Northwestern
McCORMICK SCHOOL
OF ENGINEERING

Dravid Research Group

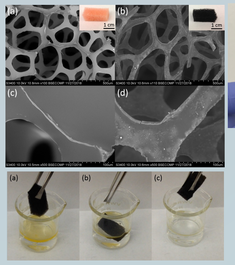
Atomic and Nanoscale Phenomena in Advanced Materials

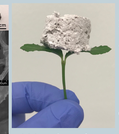
NUANCE
Atomic and Nanoscale
Characterization Experimental Center

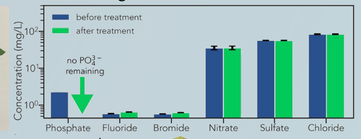
Materials for the Environment

Sponge Membranes for Water Remediation

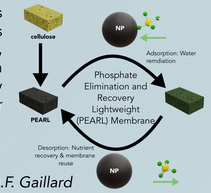
Dr. Vikas Nandwana, Benjamin Shindel, Jack Hegarty, Mike Barsoum, Kelly Matuszewski
Collaborators: Profs. J.F. Gaillard, O. Farha, A. Packman, M. Singh, Dr. S. Ribet





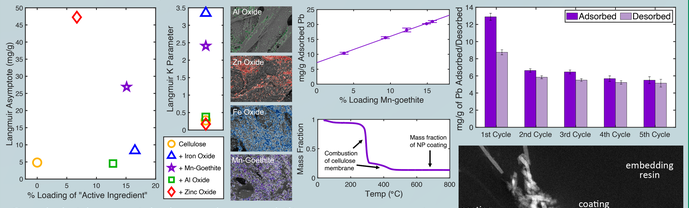


We develop sponge membranes to leverage novel nanomaterials for environmental challenges, such as oil spill remediation (OHM sponge), nutrient recovery (PEARL membrane), and other applications detailed below.



Heavy Metal Remediation

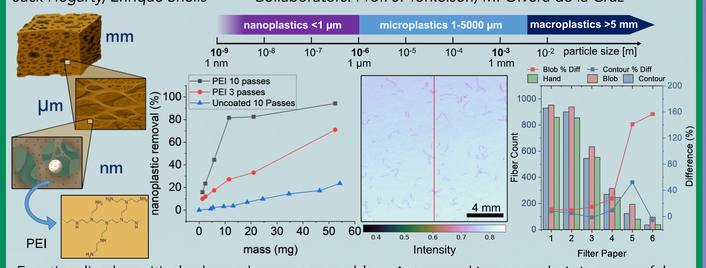
Benjamin Shindel, Kelly Matuszewski *Collaborators: Prof. J.F. Gaillard*



Our hybrid materials have the capability to remove toxic heavy metals like lead and cadmium, as well as recovering critical elements from waste-water, such as nickel and cobalt.

Micro/Nano-Plastics

Jack Hegarty, Enrique Sheils *Collaborators: Prof. J. Torkelson, M. Olvera de la Cruz*

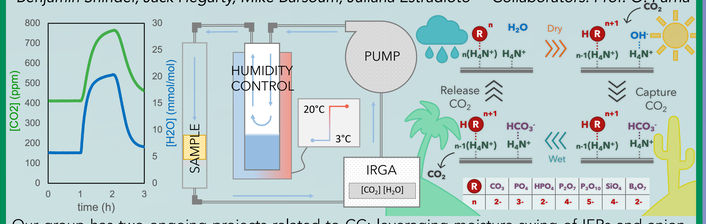


Functionalized, positively-charged sponges are able to effectively remove nano-plastics from solution.

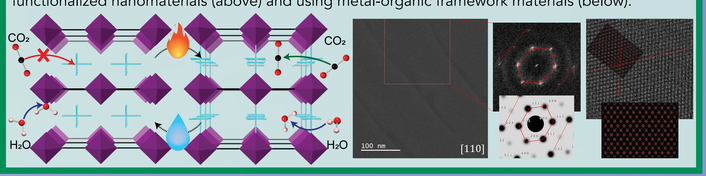
Automated image analysis is a powerful tool to analyze micro-plastic contaminants and improve their remediation.

Carbon Capture

Benjamin Shindel, Jack Hegarty, Mike Barsoum, Juliana Estradioto *Collaborators: Prof. O. Farha*



Our group has two ongoing projects related to CC: leveraging moisture-swing of IERs and anion-functionalized nanomaterials (above) and using metal-organic framework materials (below).

