University of Wisconsin MRSEC

Wisconsin MRSEC, 2017-2021

NSF DMR-1720415

National Science Foundation
MRSEC
Materials Research Science and Engineering Centers

Wisconsin MRSEC Vision

The Wisconsin MRSEC:

- ***fosters multidisciplinary teams that tackle grand challenges in the science and engineering of disordered materials, enabling new technologies and engaging with industry***
- ***creates and disseminates nation-leading research-inspired educational materials***
- ***promotes diversity and inclusion in STEM to improve the STEM research enterprise now and create the workforce of the future***

- 35 funded and affiliate faculty-level participants
  - 10 academic departments from 3 colleges
  - 10 women, 3 URM
- 26 funded graduate students and 10 postdocs
- 53 total students (undergrad and grad) and postdocs participate in Center activities

Breakthrough Research and Education Workshop 2019. BREW is an annual all-hands meeting to discuss Center research and work together on education and outreach materials.

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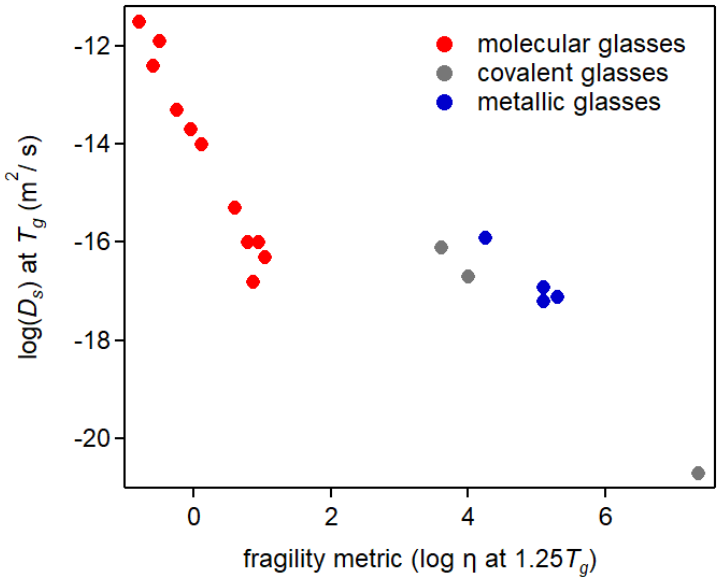
IRG 1: Stability in Glasses

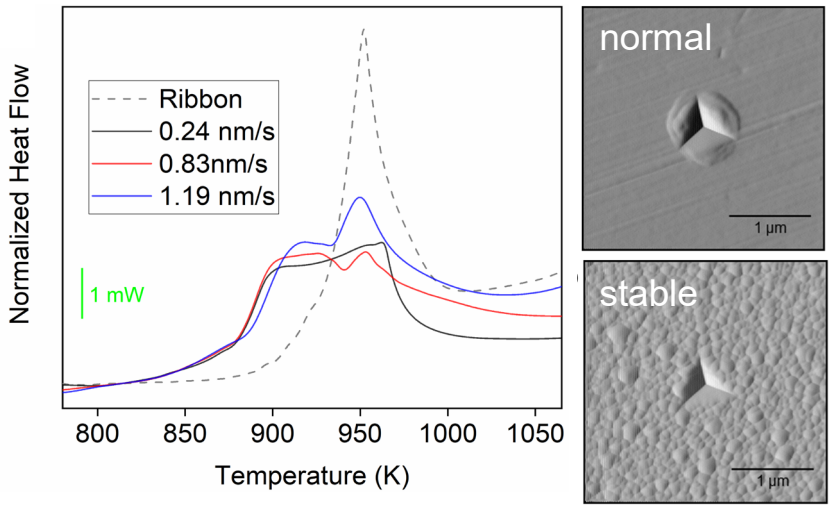
Grand Challenge: To develop fundamental molecular-level insight into glass structure, properties and processes, by unifying perspectives and tools from organic and inorganic glass research

Collaborative Impact: New understanding of glass surface dynamics across molecular, metallic, and oxide glasses, used to create new glass materials with extreme properties.

