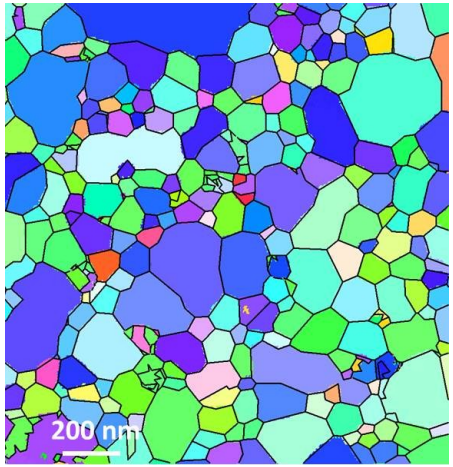


Materials Science and Engineering Program

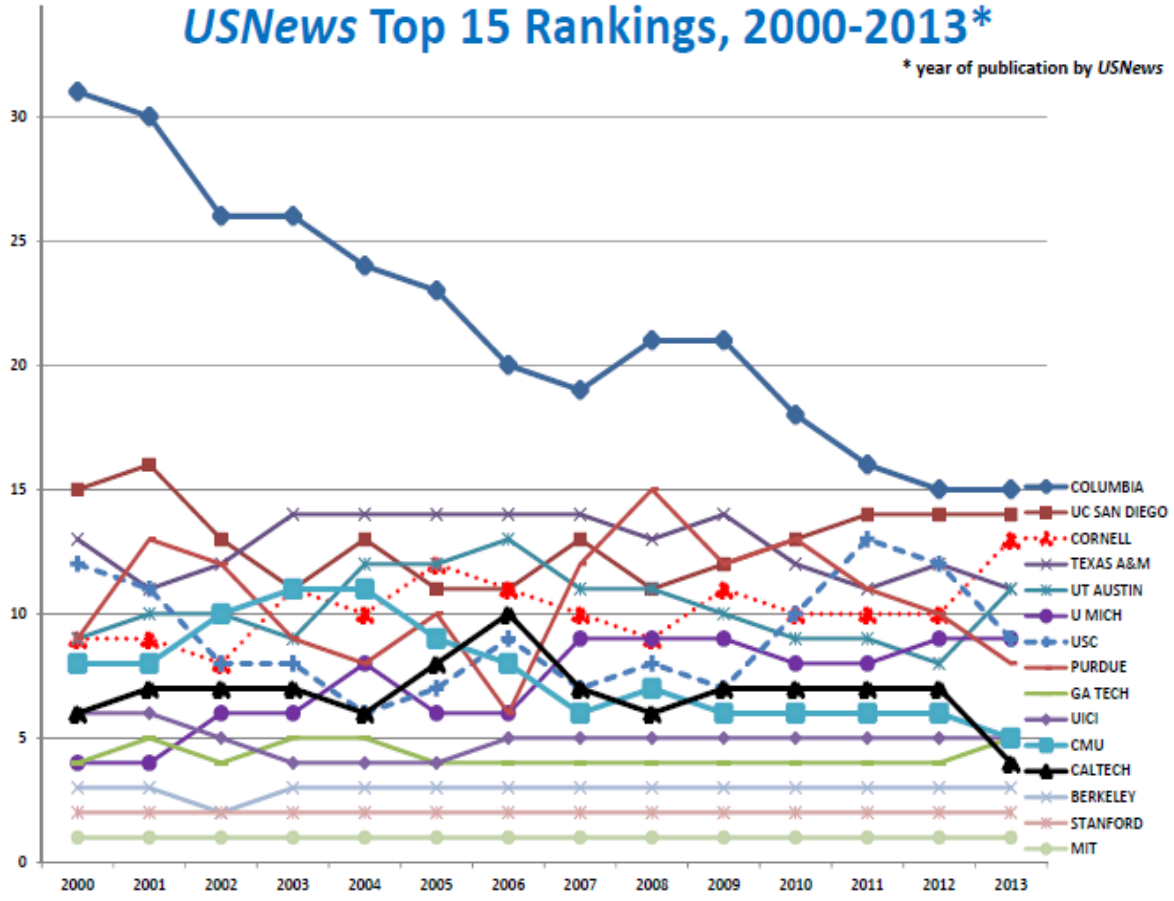
William Bailey

Department of Applied Physics and Applied Mathematics

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

Rankings: Engineering School

- Good trend over last 20 years



2016 Ranking: 13

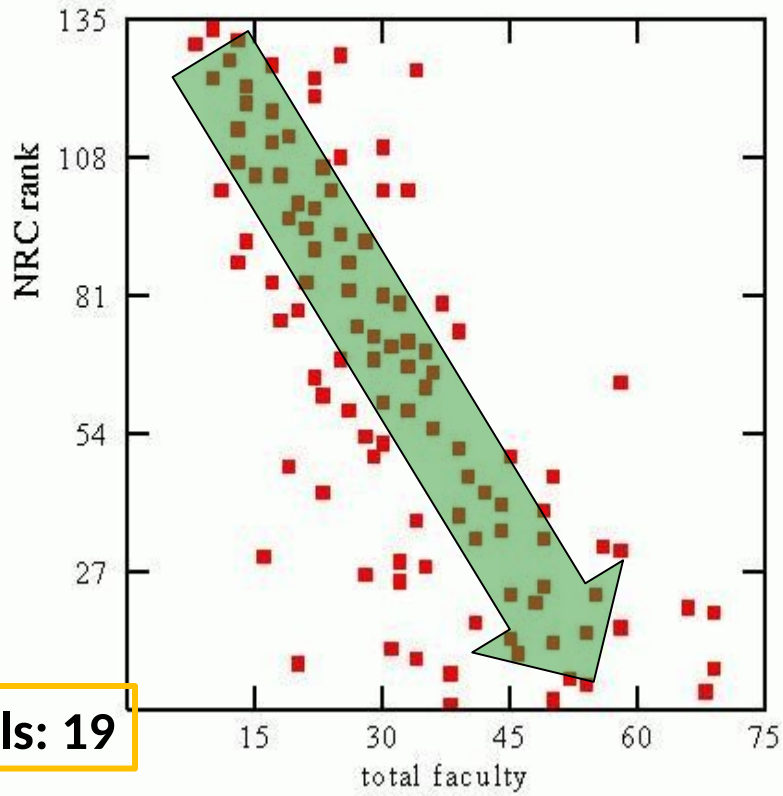
2018 Ranking: 12

2019 Ranking: 11

2021 Ranking: 14

Rankings: Materials Science

- Size Matters:
  - Plot shows NRC rankings of (physics) departments vs. number of faculty
- Columbia MSE program ranks well for size



2016 USNWR Ranking for Columbia Materials: 19

CU Faculty Focused on Materials Research

- MSE faculty = 8
- MSE+ AP/SS = 12
- MSE + SS + Physics = 17
- Materials + SS + Physics + Other SEAS = 25 ?
- Materials + SS + Physics + SEAS+ Chem = 34 ?

