

Welcome to the 15th Annual Meeting of the SRC/Sematech Engineering Research Center for Environmentally Benign Semiconductor Manufacturing

March 10 - 11, 2011

ERC: Established in 1996, as an international center, with a comprehensive program, focused on the ESH R/D for SC industry

Founding Universities

- > UArizona
- > U California Berkeley
- > MIT
- > Stanford

Other University members

- Arizona State U (1998)
- Columbia (2006 2009)
- Cornell (1998)
- Georgia Inst. of Tech. (2009)
- U Maryland (1999-2003)
- U Massachusetts (2006 2009)
- U North Carolina (2009)
- Purdue (2003 2008)
- U Texas Dallas (2009)
- Tufts (2005 2008)
- U Washington (2008-)
- U Wisconsin (2009-)

Cumulative Data:

- **16** Core member Universities
- 241 PhD and MS
- **205 Undergraduates (reported)**
- 13 Academic disciplines
- > 80% of graduates joined SC industry & suppliers (mostly ERC members)
- **10** Current member universities
- 28 Current PI/Co-PIs
- **37** Current graduate students

Evolution of ESH Scope and Application

ESH Frontiers and Scope in 1996

- Reduced PFC usage and emission
- Dilute chemistry
- Wastewater treatment and water recycle
- Water use reduction (batch tools)
- Abatement of potential VOCs and HAPs
- Lowering energy use in facilities (pumping and ventilation)
- Concern about lead and a few other compounds



Resource Distribution

ESH Ownership: Facilities group in industry; ESH was covered only in a few environmental conferences

Evolution of ESH Scope and Application

Current ESH Frontiers and Scope

- ESH aspects of nano particles and emerging materials
- ESH in high-volume nano-manufacturing
- Development of low-energy process alternatives
- Surface prep of new materials/nano-structures
- Energy recovery and reuse
- Patterning and etching of new materials
- Effect of wafer size, feature size, and single wafer processing on water, energy, and chemical usage
- Planarization of new materials
- ESH gain through additive processing and selective deposition

ESH Ownership: Shared and integrated with other research and manufacturing groups



- A. ESH Challenges of Existing Processes
- B. ESH-Friendly Novel Materials and Processes
- C. ESH Aspects of Nano-Materials
- D. Sustainable High-Volume Nano-Manufacturing

Evolution of ESH Scope and Application

Additional High-Priority Areas for Future Projects:

- PFC use reduction, replacement, and abatement (a comeback and a more challenging look!).
- Energy conservation technologies; low-energy. processing; energy recovery/recycle (key is lowentropy exchange).
- Robust and ESH-friendly processes for treating complex waste streams that contain nanomaterials and new emerging chemicals.
- New life-cycle studies (in a relevant and useful form).





- A. ESH Challenges of Existing Processes
- B. ESH-Friendly Novel Materials and Processes
- C. ESH Aspects of Nano-Materials
- D. Sustainable High-Volume Nano-Manufacturing

Current ERC Research Projects

- > Two types of projects:
 - 11 new <u>core projects</u> (2009-2012 cycle, mainly funded by the core SRC/Sematech contract; cost shared by other ERC funds)
 - 8 *customized projects* (non-core funding)
- Core projects were selected through RFP process, proposals, and review/selection by a panel appointed by Sematech and SRC.
- Customized projects are added throughout the year.
 Review and selection procedures are set by the ERC and the sponsors.

<u>Core Project in (2009 – 2012 Cycle)</u>

A) ESH Challenges of Existing Processes (4 Universities)

- Lowering the Environmental Impact of High-k and Metal Gate-Stack Surface Preparation Processes
 PIs: Yoshio Nishi (Stanford); Srini Raghavan, Farhang Shadman (U of Arizona); Bert Vermeire (Arizona State U)
- Fundamentals of Advanced Planarization: Pad Micro-Texture, Pad Conditioning, Slurry Flow, and Retaining Ring Geometry PIs: Ara Philipossian (U of Arizona); Duane Boning (MIT)

<u>Core Project in (2009 – 2012 Cycle)</u>

B) ESH-Friendly Novel Materials and Process (3 Universities)

- Low-ESH-impact Gate Stack Fabrication by Selective Surface Chemistry PI: Anthony Muscat (U of Arizona)
- Carbon Dioxide Compatible Additives: Design, Synthesis, and Application of an Environmentally Friendly Development Process to Next Generation Lithography PIs: Christopher Ober (Cornell); Juan de Pablo (U of Wisconsin)
- Improvement of ESH Impact of Back-End-of-Line (BEOL) Cleaning Formulations Using Ionic Liquids to Replace Traditional Solvents *PI: Srini Raghavan (U of Arizona)*
- > High-Dose Implant Resist Stripping (HDIS): Alternatives to ASH/Strip Method PI: Srini Raghavan (U of Arizona)
- Sugar-Based Photoacid Generators (Sweet PAGs): Environmentally Friendly Materials for Next Generation Photolithography PIs: Christopher Ober (Cornell); Reyes Sierra (U of Arizona)