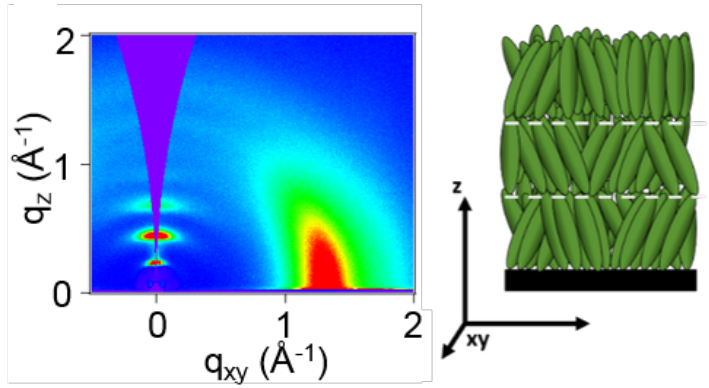
surface diffusion across glasses



enhanced stability metallic glasses



anisotropic, LC-like glasses



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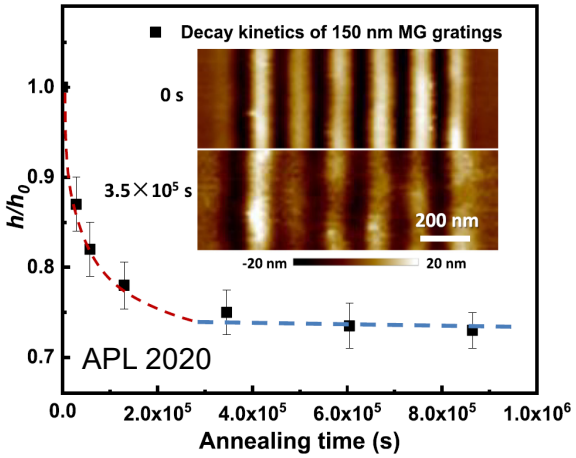
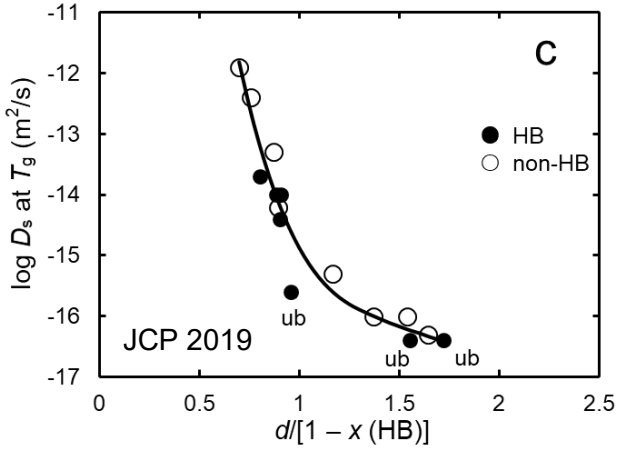
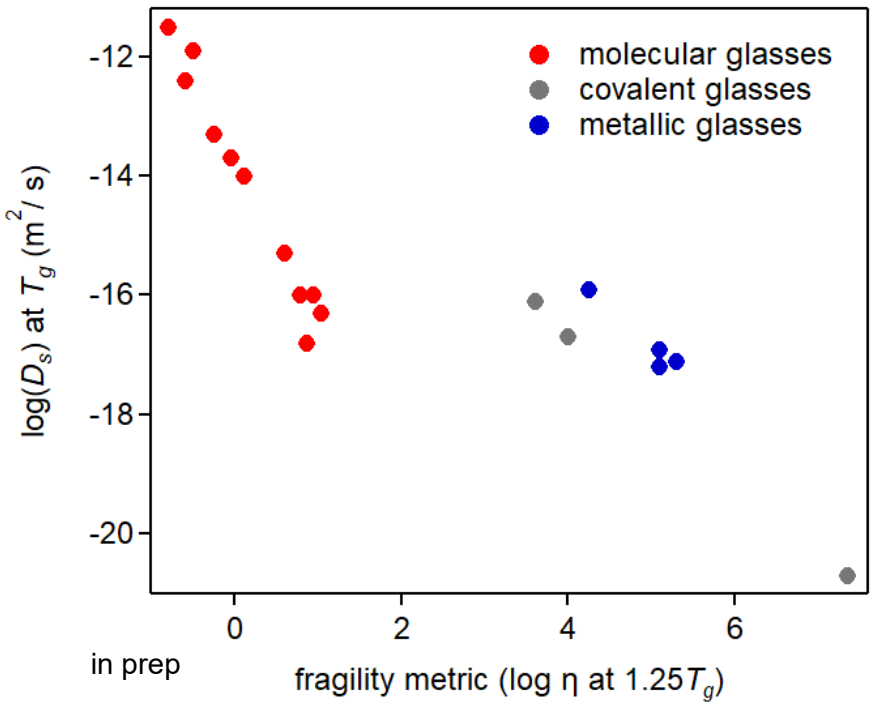
Unified Picture of Glassy Surfaces

