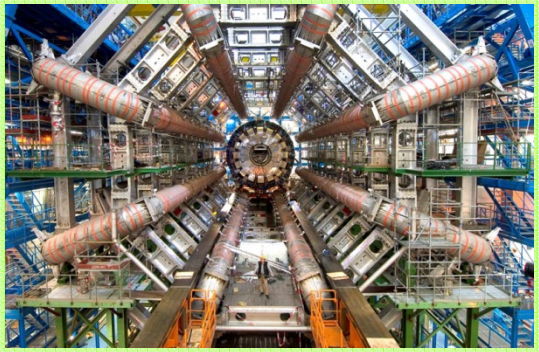
SAND2015-8030PE

# The Advanced Materials Lab at Sandia National Laboratories

Bryan Kaehr and Stan Chou
Advanced Materials Laboratory
Sandia National Laboratories
Albuquerque NM

A career in science:

## Build gigantic experiments to study the smallest things



PHYSICS

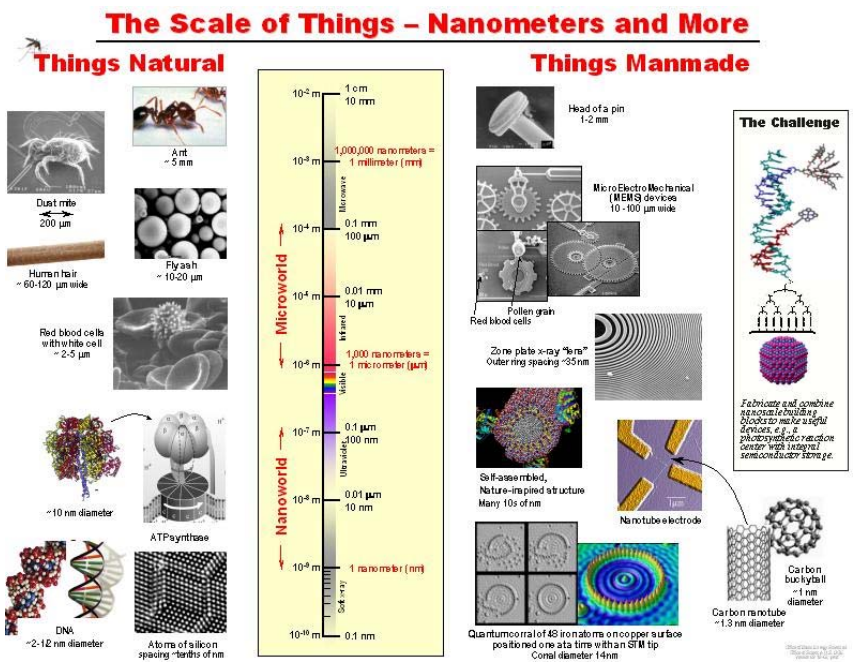
## Explore and understand our planet

BIOLOGY

## Invent new materials and technologies

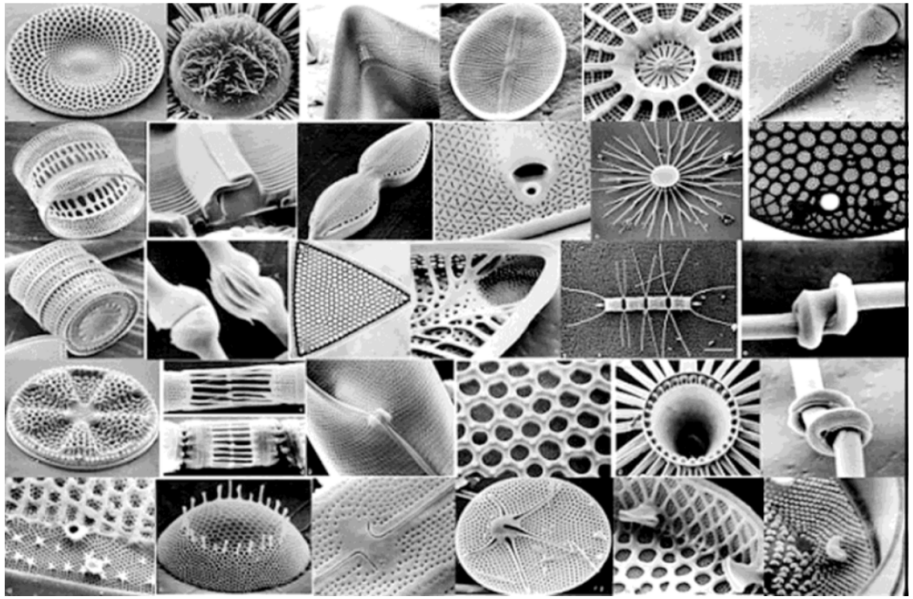
CHEMISTRY

Our work: Chemistry and Materials Science



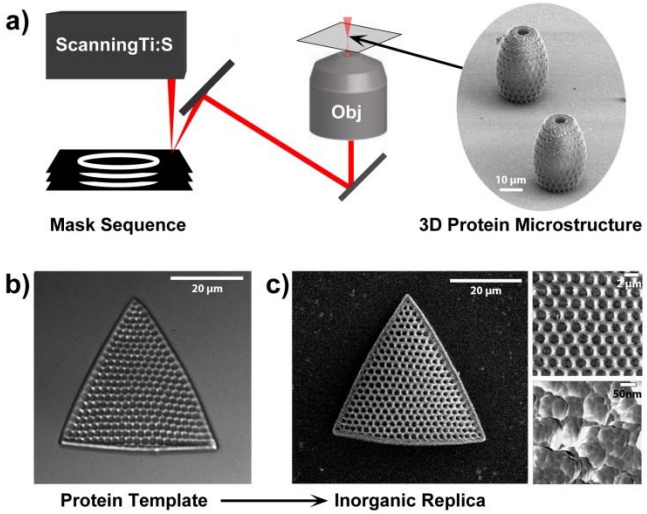

## Chemists want to learn from biology

Diatoms: algae that make nano-glass. How??



JOURNAL OF MICROELECTROMECHANICAL SYSTEMS, VOL. 16, NO. 2, APRIL 2007

Lasers & Chemistry

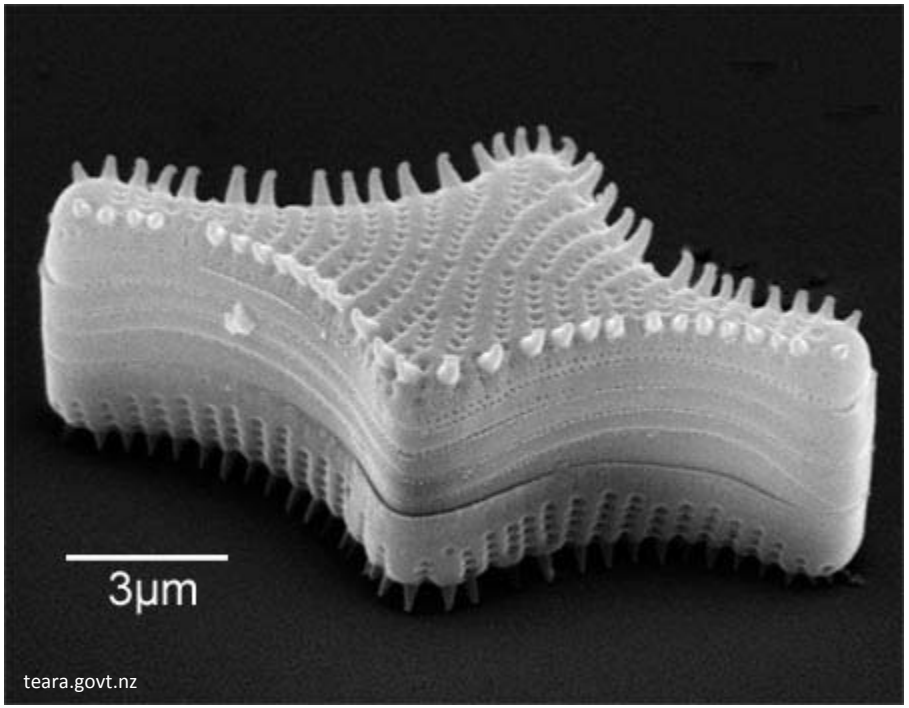



Working in a lab

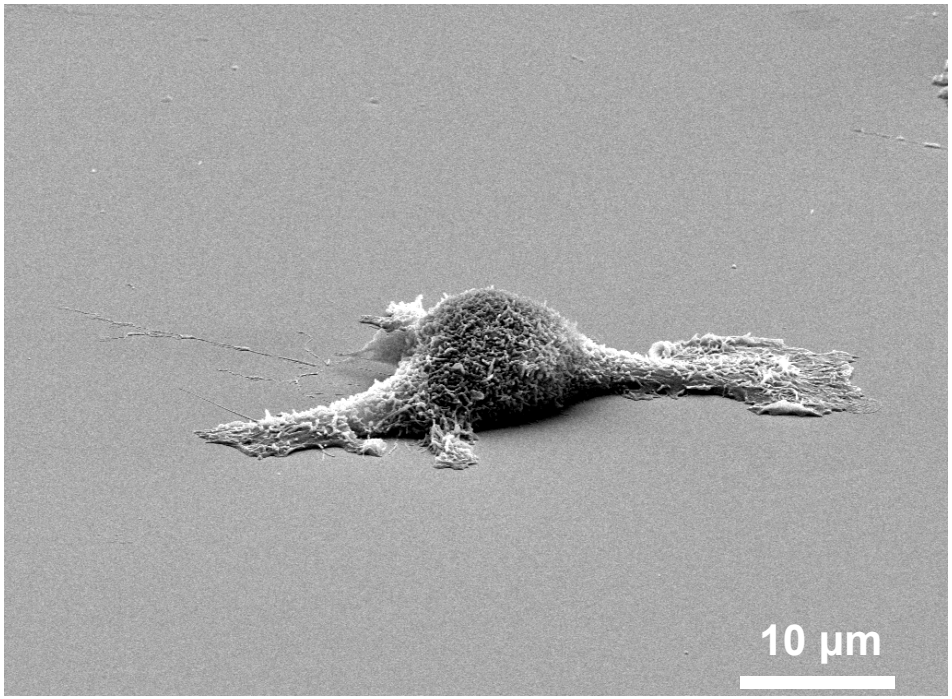
Thinking, analyzing, collaborating, writing