These are conservative estimates.

We prefer you work within APAM, but there are options in other departments.

Why Choose Columbia Materials Science?

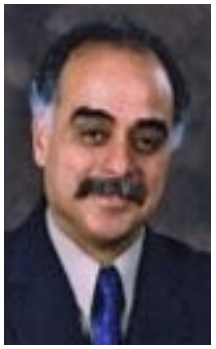
1. Looks good on your CV
2. You can go wherever you want from here
3. There are interdisciplinary opportunities (collaborative projects with other departments)
4. Excellent students (not just in MSE, also APAM, SEAS and GSAS)
5. It is in New York City

Where do you want to go from here?

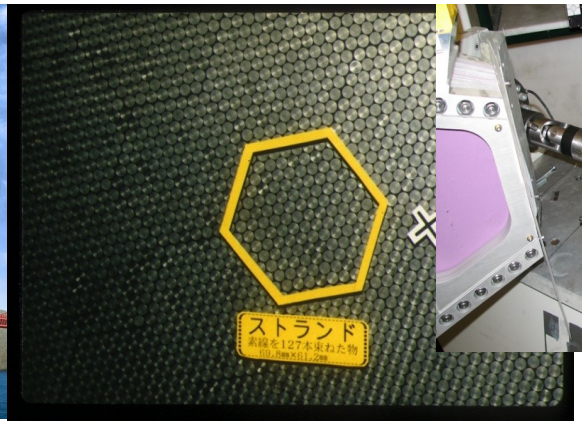
- Get a faculty position
- Get a research job in industry
- Work at as a researcher at a National Lab
- I want to get involved in venture capital and a tech startup
- Become a quant at an investment bank on Wall St. and become very rich

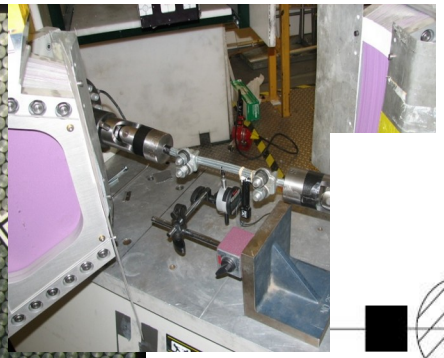
What do you want to do?