measurement of D_s adapted from molecular to metallic glasses

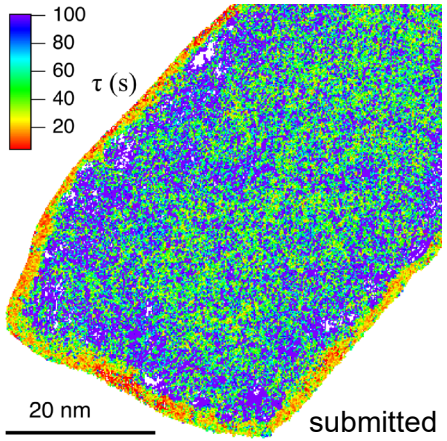


influence of H-bonding and molecular weight on D_s

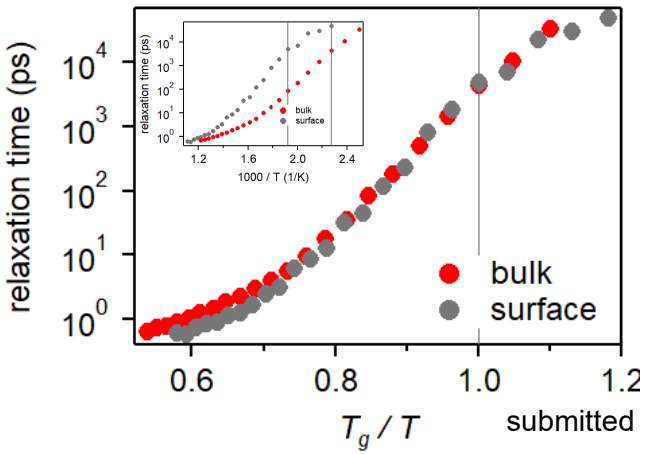




fast surface thickness and dynamic heterogeneity

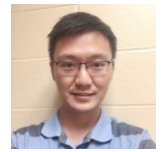


surface glass transition and dynamic rescaling

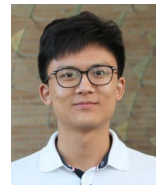


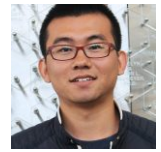
- Surface dynamics for all kinds of glasses correlate to liquid fragility, *m*
- D_s and *m* both arise from thermally-activated cage breaking
- Predictive tool for glass materials design.


Ajay Annamareddy


Chengrong Cao


Debaditya Chatterjee


Zhenxuan Chen


Yuhui Li

M. D. Ediger, D. Morgan, J. H. Perepezko, P. M. Voyles, L. Yu

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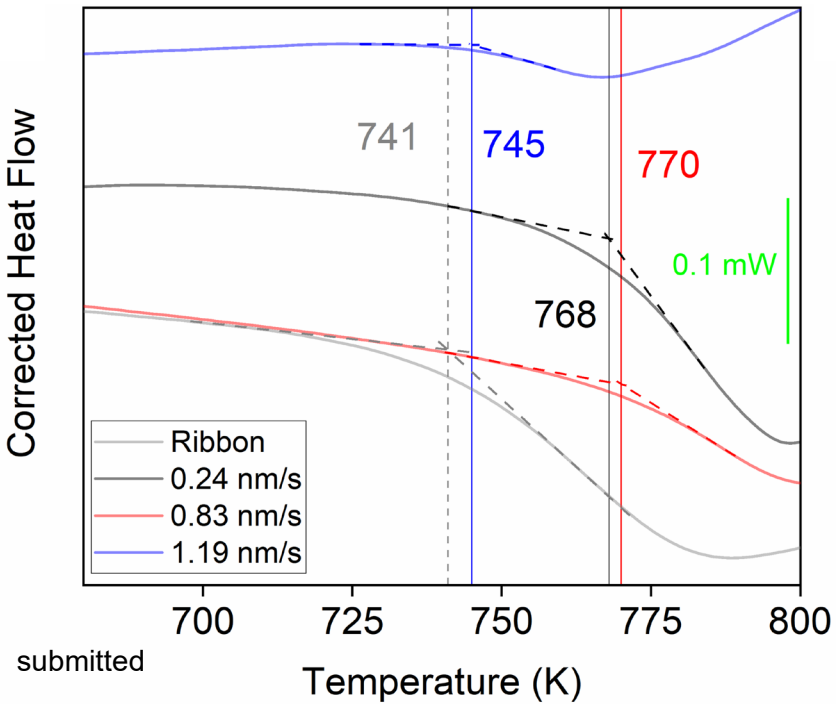
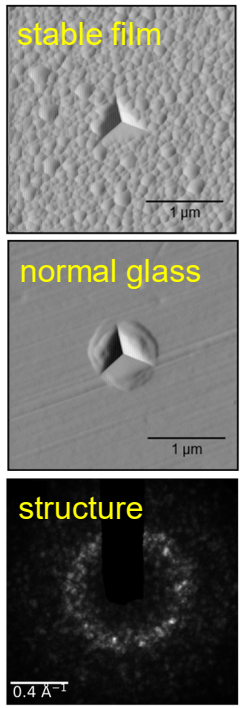
New Thin Film Glass Materials

