment Affiliates Program is a membership program that helps corporations and other organizations to engage with Stanford faculty and students who are working on research related to energy and the environment. The Affiliates Program is designed to establish relationships and facilitate communication with the broader community beyond Stanford who share their interests in these important issues.

ANN ARVIN
DEAN OF RESEARCH
STANFORD UNIVERSITY
Greg Asner
Professor, Carnegie Institution
Greg Asner is a faculty member in the Department of Global Ecology, Carnegie Institution for Science and in the Department of Environmental Earth System Science, Stanford University. He works at the interface of ecosystems, land use and climate change. He develops new technologies for science-based conservation assessments of tropical regions, including their carbon emissions, hydrologic function and biological diversity. He leads the CLASlite forest change mapping project, Spectranomics biodiversity project, and the Carnegie Airborne Observatory.

Stacey Bent
Director, TomKat Center for Sustainable Energy, Professor, Chemical Engineering
Stacey F. Bent is Director of the TomKat Center for Sustainable Energy and a Professor in the Department of Chemical Engineering at Stanford University. She also holds courtesy appointments in the Departments of Materials Science and Engineering, Electrical Engineering, and Chemistry. She leads an active research group in semiconductor processing, surface science, and materials chemistry. She and her students and postdoctoral scholars work toward applications in renewable energy devices and next-generation microelectronics. She also co-directs a DOE Energy Frontier Research Center on Nanostructuring for Efficient Energy Conversion.

Zhenan Bao
Associate Professor, Chemical Engineering
Professor Bao received her Ph.D. degree in chemistry from The University of Chicago in 1995 and joined the Materials Research Department of Bell Labs, Lucent Technologies. She became a Distinguished Member of Technical Staff in 2001. She joined the faculty of the Stanford Chemical Engineering Department in 2004. She was selected by MIT Technology Review magazine in 2003 as one of the top 100 young innovators for this century. She has been selected as one of the recipients of Stanford Terman Fellow and has been appointed as the Robert Noyce Faculty Scholar, FINmeccanica Faculty Scholar and David Filo and Jerry Yang Faculty Scholar.

Andy C. Brayshaw
Vice President Emerging Science and Promotion, BP America
Andy Brayshaw heads up emerging science and technology promotion for BP. He has extensive experience through a range of technical and managerial roles, working on exploration and development projects globally. His area of specialty is the application of science and technology to discover and recover more energy from conventional and unconventional reservoirs. He was previously Technical Director for BP Middle East and South Asia, and has undertaken senior roles in Alaska, Kuwait, UAE, Trinidad and Russia. He holds a PhD in sedimentology from University College London and a post-doctoral Royal Society Fellowship in fluid mechanics from the Florence University, Italy.

Ronald Hanson
Professor, Mechanical Engineering
Professor Hanson’s research is in the field of laser diagnostics and sensors, shock wave physics and chemistry, laser spectroscopy, chemical kinetics and combustion, and propulsion science. He is the author of three book chapters and over 400 archival refereed papers in these areas, and has served as a member of the editorial advisory boards of Combustion Science and Technology, Progress in Energy and Combustion Science, Shock Waves, the International Journal of Chemical Kinetics, and the Journal of Quantitative Spectroscopy and Radiative Transfer. He has served as Chair of the Gordon Conference on Combustion Diagnostics, Chair of the Western States Section of the Combustion Institute, and as the Program Co-Chair for the 30th Symposium (International) on Combustion. He was the Chairman of the Mechanical Engineering Department at Stanford University from 1993 to 2003.

Jeff Koseff
Director, Woods Institute for the Environment, Professor, Civil and Environmental Engineering
Professor Koseff is The William Alden Campbell and Martha Campbell Professor of Civil and Environmental Engineering, The Michael Forman University Fellow in Undergraduate Education, and the Perry L. McCarty Director of the Woods Institute for the Environment at Stanford University. Koseff’s research area falls in the emerging interdisciplinary
Yang Liu
Ph.D. Candidate, Energy Resources Engineering

Yang Liu is a third year Ph. D. student in the Department of Energy Resources Engineering at Stanford University. He holds a B. S. in Software Engineering from Shanghai Jiao Tong University in China and a M. S. degree in Petroleum Engineering from Stanford. His main research interest is in how to utilize data mining approaches to interpret huge volumes of data from permanent downhole gauges.

Michael Mahoney
Research Associate, Mathematics

Mahoney’s focus areas include developing geometric network analysis tools, i.e., using scalable approximation algorithms with a geometric or statistical flavor to analyze the structure and dynamics of large informatics graphs; developing approximate computation and regularization methods for large informatics graphs; and applications to community detection, clustering, and information dynamics in large social and information networks. He is also continuing work on randomized matrix algorithms, as well as applications to DNA single nucleotide polymorphism (SNP) data, and large-scale statistical data analysis more generally. Research interests include algorithmic and statistical aspects of modern large-scale data analysis, design, analysis, and implementation of randomized algorithms for very large matrix, graph, and regression problems, and applications to analytics and vector space analytics on large social and information networks.

