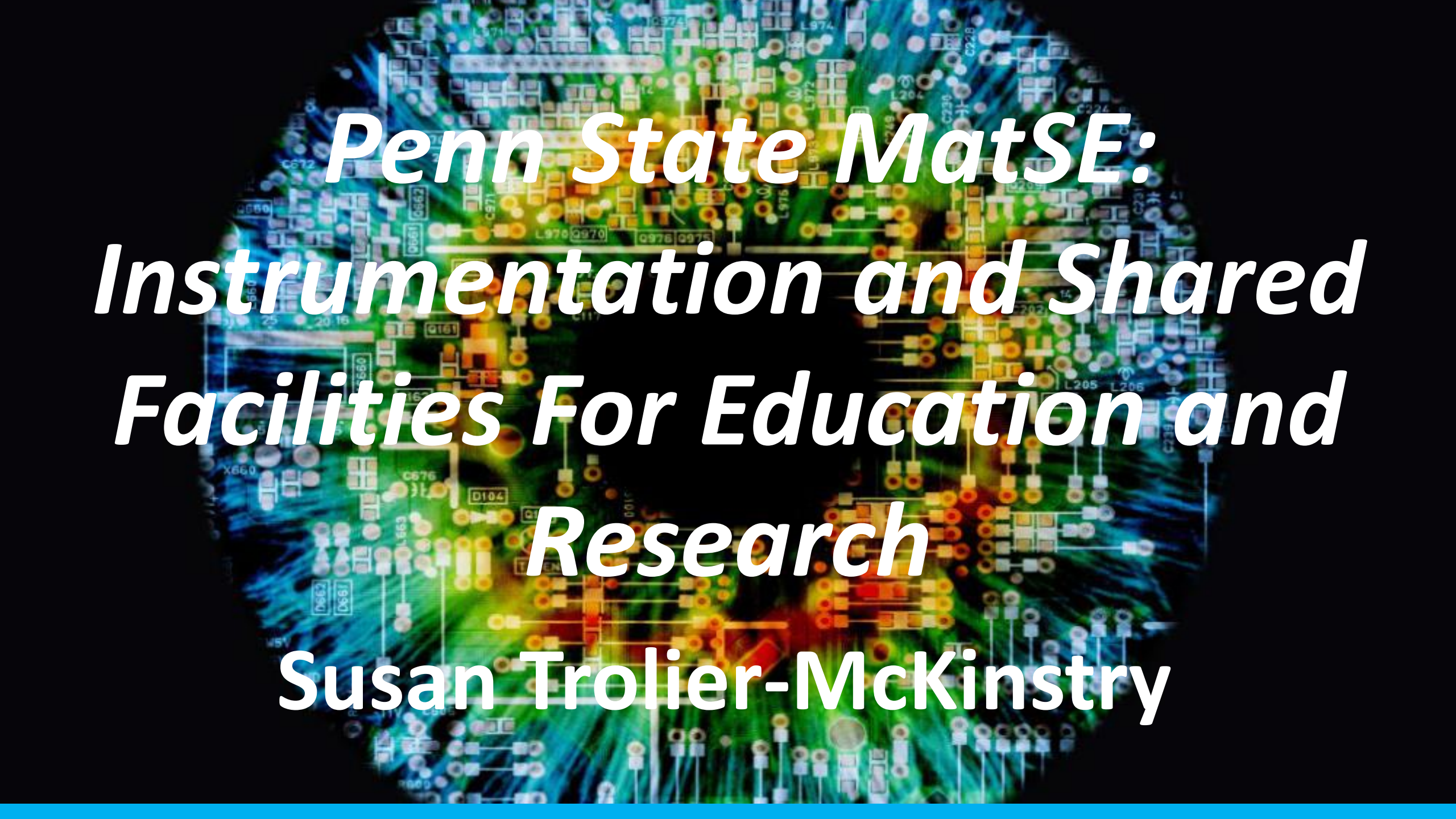


Penn State MatSE: Instrumentation and Shared Facilities For Education and Research

