Northwestern McCORMICK SCHOOL OF ENGINEERING

Dravid Research Group

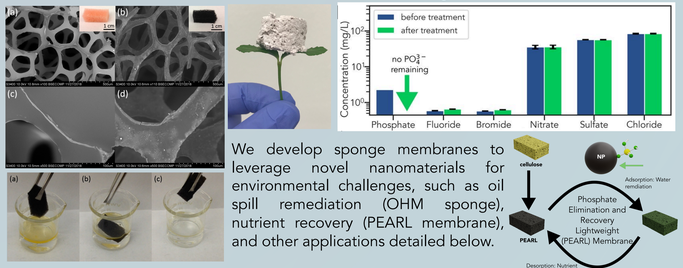
Atomic and Nanoscale Phenomena in Advanced Materials

NUANCE Atomic and Nanoscale Characterization Experimental Center

Materials for the Environment

Sponge Membranes for Water Remediation

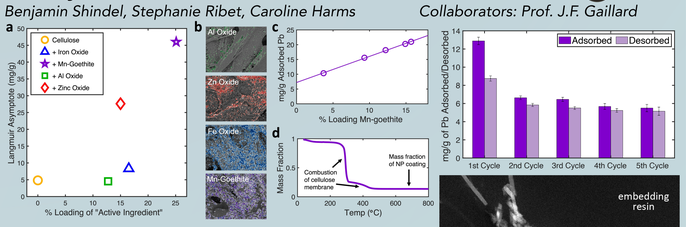
Dr. Vikas Nandwana, Stephanie Ribet, Benjamin Shindel, Jack Hegarty, Mike Barsoum
Collaborators: Profs. J.F. Gaillard, O. Farha, A. Packman, M. Singh



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

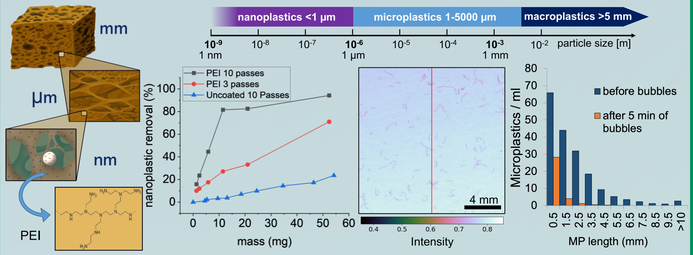
Benjamin Shindel, Stephanie Ribet, Caroline Harms *Collaborators: Prof. J.F. Gaillard*



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, Caroline Harms *Collaborators: Prof. J. Torkelson, A. Packman, M. Singh*

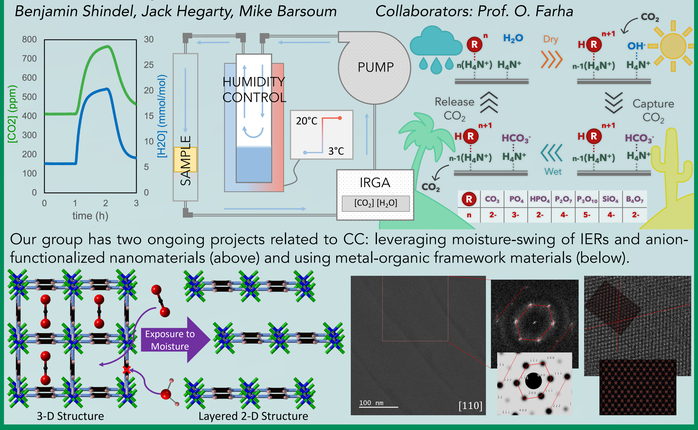


Functionalized, positively-charged sponges are able to effectively remove nano-plastics from solution.

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*

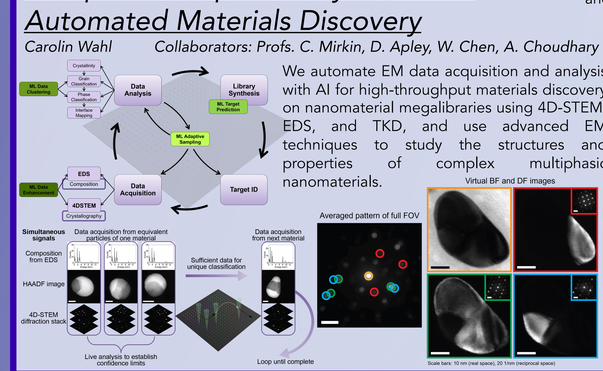


Our group has two ongoing projects related to CC: leveraging moisture-swing of IERs and anion-functionalized nanomaterials (above) and using metal-organic framework materials (below).

