The INSTITUTE for ENERGY EFFICIENCY

Science & Technology for an Efficient Energy Future
<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Who</th>
</tr>
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<tbody>
<tr>
<td>9:00 AM</td>
<td>Introduction</td>
<td>John Bowers</td>
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<tr>
<td>9:15 AM</td>
<td>AIM Photonics</td>
<td>Roger Helkey</td>
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<tr>
<td>9:30 AM</td>
<td>Sun Works</td>
<td>Jim Nelson</td>
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<tr>
<td>10:00 AM</td>
<td>PowWow Energy</td>
<td>Olivier Jerphagnon</td>
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<tr>
<td>10:30 – 10:45 AM</td>
<td>Break</td>
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<tr>
<td>10:45 AM</td>
<td>Gravity Power</td>
<td>Jim Fiske</td>
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<tr>
<td>11:15 AM</td>
<td>Ecomerit</td>
<td>Jim Dehlsen</td>
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<tr>
<td>11:45</td>
<td>Soraar</td>
<td>Steve DenBaars</td>
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<tr>
<td>12:15 – 1:30 PM</td>
<td>Lunch</td>
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<tr>
<td>1:30 PM</td>
<td>Nuclear Technologies</td>
<td>Eric McFarland</td>
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<tr>
<td>2:00 PM</td>
<td>HPE</td>
<td>Xue Huang</td>
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<tr>
<td>2:20 PM</td>
<td>Aurrion</td>
<td>Alex Fang</td>
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<td>2:40 – 3:10 PM</td>
<td>Break</td>
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<td>3:10 PM</td>
<td>Transphorm</td>
<td>Umesh Mishra</td>
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<td>3:30 PM</td>
<td>Thin Gap</td>
<td>Evan Frank</td>
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<tr>
<td>3:50 PM</td>
<td>Discussion</td>
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<td>4:15 – 6:00 PM</td>
<td>Reception</td>
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Who is IEE?

- Founded in 2008
- 40 faculty, 180 graduate & postdoctoral students
- 12 Affiliated research centers
- Supported by government grants, private philanthropy and industry partners
Six Focused Research Programs

**Lighting: Steve DenBaars**
- More efficient, lower cost LEDs --- solving “green gap” & “droop”.

**Electronics and Photonics: John Bowers**
- Optoelectronic technologies for low energy, high capacity on-chip and between chip communications

**Computing: Rich Wolski**
- Energy efficient datacenters and software

**Buildings and Design: Igor Mezic**
- Economically viable zero net-energy building systems

**Production and Storage: Gui Bazan**
- Organic and inorganic materials for higher efficiency & lower cost solar cells. Bio-inspired nanostructured anodes for batteries

**Economics and Policy: Sangwon Suh**
- Worldwide energy efficiency policy direction, measurements and standards
LIGHTING

GRAND CHALLENGE
To develop a $1 LED light bulb that is 20 times more efficient than incandescent bulbs.

Lighting consumes 22% of all US electricity. The Department of Energy estimates that widespread adoption of LED lighting can reduce energy use by 46% by 2030 – the equivalent of 50 one-GW coal-fired power plants.

Institute researchers are working to clear the last remaining hurdles to achieving high-quality, efficient and widely-available solid-state lighting.
GRAND CHALLENGE
To develop new wireless & optical communications technologies for 100x more efficient interconnects.

With the rapid growth in worldwide data, improvements in the efficiency of the fiber optic digital “superhighways” that transmit that data are essential. The multiple conversions of signals from optical to electrical and back to optical are energy intensive, slow, and scale poorly.

Institute researchers are creating technologies that address these hardware-based issues by bringing the advantages of photonics – energy efficiency, low-cost, and high capacity – to every level of digital communication, and are working on related technologies to make electronics more energy efficient.

Intel, Aurrion, HPE, Oracle
This is the highest capacity network on chip demonstrated anywhere (university or industry). Infinera: 2.2 Tbps
Computing: Rich Wolski

**GRAND CHALLENGE**
To develop a new Moore's Law for computing energy efficiency.

Data centers consume 1.5% of global energy and, if current trends hold, we'll see a 1000x increase in the volume of data by 2025. Meanwhile, computing efficiency is expected to increase only 25x over this period, leaving a huge efficiency gap.

