UNIVERSITY OF CALIFORNIA

UCMERCED

Energy Research Institute

Contributing Faculty

Jeff R. Wright, Dean

Roland Winston

Gerardo Diaz

Jennifer Lu

David F. Kelley

Carlos F. M. Coimbra

Mayya Tokman

Nonimaging Optics

- Thermodynamically efficient optics
- Solar concentration is a key technology for both thermal and photovoltaic
- Conventional solar concentrators are thermodynamically very inefficient (waste etendue)
- Solar systems that are thermodynamically efficient are more sucessful and cost effective

UC Merced's Nonimaging Optics Lab Receives $2 Million Gift

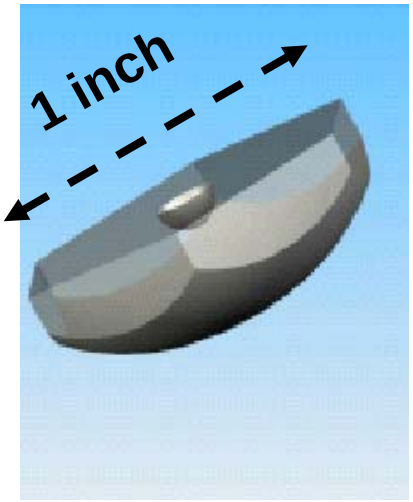
March 25, 2008

Donation will expand the university's work in clean, renewable energy

MERCED - The University of California, Merced, has received a $2 million gift from the California Community Foundation (CCF) to support the university's Nonimaging Optics (NIO) Lab, a facility developing new technologies that are improving the potential for solar resources to supply a substantial fraction of the world's energy needs.

Present and future concentrating PV systems…

… show a clear trend to miniaturization



PALO ALTO WATER
SolFocus Array

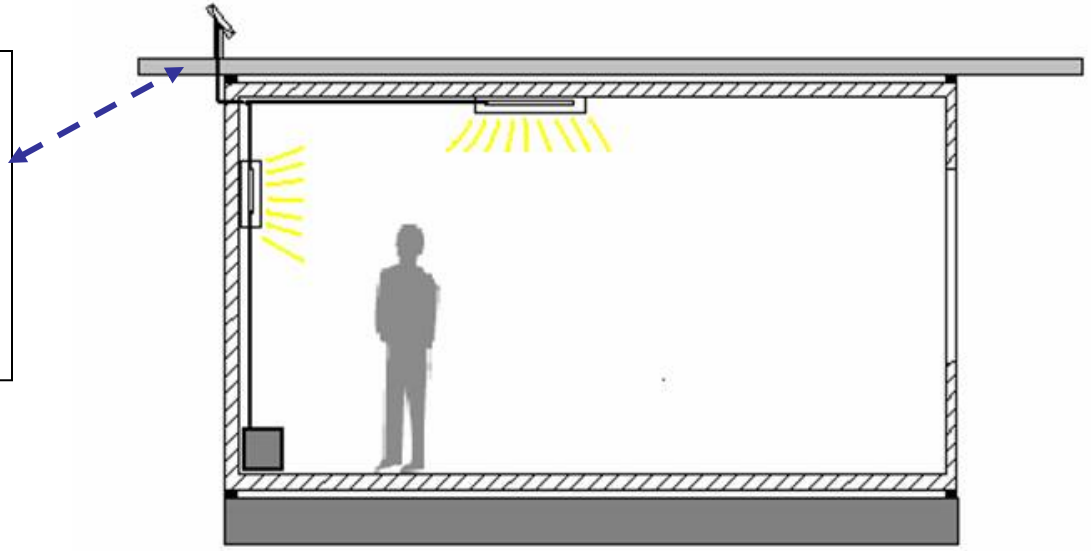
XCPC Solar Thermal Collector at UC Merced Solar Testing Facility

