Opportunities for Collaborative University - Industry Research in Sustainable Energy

E. Dan Hirleman

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Agenda

- UC Merced Overview
- University-Industry Partnerships
- Nanotech/Energy Research at UCM

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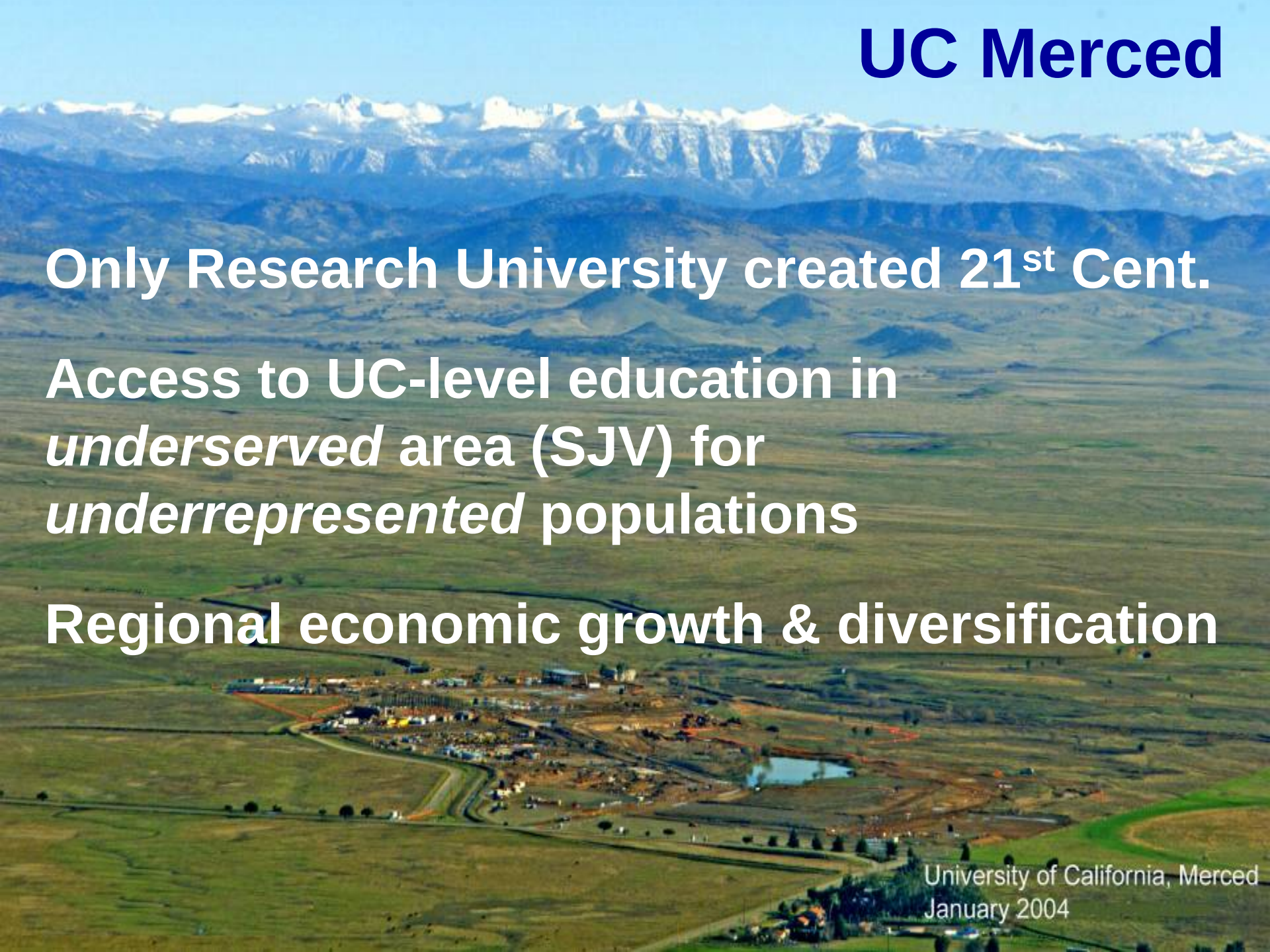
UC Merced

Only Research University created 21st Cent.

Access to UC-level education in *underserved* area (SJV) for *underrepresented* populations

Regional economic growth & diversification



Ag

Water

San Joaquin Valley

Ira J Chrisman Pumping Plant
DWR, Mettler, CA
http://aquafornia.com/wp-content/uploads/2008/08/pumps-going-up.jpg

@ Nexus of Ag, Water, Energy

Energy

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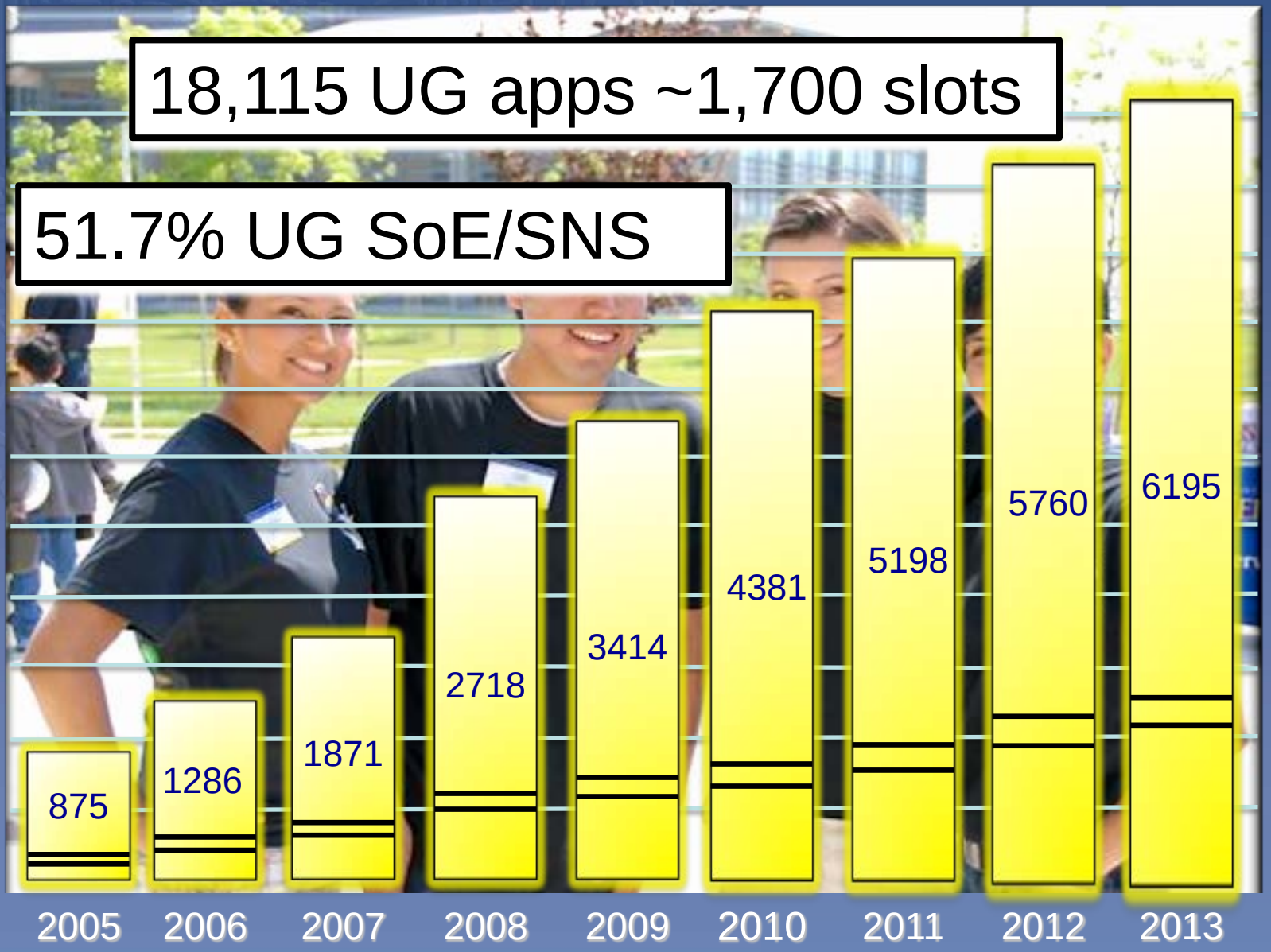
UC Merced