Hybrid Microscopy

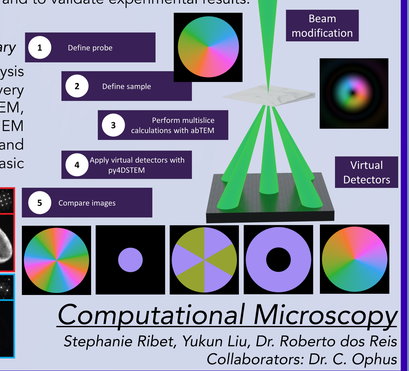
Complex Nanoparticle Systems and Automated Materials Discovery

Carolin Wahl *Collaborators: Profs. C. Mirkin, D. Apley, W. Chen, A. Choudhary*



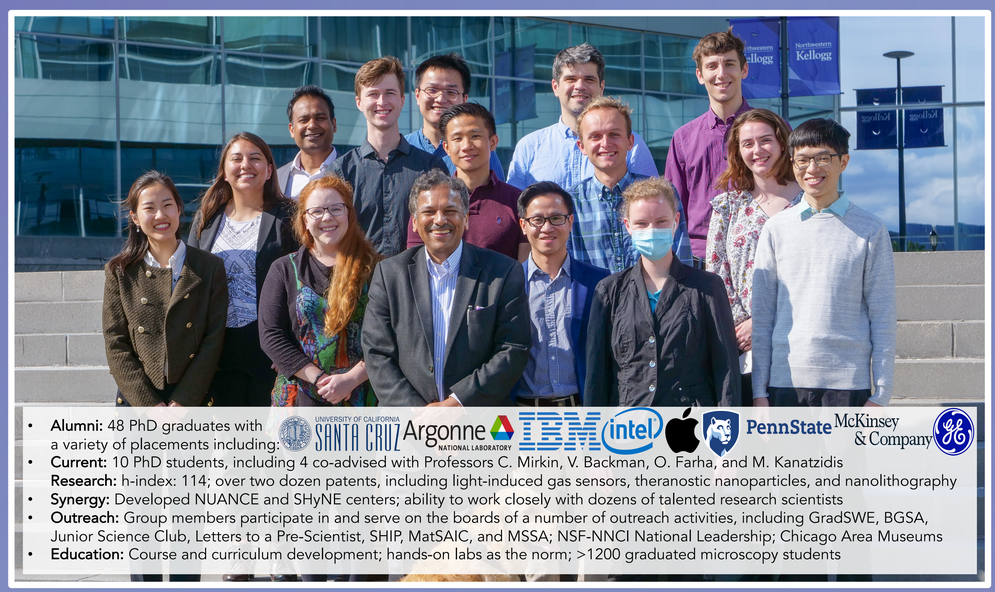
We automate EM data acquisition and analysis with AI for high-throughput materials discovery on nanomaterial megalibraries using 4D-STEM, EDS, and TKD, and use advanced EM techniques to study the structures and properties of complex multiphasic nanomaterials.

We use image simulations for technique development and to validate experimental results.



Computational Microscopy

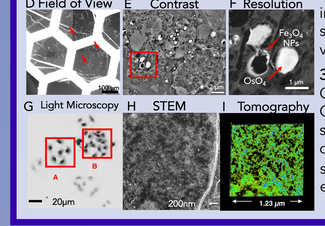
Stephanie Ribet, Yukun Liu, Dr. Roberto dos Reis
Collaborators: Dr. C. Ophus



- **Alumni:** 48 PhD graduates with a variety of placements including: UC Santa Cruz, Argonne National Laboratory, IBM, Intel, Penn State, McKinsey & Company, GE
- **Current:** 10 PhD students, including 4 co-advised with Professors C. Mirkin, V. Backman, O. Farha, and M. Kanatzidis
- **Research:** h-index: 114; 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

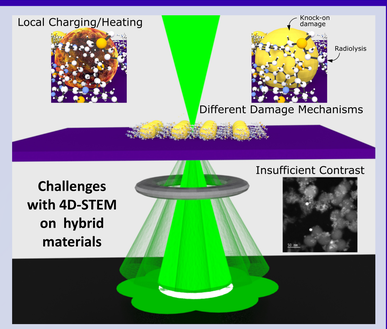
Soft Microscopy and Chromatin Imaging

Dr Kelly Parker, Wing Shun Li, Dr. Roberto dos Reis, Dr. Reiner Bleher, Eric Roth
Collaborators: Profs. M. Mrksich, V. Backman, W. Dichtel



SEM-related methods for low-voltage soft imaging. A-C: STEM-in-SEM showing high contrast and resolution for stained protein assemblies, as well as unstained polymer vesicles at different kV. D-F: Atomic number contrast (BSE) imaging in SEM of Os-stained cells showing the advantage of large field of view, high contrast, and high resolution.