Solar Lighting Research at UC Merced

Concentrated and filtered natural daylight

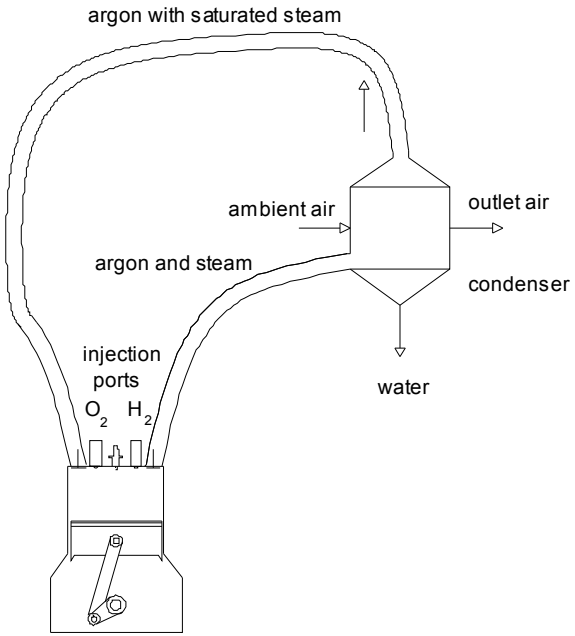
is conveyed to the interior

through a light pipe with minimal roof penetration

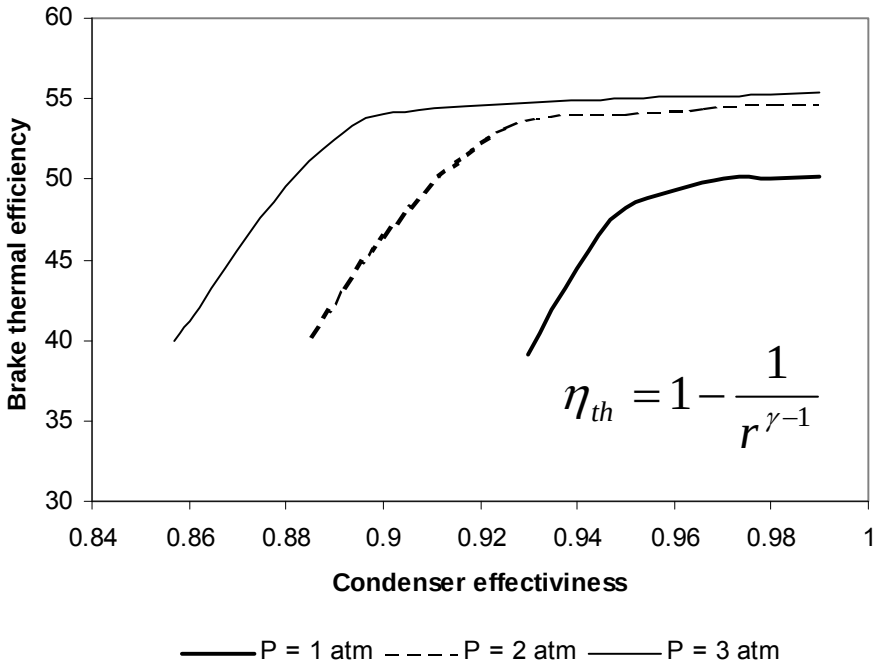


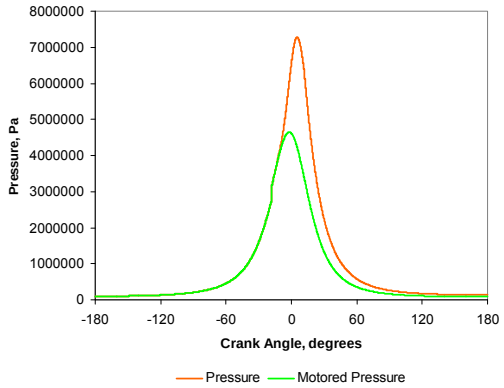
Energy at UC Merced (Prof. Diaz)

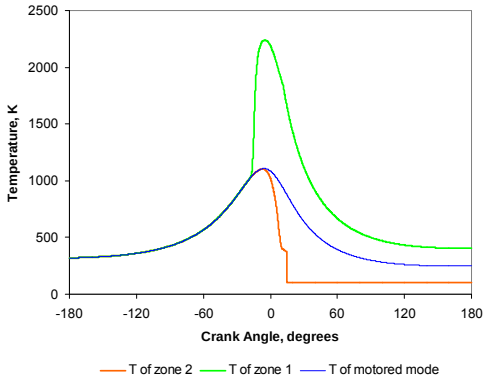
Project: Combustion in a H_2-O_2-Ar internal combustion engine (Sponsor: Lawrence Livermore National Lab)



spark ignated engine



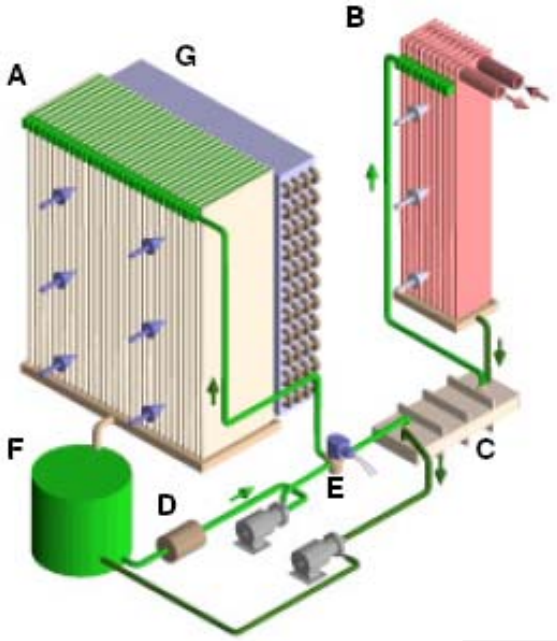




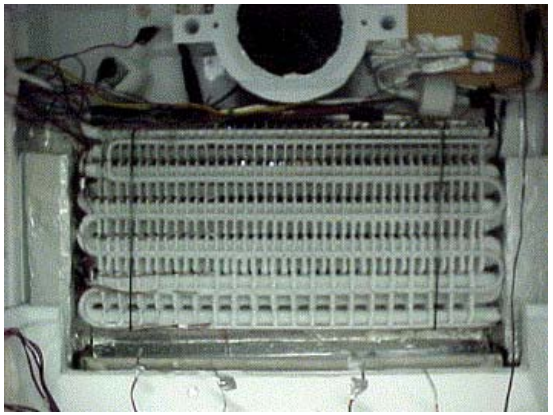
<u>Purpose</u>:
Increase efficiency and reduce emissions in internal combustion engines