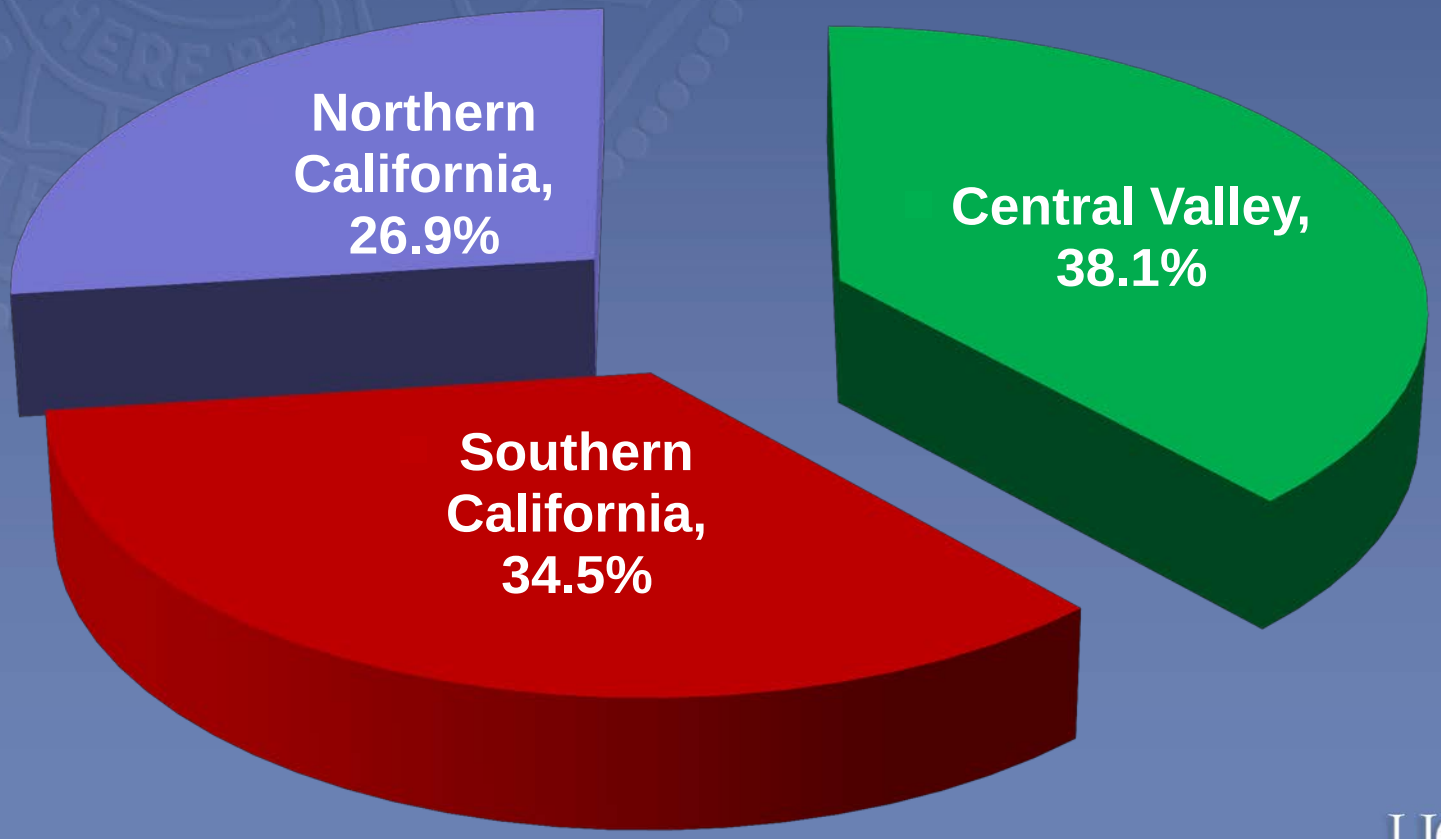
SoE
113 G
1,169 UG

UC Access - Serving California's Future

Fall 2013 - Undergraduates

62% First Generation (55% Engineering)

62% Pell Eligible (55% Engineering)



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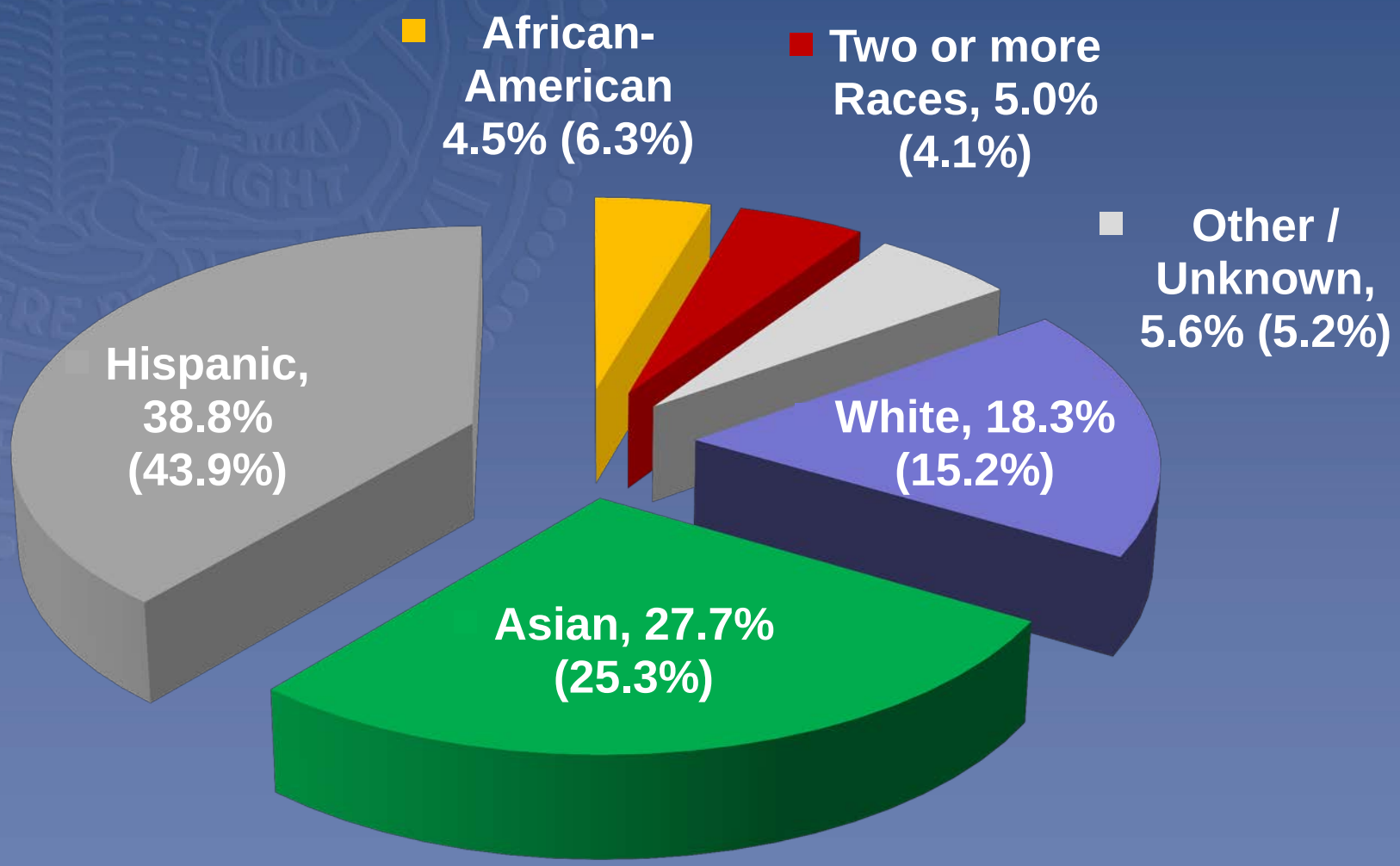
UC Access - Serving California's Future

Fall 2013 – Engineering (All) Undergraduates



Hispanic-Serving Institution
(U.S. Department of Education)

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Sustainability & UCM

Only US campus with all buildings LEED certified

One megawatt SUNPOWER solar array on 8.5 acres providing 20% of campus power and 60% of peak demand at 40% below peak power costs