Susan Trolier-McKinstry

Academic History of MATSE at PSU

1907 — Metals Science And Engineering

1923 — Ceramic Science and Engineering

1929 — Steidle Building Opens

1967 — MATSE Department Formed

1972 — Polymer Science And Engineering

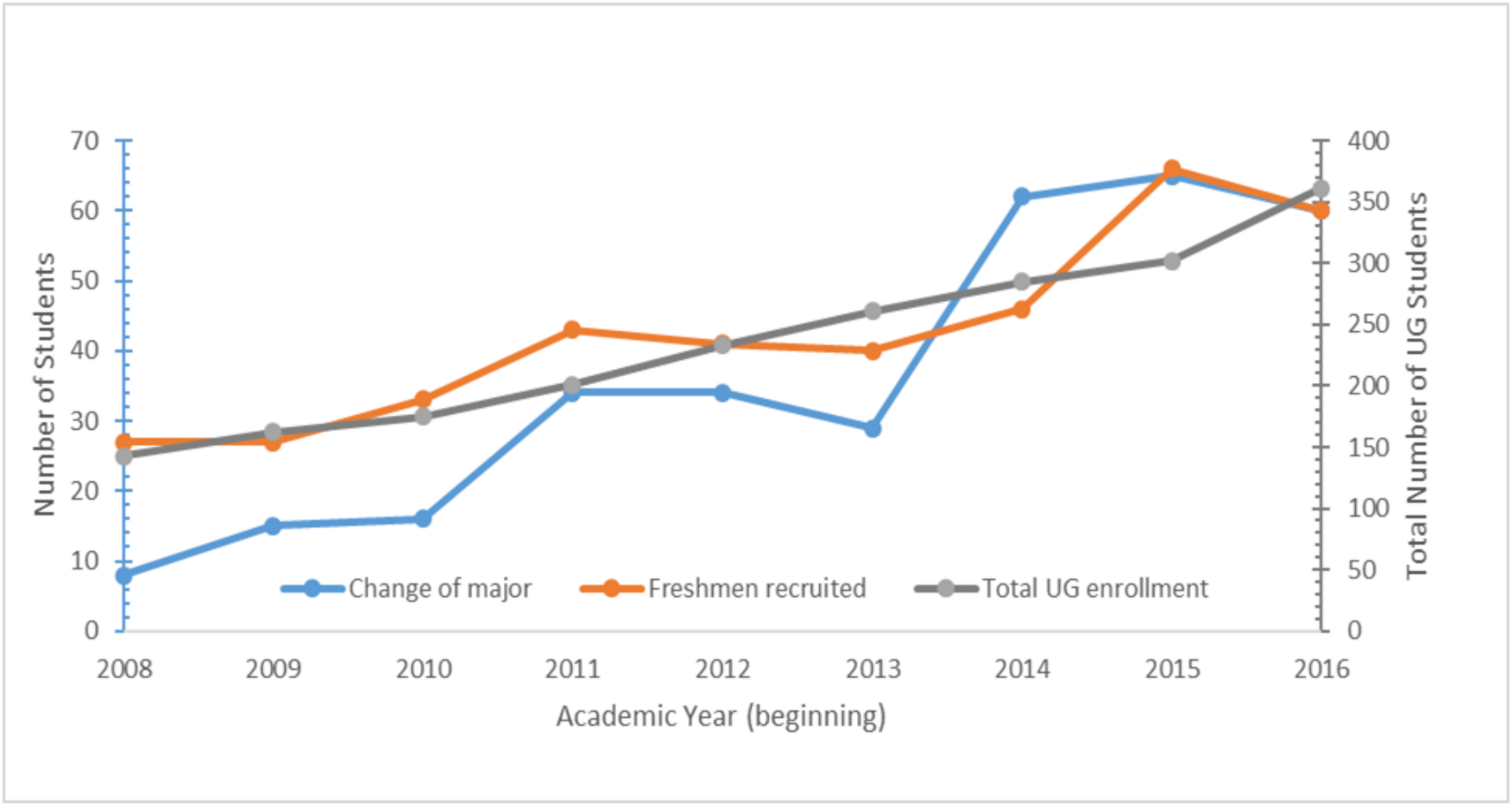
1992 — Electronic and Photonic Materials