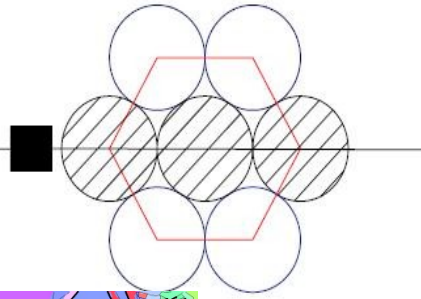
- I want to work on applied problems



Noyan

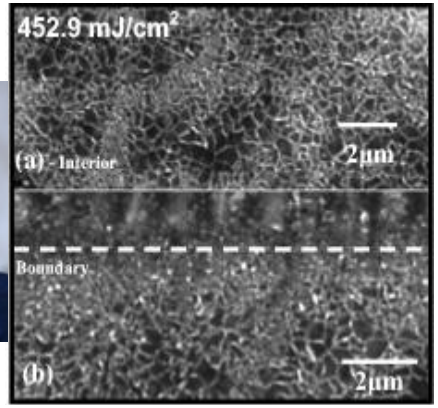


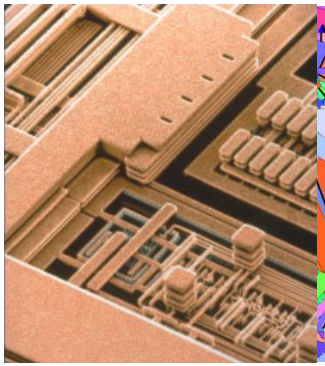


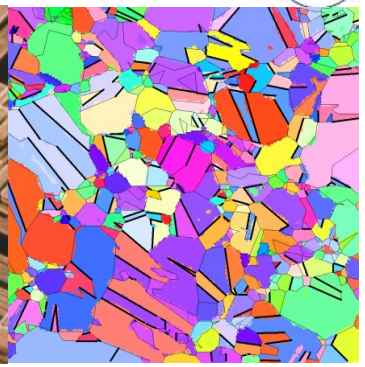


Im

Barmak

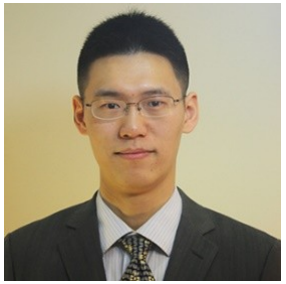






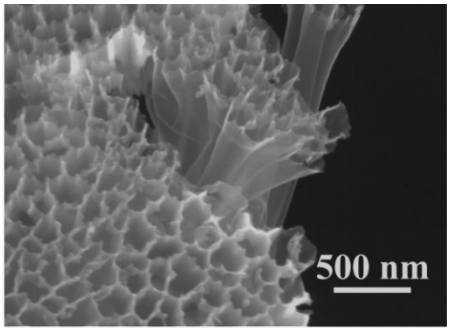
What do you want to do?