**Diatoms –**
unicellular
phytoplankton

lake-savers.com



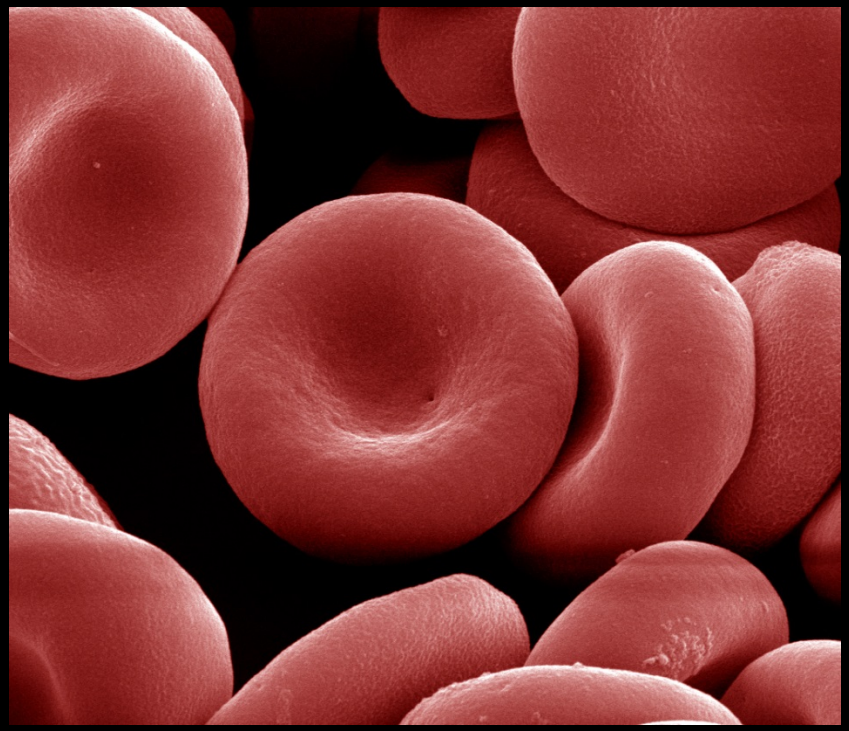

Diatom frustule




Animal cell frustule

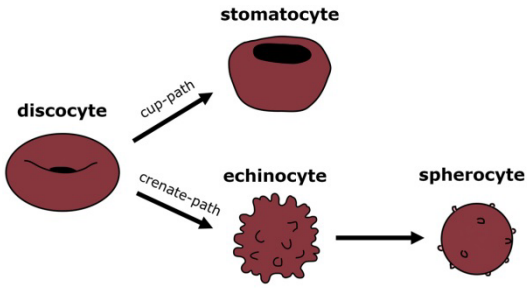

- Kaehr, B., Townson, J.L., Kalinich, R.M., **Awad, Y.H**., Swartzentruber, B., Dunphy, D.R., Brinker, C.J. (2012) Cellular complexity captured in durable silica biocomposites, *Proc Natl Acad Sci* USA**,** 109 (43) 17336-17341.
- Townson, J.L., Lin, YS. Chou, S., **Awad, Y.H.,** Coker, E.N., Brinker, C.J., Kaehr, B., (2014) Synthetic fossilization of soft biological tissues and their shape-preserving transformation into silica or electron-conductive replicas, *Nat*. *Commun.* 5:5665 doi: 10.1038/ncomms6665

Example: Red blood cells (RBCs)

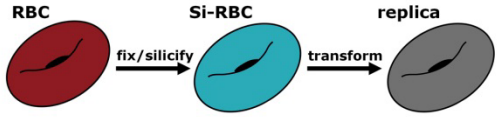


# Translation of encoded shapes into composites: **Si-RBCs**

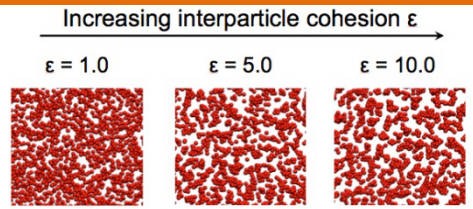
**generate shape**




**Translate to Si-RBC**



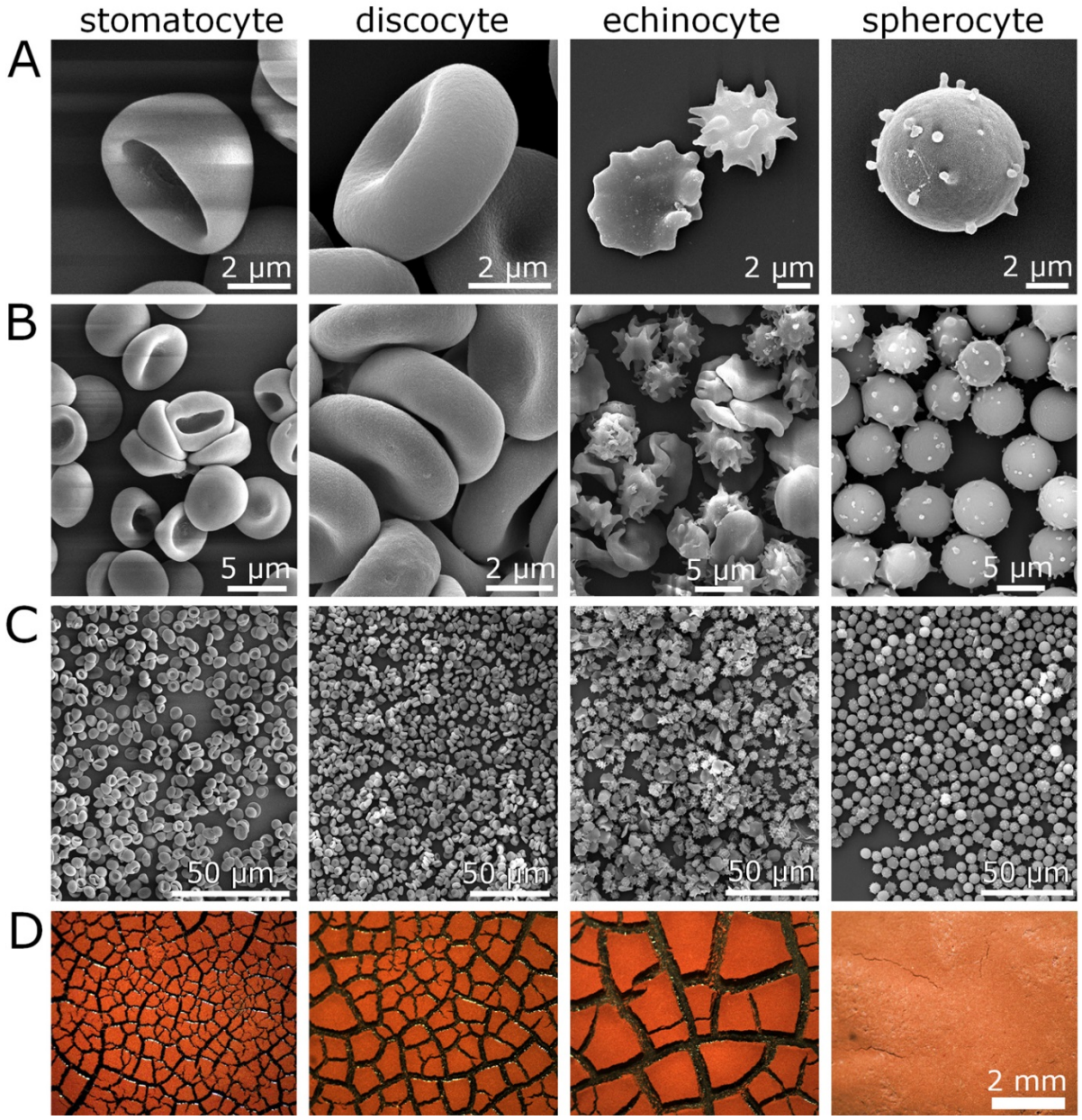

**Understanding particle interactions**




Lennard-Jones inter-particle potential for drying simulations

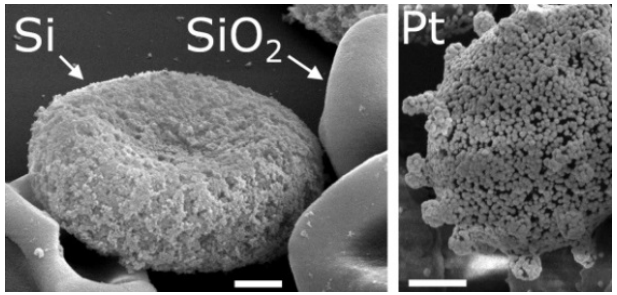
$$E = 4\varepsilon\left[\left(\frac{\sigma}{r-r_0}\right)^{12} - \left(\frac{\sigma}{r-r_0}\right)^{6}\right]$$