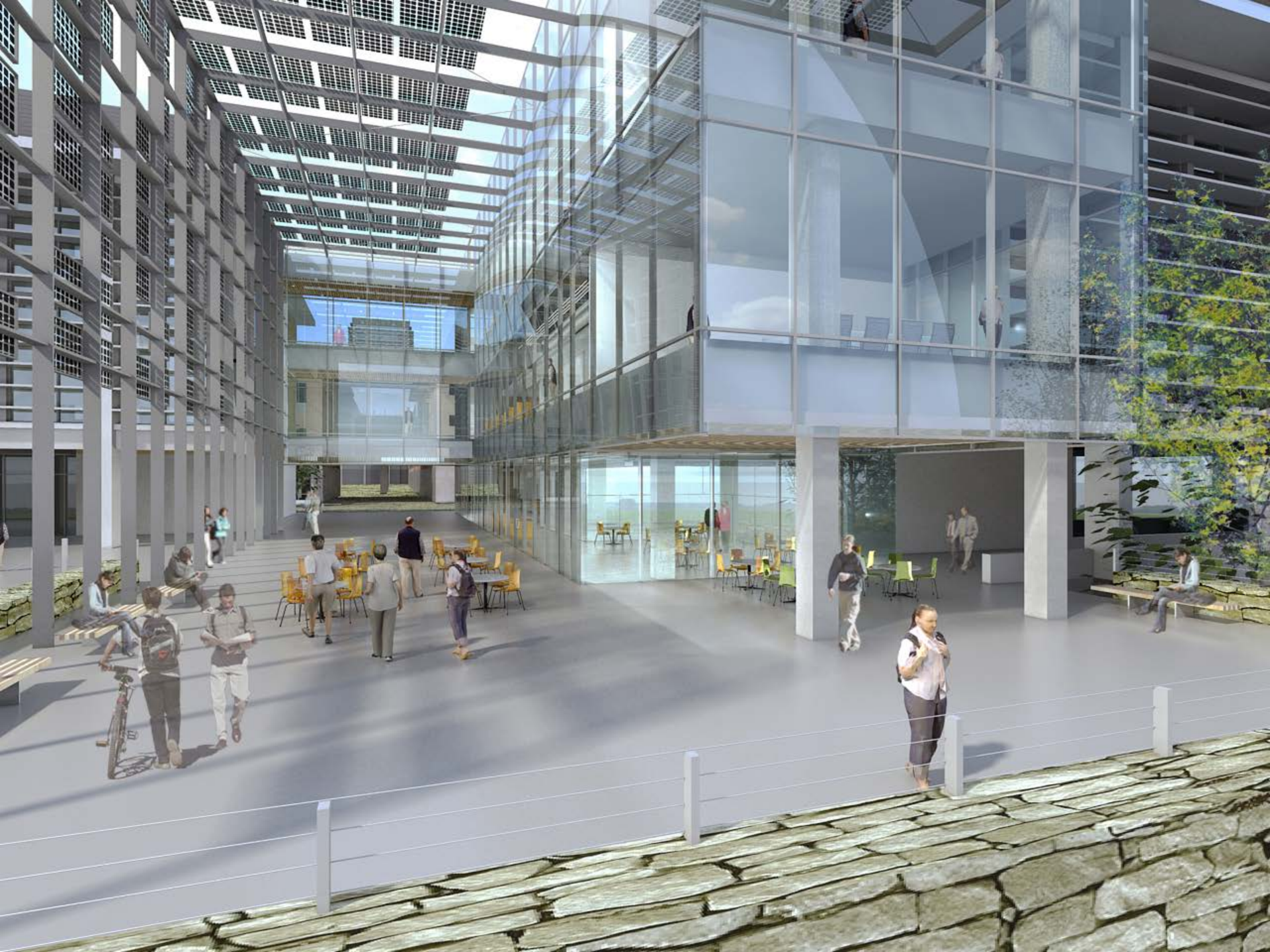
Science & Engineering 2
On track for Fall 2014 Occupancy

September Activity

Interior wall framing ongoing at all levels

Dry-in goal by Fall 2013

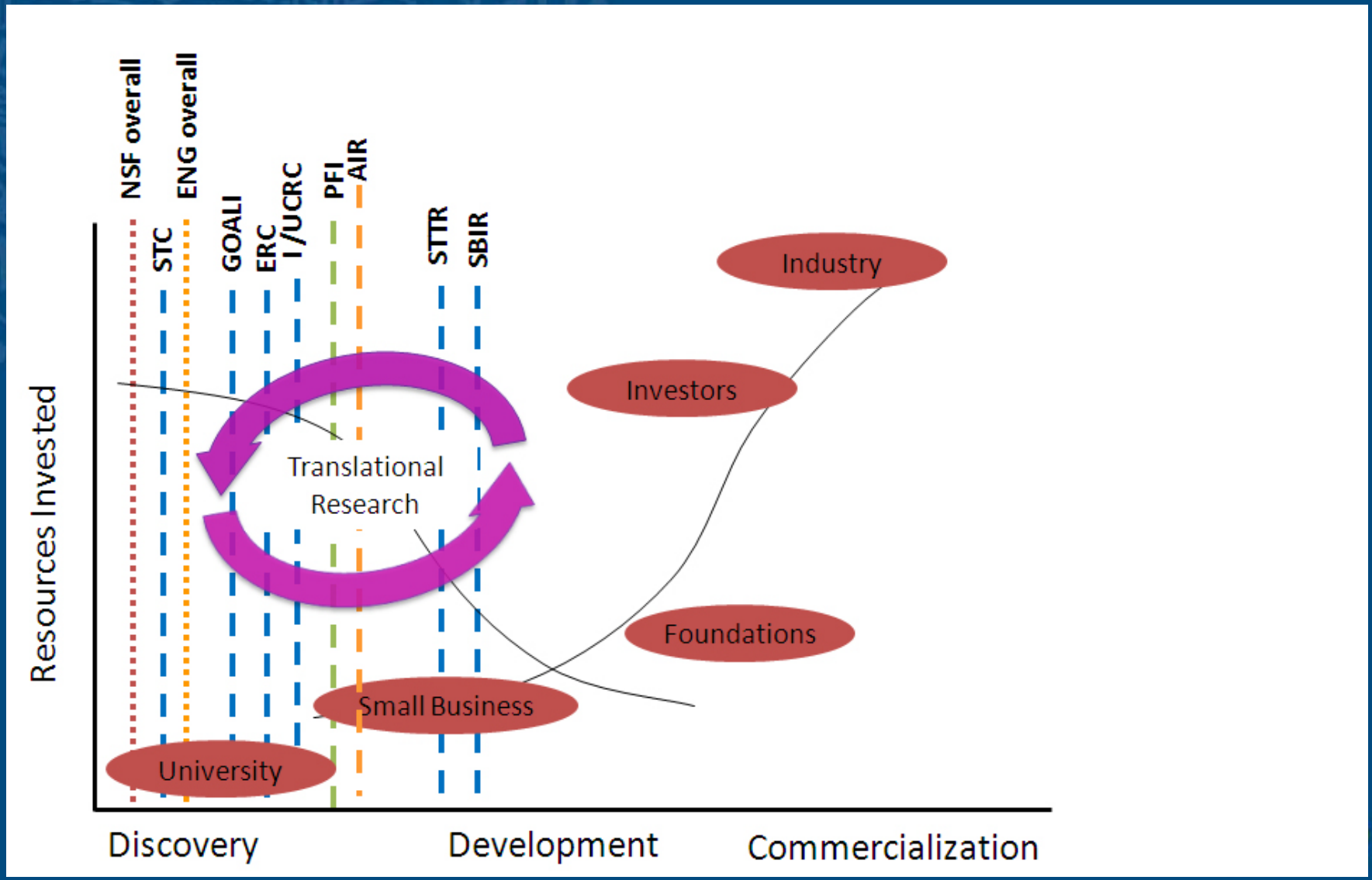
On Schedule for Fall 2014 Occupancy



University-Industry Partnerships? WHY?

- Inform/Influence Research & Education
- Targeted Recruiting
- Fill an Expertise Gap
- Acquire Knowledge/information for Problem Solving
- Funding

NSF Innovation Investments
(Dr. Tom Peterson, UCM)



Effective Practices

(Dr. Joe Gordon, AMAT, UCM EAB)

- Accept sponsored targeted graduate fellowships
- Centers with industrial members
- Industry-on-site arrangements
  - Industry Labs in Universities
- Flexible faculty consulting
  - Grant + consulting + student internship
- Encourage student and faculty leaves
  - Visiting faculty & Internships

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Challenges to Work Through
(Dr. Joe Gordon, AMAT, UCM EAB)

- IP Rights
- Indemnification
- Publication Control
- Gifts vs. Grants (Control)
- Short Tethers on Students (by faculty)

Collaboration Models: Three Case Studies

UC Solar

- UC Merced Lead Institution (Prof. Roland Winston)
- Nonimaging optics
- Solar concentration
- Solar cooling
- Solar forecasting
- Nanotech for PV
- Harness UV spectrum

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Inspection Tool Manufacturers

ADE, KLA-Tencor, Hamamatsu-Inspex
OSI, Applied Materials

Silicon Suppliers

Sumitomo

Process Tool Manufacturers

Applied Materials
(Lawrence Liv. Nat. Lab)

Consortium for Metrology of Semiconductor Nanodefects

Chip Makers

AMD, Intel,
(SEMATECH)

Calibration Materials, Methods and Standards

Duke Scientific, VLSI Standards
(ASTM, ISO, NIST, SEMI)