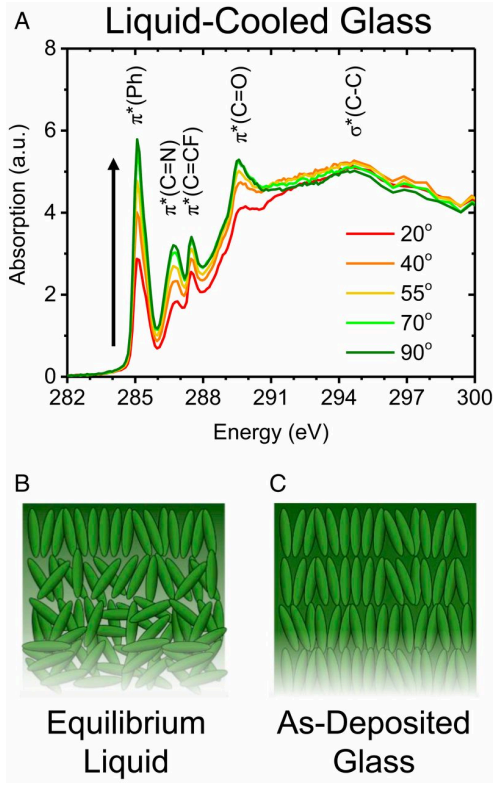
Camille Bishop

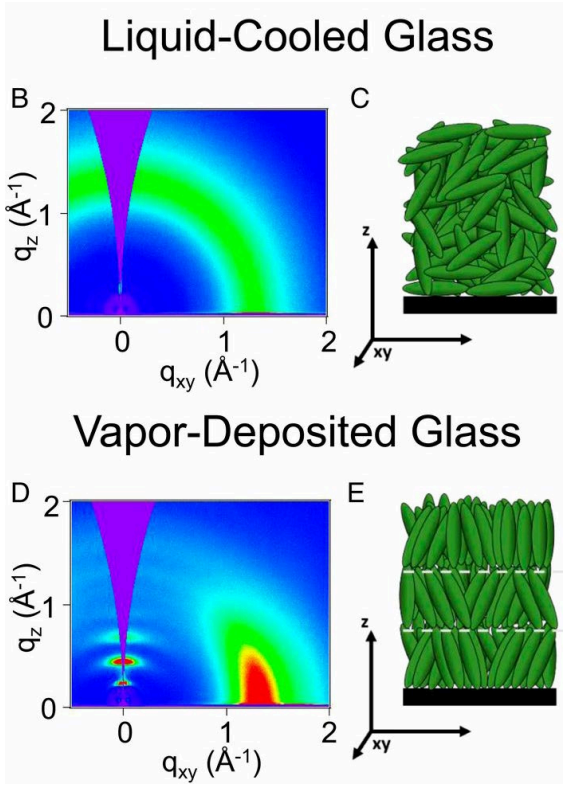
Sachin Muley



submitted







PNAS 2019

- Fast surface stabilizes metallic glass films
- Stable films have higher T_g, modulus, and hardness and greater structural order
- Applications in hard, wear-resistant coatings

- Fast surface anchors LC order in molecular glass films, even for non-mesogens
- Controllable in- and out-of-plane anisotropy
- Applications in organic optoelectronics