**Kristin Meyer (UNM-undergrad)**

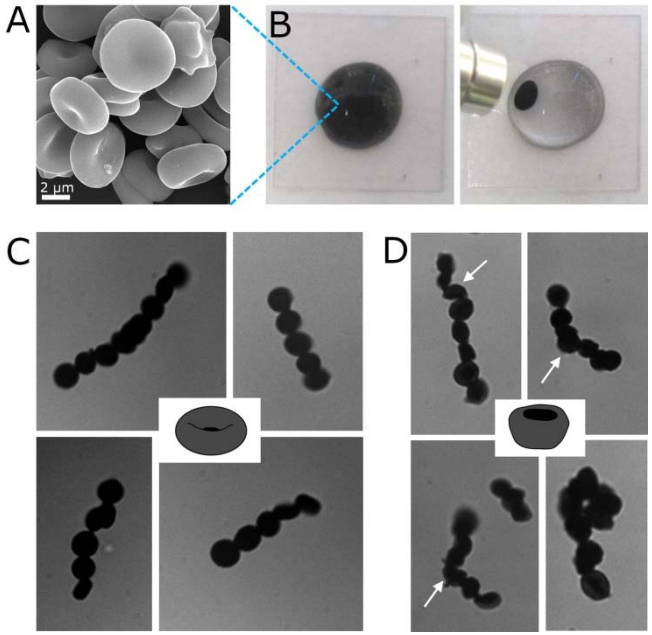


## Shape-preserving conversion to other materials

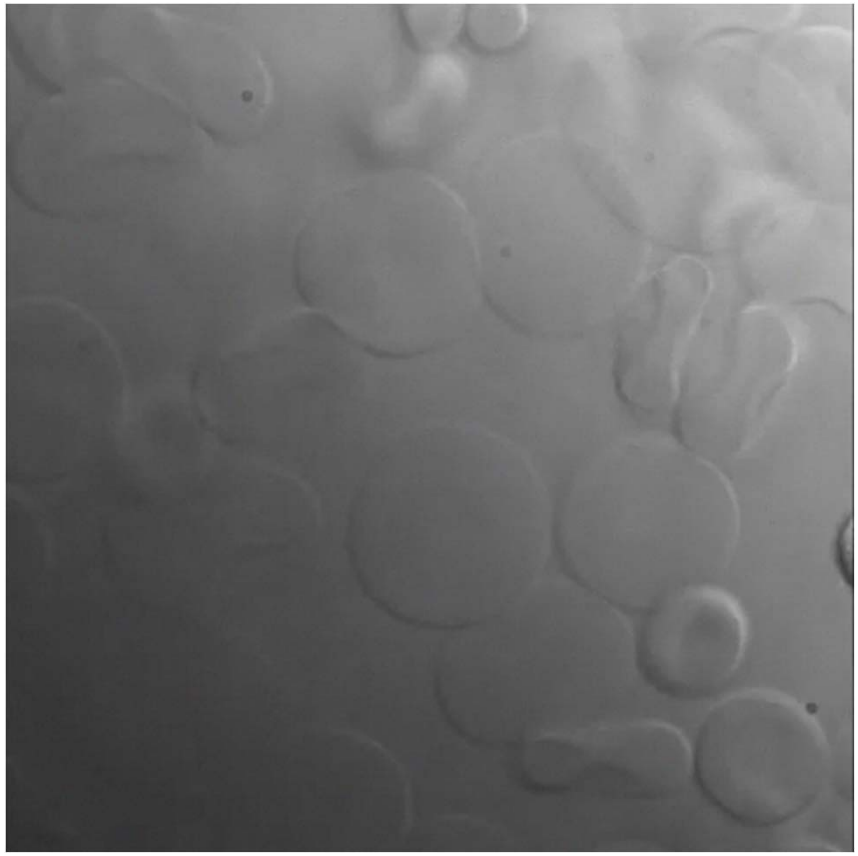
$2Mg(g) + SiO_2 \rightarrow 2MgO(s) + Si(s)$




$$\text{Si-RBC} + Fe(CH_3CO_2)_2 \xrightarrow[\text{H5N}]{700\ ^\circ\text{C}} Fe_3C\text{-RBC}$$




Soft, responsive artificial cells!



**How much school?**

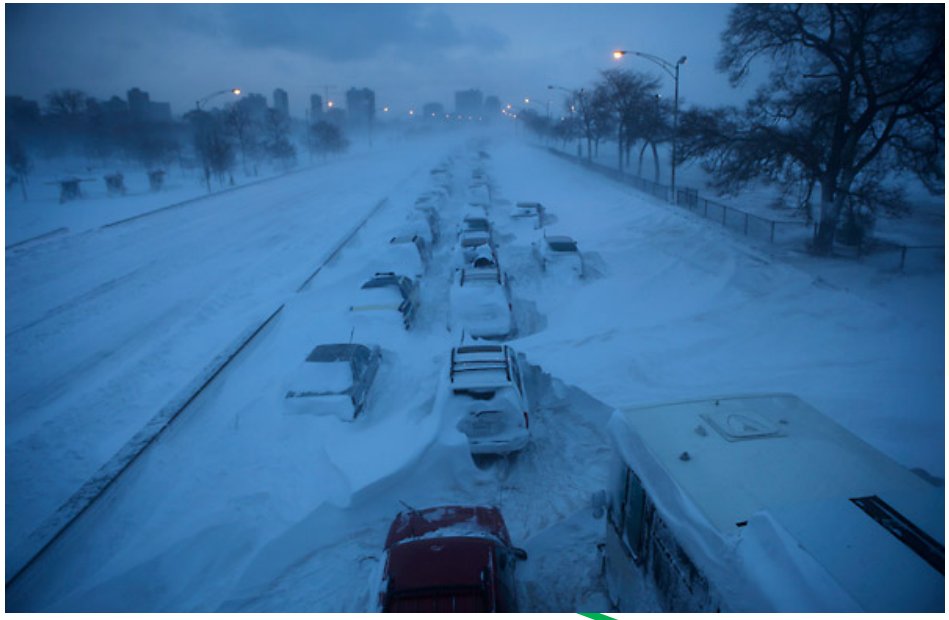
- Finish high school, ~12 yrs
- College (Bachelors), 2-6 yrs
- Graduate (PhD), 4-7 yrs
- Post-doc, 1-5 yrs

**Then I would work at _____?**

- University (professor, researcher)
- Government lab (Sandia, LANL, LLNL)
- Industry (private company)

MRS, San Francisco, April 2012

Science provides the opportunity for a very rewarding career as a productive member of society within the **international community.**

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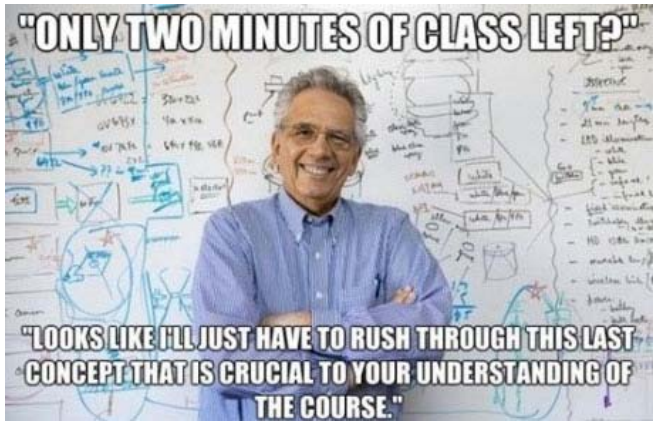
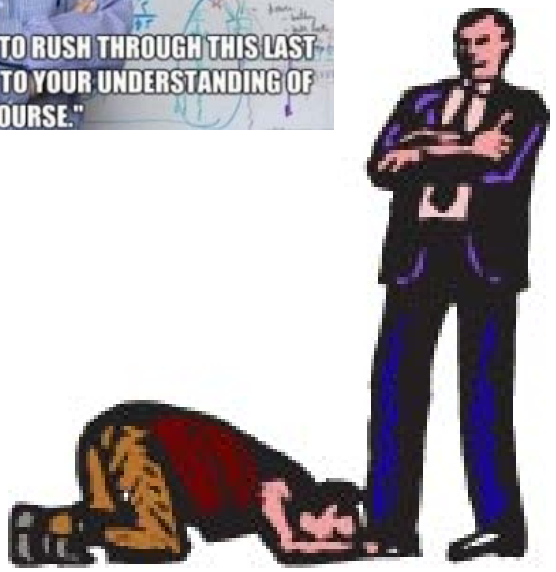
COLLEGE
BOUND


INDEPENDENCE DR
FREEDOM WAY


NOT SURE IF ACTUALLY HAVE FREE TIME
OR JUST FORGETTING EVERYTHING


"ONLY TWO MINUTES OF CLASS LEFT?"
"LOOKS LIKE I'LL JUST HAVE TO RUSH THROUGH THIS LAST CONCEPT THAT IS CRUCIAL TO YOUR UNDERSTANDING OF THE COURSE."



gle burritos

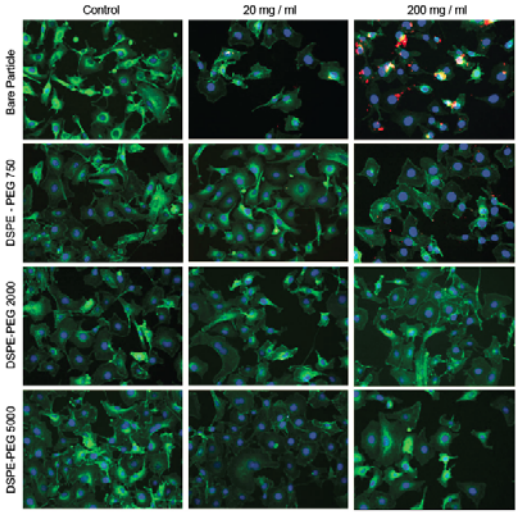
About 7,270 results (0.07 sec)