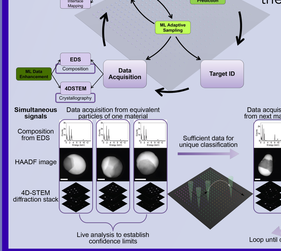


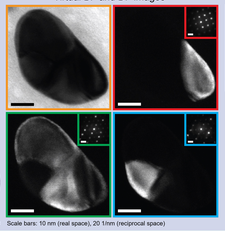
Hybrid Microscopy

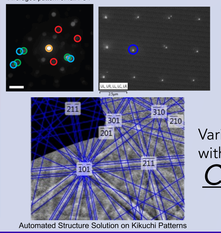
Complex Nanoparticle Systems and Automated Electron Microscopy for High-Throughput Materials Discovery

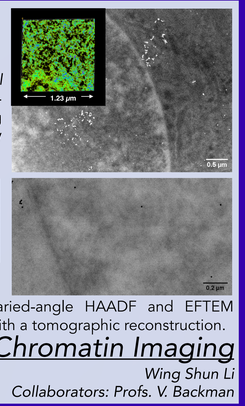
Carolin Wahl, Alp Kulaksizoglu *Collaborators: Profs. C. Mirkin, W. Chen, D. Apley, A. Agrawal*

We automate EM data acquisition and analysis with AI for high-throughput materials discovery on nanomaterial megalibraries using 4D-STEM, EDS, and TKD, and use advanced EM techniques to study the structures and properties of complex multiphasic nanomaterials.









Varied-angle HAADF and EFTEM with a tomographic reconstruction.

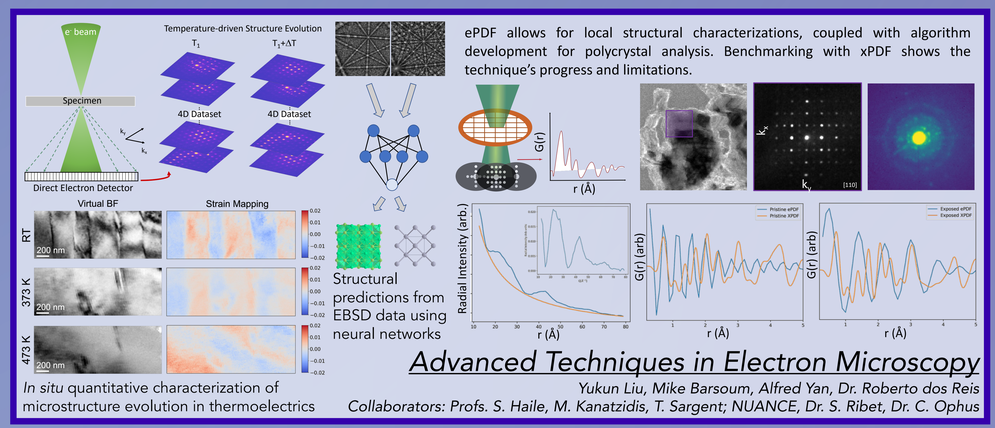
Chromatin Imaging

Wing Shun Li
Collaborators: Profs. V. Backman

- **Alumni:** 50+ PhD graduates with a variety of placements including: UC Santa Cruz, Argonne National Laboratory, IBM, Intel, Apple, PennState, McKinsey & Company, GE
- **Current:** 11 PhD students, including 5 co-advised with Professors C. Mirkin, V. Backman, O. Farha, and M. Kanatzidis
- **Research:** h-index: 120; over two dozen patents, including light-induced gas sensors, theranostic nanoparticles, and nanolithography
- **Synergy:** Developed NUANCE and SHyNE centers; ability to work closely with dozens of talented research scientists
- **Outreach:** Group members participate in and serve on the boards of a number of outreach activities, including GradSWE, BGSA, Junior Science Club, Letters to a Pre-Scientist, SHIP, MatSAIC, and MSSA; NSF-NNCI National Leadership; Chicago Area Museums
- **Education:** Course and curriculum development; hands-on labs as the norm; >1200 graduated microscopy students

Advanced Techniques in Electron Microscopy

Yukun Liu, Mike Barsoum, Alfred Yan, Dr. Roberto dos Reis
Collaborators: Profs. S. Haile, M. Kanatzidis, T. Sargent; NUANCE, Dr. S. Ribet, Dr. C. Ophus



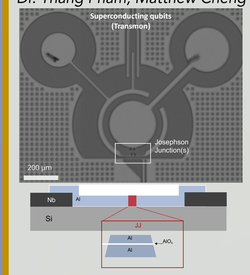
ePDF allows for local structural characterizations, coupled with algorithm development for polycrystal analysis. Benchmarking with xPDF shows the technique's progress and limitations.