Stephen Monismith
Department Chair and Professor, Civil and Environmental Engineering

Professor Monismith, the Obayashi Professor in the School of Engineering, received his BS, MS, and PhD degrees from the UC Berkeley Department of Civil Engineering. His current research uses field, lab, and computational experiments to look at coastal, estuarine and lake physics, focusing on mixing and transport processes that are central to ecology, biogeochemistry and environmental management. Through his work on estuarine dynamics, he has been active in Bay-Delta issues. In recent years, much of his efforts have focused on coral reef flows, work that he is now extending to the kelp forests of California. Through his coral reef work, he had the opportunity to serve as the project director for a unique NATO-supported collaboration between Israeli and Jordanian scientists studying the northern Gulf of Aqaba.

Franklin M. (“Lynn”) Orr, Jr.
Director, Precourt Institute for Energy, Professor, Energy Resources Engineering

Professor Orr became the director of the Precourt Institute for Energy at Stanford upon its establishment in 2009. He served as director of the Global Climate and Energy Project from 2002 to 2008. Orr was the Chester Naramore Dean of the School of Earth Sciences at Stanford University from 1994 to 2002. He has been a member of the Stanford faculty since 1985 and holds the Keleen and Carlton Beal Chair of Petroleum Engineering in the Department of Energy Resources Engineering, and is a Senior Fellow at the Woods Institute for the Environment. His research activities focus on how complex fluid mixtures flow in the porous rocks in the Earth’s crust, the design of gas injection processes for enhanced oil recovery, and CO2 storage in subsurface formations. Orr is a member of the National Academy of Engineering. He serves as vice chair of the board of directors of the Monterey Bay Aquarium Research Institute, and he chairs the Science Advisory Committee for the David and Lucille Packard Foundation and was a foundation board member from 1999-2008.

Ram Rajagopal
Assistant Professor, Civil and Environmental Engineering

Ram leads a laboratory for creating sustainable engineering systems, with renewable energy systems as one of the main focus areas. He received his Ph.D. in electrical engineering and computer sciences and master’s degree in statistics from the University of California, Berkeley. He has specialized in creating and deploying large sensing systems, and using the generated data together with novel statistical algorithms and stochastic control to achieve sustainable transportation, energy, and infrastructure networks. In his dissertation work, he created several types of wireless sensors that measure traffic flow and road pavement conditions.
**Chris Scholin**  
*President and CEO, Monterey Bay Aquarium Research Institute*

Chris served as Chair of MBARI’s Research Division from mid-2005 to early 2009 before appointment as President and CEO in late 2009. He currently serves on an External Advisory Committee for the University of Miami’s Oceans and Human Health Center, the Management Committee of the Center for Ocean Solutions, and the Board of Trustees of the Monterey Bay Aquarium. He maintains an active research program that focuses on development and application of instruments for collecting and analyzing microorganisms remotely in coastal, open ocean, and deep-sea environments.

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**Debbie Senesky**  
*Assistant Professor, Aeronautics and Astronautics*

Debbie G. Senesky received the Ph.D. degree in mechanical engineering from the University of California, Berkeley, in 2007. From 2007 to 2008, she was a Design Engineer for GE Sensing (formerly known as NovaSensor) developing sensors for healthcare and automotive applications. From 2008 to 2012, she was a postdoctoral researcher at the Berkeley Sensor and Actuator Center developing silicon carbide (SiC) sensing technology for extreme harsh environments. Recently, she has been appointed to the faculty in the Aeronautics and Astronautics Department at Stanford University. Her research interests include the development of micro- and nano-scale sensors, wide bandgap electronics and ceramic materials for operation within extreme harsh environments.

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**David Shimbo**  
*Director, BP Chief Technology Office*

David Shimbo’s focus is on oilfield and refinery operations. David has worked as a petroleum engineer for Exxon, BP, and Halliburton/Landmark in Houston, Alaska, California, the Middle East, Mexico, Brazil and Kazakhstan. He also worked for IBM, Oracle and Bechtel as an energy consultant and solution architect and founded two technology startups in Silicon Valley. David is committed to building advanced technology solutions that contribute to BP’s bottom line profitability and has a strong interest in operational projects involving exploration, drilling, production, refinery operations, maintenance, and health/safety/environmental compliance. David has a BS in Chemical Engineering and a BS in Geology from Tufts University. He has a MS in Petroleum Engineering and a MS in Industrial Engineering from Stanford University.