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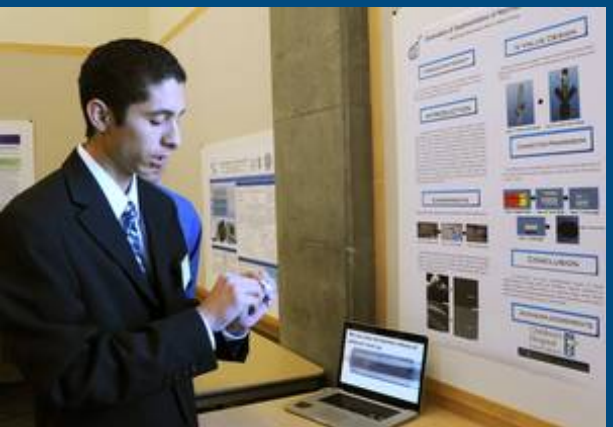
Innovation and Design Clinic

- Interdisciplinary teams
- Design, build, demonstrate project
- Innovation & tech transfer mindset
- Project Management, P/C/FDR, IP, Ethics
- Mentored & sponsored experience
- Students in IDC assign IP



2013 IDC Projects:

- Real-time Water Monitoring Network (DWR)
- UAV Sensing of Pipeline Leaks (PG&E)
- Volatile Organic Compound (VOC) Reduction (Grundfos)
- Biogas Purification System (Hilmar)
- Salt Recycling Management for SJV (DWR)
- Process Water Recycling (E&J Gallo)
- SJV Soil Salinity Mapping using UAVs (MESA)
- Heat Rejection using Irrigation Canal (UCM)
- Automated Microgrid Demand Response (LLNL)

Faculty Research: Nanotech / Energy

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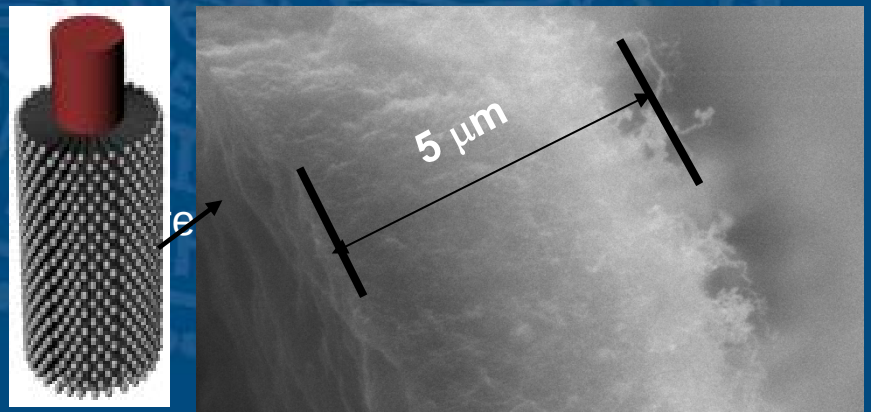
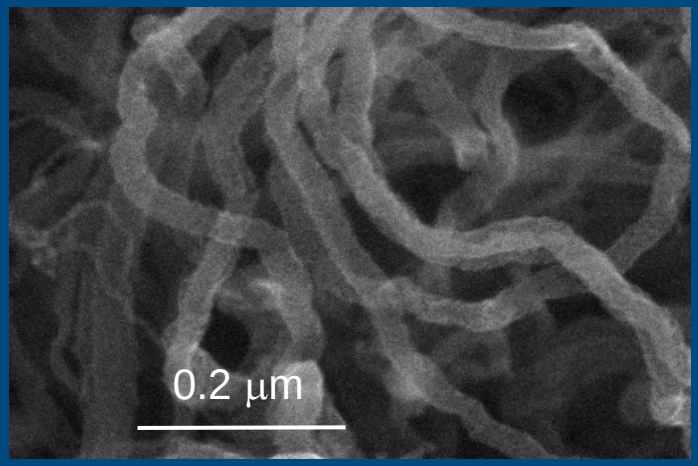
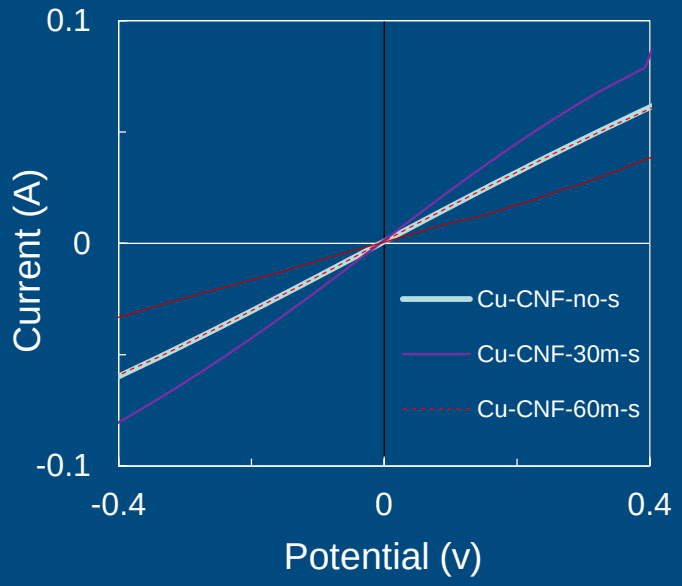
Nanoelectrodes: Direct growth of C nanofibers on Cu (Prof. Jennifer Lu)

Tuning catalyst for a well-defined and upright carbon nanofiber (CNF) array





Excellent contact with low ohmic loss



Sonication time (Min)	0	30	60	Cu to Cu
Contact Resistance (Ω)	6.5	4.8	5.7	4.4

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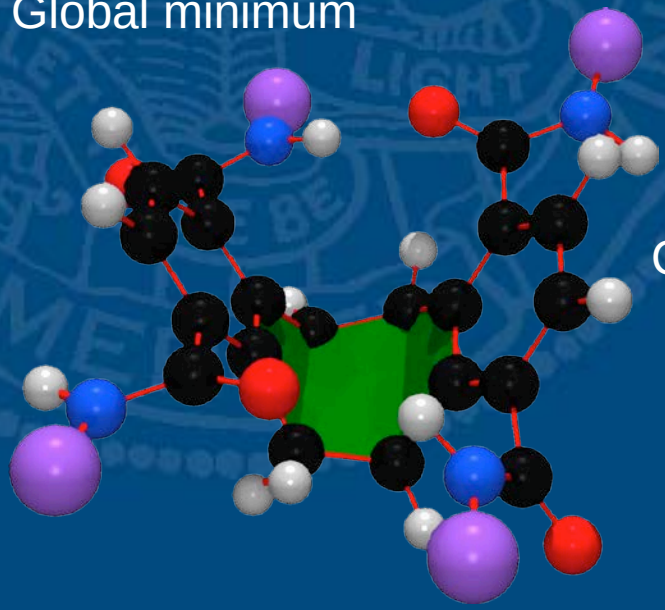
Agile Thermal Switch
(Prof. Jennifer Lu)

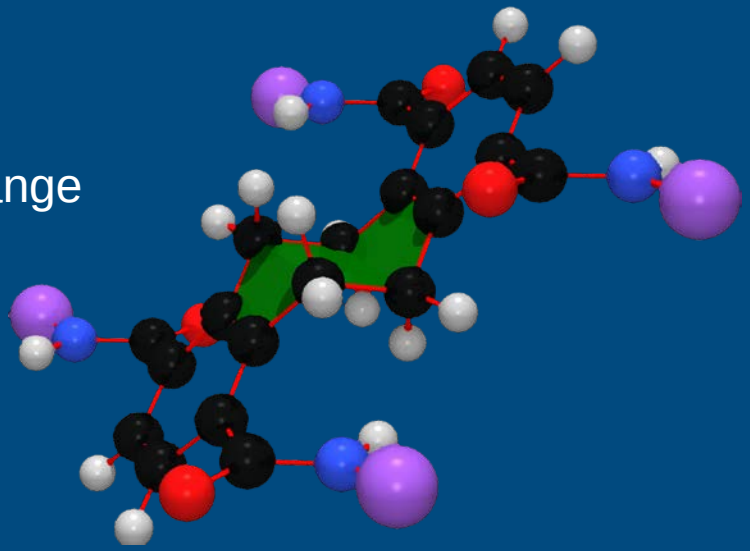
Twist Boat:
Global minimum



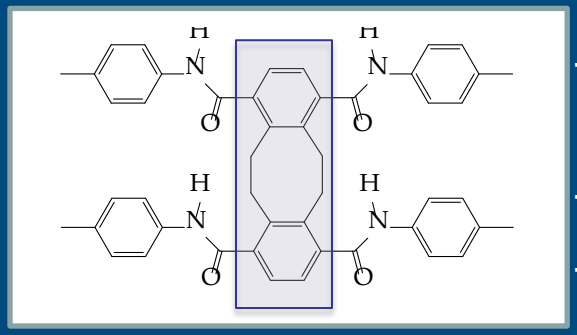
Conformational change

40% Shrinkage

Chair: Local minimum



S-dibenzocyclooctadiene



- Low energy, i.e. NIR or thermal stimulation induces contraction
- Intrinsically reversible
- No UV damage (as opposed to azobenzene photoisomerization)

J. Lu "Large negative thermal expansion of a polymer driven by a submolecular conformational change", *Nature Chemistry*, Available online, DOI: 10.1038/nchem.1780.

