Northwestern
McCORMICK SCHOOL
OF ENGINEERING

Dravid Research Group

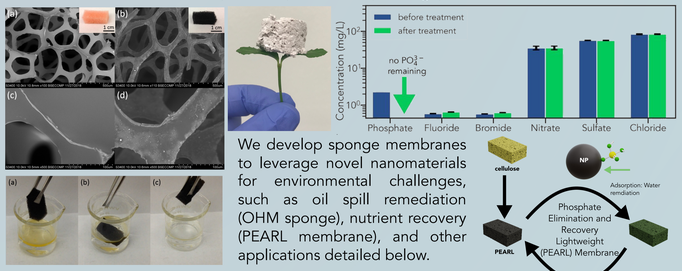
Atomic and Nanoscale Phenomena in Advanced Materials

NUANCE
Atomic and Nanoscale
Characterization Experimental Center

Materials for the Environment

Sponge Membranes for Water Remediation

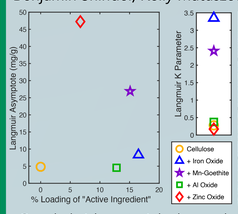
Dr. Vikas Nandwana, Benjamin Shindel, Jack Hegarty, Mike Barsoum, Kelly Matuszewski, Elias Kallon
Collaborators: Profs. J.F. Gaillard, O. Farha, A. Packman, M. Singh, Dr. S. Ribet

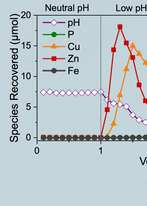


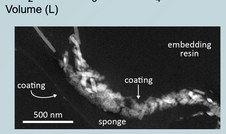
We develop sponge membranes to leverage novel nanomaterials for environmental challenges, such as oil spill remediation (OHM sponge), nutrient recovery (PEARL membrane), and other applications detailed below.

Heavy Metal Remediation

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



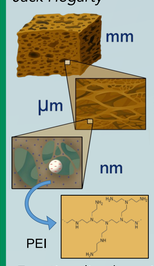


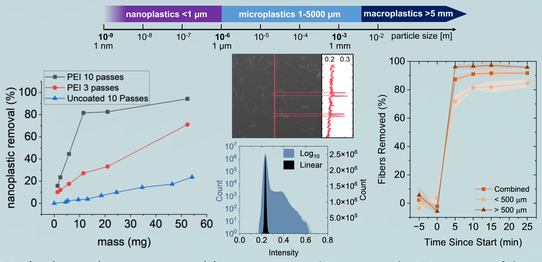


Our hybrid materials have the capability to remove toxic heavy metals like lead and cadmium, as well as recovering critical elements from waste-water, such as nickel and cobalt.

Micro/Nano-Plastics

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



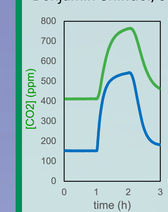


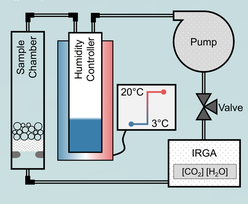
Functionalized, positively-charged sponges are able to effectively remove nano-plastics from solution.

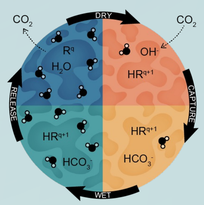
Automated image analysis is a powerful tool to analyze micro-plastic contaminants and improve their remediation.

Carbon Capture

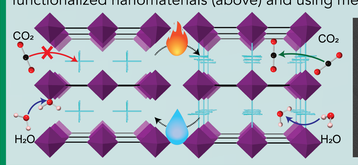
Benjamin Shindel, Jack Hegarty, Mike Barsoum *Collaborators: Prof. O. Farha*

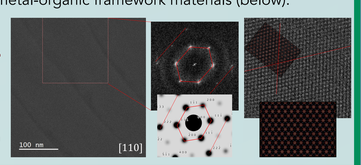






Our group has two ongoing projects related to CC: leveraging moisture-swing of IERs and anion-functionalized nanomaterials (above) and using metal-organic framework materials (below).