*Institute researchers are working to close this looming gap by pursuing solutions that reduce the energy use associated with cooling loads, inefficient server use, and wasteful computer processes.*

Eucalyptus, HPE: Open source Cloud Technology
PowWow: Energy and water efficient agriculture
BUILDING & DESIGN

GRAND CHALLENGE
To develop an economically viable building system with zero net energy.

Buildings consume 72% of U.S. electricity and 40% of all U.S. energy. Getting buildings to zero net energy will dramatically reduce U.S. energy use – but getting there will take more than upgrading windows and insulation.

Institute researchers are developing smart building energy management systems to accelerate the transition to zero net energy buildings. Our overarching goal is to develop optimized control systems that will operate buildings at peak comfort and efficiency levels by automatically controlling HVAC, lighting and shading in smart and robust ways.
PRODUCTION & STORAGE

GRAND CHALLENGE

To develop solar cells with double the efficiency at 1/10th of the cost.

Most of the energy we use today is generated by burning fossil fuels, with negative consequences for the environment, our economy, and our geopolitical stability. That makes finding sufficient supplies of clean energy a critical challenge. Since many of these alternative energy sources are intermittent, such as solar and wind energy, highly-efficient energy storage systems, such as batteries and flywheels, are required for their full and effective realization.

Institute researchers are working on a range of technologies to generate and store clean, renewable energy.
SANGWON SUH

SUSTAINABILITY

GRAND CHALLENGE
To influence worldwide energy efficiency policy directions, measurements, and standards.

The integration of new technologies into the marketplace requires an understanding of not just the relevant technical issues, but also the social, environmental and resource issues impacting those technologies.

Institute researchers investigate the range of ways that research, economics, and the environment interact to find policy solutions that proactively shape the market for the benefit of society.
“TomKat UC Carbon Neutrality Project”

This project will facilitate and manage a set of project teams aimed at developing solutions to the most challenging aspects of the UC Carbon Neutrality Initiative. Each project will consist of a highly collaborative team of faculty, students, and staff from a wide range of disciplines at ten UC campuses and its three affiliated national laboratories. The outcomes of the work of these project teams will include economic and technical analysis of emerging technologies and systems, meta-analysis and synthesis of existing data to develop shared information resources, strategic roadmaps for the campuses, policy analysis and recommendations, field trials, and prototypes of emerging technologies.

- **Project Director:** Dave Auston
- **Donor:** TomKat Foundation
- **Partners:** National Center for Ecological Analysis and Synthesis (NCEAS), The Bren School of Environmental Science & Management, and The Applied Working Group of the UC Global Climate Leadership Council (ARWG).
- 18 months
Ongoing Research Programs

“Irrigation Optimization and Well Pump Monitoring Leveraging Smart Meter Data”

The overall objective of this project is to demonstrate energy efficiency farming practices and a scalable well pump monitoring solution on more than 1,000 acres of farmland. Unlike existing solutions that require hardware installations, this platform leverages existing smart meter data from power utilities to measure groundwater extraction and integrates other data sources into a user-friendly software tool to assist growers to optimize irrigation. By using this platform, farms will be able to reduce energy and water consumption while maintaining or improving crop yields.

- **UCSB PIs**: Roland Geyer, Chandra Krintz, Rich Wolski
- **Agency**: California Energy Commission via PowWow Energy, Inc.
- **Partners**: PowWow Energy, Inc. (prime), UC Davis
- **30 months**
“Highly Powerful Capacitors Boosted with Both Anolyte and Catholyte”

To develop a technology to combine the technical advantages of both batteries and electrical double Layer Capacitors (EDLCs) into a single electrical storage device for electric vehicles (EVs). The approach is to mechanistically integrate battery reactions into the configuration of EDLCs to create a new energy device that can be charged in less than 2 minutes (compared to hours for batteries), meet or exceed the lifetime of EVs, and deliver much higher power density than any battery.