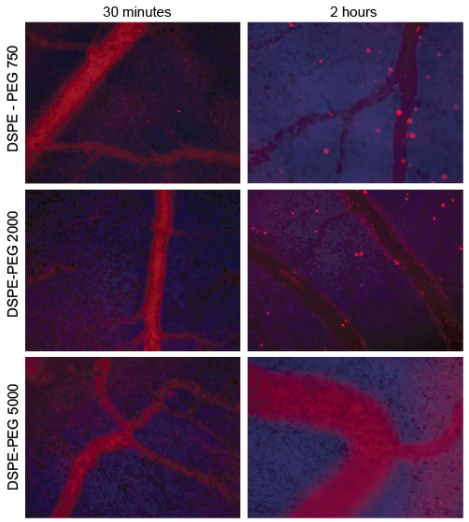
Articles

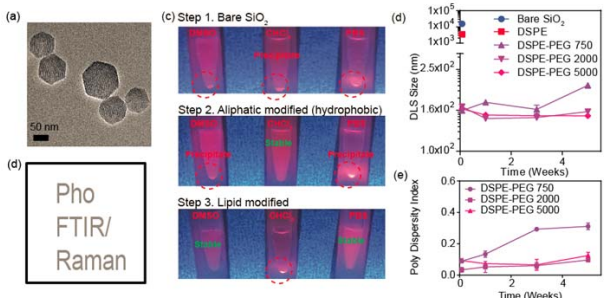
Outbreaks of gastrointestinal illness of unknown etiol

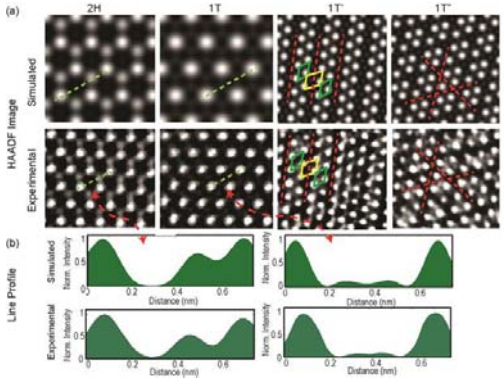
dity and
astroint
Illinois,
chools,

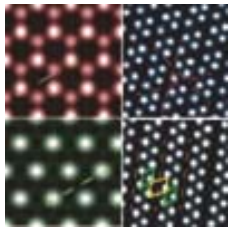
"Sir, I am every kind of scientist"

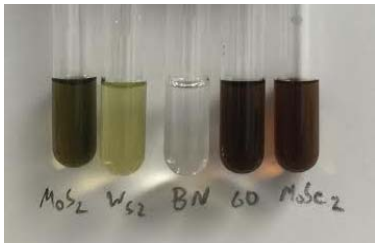



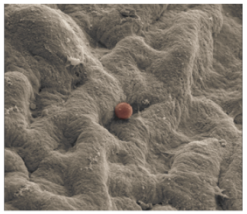



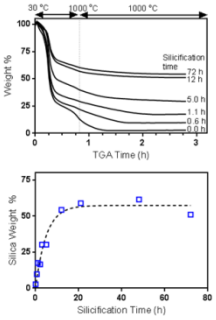





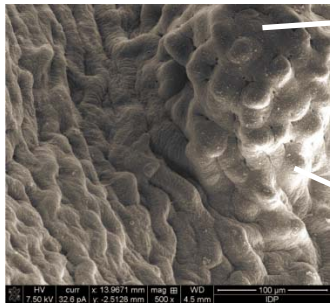

Other 2D colloidal inks

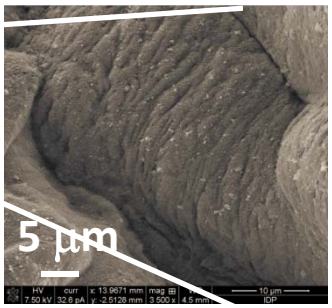
Condensation Rate

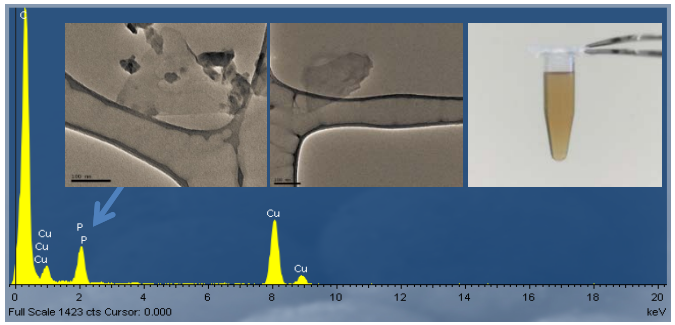





- Thermo-Gravimetric Analysis (TGA)
- Residual Weight (silica) after organic template removal






http://blog.oregonlive.com/siliconforest/2011/02/when_the_president_comes_to_vi.html