Energy at UC Merced (Prof. Diaz)

Project: Integrated hybrid refrigeration system using liquid desiccants (Sponsor: California Energy Commission)



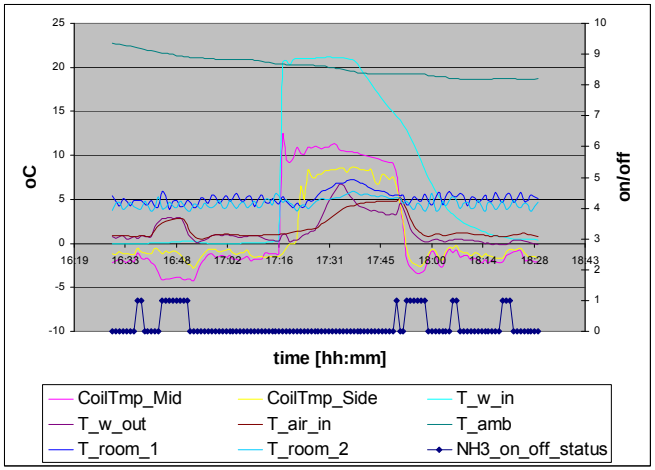
by AIL Research

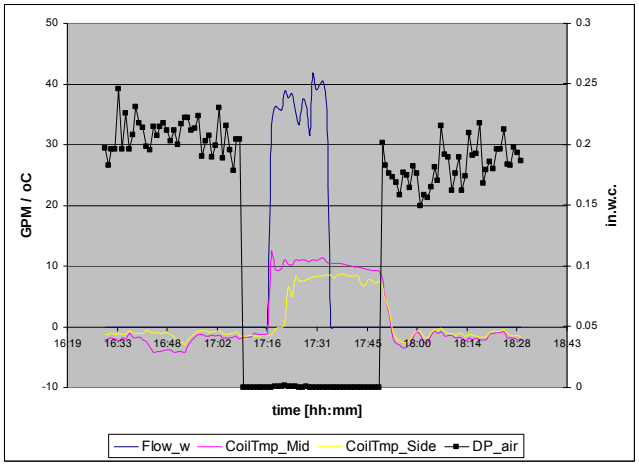


Ozkan and Ozil (2006)

Aslan Cold Storage and Del Monte products

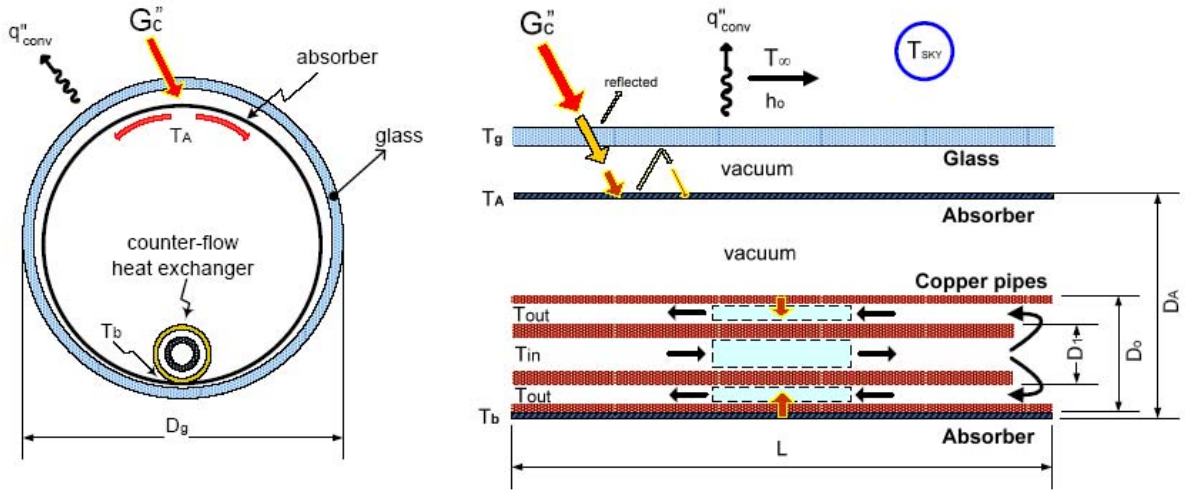
<u>Purpose</u>:
Reduce energy and water consumption in the food industry



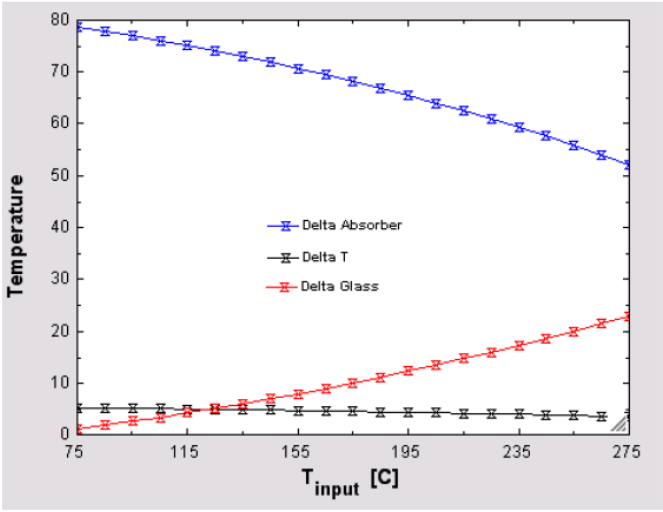


600 gallons of water used per defrost cycle

Collaboration: Development of low-cost, high temp. solar collectors for mass production (Sponsor: CEC, PI: R. Winston)