- **PIs:** Galen Stucky, Dave Auston
- **Agency:** DOE Advanced Research Projects Agency-Energy (ARPA-E)
- **Subcontracts:** Univ. of Oregon, OSU
- **36 months**
“Chemical Life Cycle Collaborative (CLiCC)”

The primary objective of this collaborative is to develop, implement and disseminate an open-access, online tool for rapid and efficiency characterization of chemical life-cycle impacts. The CLiCC tool is being developed to evaluate life-cycle impacts for chemical and materials at an early stage of the chemical product development process, when the precise manufacturing routes and fates of the products are still uncertain.

- **PIs:** Sangwon Suh, Arturo Keller, Dave Auston, Mike Doherty, Ram Seshadri, Susannah Scott
- **Agency:** Environmental Protection Agency (EPA)
- 48 months
“High Efficiency Quantum-Dot Photonic Integrated Circuit Technology Epitaxially Grown on Silicon”

To develop a technology for scaling high efficiency datacenter and supercomputer photonics to 300 mm wafers at low cost with high performance. Successful development of the proposed technology can solve the bandwidth capacity bottleneck of electronic chips and reduce the power necessary for interconnecting ICs, addressing a major impending need for high volume, low power, low cost silicon photonic optical interconnects for data centers, supercomputers and fiber to the home (FTTH).

- **PIs:** John Bowers, Art Gossard
- **Agency:** ARPA-E (DOE)
- **36 months**
The National Medal of Technology and Innovation represents the nation’s highest honors for achievement in leadership in advancing the fields of science and technology.

For ground-breaking scientific and technological advances in semiconductor molecular layered materials.

Art is a close collaborator, and leads the epitaxial III-V on silicon growth effort at IEE.
“Chip-scale Optical Resonator Enabled Synthesizer (CORES)”

A fundamental program of research and development to implement direct digital synthesis of optical frequencies in a single integrated chip-scale package. The outcome of this work will be a revolutionary Chip-scale Optical Resonator Enabled Synthesizer (CORES) that provides a laser output with programmable optical frequency resolution of one part in $10^{14}$ across 50 nm of bandwidth centered at 1500 nm.

- **PIs:** John Bowers, Luke Theogarajan, Dan Blumenthal
- **Agency:** DOD Advanced Research Projects Agency (DARPA)
- **Subcontracts:** Univ. of Virginia, Caltech, EPFL, Aurrion
- **Other Partners:** NIST (*direct funded*)
- **42 months**

Optical clocks with the highest precision at 1/1000 the power of present optical clocks
2015-16 Seminar Series

Matt Price
Commercial Operations & Industry Partnerships
Cyclotron Road

Cyclotron Road, A New Pathway for Hard Technology Entrepreneurs at Lawrence Berkeley National Laboratory
October 1, 2015 | 4:00pm | Elings 1601

John Bowers
Director, The Institute for Energy Efficiency
Deputy Director, AIM Photonics
Kavli Professor, Electrical & Computer Engineering
University of California, Santa Barbara

American Institute for Manufacturing Integrated Photonics: Implications for the Future
September 24, 2015 | 4:00pm | ESB 1001

Clint Scow
Professor, Electrical & Computer Engineering
University of California, Santa Barbara

Opportunities and Challenges for Photonics in Next-Generation Data Centers
October 22, 2015 | 4:00pm | ESB 1001

Andrew A. Chien
William Eckhardt Prof. of Computer Science
University of Chicago & Argonne National Laboratory

Assessing Opportunities to Exploit Stranded Power
October 29, 2015 | 4:00pm | ESB 1001

Pedro Pizarro, Energy Leadership Lecturer
President, Southern California Edison

California’s Low Carbon Future: Energy Efficiency and Distributed Energy Resources
November 2, 2015 | 7:00pm | Pollock Theatre

Nai-Chang Yeh
Co-Director, Fletcher Jones Foundation
Kavli Nanoscience Institute & Professor of Physics
California Institute of Technology

Single-Step Low-Temperature Growth of High-Mobility Large-Area Graphene and the Potential Applications
November 12, 2015 | 4:00pm | ESB 1001

Xinyu Zhang
Assistant Professor, Department of Electrical & Computer Engineering
University of Wisconsin, Madison

Energy Efficient WiFi Display
November 19, 2015 | 4:00pm | ESB 1001

Jonathan Klamkin
Associate Professor, Electrical & Computer Engineering
University of California, Santa Barbara

Integrated Photonic Technologies for On-Chip and Space Applications
December 3, 2015 | 4:00pm | ESB 1001

Ray Beausoleil
Fellow, Systems Research
Hewlett Packard Labs

VLSI Photonic Quantum Technologies for Classical IT
January 7, 2016 | 4:00pm | ESB 1001

Philip Warburg, Energy Leadership Lecture
Environmental Lawyer and Author

Harness the Sun: America’s Quest for a Solar-Powered Future
January 19, 2016 | 4:00pm | Corwin Pavilion
2015-16 Seminar Series (cont.)