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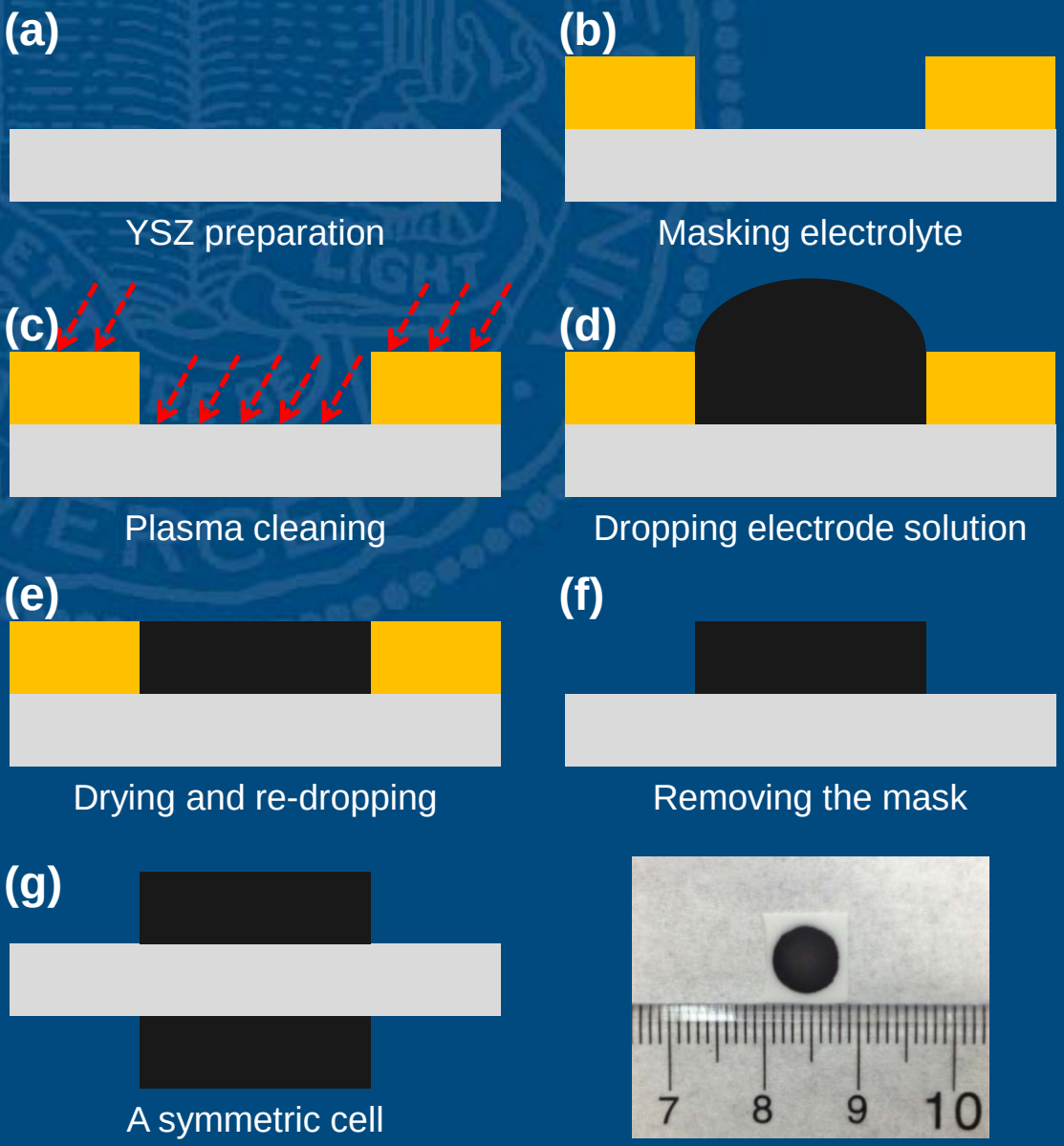

Drop casting procedure for graphene based electrodes on a Yttria-stabilized Zirconia (YSZ) electrolyte

(Prof. Min Lee)

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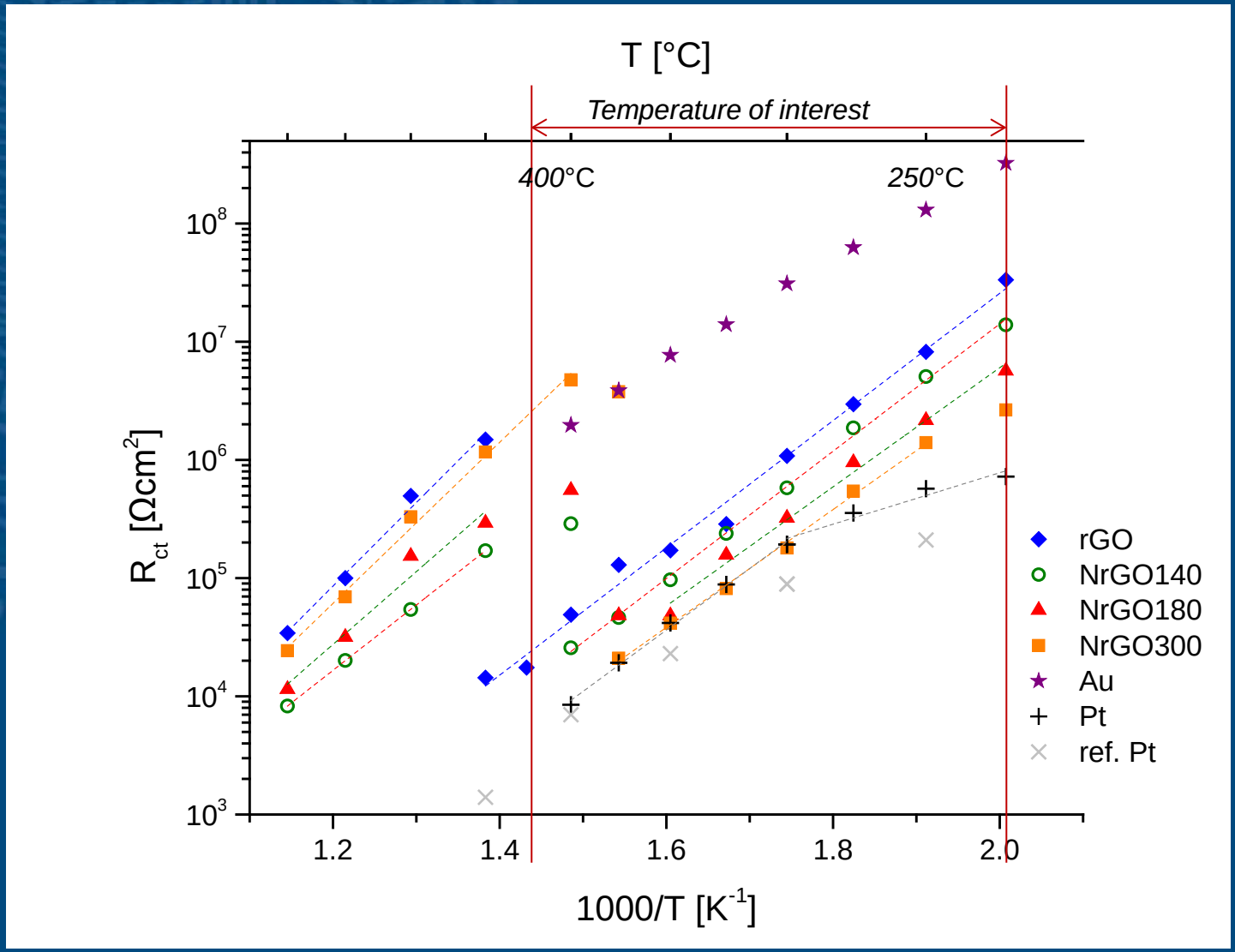

Performance comparison from EIS results,
Results from platinum-based cell shown as reference.
(Prof. Min Lee)