1998 — One Degree 4 Options

2012 — One Department One Degree New Curriculum

2016 — "New" Steidle Opens

Undergraduate student growth in MatSE at Penn State



PennState Materials Research Institute

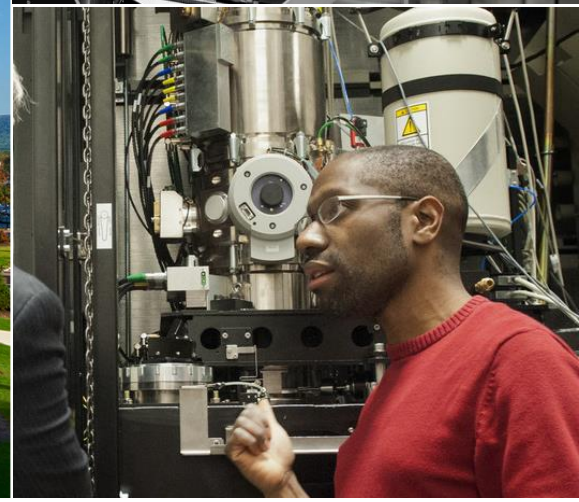
Integrated Infrastructure

MILLENNIUM SCIENCE COMPLEX

Steidle Building

Built in 1929 and completely renovated in 2016. Houses undergraduate teaching labs, advanced processing, 3D printing, rheometry, nano particle handling, and collaboration space.

275,000 square foot Millennium Science Complex houses 35,000+ ft^2 of user facility including Materials Characterization Laboratory and 9,500 ft^2 class 10/100 Cleanroom



Labs co-located in state-of-the-art building on central campus

PennState Materials Research Institute

PSU User Facilities Vision

MILLENNIUM SCIENCE COMPLEX

Vision: Catalyze excellence in interdisciplinary research in nanoscale science, engineering, and technology, with impacts in **discovery**, **innovation**, **technology transition**, and **education** at Penn State and beyond.

The user facilities enhance PSU research infrastructure to:

- Enable high-impact research outcomes in and at the intersection of engineering, physical and life sciences.
- Serve as an epicenter of excellence in the University and beyond.
- Provide an outstanding educational resource regionally, nationally, and globally.
- Develop partnerships that facilitate tech transition and commercialization