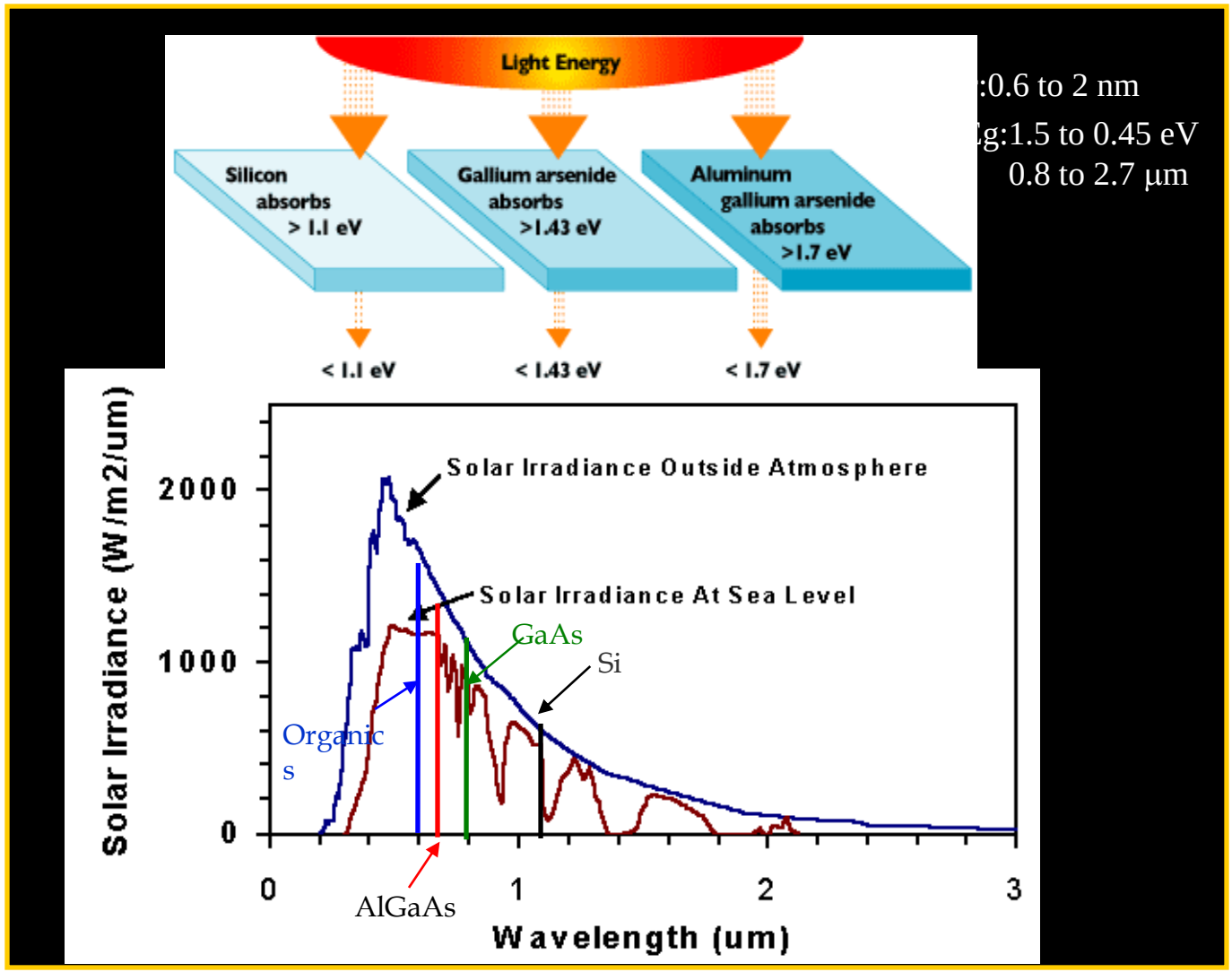
G_s [W/m2]	T_{output} [C]	δT [K]	$T_{absorber}$ [C]	$T_{absorber}$ [C]	T_{base} [C]	T_{glass} [C]	T_{glass} [C]	q_{cond} [W]	Eff_{total}
1000	80.17	5.171	153.6	78.58	102.8	28.12	1.124	221.9	0.7881
1100	80.69	5.69	161.5	86.46	105.5	28.92	1.921	244.1	0.7883
1200	81.21	6.206	169.3	94.3	108.3	29.74	2.744	266.2	0.7881
1300	81.72	6.719	177.1	102.1	111.1	30.59	3.595	288.3	0.7877
1400	82.23	7.23	184.9	109.9	113.8	31.47	4.473	310.2	0.7871
1500	82.74	7.739	192.6	117.6	116.5	32.38	5.378	332	0.7863
1600	83.25	8.245	200.3	125.3	119.3	33.31	6.311	353.7	0.7854
1700	83.75	8.749	208	133	122	34.27	7.271	375.3	0.7844
1800	84.25	9.25	215.6	140.6	124.7	35.26	8.259	396.8	0.7832
1900	84.75	9.749	223.1	148.1	127.3	36.28	9.275	418.2	0.782
2000	85.24	10.24	230.7	155.7	130	37.32	10.32	439.5	0.7807