**James Buckwalter**  
Professor, Electrical & Computer Engineering  
University of California, Santa Barbara  
*Mixed-signal Circuit Techniques for High-linearity 50 Gs/s Sampling and Pulsewidth Modulation for High-Speed Signaling*  
January 21, 2016 | 4:00pm | ESB 1001

**Eric McFarland**  
Professor, Chemical Engineering  
University of California, Santa Barbara  
*Sustainable Power From Nuclear Reactions: An Imperfect Option Amongst Few*  
January 28, 2016 | 4:00pm | ESB 1001

**Steven Koonin**  
Director, Center for Urban Science and Progress  
New York University  
*Adventures in Urban Informatics*  
February 4, 2016 | 2:30pm | ESB 1001

**David Wood**  
Professor, Computer Sciences  
University of Wisconsin, Madison  
*Energy-Proportional Computing: A New Definition*  
February 4, 2016 | 4:00pm | ESB 1001

**Walter Cunningham**  
Astronaut & Author  
*The Global Warming War – Alarmists vs. Realists*  
February 10, 2016 | 4:00pm | ESB 1001

**Pallab Bhattacharya**  
Professor, Electrical Engineering & Computer Science  
University of Michigan, Ann Arbor  
*III-Nitride Quantum Dot and Dot-in-nanowire Light Sources: From Visible to Near-Infrared*  
February 18, 2016 | 11:00am | ESB 1001

**Philip Lubin**  
Professor, Physics  
University of California, Santa Barbara  
*Photonic Propulsion for Relativistic Flight: Enabling the First Interstellar Missions*  
April 21, 2016 | 4:00pm | ESB 1001
Recognized by the National Academy for their highly prolific spirit of invention

John Bowers  Umesh Mishra  Galen Stucky

“Have demonstrated a highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development, and the welfare of society.”
Chris Van de Walle

Contributions to the theory of semiconductor interfaces and its impact on optoelectronic devices

Michael Doherty

For the design of methods for complex distillation and crystallization processes
### New Faculty Since 07/01/15

<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
<th>Title</th>
<th>Start Date</th>
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<tbody>
<tr>
<td>Steve Barley</td>
<td>TMP</td>
<td>Professor</td>
<td>7/1/15</td>
</tr>
<tr>
<td>Dan Gianola</td>
<td>Materials</td>
<td>Associate Professor</td>
<td>11/1/15</td>
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<tr>
<td><strong>Jonathan Klamkin</strong></td>
<td>ECE</td>
<td>Associate Professor</td>
<td>7/1/15</td>
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<tr>
<td>Luzzatto-Fegiz Paolo</td>
<td>ME</td>
<td>Assistant Professor</td>
<td>7/1/15</td>
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<tr>
<td>Jason Marden</td>
<td>ECE</td>
<td>Assistant Professor</td>
<td>7/1/15</td>
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<tr>
<td>Renee Rottner</td>
<td>TMP</td>
<td>Assistant Professor</td>
<td>7/1/15</td>
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<tr>
<td><strong>Clint Schow</strong></td>
<td>ECE</td>
<td>Professor</td>
<td>7/1/15</td>
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<tr>
<td>Yon Visell</td>
<td>ECE/MATP</td>
<td>Assistant Professor</td>
<td>7/1/15</td>
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The coal sector’s descent happened remarkably fast. Peabody is the fifth and largest US coal producer to enter bankruptcy in the last year.
If solar energy grows over the next five years like it did in the last fifteen, it will account for a quarter of global power generation. With the rapid advance in electric vehicle technology, the energy field is changing rapidly.

Congrats to Jim Dehlsen on Wind Power (GE and UTC) and Ecomerit
Congrats to Jim Nelson on Solar Power (Solar3D, now SunWorks)