3D chromatin structure reconstruction. G: Cells stained with Osmium with Click-EM. H: STEM HAADF Image showing the mass distribution of chromatin. I: 3D chromatin structure reconstructed from electron tomography.



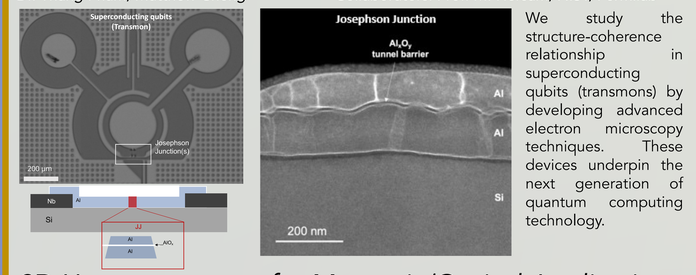
4D STEM and Hybrid Microscopy

Stephanie Ribet, Mike Barsoum, Dr. Roberto dos Reis
Collaborators: Profs. S. Haile, M. Kanatzidis, T. Sargent; NUANCE

Quantum and Energy Materials

Superconducting Quantum Systems and Materials

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

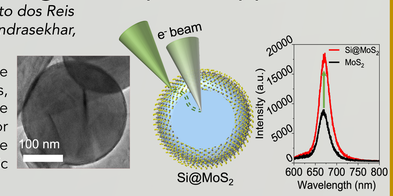


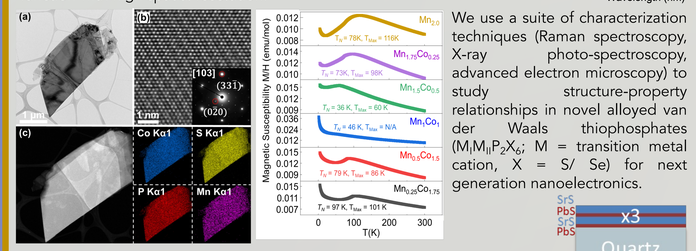
We study the structure-coherence relationship in superconducting qubits (transmons) by developing advanced electron microscopy techniques. These devices underpin the next generation of quantum computing technology.

2D Heterostructures for Magnetic/Optical Applications

Matthew Cheng, Yea-Shine Lee, Dr. Roberto dos Reis
Collaborators: Profs. M. Kanatzidis, V. Chandrasekhar, K. Aydin, C. Wolverton, Kobe University

Silicon-MoS_2 core-shell structures have promising optical applications (lasers, photodetectors, display screens). The silicon core couples with the 2D MoS_2 for enhanced light-matter interaction. We use EELS to extract the system's dielectric function with high spatial resolution.



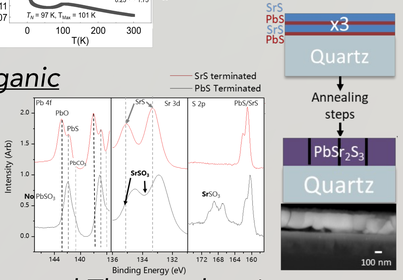


We use a suite of characterization techniques (Raman spectroscopy, X-ray photo-spectroscopy, advanced electron microscopy) to study structure-property relationships in novel alloyed van der Waals thiophosphates ($M_IM_{II}P_2X_6$; M = transition metal cation, X = S/ Se) for next generation nanoelectronics.

Wide-Band Gap Inorganic Photovoltaics

Patricia Lohman Meza
Collaborators: Prof. M. Kanatzidis

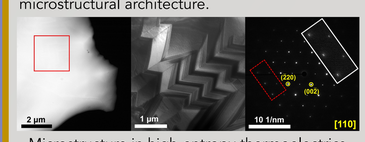
We study the structure-optical property relationships in ternary chalcogenides systems utilizing microscopy to optimize the synthesis of all-inorganic photovoltaics.



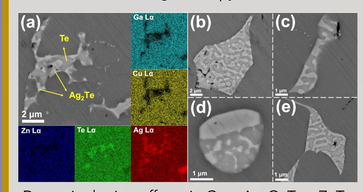
Hierarchically Architectured Thermoelectrics

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

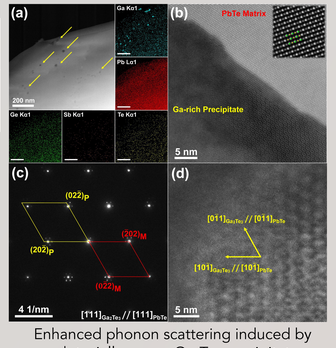
We perform S/TEM analysis to elucidate the underlying principles of formation and properties of thermoelectric materials. We further optimize the thermoelectric performance via all-length-scale microstructural architecture.



Microstructure in high-entropy thermoelectrics



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



Enhanced phonon scattering induced by endotaxially grown Ga_2Te_3 precipitates