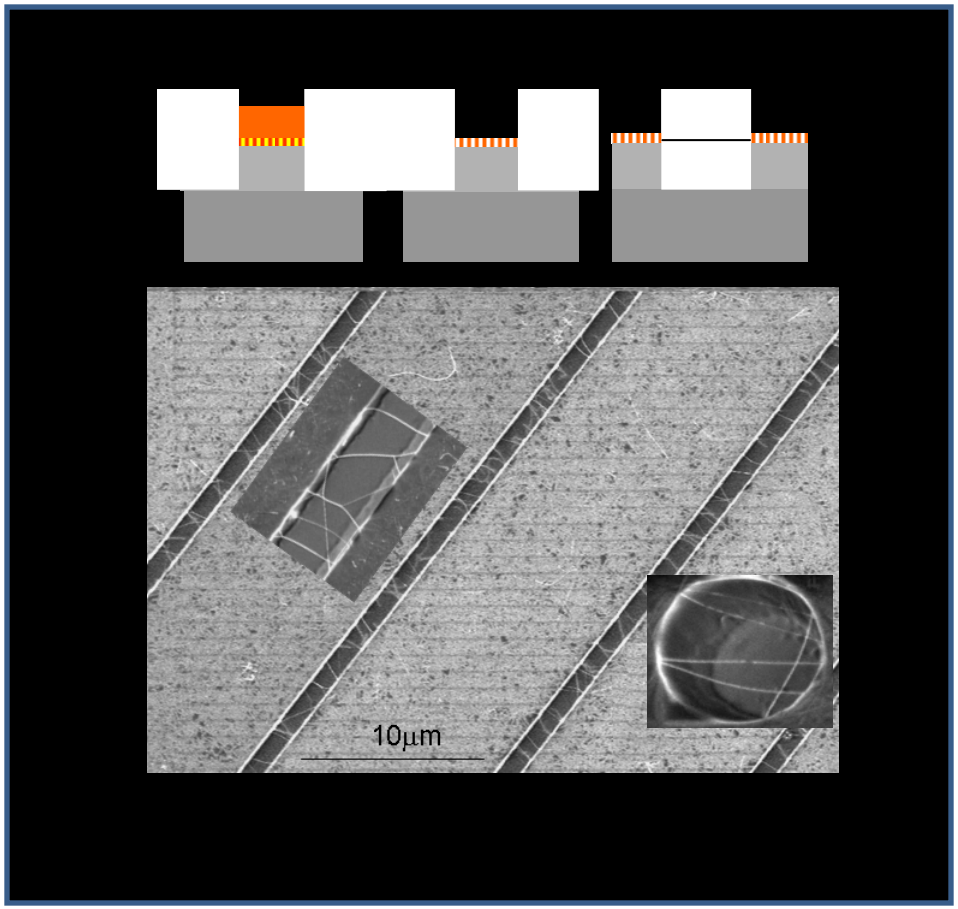
Conventional Photovoltaic Devices

Jennifer Lu

Most PV cells use < 55% of the energy of sunlight, because this energy is either less than the bandgap of the material or carrier excess energy

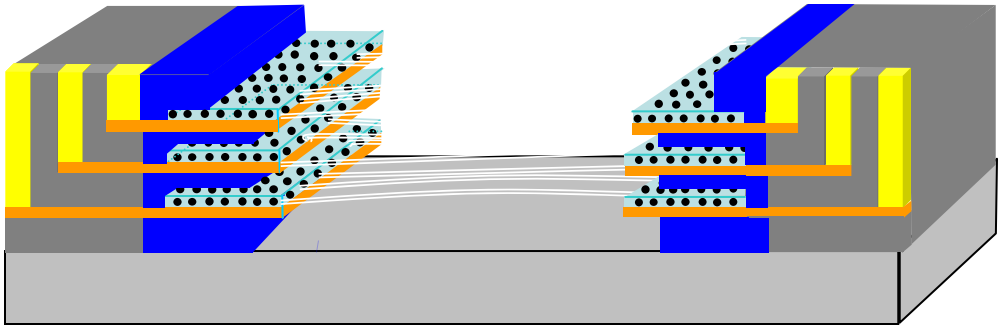


Suspended CNTs



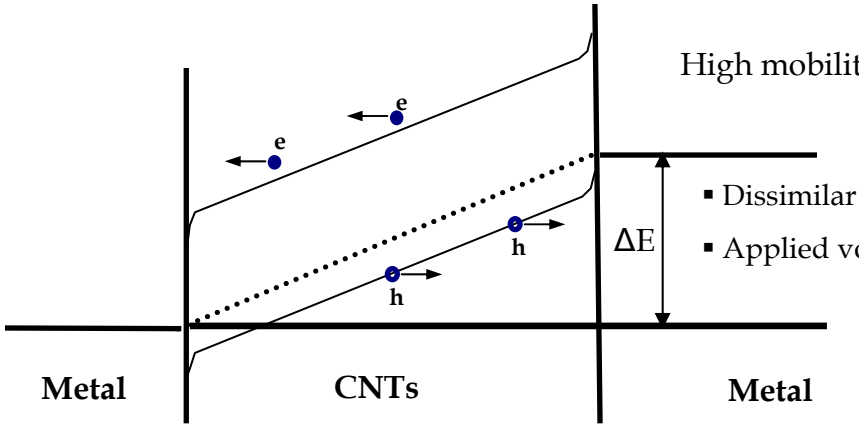
3D Suspended CNTs

Direct bandgap material with very high absorption of almost entire solar spectrum and stable