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**Henry Swartzlander**  
*Unit Manager Process Automation, Chevron Energy Technology Company*

Henry has a Bachelor of Science in Electrical Engineering (1981) from the University of Colorado. He started his career with Chevron in 1979 as a reservoir engineer within the Denver division. He worked as a field production engineer for 10 years in Denver and across Colorado, eventually becoming the Engineering Manager in Cortez. In April 2007, Henry assumed his current position as Process Automation Unit Manager. The Process Automation Team is approximately 120 people worldwide and supports distributed control systems, alarm management, measurements, cyber security, instruments, analyzers, end devices, control valves, wireless technologies, dynamic simulation, advanced process controls, and safety instrument controllers.

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**Jack Wenstrand**  
*Director, University Relations and External Research, Agilent*

Jack Wenstrand received his B.S.E. and M.B.A. degrees from the University of Michigan, and his M.S. and Ph.D. degrees in electrical engineering from Stanford University. He lived in Japan for a year while conducting doctoral research in Toshiba’s ULSI Research Laboratory. At Hewlett-Packard, later Agilent Technologies, he developed systems for rapid and productive silicon process R&D. Jack was R&D manager and Chief Technologist for Agilent’s Sensor Solutions Division, with responsibility for mobile imaging and optical navigation products. Presently, Jack leads Agilent’s global university relations and external research programs while concurrently serving as consulting professor of Electrical Engineering at Stanford. His research interests include sensor networks and machine interpretation of complex sensory input.
Energy and environmental research is a major theme at Stanford and is found in nearly every academic discipline. Stanford emphasizes an interdisciplinary approach, recognizing that energy and environmental research activities are interwoven within the fabric of nearly all Stanford academics.

FINDING RESEARCH GERMANE TO YOUR INTERESTS
It can be difficult for those outside the Stanford community to quickly grasp the scope of energy and environment research activities on campus or to understand where specific research is being conducted in a particular area of commercial interest. Among the benefits that the Energy and Environment Affiliates Program aims to deliver to our members is assistance in understanding what specific research is taking place at Stanford, who is conducting it, and how to engage directly with those activities.

For details, visit the Affiliates Program website at eeap.stanford.edu.

MEMBER BENEFITS
Affiliates Program members are entitled to the full range of benefits, including:
- Support for Ph.D. student research through participation in the Fellow-Mentor-Advisor Program;
- In-depth interactions with faculty and graduate students;
- Company visits by faculty and graduate students;
- Facilitated graduate student recruiting opportunities;
- Access to research papers and computer models;
- Use of a directory of Stanford research activities in energy and the environment;
- Opportunity to establish a visiting scientist at Stanford; and
- Invitations to Affiliates Program symposia and semi-annual conferences.

FELLOW-MENTOR-ADVISOR PROGRAM
Affiliates Program membership includes participation in the Fellow-Mentor-Advisor (FMA) Program. The goal of the FMA Program is to establish a relationship between a Ph.D. student ("Fellow"), an employee of the company ("Mentor"), and a professor ("Advisor"). A portion of the annual membership fee is given to a professor of the company's choosing to help support a Ph.D. Fellow. The Affiliates Program can assist the company in making this choice. The FMA Program is about creating a relationship. It is not sponsored research, but it is an opportunity for the company to get close to the professor, the student, and the student's research.

Membership in the Energy and Environment Affiliates Program is US$150,000 per year. Affiliates Program revenue is used to support Ph.D. student research, symposia and workshops, seed projects, equipment purchases, faculty and graduate student travel, and program operations. One FMA Program allocation is included in the annual membership fee. Companies can obtain additional FMA Program allocations for US$75,000 each.

CONTACT INFORMATION
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ABOUT STEVE EGLASH
Steve Eglash is responsible for developing and managing interactions for corporations and other organizations that have an interest in Stanford’s research, faculty, and graduate students in energy-related and environmental fields. His background is in renewable energy, business, technology, and finance. Eglash was president and CEO of Cyrium Technologies, a solar energy startup company, and a consultant and advisor to the National Renewable Energy Laboratory and the U.S. Department of Energy. He received his Ph.D. and M.S. degrees from Stanford University, and a B.S. degree from U.C. Berkeley, all in electrical engineering.
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<td>Ronald Hanson</td>
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<td>Kyla Dahlin, Biology</td>
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The Energy and Environment Affiliates Program is a membership program that helps corporations and other organizations to engage with Stanford faculty and graduate students in energy-related and environmental areas. The Affiliates Program is about establishing relationships and facilitating communication.

The Geballe Laboratory for Advanced Materials (GLAM) facilitates education and research on advanced materials in science and engineering.

The Woods Institute is pioneering innovative approaches to meet the environmental challenges of the 21st century.

The Precourt Institute for Energy (PIE) engages in a broad-ranging, interdisciplinary program of research and education on energy.