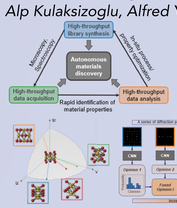




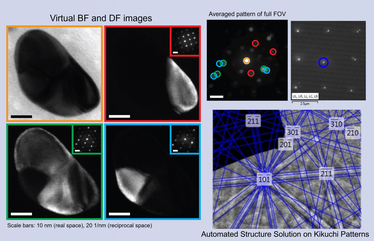
Hybrid Microscopy

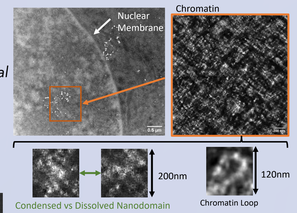
Nanoparticle Systems and Automated Electron Microscopy for High-Throughput Materials Discovery

Alp Kulaksizoglu, Alfred Yan *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.

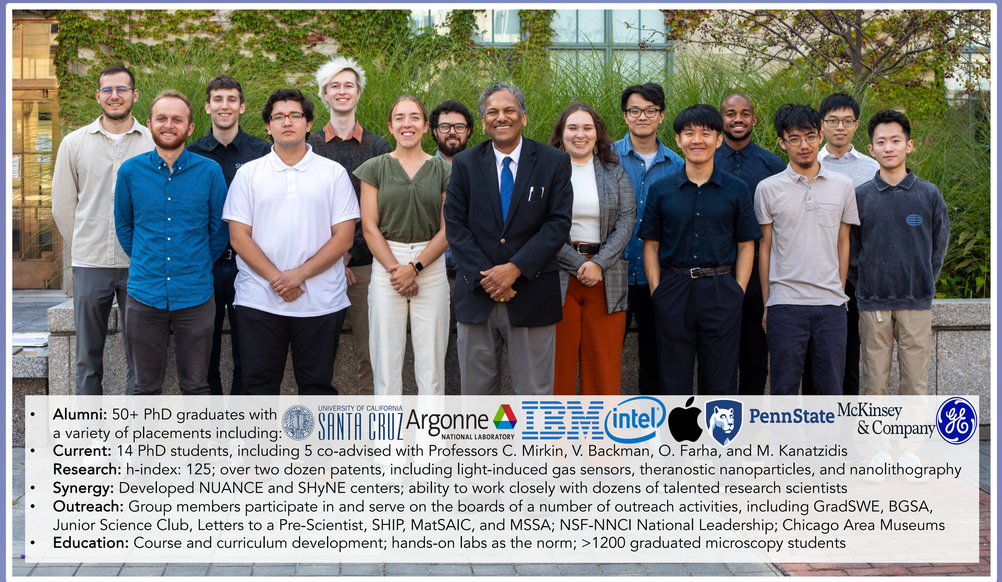




We use electron tomography and Click-EM to study chromatin organization in human cells, investigating the roles of chromatin loop extrusion, nuclear cation regulation, and histone modifications on chromatin nanodomain density.

Chromatin Imaging

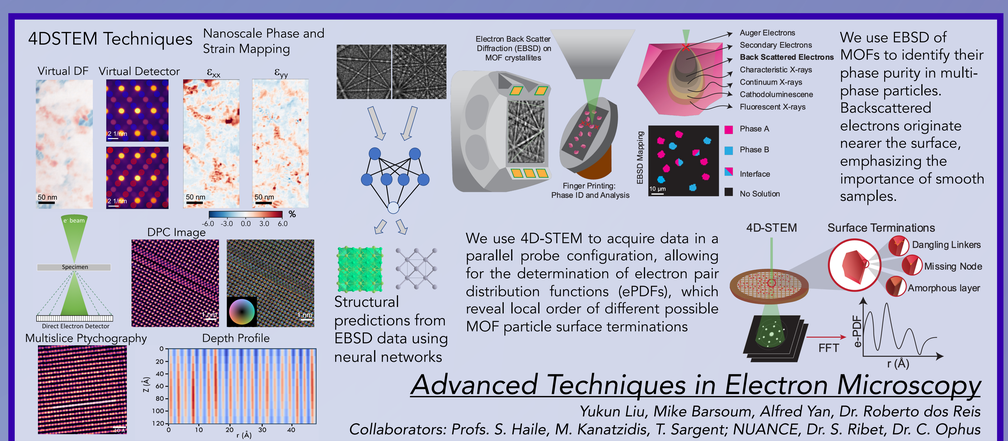
Wing Shun Li
Collaborators: Profs. V. Backman