- Photodetector
- Solar cell
- Biological Sensor
- Transistor

Sacrificial layer Metal contact High refractory metal Catalyst

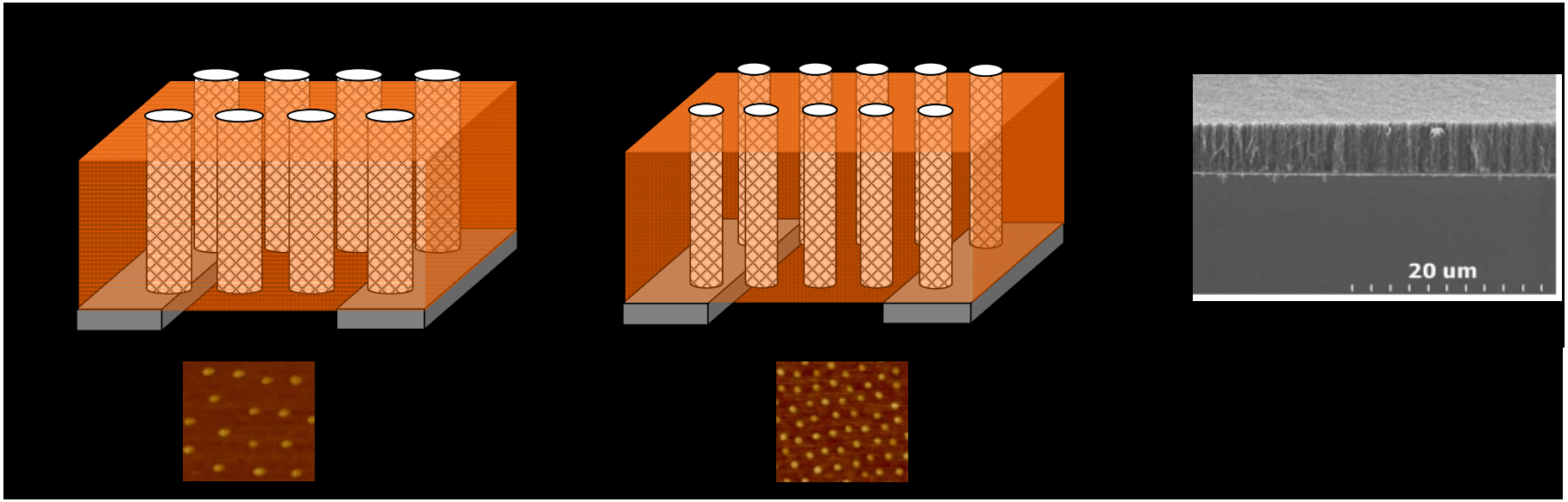


High mobility and intrinsic long recombination time

- Dissimilar metals
- Applied voltage bias

Vertically Aligned CNT Composites

Utilization of smooth inner walls for gas separation/purification/storage

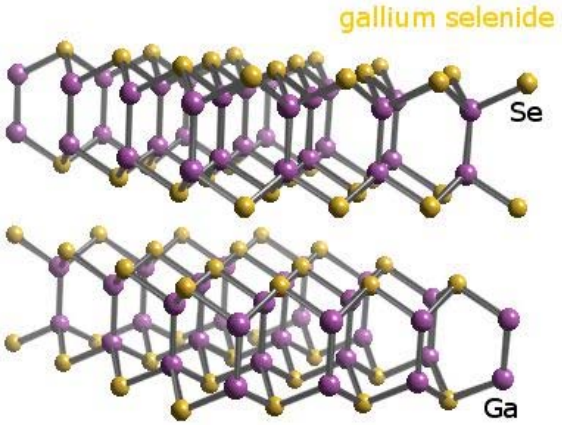


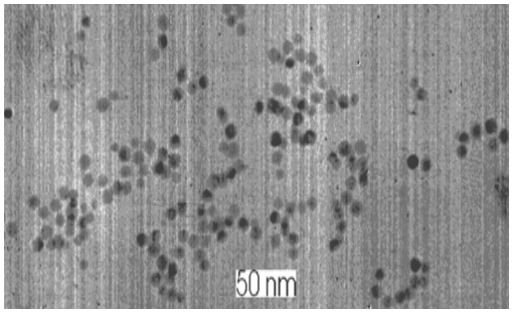
Channel size, CNT diameter can be tuned by catalyst size