M. D. Ediger, D. Morgan, J. H. Perepezko, P. M. Voyles, L. Yu

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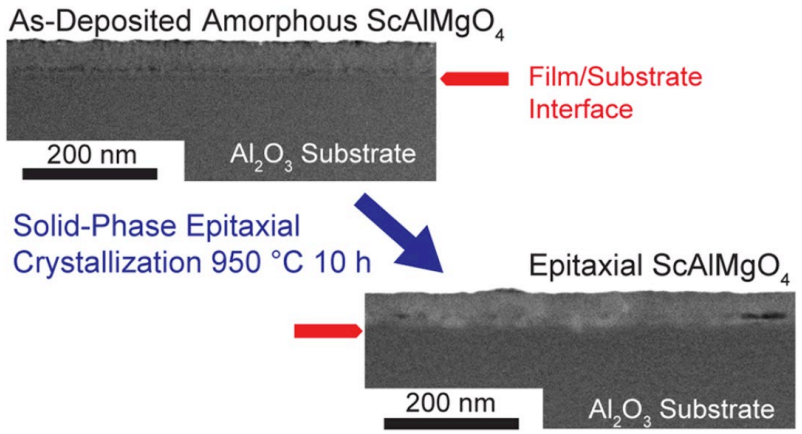
IRG 2: New Approaches to Thin Film Oxides

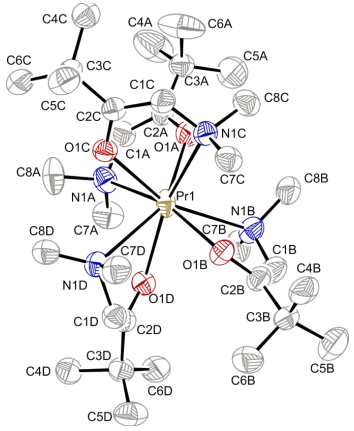
Grand Challenge: To create structurally, chemically and topographically complex epitaxial metal oxide crystals with new compositions and complex 3D geometries from amorphous layers.

Collaborative Impact: Interdisciplinary discovery of kinetic phenomena underpinning solid-phase crystallization, expanded scope of epitaxial crystalline complex oxides, and novel electronic and magnetic phenomena

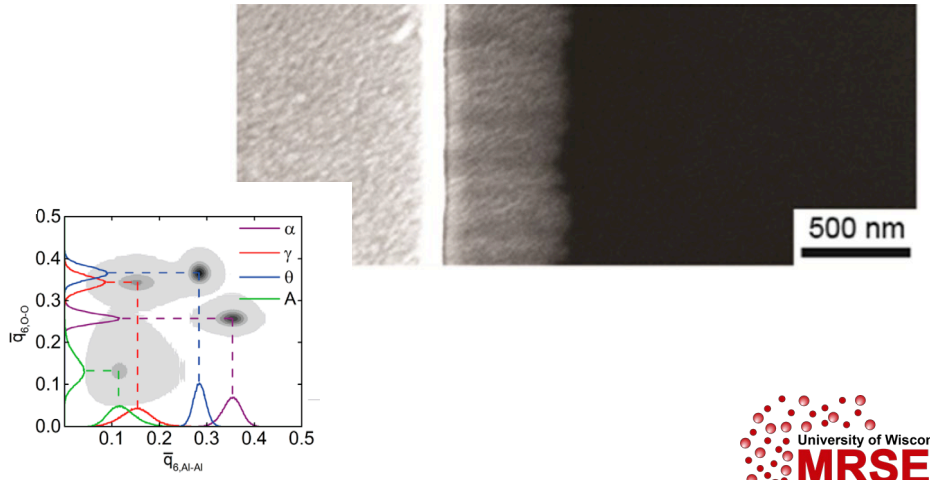
expanded scope of epitaxial multicomponent oxides



precursors for lanthanide complex oxide ALD



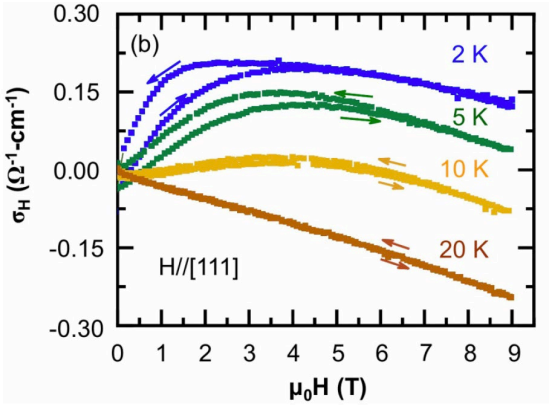
kinetic fundamentals of nanoscale solid-phase crystallization