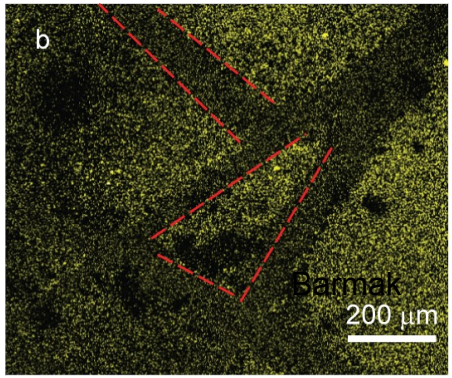
- I want to work on applied problems



Yang

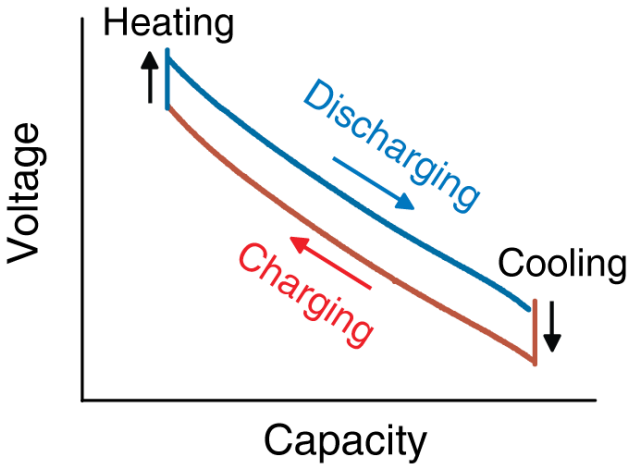
Material Design & Characterizations





Next Generation Batteries and Thermal Energy Harvesting

High-energy Flow batteries



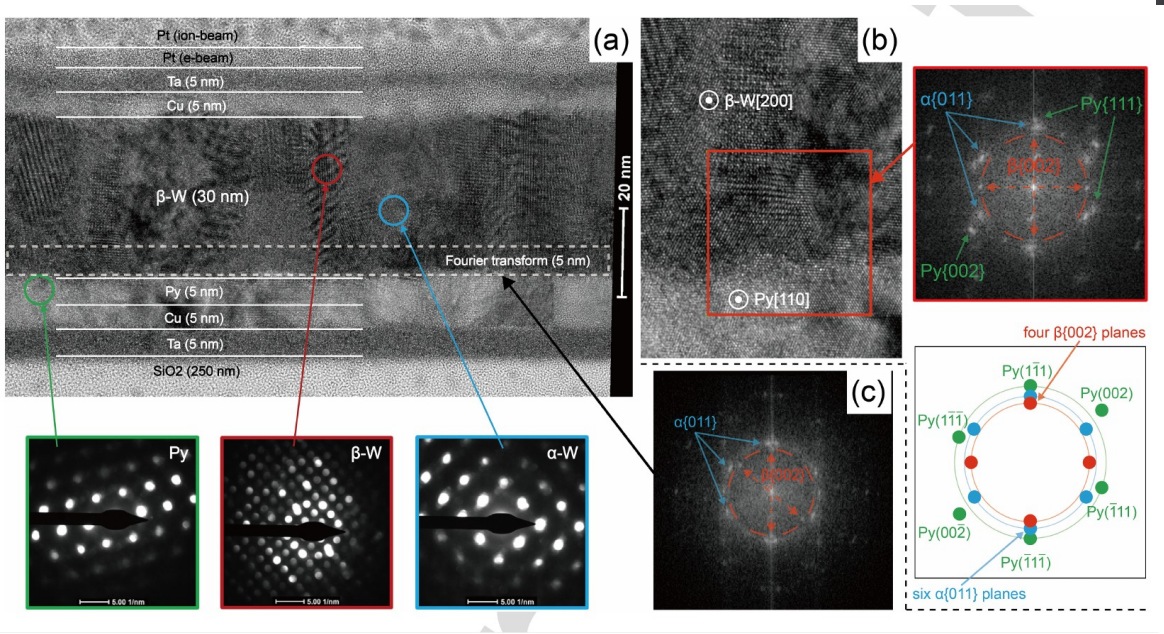
Thermo-Batteries

What do you want to do?

- I want to work on the next generation of electronics (thin films, heterostructures)

Bailey

Barmak

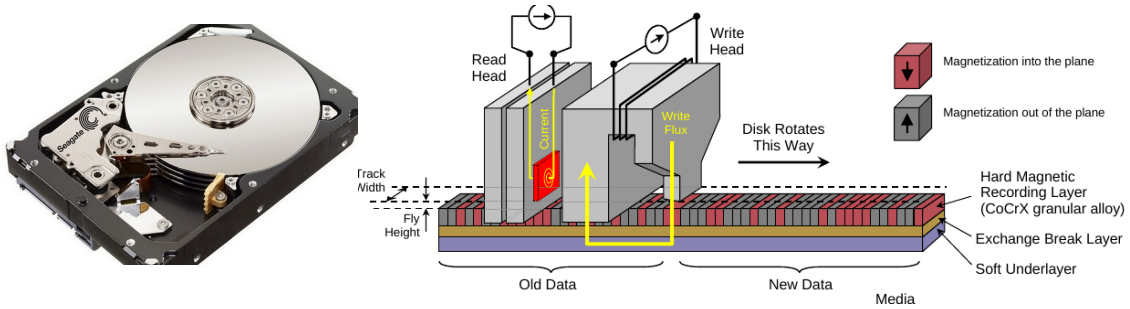


Noyan

Im

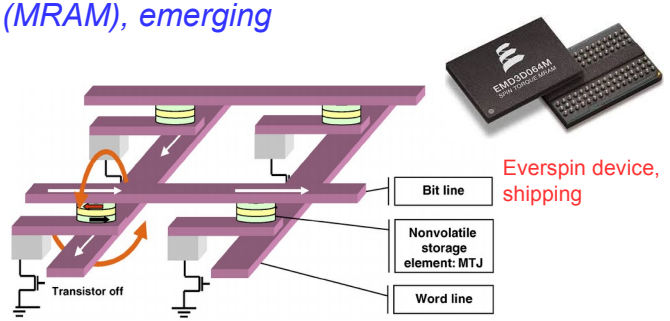
What do you want to do?

Hard disk drives (HDD): $30B/yr in sales



courtesy R. New, HGST/Western Digital

Magnetic random access memory (MRAM), emerging

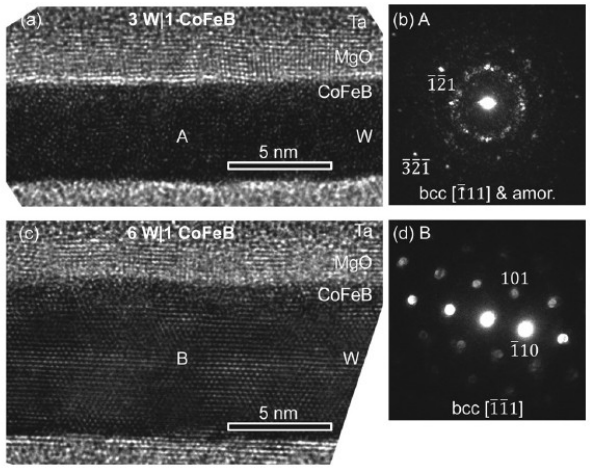


Everspin device, shipping

B. Dieny, L. Prejabnu, SPINTEC (2017)

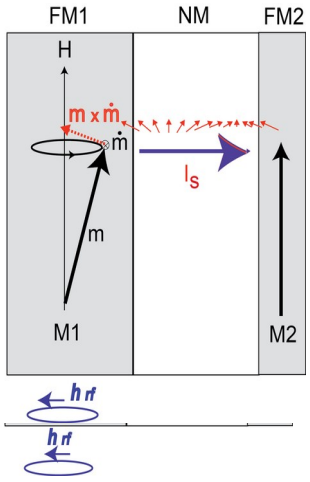
Materials: ultrathin films & heterostructures