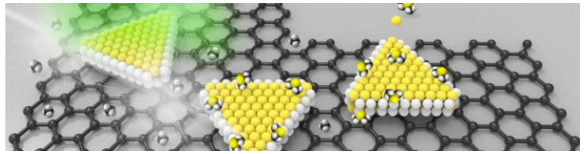
PennState Materials Research Institute

Four Lab Solution: Theory, Synthesis, Fabrication, Characterization

MILLENNIUM SCIENCE COMPLEX

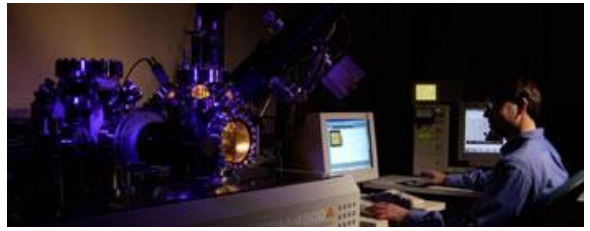
MCC

2DCC-MIP



Nanofab

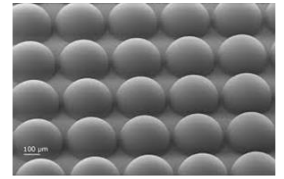
Material Characterization Lab

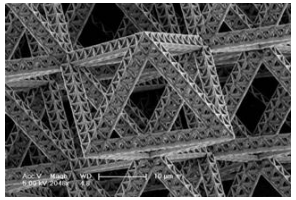


Evaluate material candidates

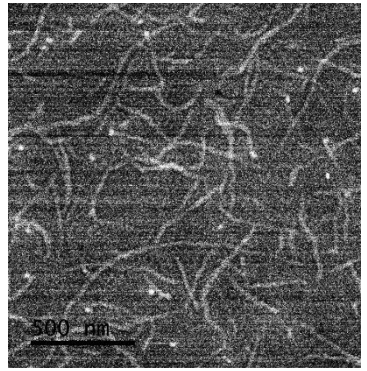
Synthesize materials

Fabricate Devices/Structures





Characterize materials



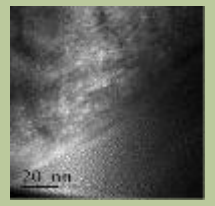
PennState Materials Research Institute

Materials Characterization Lab: IMAGING SCIENCE

MILLENNIUM SCIENCE COMPLEX

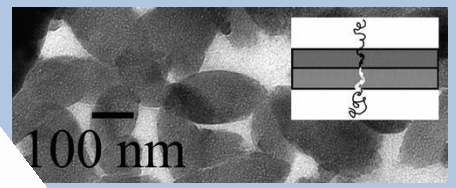
4Å virus maps
Hafenstein Lab

Artificial Aquaporin 2D c.

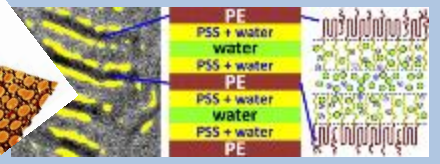


Preliminary results (Kumar-Kabius)

Artificial platelets and vesicles



Fuel cell membranes



Ionic polymers

Battery electrolytes

THE HUCK INSTITUTES OF THE LIFE SCIENCES

PennState College of Medicine

MRI Materials Research Institute

Partnerships between institutes, departments, and faculty enable infrastructure

Life Sciences / Medicine / Environment / Materials / Energy

PSU cryo-TEM : Opportunities in Soft-Bio Materials (70% Life Science-30% Materials) –structural polymer, structural proteins, Virus, DNA, RNA.

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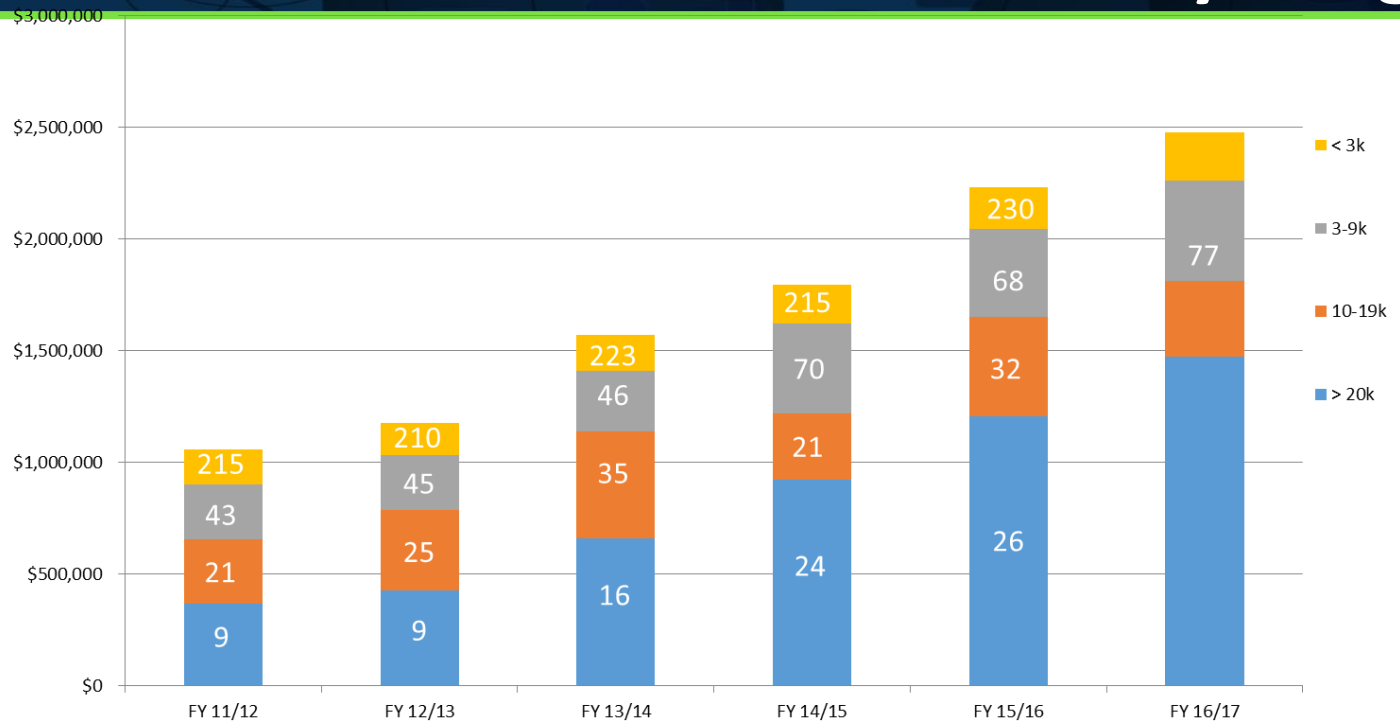
Materials Characterization Laboratory Usage