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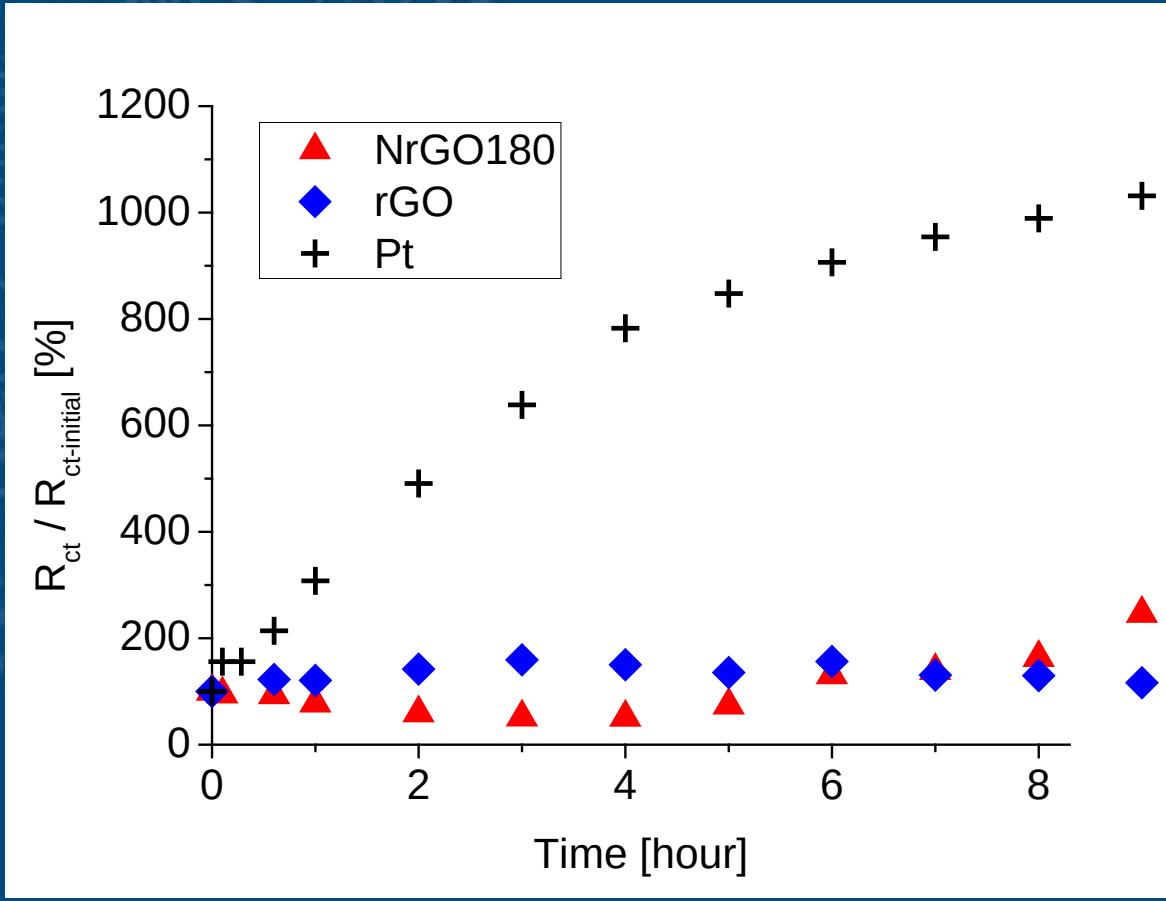

Durability with time. Graphene-based electrodes showed superior durability over platinum. (Prof. Min Lee)

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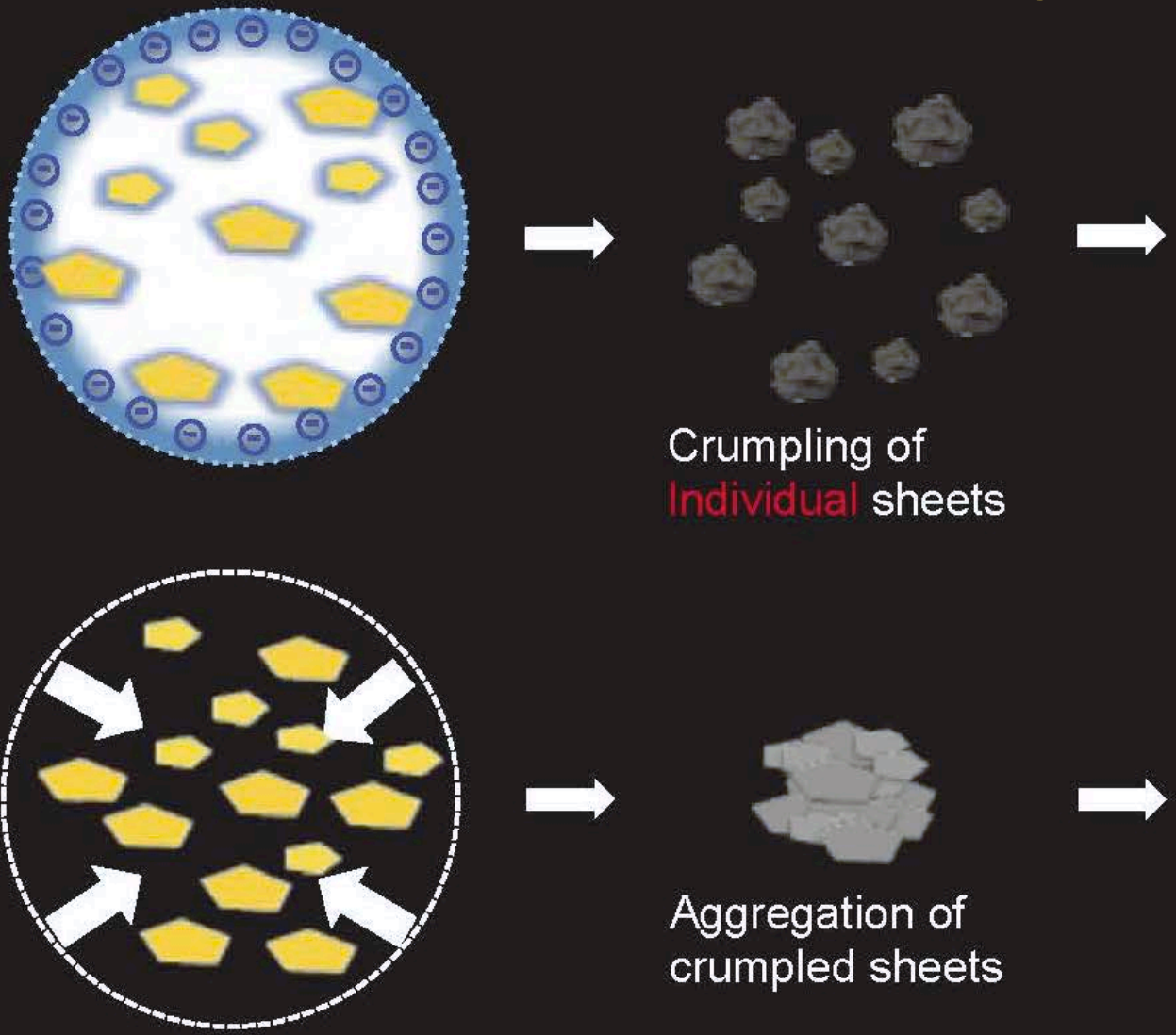
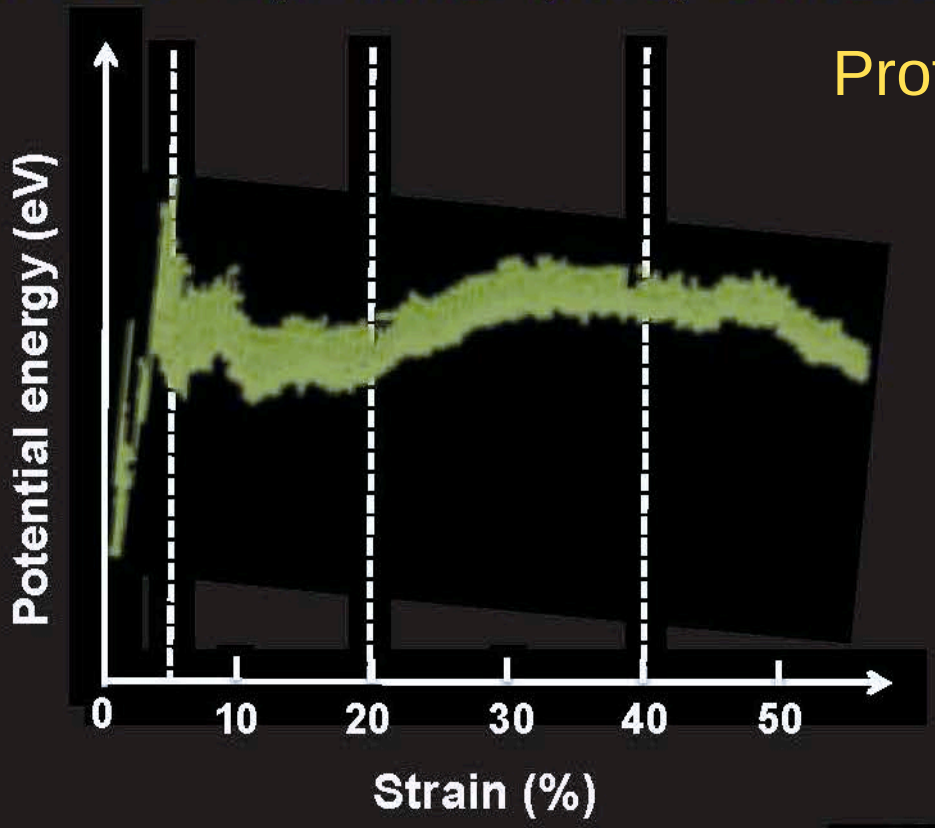
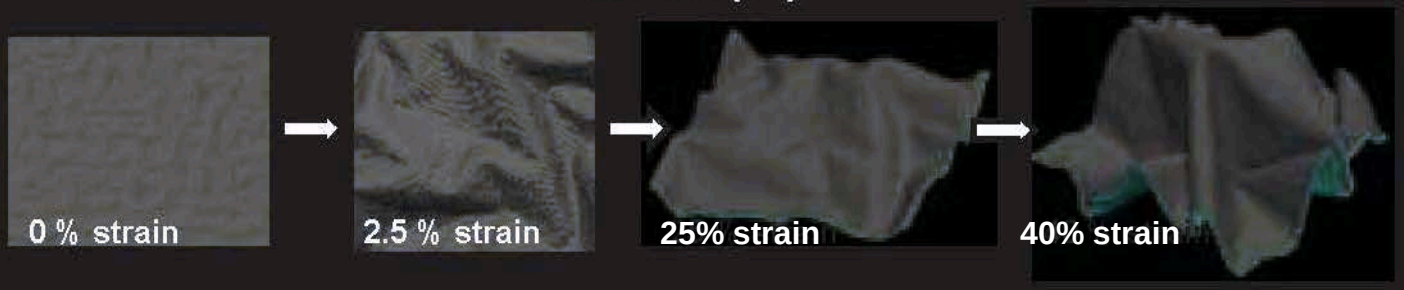
Prof. Vincent Tung