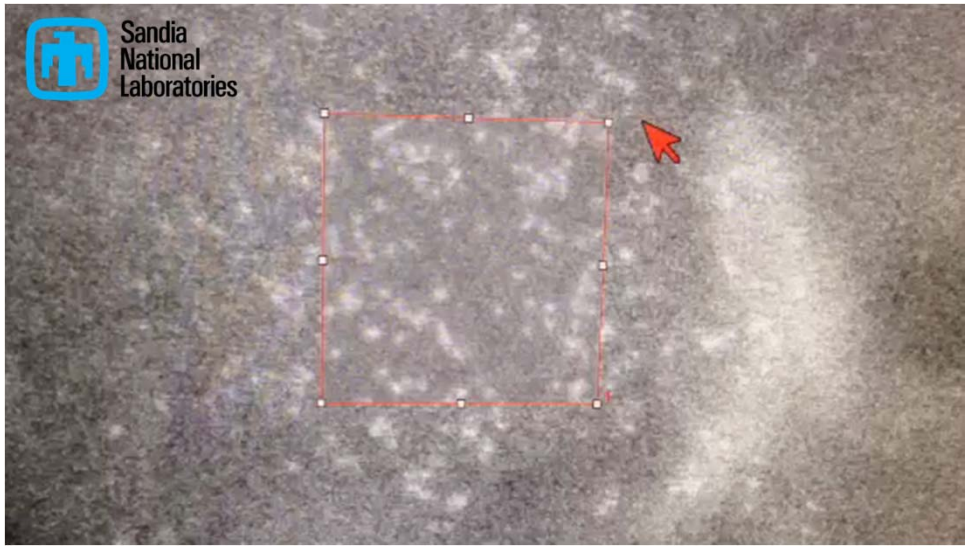



Photo: Ping Lu

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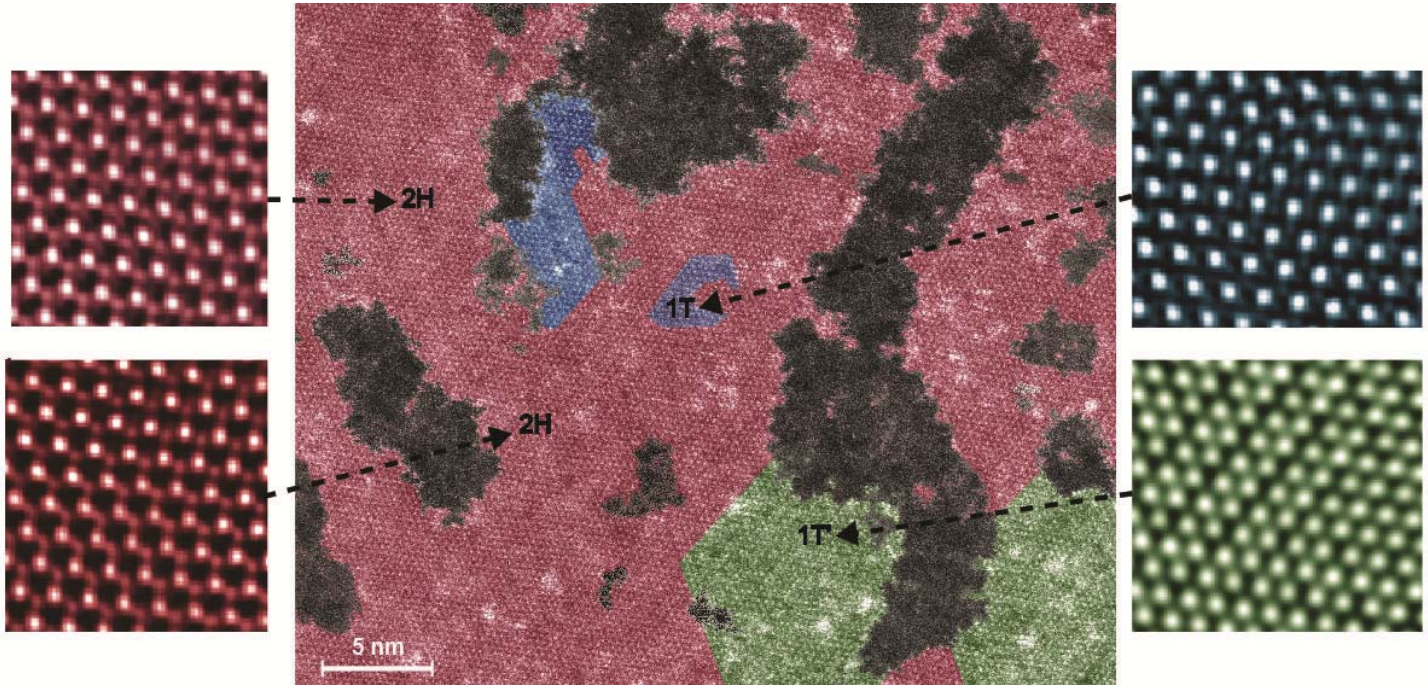
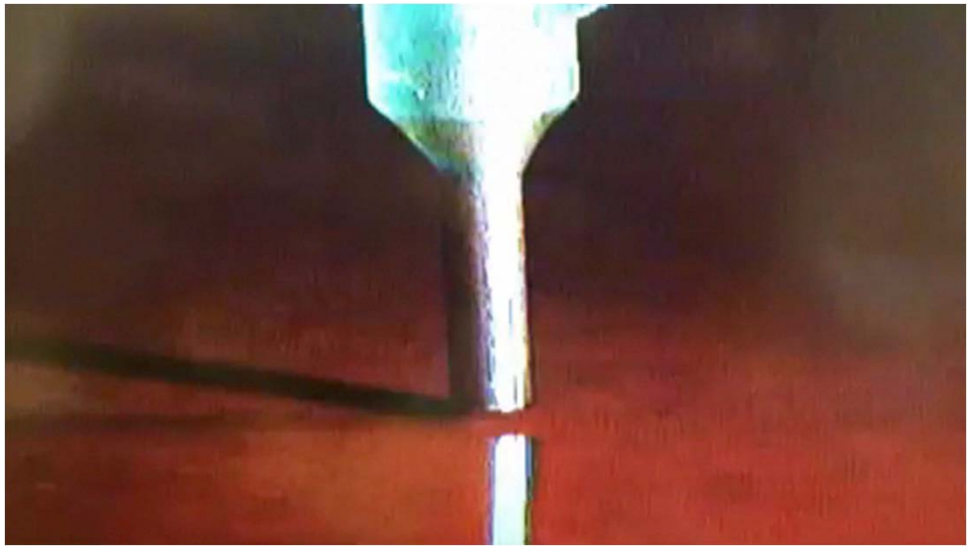
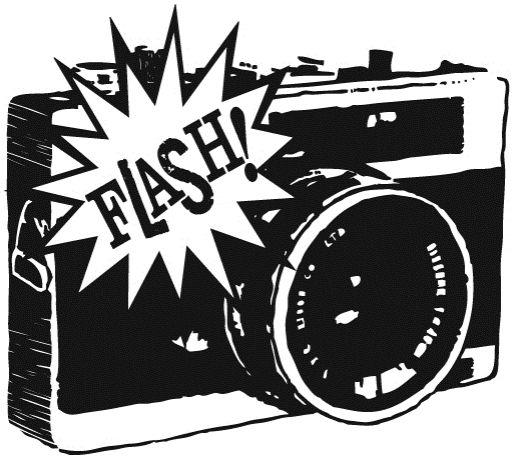
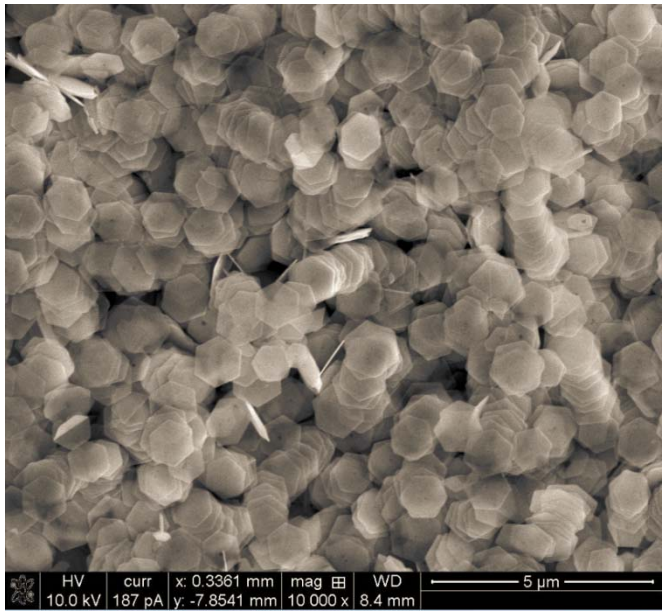
National
Laboratories



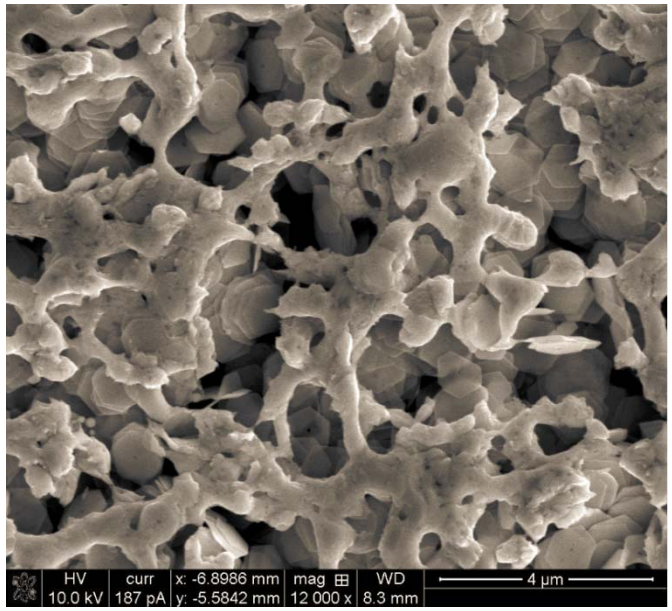




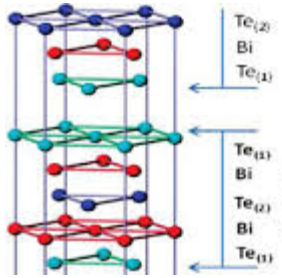

**As Deposited**

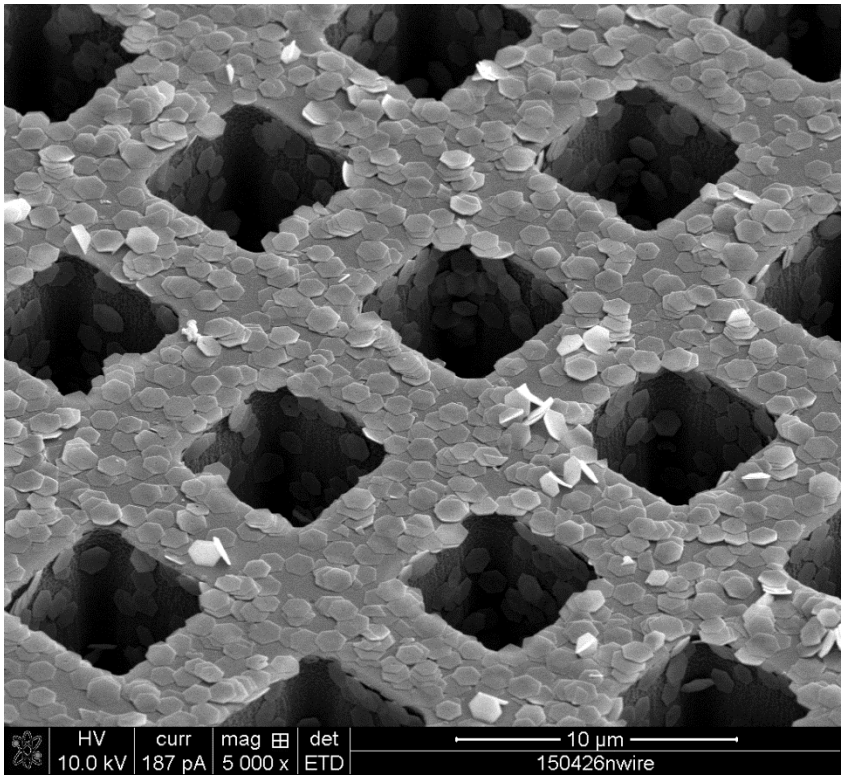



**Flash Annealed**



## Patterning Thermoelectric nanoplatelets



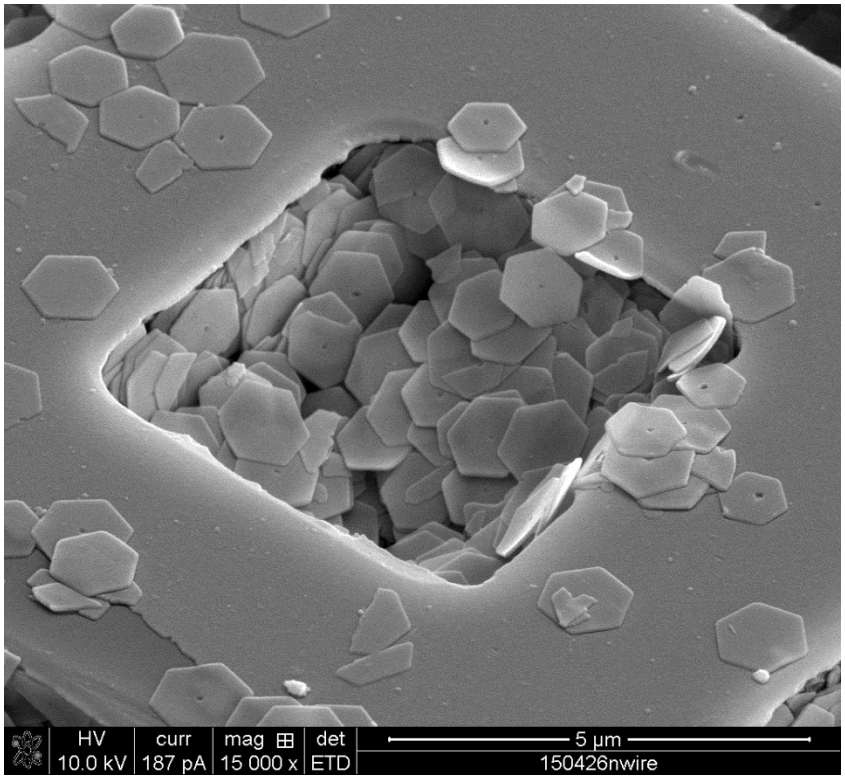




Photo: Bryan Kaehr

# Keep Curious



The Advanced Materials Laboratory, a part of Sandia National Labs since August, 1992