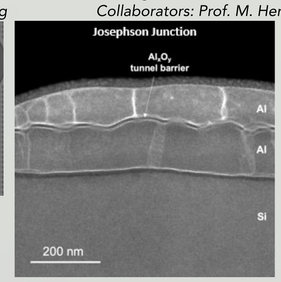
In situ quantitative characterization of microstructure evolution in thermoelectrics

Quantum and Energy Materials

Superconducting Quantum Systems and Materials

Dr. Thang Pham, Matthew Cheng *Collaborators: Prof. M. Hersam; NIST, Fermilab*





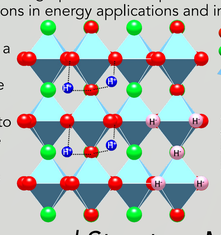
We study the structure-coherence relationship in superconducting qubits (transmons) by developing advanced electron microscopy techniques. These devices underpin the next generation of quantum computing technology.

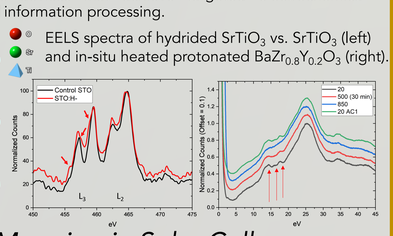
Hydrogen in Energy and Information Systems (HEISs)

Yea-Shine Lee, Dr. Roberto dos Reis *Collaborators: Profs. S. Haile, M. Bedzyk, J. Rondinelli, C. Wolverton, L. Chen; FSU, MIT, CSM, UT, UIUC*

We address fundamental questions of hydrogen incorporation and transport in solid-state materials for high-performance protonic devices that achieve targeted electrochemical transformations in energy applications and information processing.

Detecting hydrogen is a challenging task. We use analytical techniques to study subtle changes in solid oxides due to H speciation.

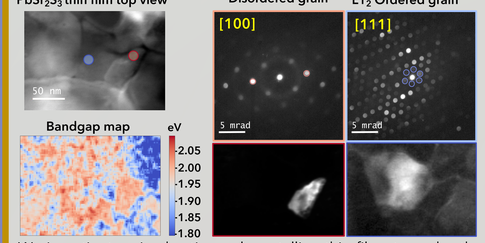




EELS spectra of hydrided $SrTiO_3$ vs. $SrTiO_3$ (left) and in-situ heated protonated $BaZr_{0.8}Y_{0.2}O_3$ (right).

Bandgap and Structure Mapping in Solar Cells

Patricia Meza, Dr. Roberto dos Reis. *Collaborators: Prof. M. Kanatzidis*

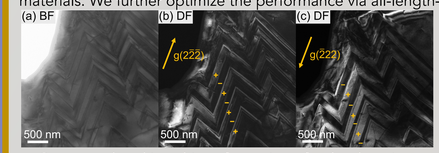


We investigate mixed cation polycrystalline thin films to probe the effect of nanoscale ordering on properties like bandgap to help synthesize better solar cells, using STEM, EELS, and HAADF.

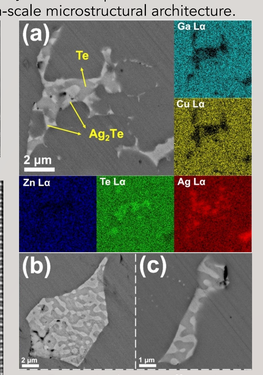
Hierarchically Architectured Thermoelectrics

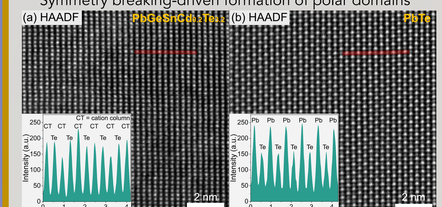
Yukun Liu *Collaborators: Profs. M. Kanatzidis, C. Wolverton, G. Snyder*

We perform S/TEM analysis to elucidate structure-property relationships in thermoelectric materials. We further optimize the performance via all-length-scale microstructural architecture.



Symmetry breaking-driven formation of polar domains





Short-range atomic disorder in high-entropy thermoelectrics

Dynamic doping effects in $Cu_{1-x}Ag_xGaTe_2$–ZnTe