<u>Core Project in (2009 – 2012 Cycle)</u>

C) ESH Aspects of Nano-Materials (6 Universities)

- Development of Quantitative Structure-Activity Relationship for Prediction of Biological Effects of Nanoparticles Associated with Semiconductor Industries PIs: Yongsheng Chen (Georgia Inst. of Technology), Trevor Thornton, Jonathan Posner (Arizona State U)
- Environmental Safety and Health (ESH) Impacts of Emerging Nanoparticles and Byproducts from Semiconductor Manufacturing
 PIs: Jim Field, Reyes Sierra, Scott Boitano, Farhang Shadman (U of Arizona); Buddy Ratner (U of Washington)
- Computational Models and High-Throughput Cellular-Based Toxicity Assays for Predictive Nanotoxicology PIs: Alex Tropsha, Russell Mumper (U of North Carolina)
- Predicting, Testing, and Neutralizing Nanoparticle Toxicity
 PIs: Steven Nielsen, Rockford Draper, Paul Pantano, Inga Musselman, Gregg
 Dierkmann, (U of Texas- Dallas); Ara Philipossian (U of Arizona)

<u>Customized Program on:</u> <u>High-Volume Nano-Manufacturing (HVnM)</u> *Co-sponsored by Intel and ERC*

- > Lowering Slurry Use and Waste in CMP Processes: Investigation of the Relationship between Planarization & Pad Surface Micro-Topography
- > Lowering Waste in CMP Processes: Retaining Ring and Conditioner Interactions
- > Develop an AFM-Based Methodology to Optimize APM Composition for Removing Particles from Surfaces
- > Novel Methods for Reducing UHP Gas Usage in Fabs
- > Integrated Electrochemical Treatment of CMP Waste Streams for Water Reclaim and Conservation
- > New Project: Damage-Free and Energy-Efficient Megasonic Cleaning

Synergy in Funding

- SRC (core)
- Sematech/ISMI (core)
- Other industrial members
- Customized projects
- Cost sharing by participating universities
- Grants from Federal and State agencies
- Gifts and donations
 - Endowments
 - Fellowships
 - Unrestricted industry gifts

Successful funding leverage

New Projects Selection



Welcome Note

New Industrial Affiliate Members:

- Morgan Ceramics
 - Neil Winterbottom
 - David Slutz
- Entegris Corp.
 - Joseph Smith

<u>AGENDA</u> 2011 SRC/SEMATECH ERC REVIEW MEETING

Wednesday, March 9

2:00 – 4:00 PM	Workshop on Emerging Research Topics Co-chairs: Dan Herr (SRC); Ron Remke (ISMI)	
	 <u>Speakers:</u> Dan Herr (SRC); Tim Yeakley (TI); Frank Robertson (Intel) Reed Content (Global Foundries); Laurie Beu (ISMI) Hsi-An Kwong (Freescale); Steve Trammell (ISMI); Joe Draina (ISMI) 	
	Open forum and discussion	
4:00 – 5:00 PM	TAB/PAG Meeting: Finalize the ESH Needs Document	
	Thursday, March 10	
7:00 – 7:45 AM	Continental Breakfast and Registration [Pima/Sabino Foyer]	
7:30 – 7:50 AM	TAB/PAG Caucus [Ventana]	
7:50 – 8:15 AM	Introduction and Overview: Farhang Shadman [Pima/Sabino]	