Molecular Dynamic (MD) Simulations

Prof. Vincent Tung





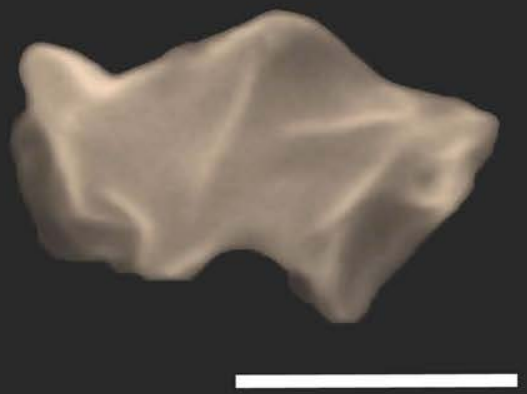
Prof. Vincent Tung

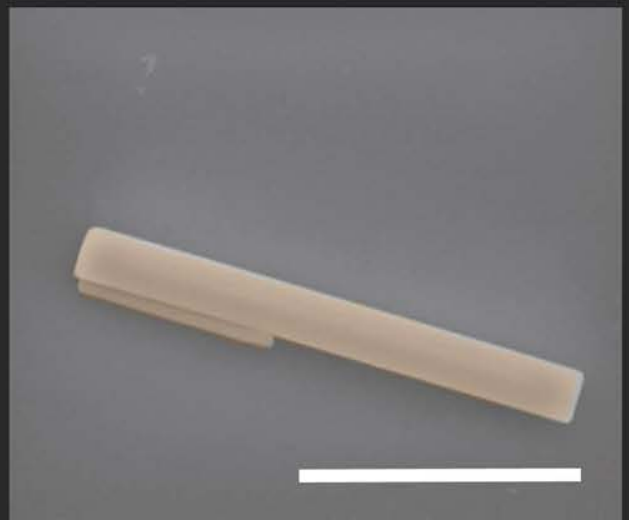
Aspect ratio, W/L, ~1

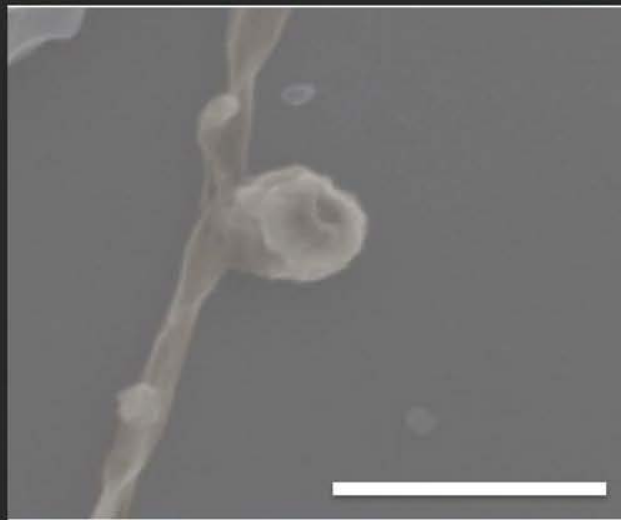
Crumples

Tubes

Knots

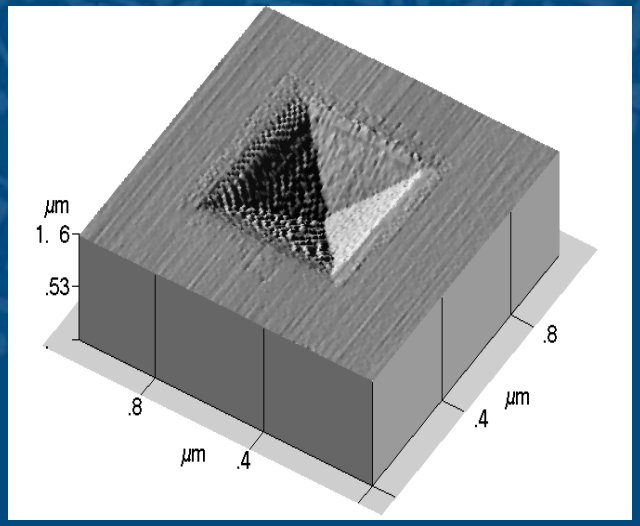






Nanofeature Metrology Challenges

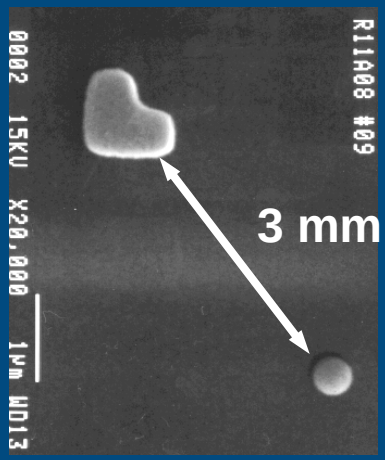
Bulk Si Defects

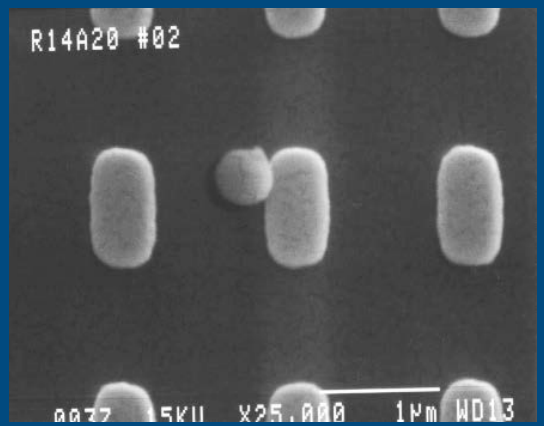


- Shape – in bulk Si octahedron formed by (111) facets
- Edge length along [110] ≅ 100 nm
- Density ≅ 5 × 10^6 cm^{-3}
- Cause – oxygen impurities during Czocralski (CZ) crystal growth
- Exposed during processing

Contamination Particles on Patterned Surfaces

482 nm PSL spheres on SRC/SEMATECH Defect Standard Si wafer. Features are 250 nm thick SiO2