MILLENNIUM SCIENCE COMPLEX



- Higher Quality Research
- Recruiting Students
- Recruiting Faculty
- Company/University Cooperation
- Penn State Leadership

	FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17
PI's	288	289	320	330	356	356
Unique Users	860	861	943	980	1026	1056
Total Income	$1.06M	$1.18M	$1.53M	$1.75M	$2.17M	$2.45M
PSU Income (YOY change)	*$967k*	*$1.03M (+6%)*	*$1.32M (+28%)*	*$1.45M (+10%)*	*$1.73M (+20%)*	*$1.92M (+10%)*
Industry Income, ARSO (YOY change)	$93K	$153K (+39%)	$213K (+28%)	$297K (+28%)	$439K (32%)	$532K (+18%)

MCL Materials Characterization Lab

PennState Materials Research Institute

2D Crystal Consortium
NSF Materials Innovation Platform

NSF

MILLENNIUM SCIENCE COMPLEX

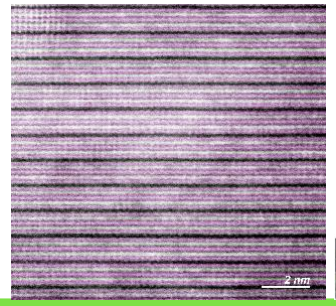
NSF Division of Materials Research: **Materials Innovation Platforms (MIPs)**

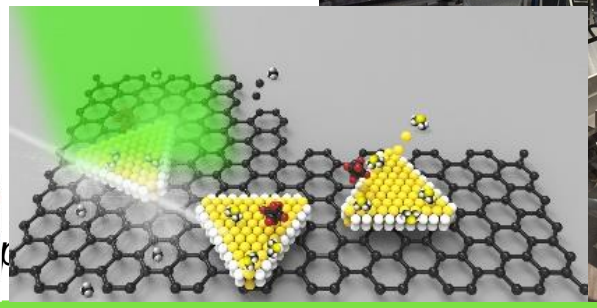
MIPS are **national user facilities** - the first round (awarded in 2016) are focused on **bulk crystal growth and epitaxy** of hard crystalline materials using a **materials genome approach** (theory-synthesis-characterization). Major installations made in 2017 to develop this national consortium.

Basic components of a MIP:

- National User Facility/Program
- In-House Research
- Education and Outreach

A 5-year, $17.8 million Platform at Penn State University to advance the synthesis of 2D layered chalcogenides for next generation electronics.





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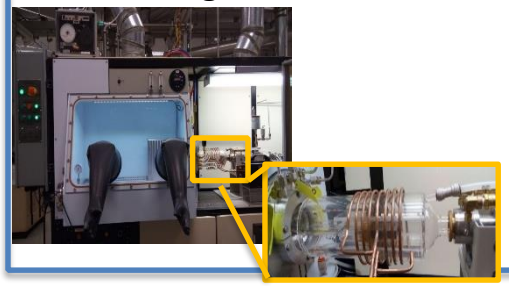
User Facilities

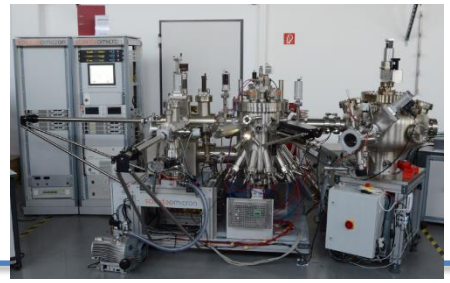
Synthesis and *In situ* Characterization of Thin Films