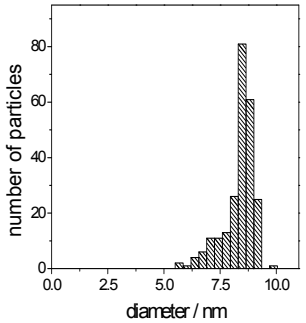
Nanoparticle size (nm)	CNT diameter (nm)
2.2 (±0.1)	1.1(±0.4)
3.8 (±0.2)	1.7(±0.5)

David F. Kelley - Spectroscopy and dynamics of two-dimensional semiconductor quantum dots

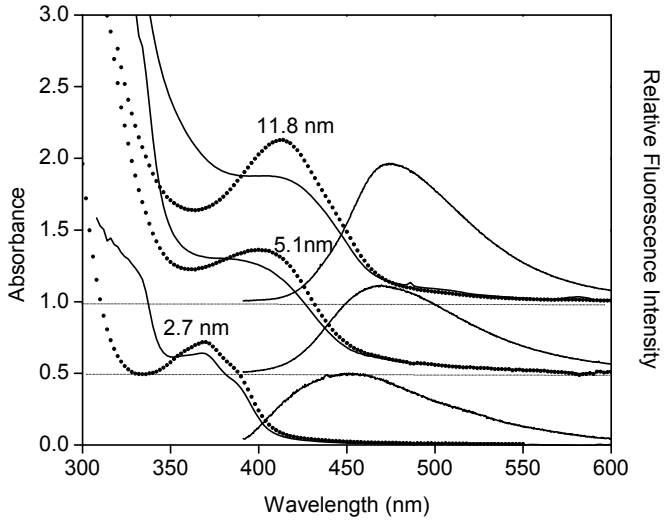
The Kelley research group has focused on two-dimensional semiconductor nanoparticles, specifically GaSe. The crystal structure is depicted to the right, and TEM images, below.





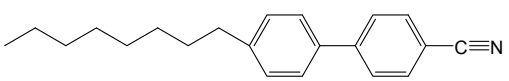


The nanoparticles are two-dimensional, single tetra-layer (Se-Ga-Ga-Se) sheets. These particle strongly absorb and emit light. Their spectra are strongly size dependent, as shown in the spectra on the right. Particle aggregation causes the spectra to be size dependent, and aggregate spectra are shown with dotted curves (right).



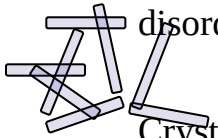
Organic Liquid Crystals(4-octyl, 4'-cyano biphenyl, 8CB) doped with GaSe nanoparticles

8CB

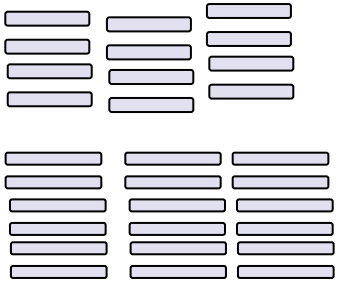


Smectic-A 20 – 34 °C orientational and z- positional order (aligned, disordered layers)

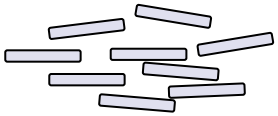
Isotropic > 41°C true liquid – no positional or orientational order



Crystalline < 20 °C completely ordered

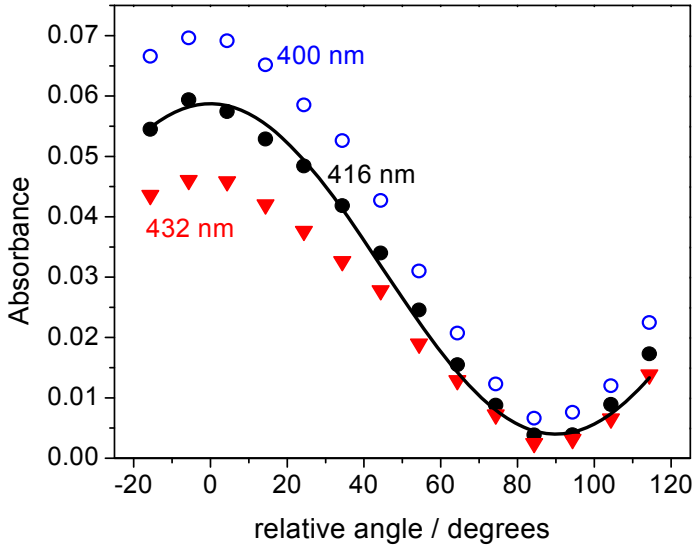


Nematic 34 – 41°C orientational but no positional order



8CB lines up along the "director axis" in the nematic, smectic-A and crystalline phases. The director axis is established be local electric fields. The nanoparticles are aligned by the liquid crystal environment. The figure at the right shows the sample absorbance as a function the angle between the polarization of the light and the liquid crystal director axis.

Exciton transport is rapid through the aligned nanoparticle aggregate.



The Solar Irradiation Mapping Initiative (SIMI)

Forecasting Solar Power Availability in Real-Time for California

UC Merced

The Solar Irradiation Mapping Initiative (SIMI) is a new effort of the Merced Energy Research Institute (MERI) and the Schools of Engineering of UC Merced and UC Davis.

SIMI is an ongoing research project that combines the processing of satellite data, weather radar information and data from ground solar stations and sensors to determine and forecast solar energy availability for the entire state of California.