*Developing materials science and engineering technology in the National Interest*

# *Opportunities for Laboratory Experience at the Advanced Materials Laboratory (AML)*


Sandia National Laboratories
Albuquerque, New Mexico

*Randy Schunk*
Manager, AML

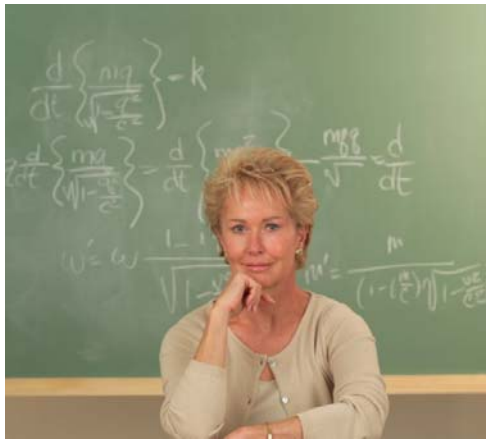

For the Albuquerque Institute of Mathematics and Science (AIMS)
September 18, 2015

*" . . . provide exceptional service in the National interest."*

# *Become a part of the research teams here at the AML*

WIIFM: another pair of hands in the lab, a warm feeling that we're actually helping the next generation of scientists and engineers get a start, a chance to mentor

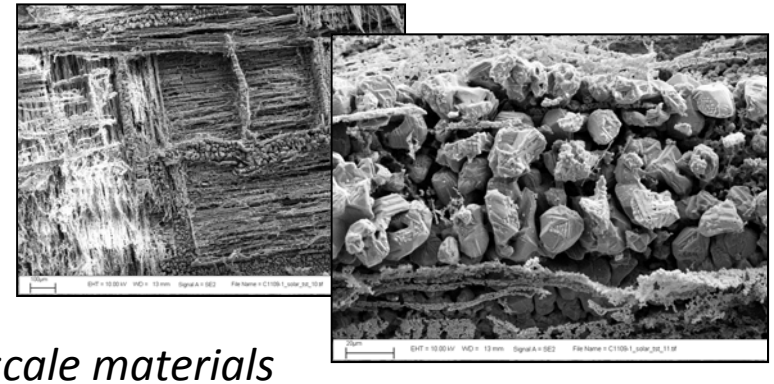
WIIFY: real laboratory experience, a chance to see if you really want to pursue a career in science/engineering, a chance to be a part of a world-class research team, excellent mentors, a chance to contribute to research that "*makes a difference*," letters of recommendation, "experience" to include on your resume*, a grade*

# *The AML has a wide range of capabilities important to Sandia's mission*

*Synthetic Chemistry*
- *nano particles*
- *catalysts*
- *films*
- *bulk materials*
- *surface functionalization*

*Ceramic processing*
- *science of sintering*
- *composite materials*
- *unique fabrication*
- *novel characterization*

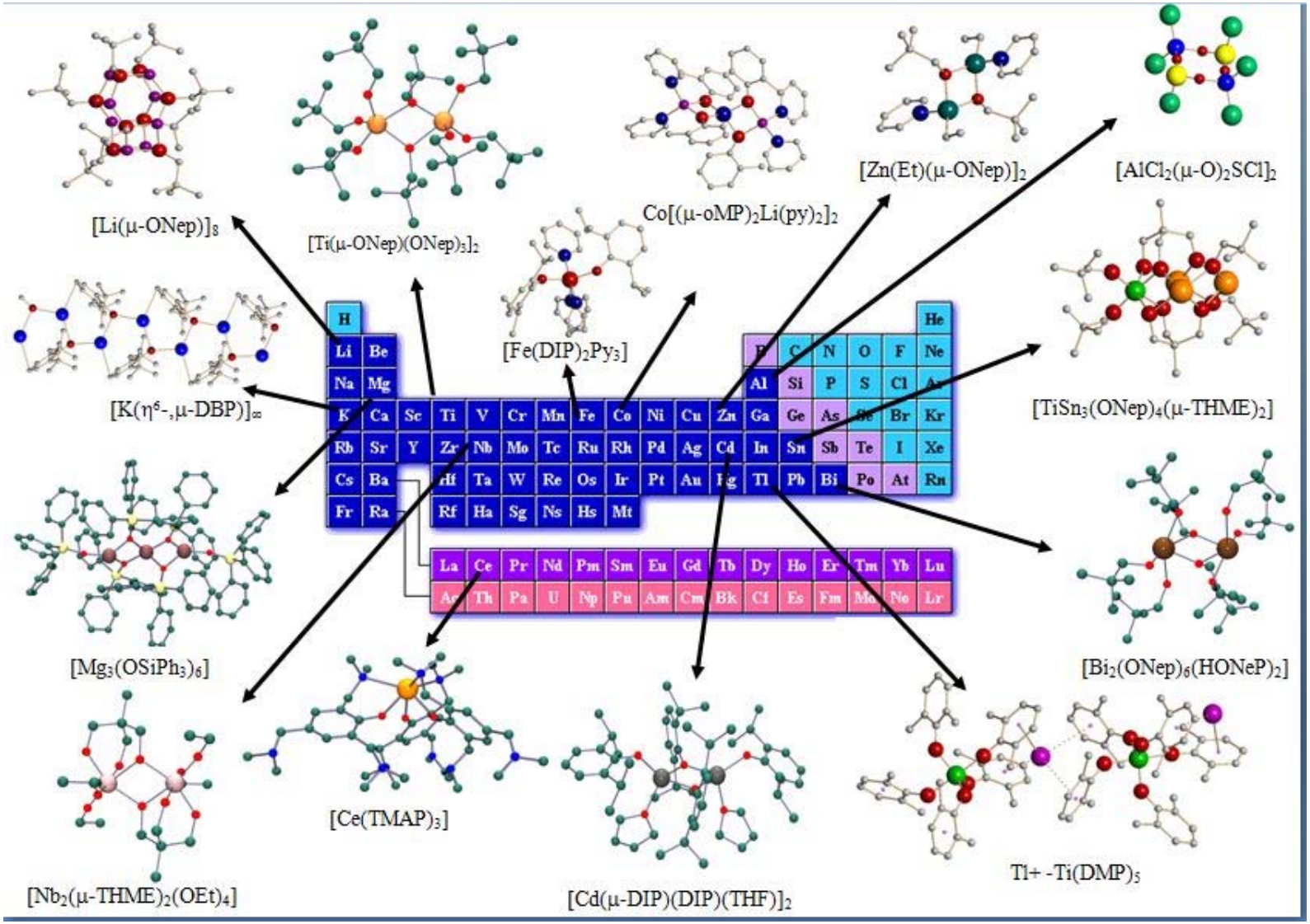


*Nano-scale materials*
- *synthesis*
- *characterization*
- *self-assembly*
- *direct write*

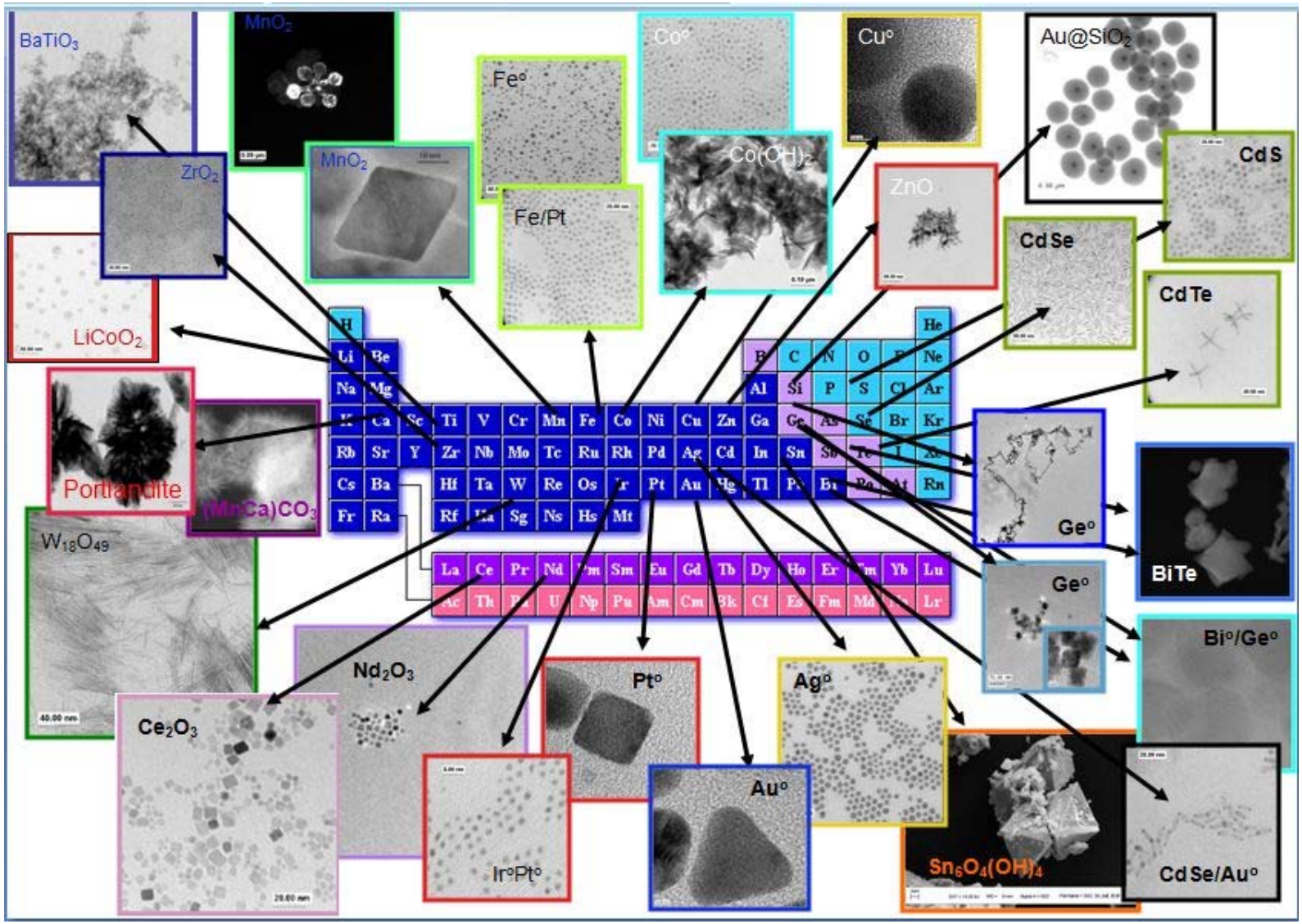
*Bio-, Nano-materials capability*
- *BSL-2 Laboratory*