- **Alumni:** 50+ PhD graduates with a variety of placements including: UNIVERSITY OF CALIFORNIA SANTA CRUZ, Argonne NATIONAL LABORATORY, IBM, intel, PennState, McKinsey & Company, GE
- **Current:** 14 PhD students, including 5 co-advised with Professors C. Mirkin, V. Backman, O. Farha, and M. Kanatzidis
- **Research:** h-index: 125; 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



We use 4D-STEM to acquire data in a parallel probe configuration, allowing for the determination of electron pair distribution functions (ePDFs), which reveal local order of different possible MOF particle surface terminations

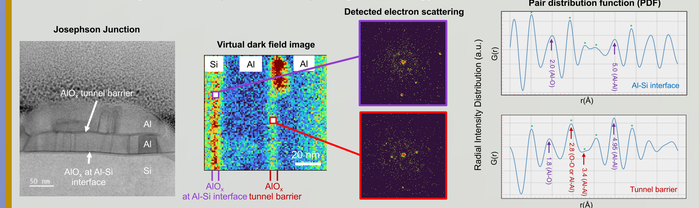
We use EBSD of MOFs to identify their phase purity in multi-phase particles. Backscattered electrons originate nearer the surface, emphasizing the importance of smooth samples.

Quantum and Energy Materials

Superconducting Quantum Systems and Materials

Peter Lim *Collaborators: Profs. M. Hersam, M. Bedzyk, J. Rondinelli, V. Chandrasekhar, Fermilab, NIST, Ames, Rigetti*

We use advanced electron microscopy techniques to study the nanoscale structure and chemistry affecting the coherence of superconducting transmon qubits. These devices are at the forefront of next-generation quantum computing technology.

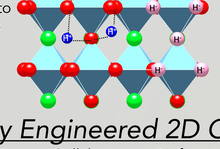


Hydrogen in Energy and Information Systems (HEISs)

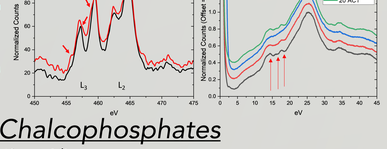
Liz Griffin, Dr. Roberto dos Reis. *Collaborators: Profs. S. Haile, M. Bedzyk, J. Rondinelli, C. Wolverton, L. Chen; FSU, MIT, CSM, UT, UIUC*

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.

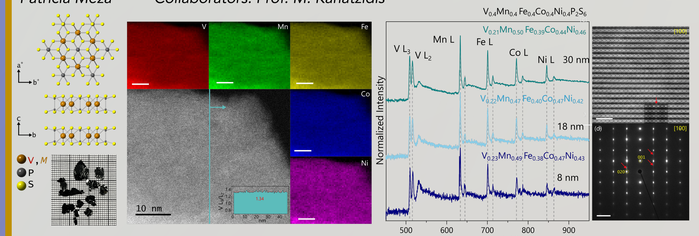


EELS spectra of hydrided $SrTiO_3$ vs. $SrTiO_3$ (left) and in-situ heated protonated $BaZr_{0.8}Y_{0.2}O_3$ (right).



Entropy Engineered 2D Chalcophosphates

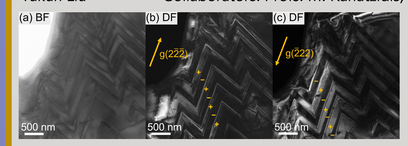
Patricia Meza *Collaborators: Prof. M. Kanatzidis*



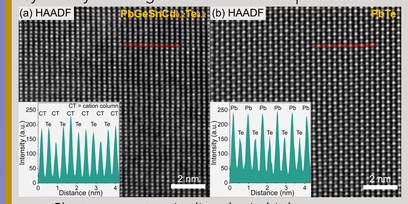
Through collaboration with the Kanatzidis group, we grow 2D mixed metal chalcophosphates. To confirm metal mixing at the nanoscale, we employ EELS chemical and oxidation state mapping. Finally, we characterize the magnetic properties of theses new materials.

Hierarchically Architectured Thermoelectrics

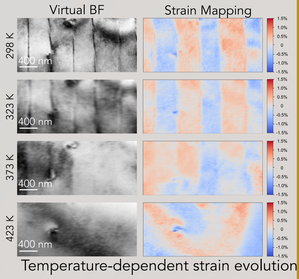
Yukun Liu *Collaborators: Profs. M. Kanatzidis, C. Wolverton, G. Snyder*



Symmetry breaking-driven formation of polar domains



Short-range atomic disorder in high-entropy thermoelectrics



Temperature-dependent strain evolution

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