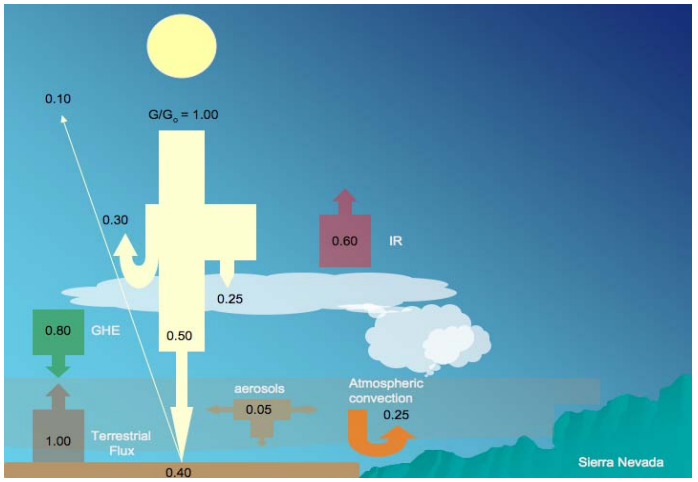
Research Team

Carlos F. M. Coimbra (solar observatories and system integration), Associate Professor of Mechanical Engineering and Applied Mechanics, UC Merced

Qinghua Guo (GIS and satellite data processing), Assistant Professor of Environmental Systems, UC Merced

Alberto E. Cerpa (distributed sensor networks), Assistant Professor of Electrical Engineering and Computer Science, UC Merced

Jean-Pierre Delplanque (instrumentation and ground data support), Associate Professor of Mechanical and Aeronautical Engineering, UC Davis



The determination of the direct normal irradiance (DNI) at the ground level involves complex mechanisms that are mostly influenced by the lower atmosphere.

The SIMI Concept

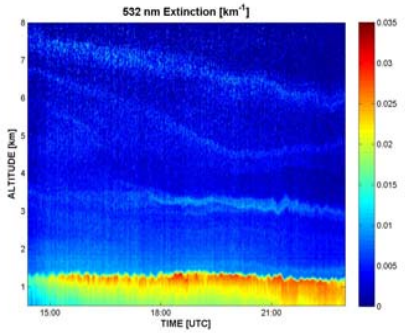
remote sensing

+

ground solar stations

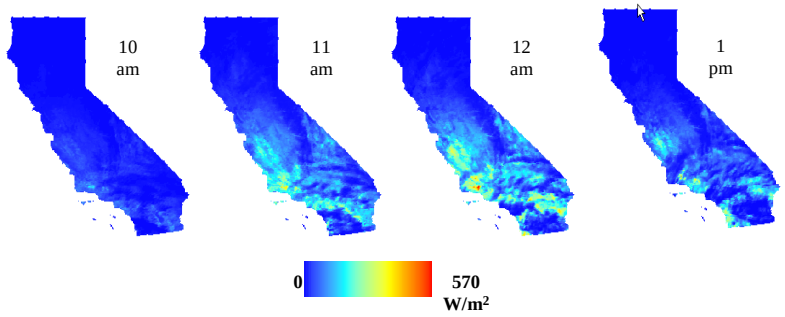
+

radar data and network of low-cost sensors



Benefits of SIMI: Through a unique design of solar observatories, low-cost sensors, and data integration, SIMI will provide real-time and prospective solar power availability information for solar-based technologies for the state of California. The data will also aid in decision-making regarding installation, incentives and policies for solar technologies through the consideration of several geographical and financial constraints. The information from SIMI's Web-based GIS (Geographic Information System) will facilitate the promotion and management of solar energy utilization in California, and will provide unique capacity for CA utility companies to manage efficiently the power grid in our state.

Forecasting Capability for DNI and Global Irradiance for the entire state of California (shown below is the DNI for 1/1/2008 at four different times of the day)



Global Energy & Security
Pilot Graduate Program

Mayya Tokman

University of California, Merced



Motivation & Proposal:

Growing energy and water needs, energy security, nuclear proliferation and climate change are some of the crucial challenges of today's society. *These issues will have to be addressed by the workforce of the 21st century.*

UC Merced proposes establishment of a graduate program designed to accommodate the increasing interdisciplinary and international demands on professionals working on energy, environmental and security issues.

Global Curriculum:

A flexible and interdisciplinary curriculum of the two-year Masters Program will be supported by a consortium of universities around the world. Participants include:

- University of California, Merced (UC Merced) [in collaboration with Lawrence Livermore National Laboratory (LLNL)]

Program Composition:

The pilot program will focus on the following four areas:

- ENERGY AND ECONOMY
  - *Energy and Sustainable Development*
  - *World Energy markets and Energy Econometrics*
  - *Economy of Advanced Energy Technologies*
- ENERGY AND ENVIRONMENT
  - *Fossil Fuels and Global Warming*
  - *Renewable Energy Sources*
  - *Energy and Green Politics*
- ENERGY AND SECURITY
  - *Nuclear Power and Nuclear Weapons Proliferation*
  - *Energy and International Conflicts Resolution*
  - *Energy Systems and Terrorism*
- ENERGY MANAGEMENT
  - *Energy Strategic Planning and National Energy*
  - *Management of Energy Projects/Innovations*
  - *Energy Emergency Management*