*Characterization capabilities*
- *x-ray diffraction*
- *IR, EA, TA, etc.*
- *optical microscopy*

# *Chemical Synthesis underpins our capabilities to support Sandia's mission*



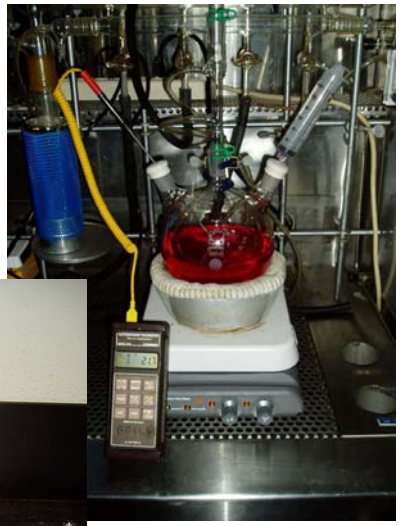
# *Chemical Synthesis allows us to make and characterize a variety of novel materials*

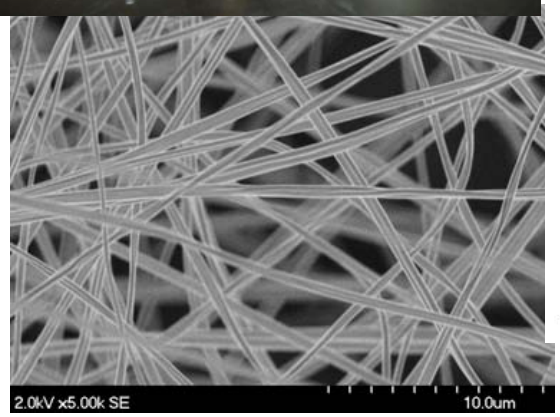


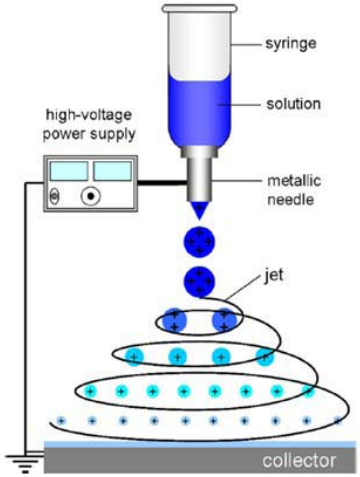
# *What you might learn in our chemical synthesis labs*

*Working safely in a chemical synthesis laboratory*
Manipulating chemicals in a glove box
*Laboratory safety*
Schlenk line techniques
*Laboratory safety*
Working and playing well with others
*Laboratory safety*
Characterization techniques (XRD, EA, IR, others)
*Laboratory safety*
Solution-precipitation techniques
*Laboratory safety*
Electrospinning of nano fibers
*Laboratory safety*
Learn the language of chemistry
*Laboratory safety*

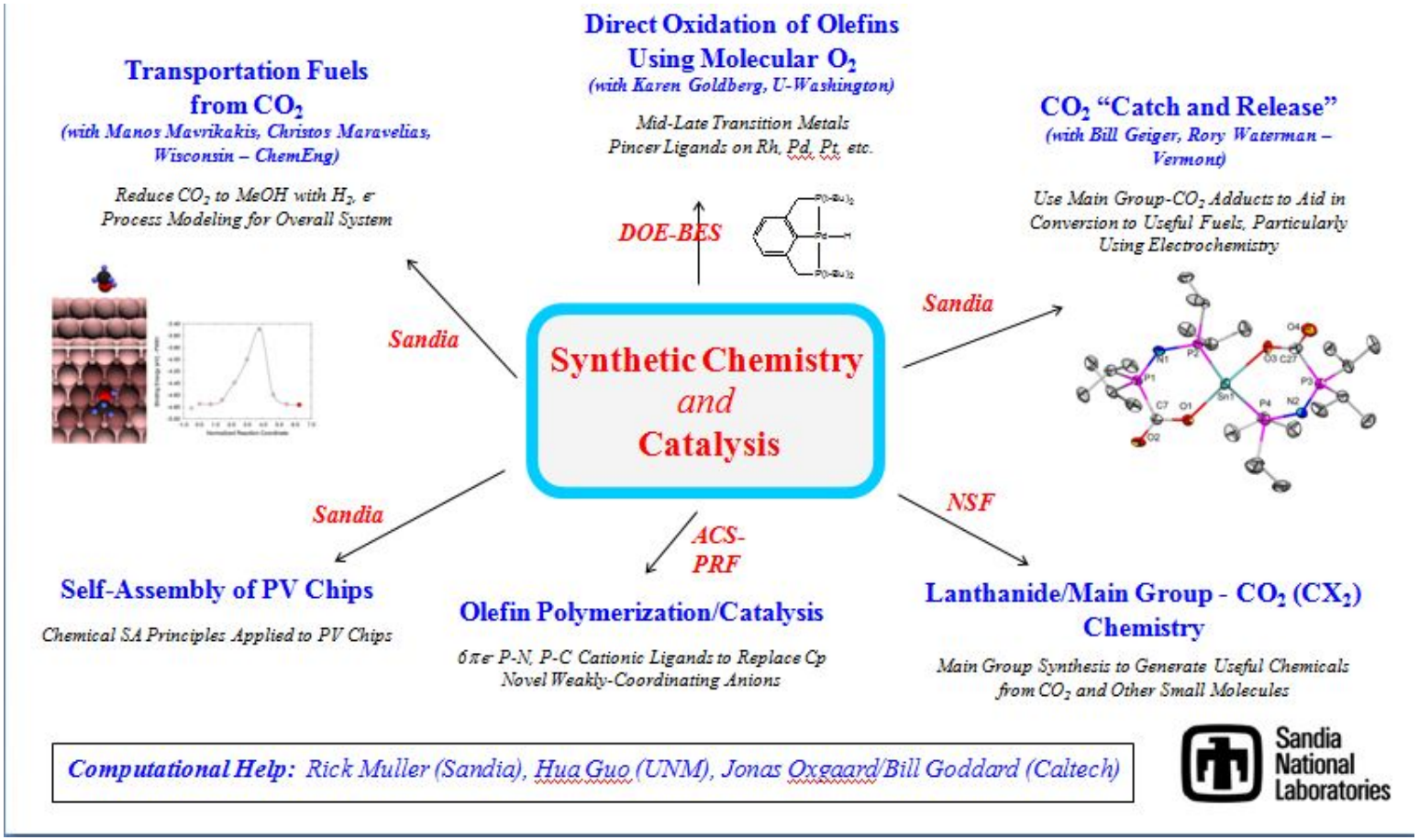
*Have I mentioned working safely in a laboratory setting?*





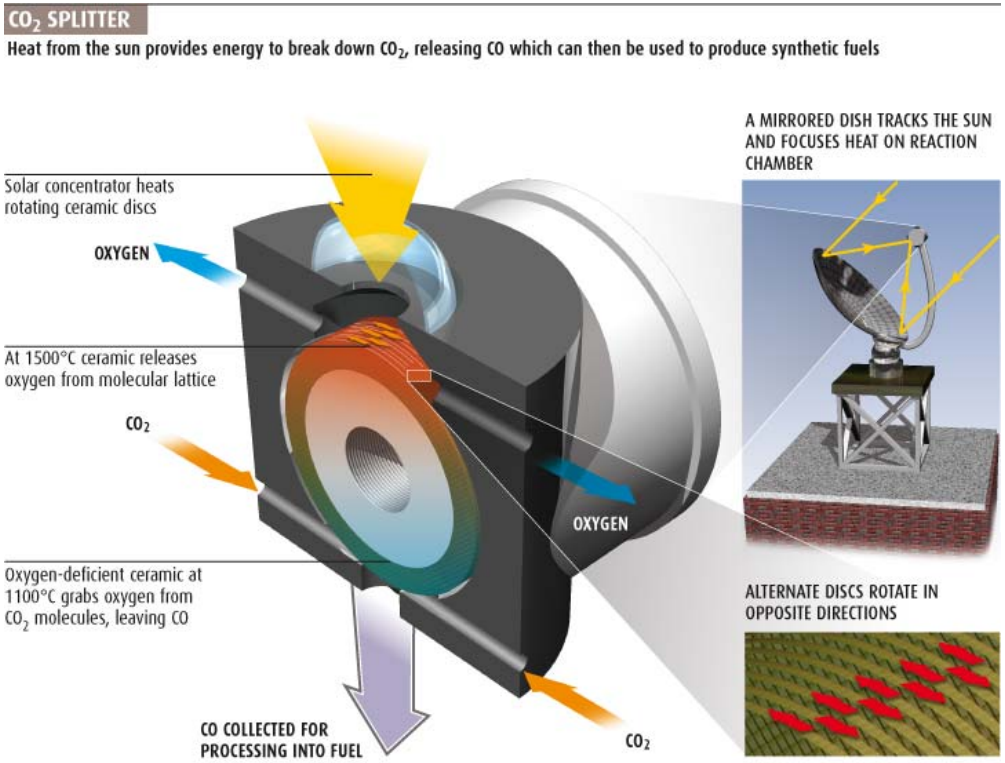



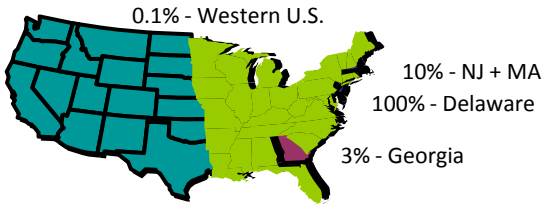
# *Our catalysis work builds on our strategic investment in synthetic chemistry*



# *The sunshine-to-petrol (S2P) project packages our capabilities in the R to D to A cycle*

Sunlight + $CO_2$ + $H_2O$ → Fuel + $O_2$




Nominal Equivalent Land Area Required to Produce 20 mbpd at a given efficiency.