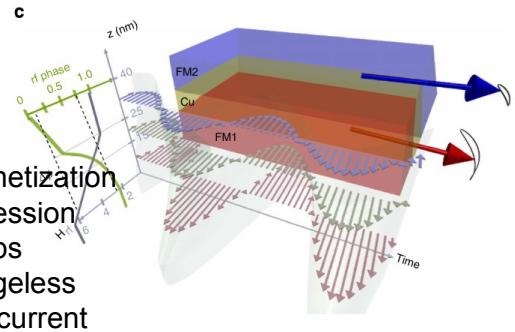
Ultrathin tungsten films for giant spin Hall effects



Liu et al APL 107 232408 (2015)

Study of new physical phenomena





Magnetization precession pumps chargeless spin current

Bailey et al Nature Comms 4 2025 (2013)

What do you want to do?

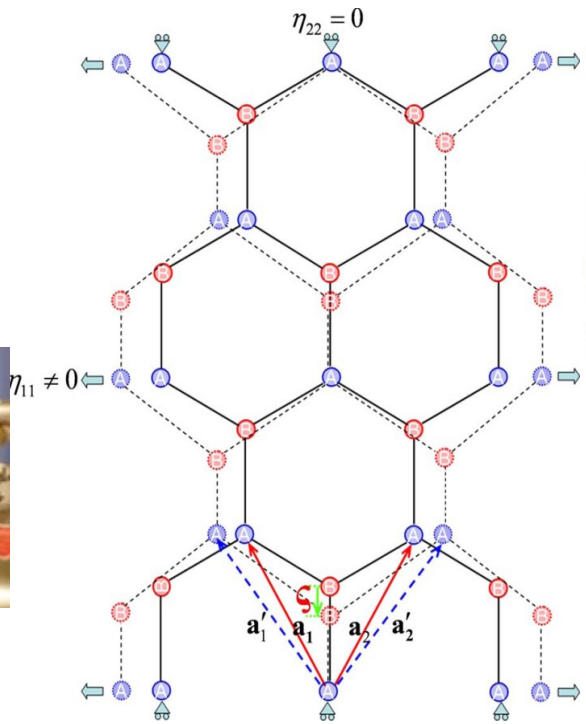
- I want to work on 2D / quantum materials. I heard they are really hot right now.

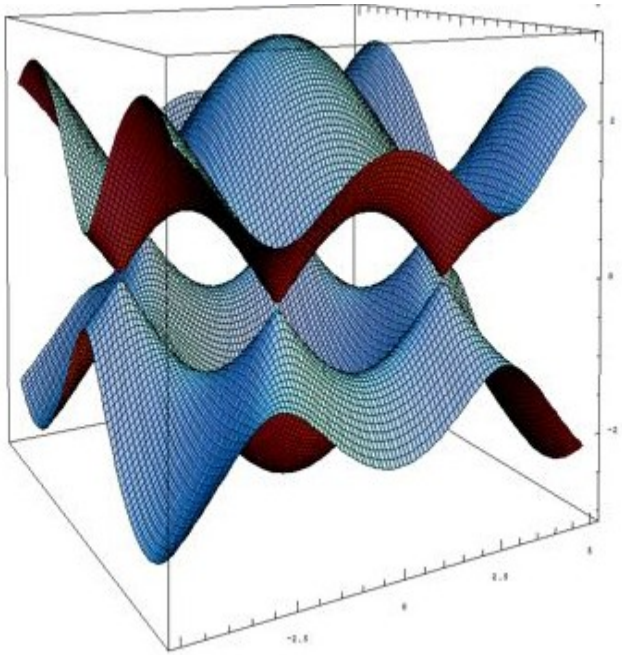
Marianetti

Pasupathy (Phys)

Hone (ME)

Pinczuk (AP/SS)