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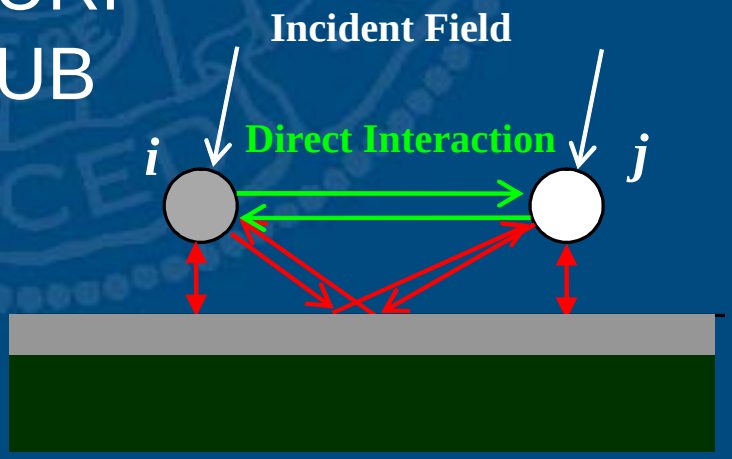
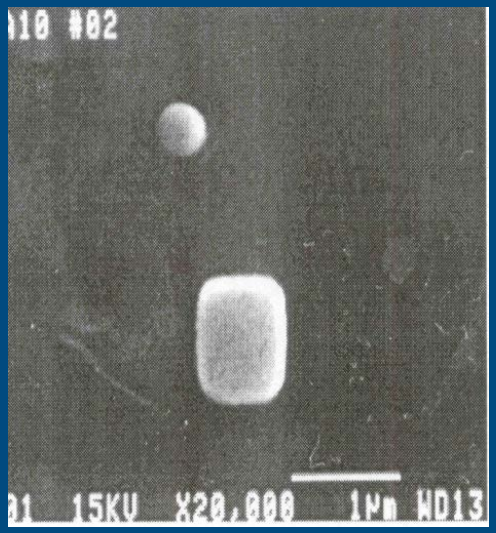
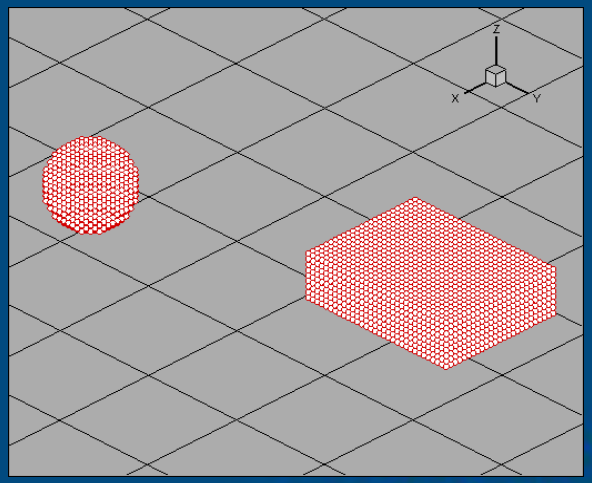
Scattering by Features on (and in) Filmed Substrate

- Discrete-dipole approx.
  DDSURF
  DDSUB

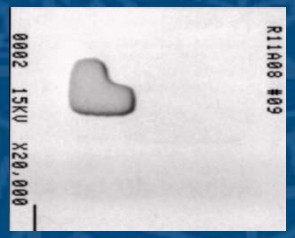




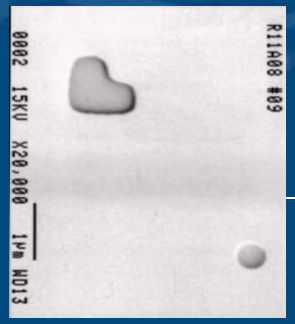
- Nonspherical, inhomogeneous features
- Sommerfeld integrals account for film



DDSURF: Interactive Scatter



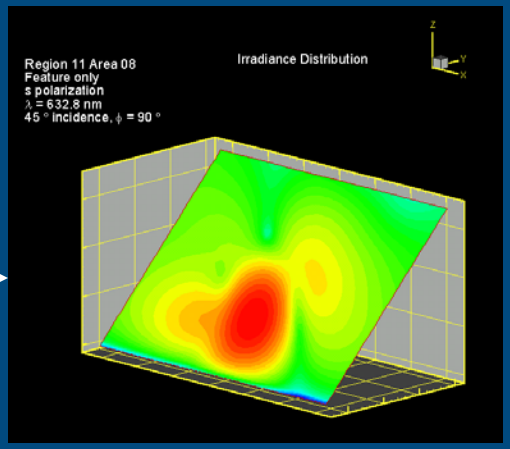
(a) feature only

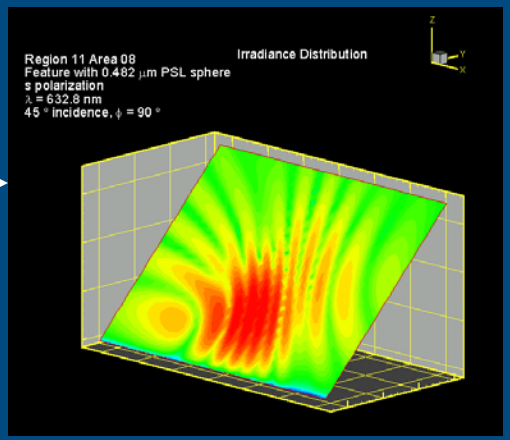


(b) SiO_2 200-nm thick "L" feature with 0.482 μm PSL sphere on a silicon surface

DDSURF
(Iterative procedure to satisfy the governing Maxwell Equations)

CREATAR
– configures dipole lattice array
DDSURF
– calculates the internal field
FFSURF
– calculates the external field





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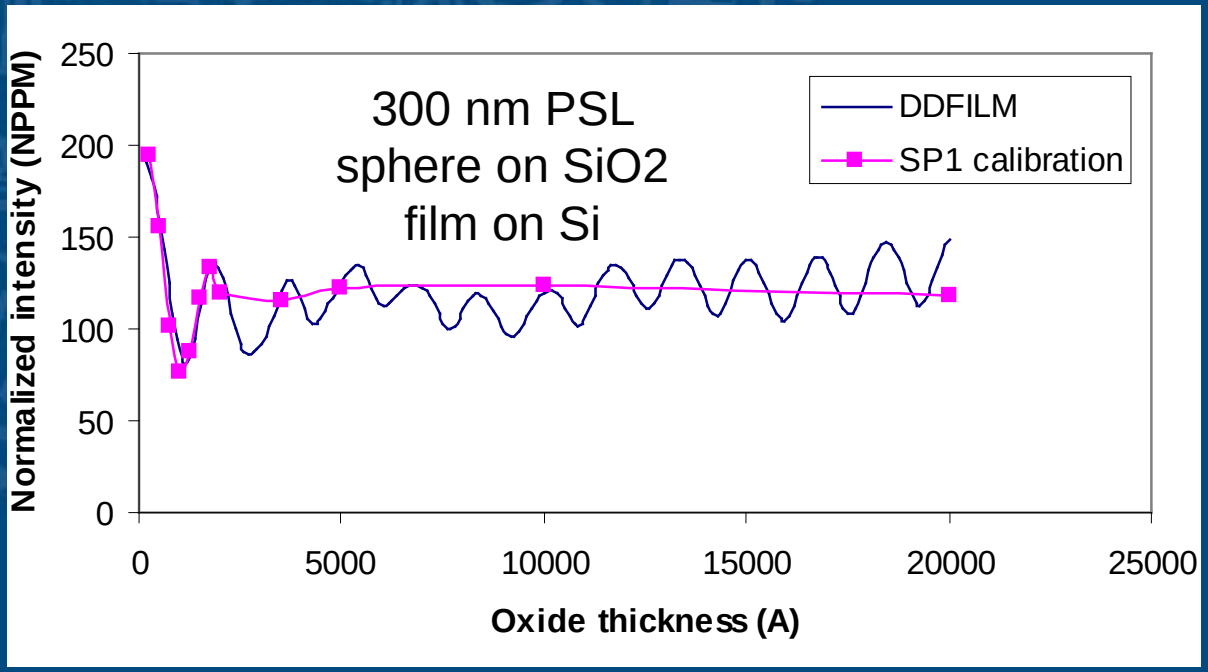
Scattering by Features on a Substrate



R. Schmehl, B. Nebeker, and E. D. Hirleman, "The Coupled-dipole Method for Scattering by Particles on Surfaces Using a 2-D FFT Technique," *Journal of the Optical Society of America: A*, V. 14, pp. 3026-3036 (1997).

E. J. Bawolek, J. B. Mohr, E. D. Hirleman, and A. Majumdar, "Light Scatter from Polysilicon and Aluminum Surfaces and Comparison with Roughness Statistics by AFM", *Applied Optics*, V. 32, pp. 3377-3400 (1993).

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Thank you!

and

Questions?

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