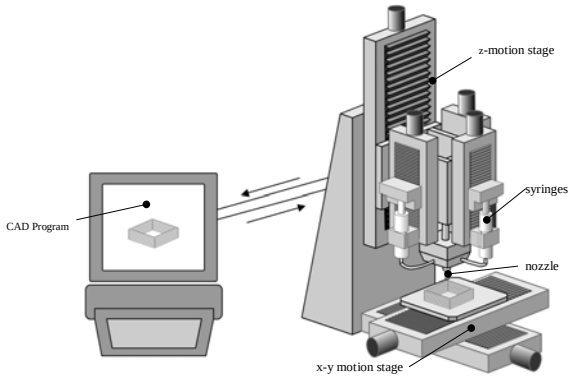
Sunlight to fuel efficiency assuming solar resource equivalent to Albuquerque – 2600 kWh/m$^2$/yr.

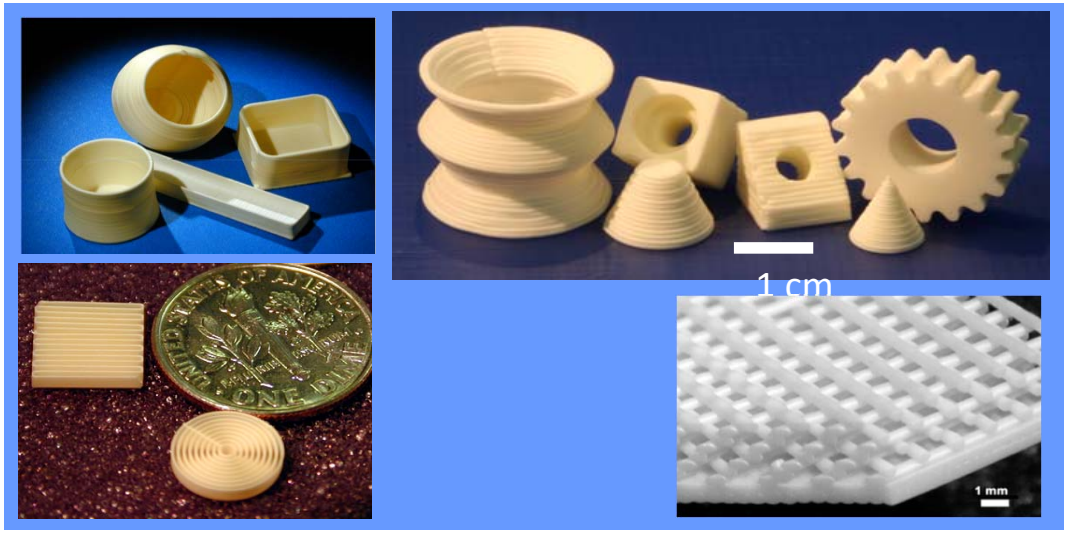
U.S. Petroleum consumption - 20 million bbls/day

*Counter-Rotating-Ring Receiver/Reactor/Recuperator (CR5)*

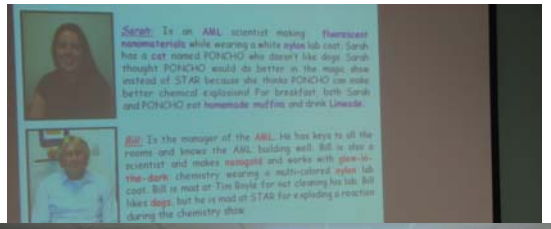
# *"Robocasting" is a capability to make unique ceramic parts and electrical circuits*

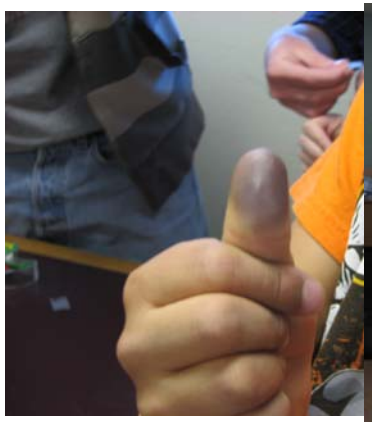
Challenges*: Mechanical design, computer programming, slurry/ink properties,*

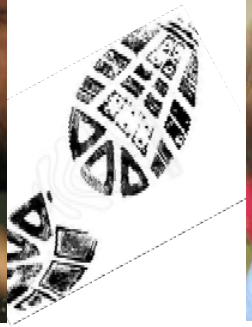


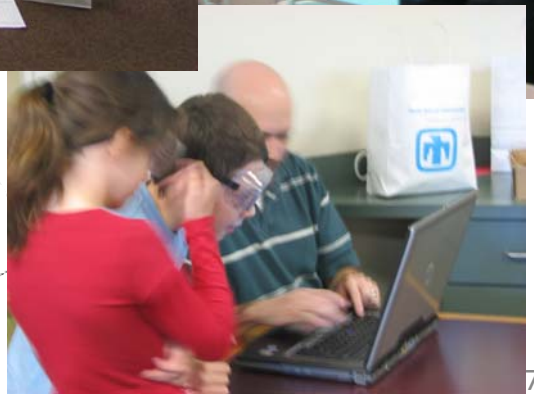



# *Being a part of the AML allows you to become a mentor as well*







# *Necessary qualities to be a part of the AML research team*

Dependability – *be here when you say you're going to be here – this is a job, not a hobby – we will depend on you to get things done in support of Sandia's mission*

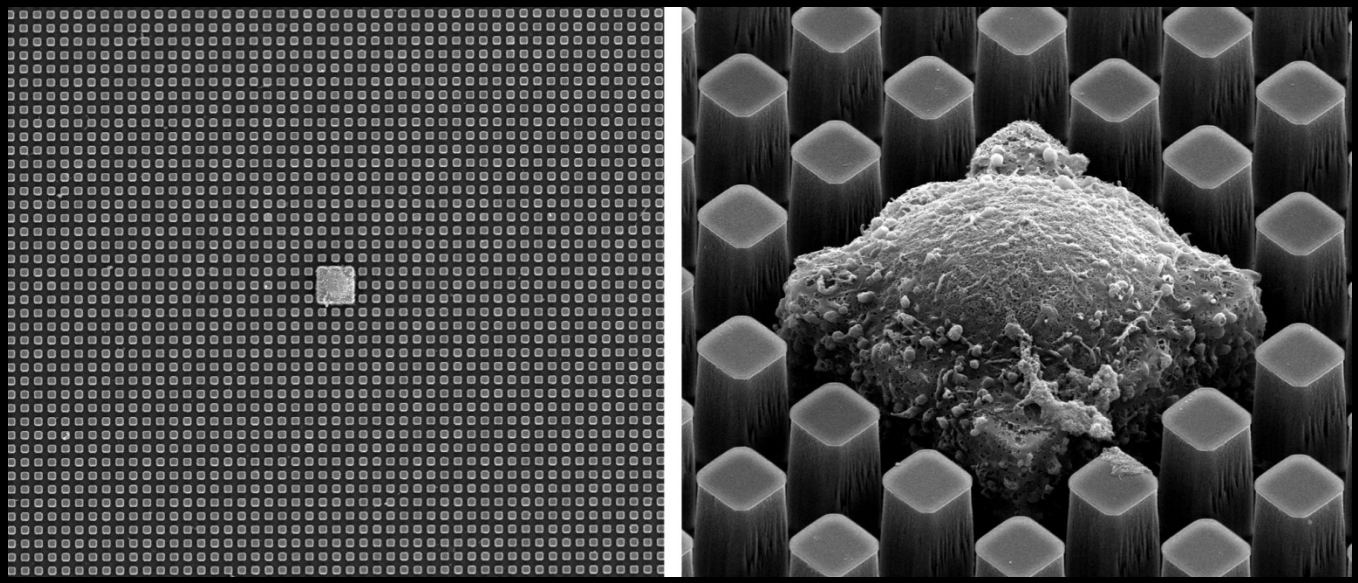
Openness - *be open to working as part of a diverse team – take direction*

Thoughtful - *be willing to learn new skills and new concepts – put thought and creativity into the work – work safely!!!*

Confident - *be comfortable working in an environment in which there may be no "correct" answer – be ready to fail, lots and lots of times*

*WORK SAFELY!!!!*

Questions?



Others? Email me at bjkaehr@sandia.gov