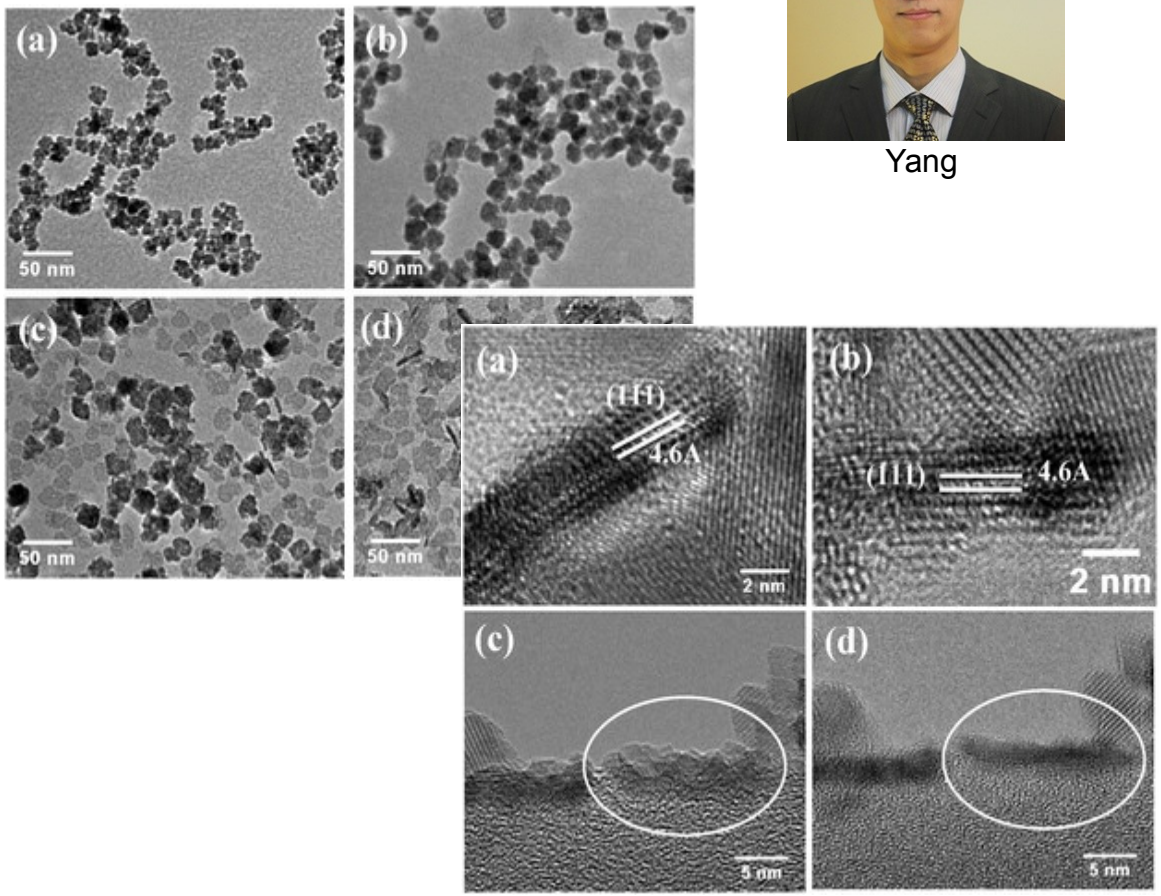
What do you want to do?

- I want to make nanomaterials

Chan

Owen (Chem)

Yang

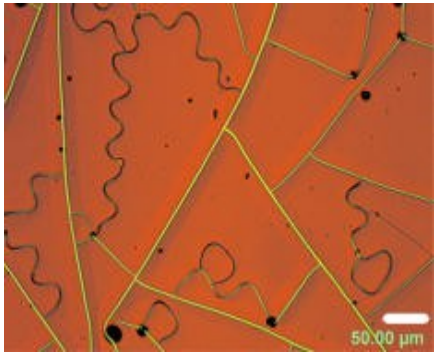


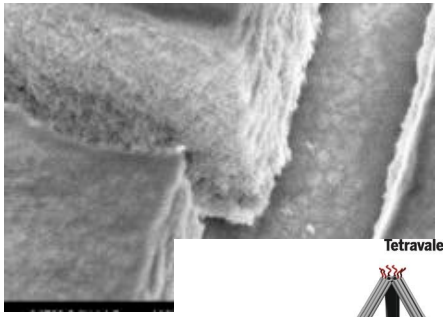
Herman (w/AP SS)

Nuckolls (Chem)

What do you want to do?