Chalcogenide MOCVD



Hybrid Chalcogenide MBE

Multi-Module UHV MBE



Bulk Crystal Growth

Vertical Bridgman

Chemical Vapor Transport (2)

Support Equipment – Ampoule Preparation

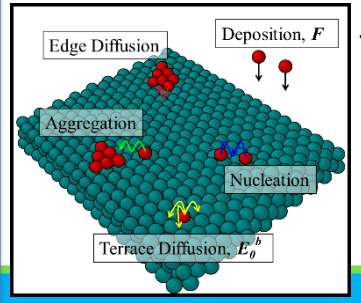
Quartz Sealing

Compounding

Ampoule Loading

Theory and Simulation

Reaction Kinetics



Short Time Scale – ReaxFF
Long Time Scale – Accelerated MD and phase-field methods

Thermodynamics & Reaction Kinetics

Unique Aspects

- *Personnel*
  Materials Computation
- *Technical Strength*
  MCC
  ICS-ACI

PennState Materials Research Institute

Nanofab Research Training

MILLENNIUM SCIENCE COMPLEX

Video first training for equipment

Improved Training on Equipment
Easy Ways to Refresh
More Efficient Transition to Student Independence
More Effective Use of Research $
Better Time Management for Facility Staff

PennState Materials Research Institute

Facilities, Education and Outreach

MILLENNIUM SCIENCE COMPLEX

Goals

1. Prepare a talented and diverse workforce
2. Enable outstanding research and education
3. Enhance public awareness of science and technology

Activities

1. Multiple courses run in the facilities, including Materials Characterization, and Semiconductor Integrated Circuit Technology
2. Graduate Student and undergraduate research relies heavily on technical staff for training, safety, and tool maintenance
3. Technical Training Experience opportunities to strengthen skills of community college students
4. RET, 'Train-the-Trainer' and REU experiences
5. Webinar series and workshops

Graphene and Beyond Workshop

The Penn State Data Center houses CyberLAMP

MCC in CyberLAMP

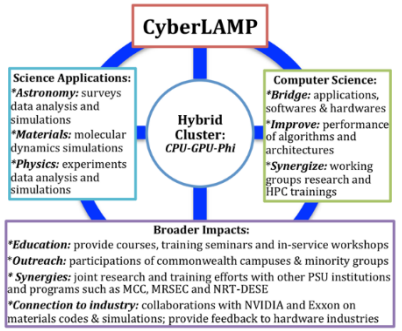
The CyberLAMP cluster occupies ~70 sq. ft. of floor space for 10 racks, and it requires ~105 kW of power and 30 tons of cooling.

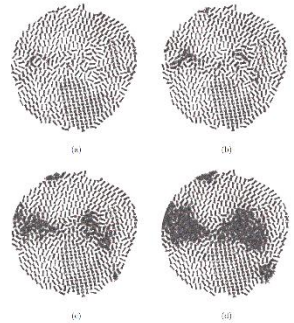
- PI; Yuexing Li (Astronomy), co-Pis: Doug Cowen (Physics), Eric Ford (Astronomy), Adri van Duin (MCC, MNE), Mahmut Kandemir (EE)
- Mixed CPU/GPU cluster – state-of-the-art GPU (P100)
- Major computational resource for new MRI cryo-TEM (Susan Hafenstein)
- Online since May 2017 – over 80% current CPU usage
- Major HPC resource for various MCC members

Adri van Duin

Kristen Fichthorn

Jorge Sofo





Atomistic-scale simulation of Kevlar fiber response to extreme strain (van Duin group)

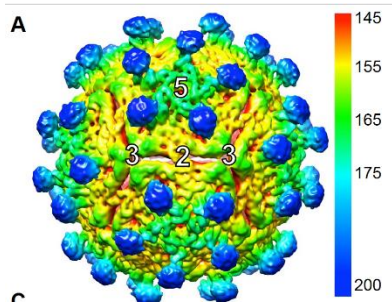


Image of virus-structure (Hafenstein group)