8:15 – 9:00 AM	Multi-university sample exchange program, Jim Field (UA) Environmental Safety and Health (ESH) Impacts of Emerging Nanoparticles and Byproducts from Semiconductor Manufacturing Jim Field, Scott Boitano, Reyes Sierra, Farhang Shadman (UA) Buddy Ratner (U. Washington)
9:00 – 9:35 AM	Predicting, Testing, and Neutralizing Nanoparticle Toxicity Steven Nielsen, Rockford Draper, Paul Pantano, Inga Musselman, Gregg Dieckmann (UT- Dallas)
9:35 – 10:10 AM	Development of Quantitative Structure-Activity Relationship for Prediction of Biological Effects of Nanoparticles Associated with Semiconductor Industries Yongsheng Chen (Georgia Tech), Jonathan Posner, Trevor Thornton (ASU)
$10:10 - 10:25 \mathrm{AM}$	Break [Pima/Sabino Foyer]
10:25 – 11:00 AM	High-Throughput Cellular-Based Toxicity Assays for Manufactured Nanoparticles and Nanostructure-Toxicity Relationship Models Alex Tropsha, Russell Mumper (UNC-Chapel Hill)
11:00 – 11:25 PM	Low-ESH-Impact Gate Stack Fabrication by Selective Surface Chemistry Anthony Muscat (UA)
11:25 – 12:00 PM	Lowering the Environmental Impact of High-k and Metal Gate-Stack Surface Preparation Processes Yoshio Nishi (Stanford), Srini Raghavan, Farhang Shadman (UA); Bert Vermeire (ASU)
12:00 – 12:30 PM	Sugar-Based Photoacid Generators (Sweet PAGs): Environmentally Friendly Materials for Next Generation Photolithography Chris Ober (Cornell), Reyes Sierra (UA)
12:30 – 1:30 PM	Lunch [Canyon Rooms]

1:30 – 2:00 PM	Supercritical Carbon Dioxide Compatible Additives: Design, Synthesis, and Application of an Environmentally Friendly Development Process to Next Generation Lithography Chris Ober (Cornell), Juan dePablo (U. Wisconsin)
2:00 – 2:40 PM	Fundamentals of Advanced Planarization: Pad Micro-Texture, Pad Conditioning, Slurry Flow, and Retaining Ring Geometry Ara Philipossian (UA), Duane Boning (MIT)
2:40 – 3:00 PM	Development of an All-Wet Benign Process Based on Catalyzed Hydrogen Peroxide (CHP) Chemical System for Stripping of Implanted State-of-the-Art Deep UV Resists Srini Raghavan (UA)
3:00 – 3:20 PM	Improvement of ESH Impact of Back End of Line (BEOL) Cleaning Formulations Using Ionic Liquids to Replace Traditional Solvents Srini Raghavan (UA)
3:20 – 3:30 PM	General Discussion
3:30 – 3:40 PM	Simon Karecki Award Presentation

3:40 – Open	Poster Session [Madera]
4:15 – 5:15 PM	SRC Student/Industry Networking Event [Madera/Pima]
4:15 – Open	Hors d'oeuvres [Madera/Pima]
5:00 – Open	Cash bar [Madera/Pima]
5:15 – 7:45 PM	TAB/PAG Caucus w/ working dinner [Sabino]
6:30 – Open	Buffet Dinner [Canyon Foyer & Canyon]
7:30 – Open	PIs group planning meetings [Canyon]

Friday, March 11

6:30 – 7:30 AM	Continental Breakfast	
7:30 – 7:35 AM	Welcome by Dean Goldberg	
7:35 – 8:45 AM	 <u>Special Session on Customized and Proposed Projects</u> <i>Reducing Water and Energy Usage in Patterned Wafer Rinsing</i>: Jun Yan (UA) <i>Update on Energy Use Reduction</i>: Tom Huang (ISMI) <i>Plasma Chemistries for Patterning Complex Metal Oxide Materials</i>; Invited Presentation: Jane Chang (UCLA) <i>Summary of other proposed projects</i>: Farhang Shadman (UA) 	
8:45 – 8:55 AM	Break [Pima/Sabino Foyer]	
8:55 – 10:30 AM	ERC/Intel Initiative on High-Volume Nano-Manufacturing Introduction: Gopal Rao (Intel) Keynote talk: Gabe Quenneville (Intel) Academia/Industry Partnership to Enhance Research in Energy & Sustainability for next generation High-Volume Nano Manufacturing	
	 Project Reports: Lowering Slurry Use and Waste in CMP Processes: Ara Philipossian (UA) Novel Methods for Reducing UHP Gas Usage in Fabs: Roy Dittler (UA) Development of an AFM-Based Methodology to Optimize APM Composition for Removing Particles from Surfaces: Srini Raghavan (UA) New Project: Damage Free and Energy Efficient Megasonic Cleaning: Manish Keswani (UA) Integrated Electrochemical Treatment of CMP Waste Streams for Water Reclaim and Conservation: Farrell (UA) 	
	Recognitions and Closing Remarks	

10:30 – 11:45 AM	Industrial Advisory Board Meeting [Pima/Sabino]
11:45 – 12:45 PM	Buffet Lunch [Pima/Sabino Foyer & Canyon]
11:45 – 12:45 PM	Feedback to PIs [Pima/Sabino]
12:45 – 2:00 PM	Executive Advisory Board Meeting [Board Room]
2:00 PM	Program End