- I want to assemble nanoparticles into devices and measure properties

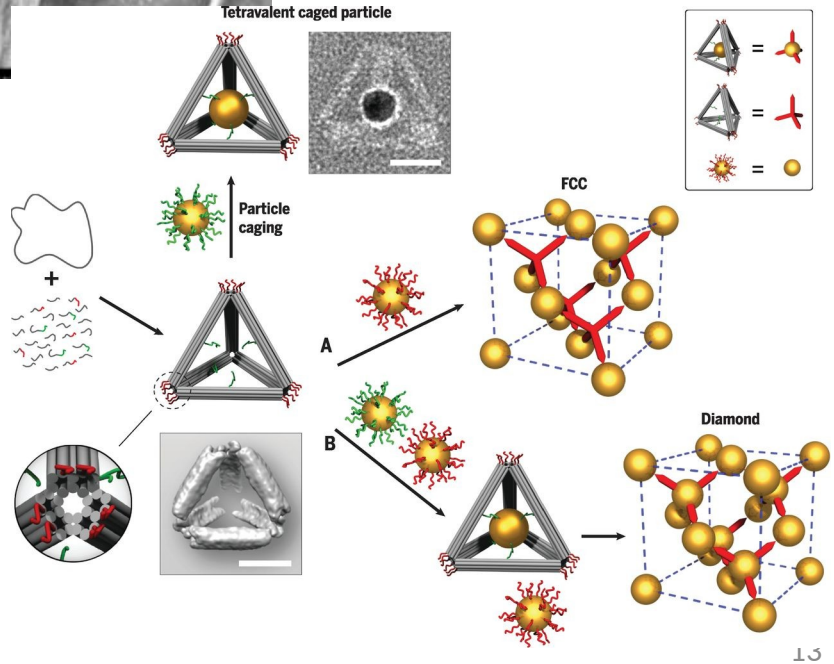




Herman

Venkataraman (AP/SS)

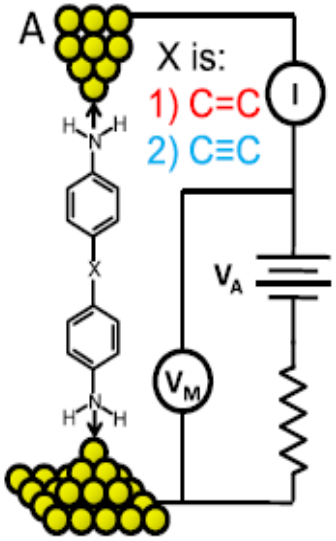
Gang (Joint with Chem E+BNL)



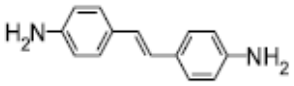
What do you want to do?

- I want to do more fundamental science with potential applications

Venkataraman

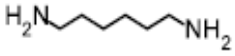


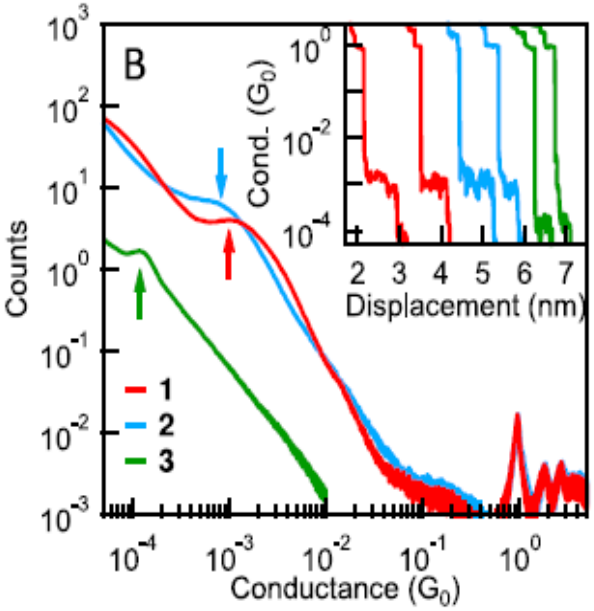
Molecule 1



Molecule 2

Molecule 3





Lipson (EE)

Gaeta (AP/SS)

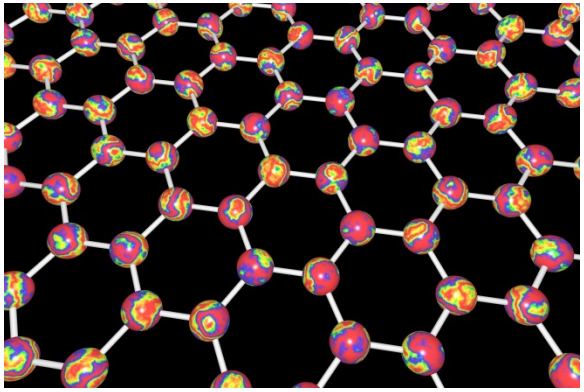
What do you want to do?

- I want to do theory

Millis (Phys)