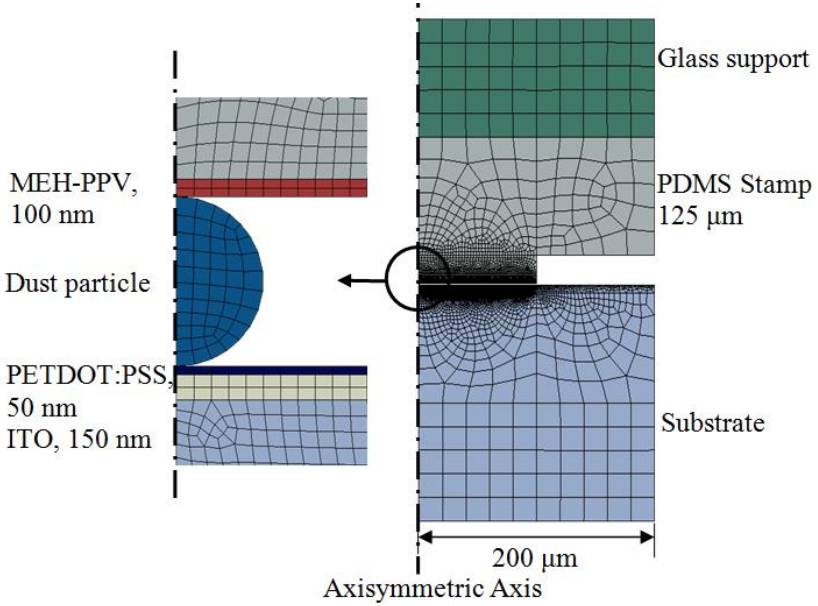
PennState Materials Research Institute

Facility-Led Seed Grant Programs

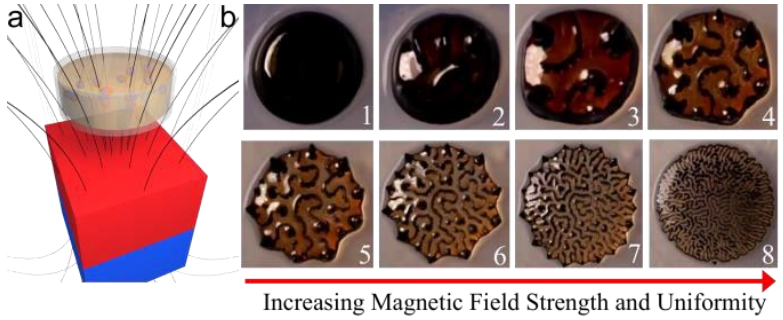
MILLENNIUM SCIENCE COMPLEX

MCC seed grants

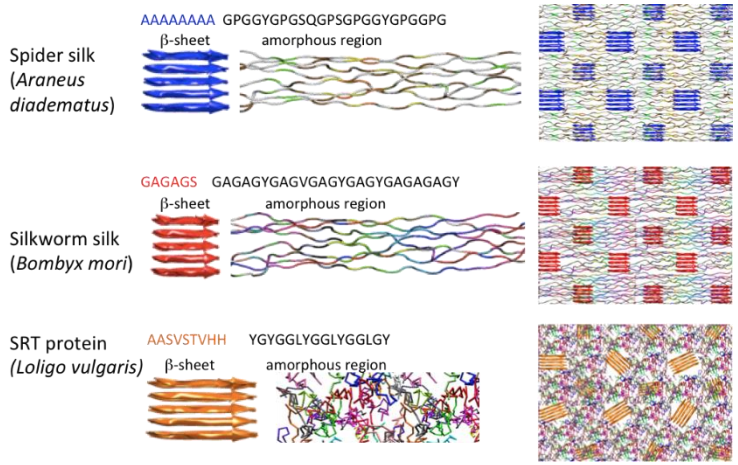
Jing Du
polymer/transition metal oxides



Tak-Sing Wong and Long Qing Chen
ferrofluids for biomedical applications



Melik Demirel
polymeric proteins



Spring 2017: bio/material interfaces

Goals MCC seed grants:

- Strengthen PSU theory methods
- Align theory with MRI goals
- Increase MRI-awareness amongst new PSU theory faculty
- Encourage new collaborations