Marianetti

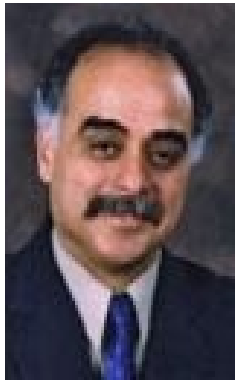
Wentzcovitch



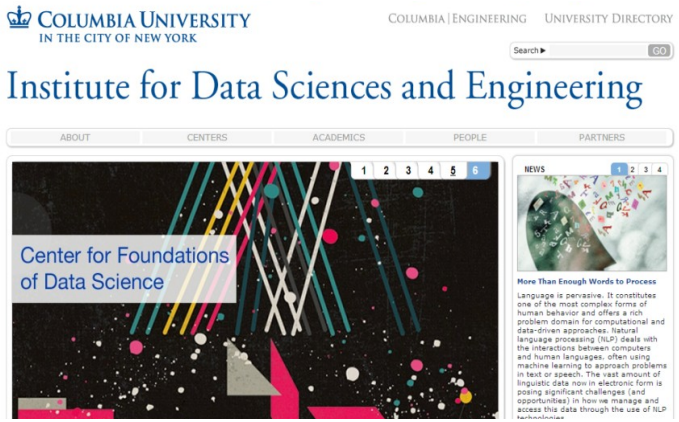
- I want to do computational materials science

Marianetti

Billinge
(Joint with BNL)



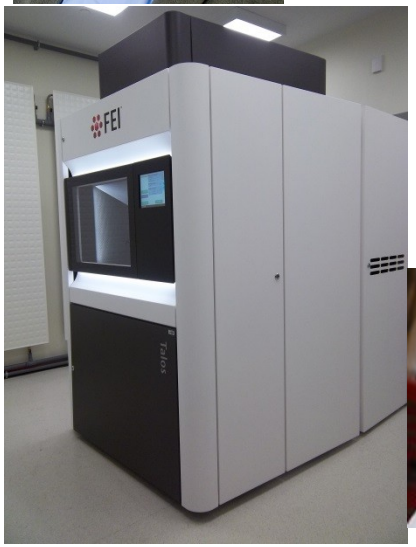
Noyan

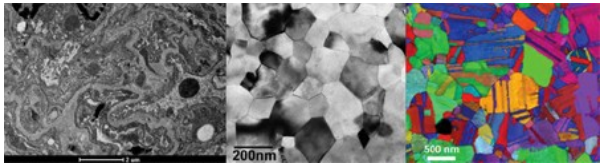


What do you want to do?

- I want to build/use state of the art instrumentation

NSLS II – Brookhaven National Lab (90 miles on L.I.E.)





Research Centers: MRSEC

- I want to work in a collaborative interdisciplinary environment to solve mankind's persistent problems

COLUMBIA NANO INITIATIVE

CENTERS | SHARED FACILITIES | CISE | SEMINARS & EVENTS | PEOPLE | RESOURCES

PEOPLE
CISE
CCNY
CISE Executive Committee
EFRC
Faculty
MRSEC
Research Scientists
Staff Scientists

Mrsec

James Hone

Wang Fong Jen Professor of Mechanical Engineering / MRSEC Managing Director
240 S.W. Mudd, Mail Code 4703
Tel: (212) 854-6244
Fax: (212) 854-3304
Email: jh2228@columbia.edu
Website: Home Page

Lia Krusin-Elbaum

MRSEC Co-Director, Professor, CCNY
160 Convent Avenue, Marshak 317
New York, NY 10031
Tel: 212-650-5597
Fax: 212-650-6940

Curriculum in MSE (MS/Ph.D. track)

MS in MSE

18 points:

MSAE E4100: Crystallography
MSAE E4200: Theory of crystalline materials: phonons
MSAE E4201: Materials thermodynamics and phase diagrams
MSAE E4202: Kinetics of transformations in materials
MSAE E4206: Electronic and magnetic properties of solids
MSAE E4215: Mechanical behavior of structural materials

- Materials properties
- Materials structure, synthesis / processing

...with concentration in Materials Theory + Simulation

MSAE4100: Crystallography
MSAE4200: Theory of crystalline materials: phonons
MSAE4201: Materials thermodynamics and phase diagrams
MSAE4202: Kinetics of transformations in materials
MSAE4206: Electronic and magnetic properties of solids
MSAE4215: Mechanical behavior of structural materials

the following twelve (12) points of electives are required:
MSAE4203: Theory of crystalline materials: electrons
MSAE6085: Computing the electronic structure of complex materials
APMA4300: Introduction to numerical methods
MSAE6273: Materials science reports

+PDE or Linear Algebra course

+12 points of electives, large menu

Why pick Columbia Materials/Solid State?

If you come to Columbia you will

- Work with great faculty
- Work with great students
- Work on great problems
- Have great career opportunities

These are things we share with the top-ten Materials/Solid State programs where you may have offers…

Why pick Columbia Materials Science?

But we are different from the other top-ten schools:

You will work in a rich interdisciplinary environment – not a "silo"
(characteristic of large departments, e.g. MIT, Stanford, Northwestern)

- Small Materials Science program embedded in a diverse, vibrant, interdisciplinary environment
- You will (likely) also work with people from Chemistry|Physics|Electrical Engineering|Chemical Engineering|Mechanical Engineering
- You will (likely) socialize with people doing research in Applied Math|Plasma Physics|Climate Science|High end computing

Why pick Columbia Materials/Solid State?

- You will also live in New York City!

You are all excellent

We really want you to come!