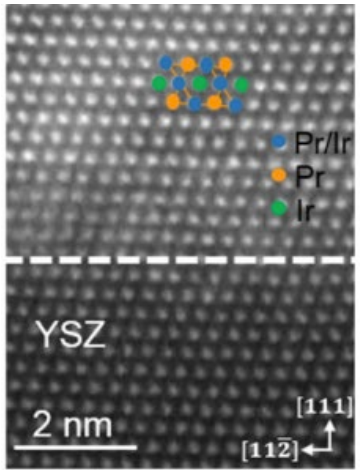


Expanding the Compositional Scope of Epitaxial Complex Oxides

Lu Guo

epitaxial $Pr_2Ir_2O_7$ thin films

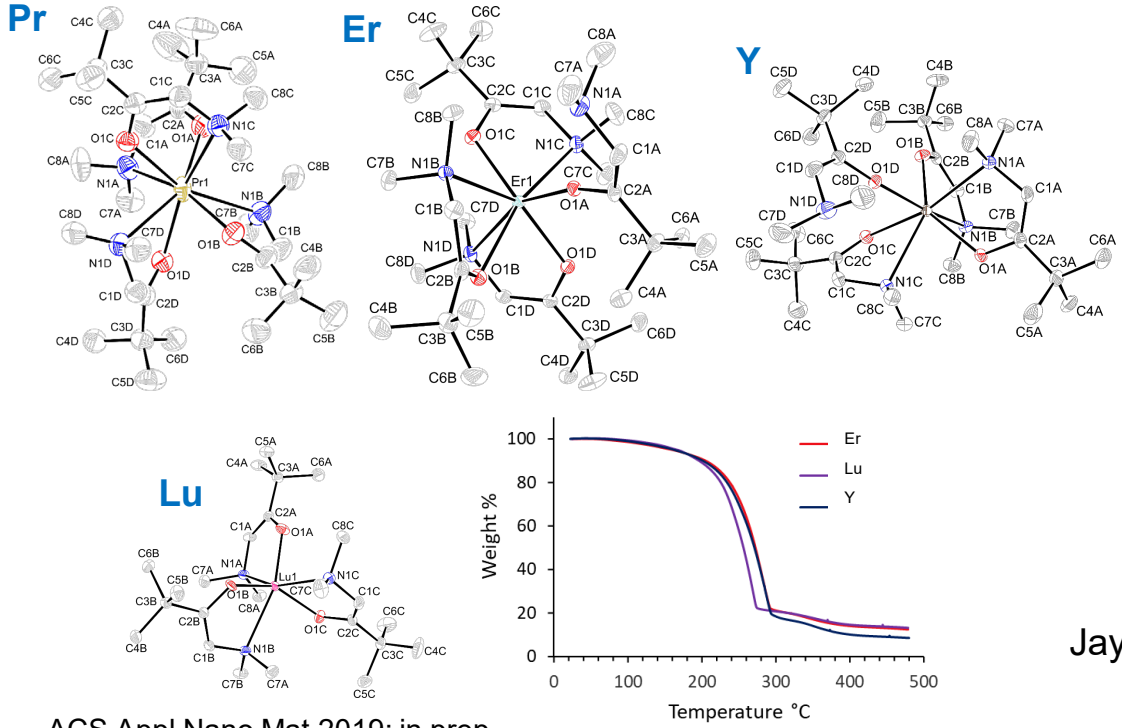




PRB 2020

- Strained epitaxial iridate thin films
- Synthesis via solid-phase epitaxy avoids Ir volatility
- Novel magnetic ordering: Topological spontaneous Hall effect at higher temperatures than bulk arises from small lattice distortions

lanthanide enaminolate ALD precursors



ACS Appl Nano Mat 2019; in prep

- New versatile class of lanthanide complex oxide atomic layer deposition precursors
- Applies across lanthanide series, ligands adjusted for lanthanide contraction
- Precise conformal deposition

Wathsala Waduge

Navoda Jayakodiarachchi

Dr. Peng Zuo

C. Winter, T. F. Kuech, P. G. Evans, S. E. Babcock, C. B. Eom

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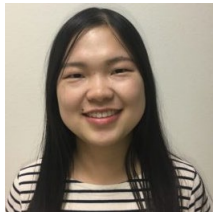
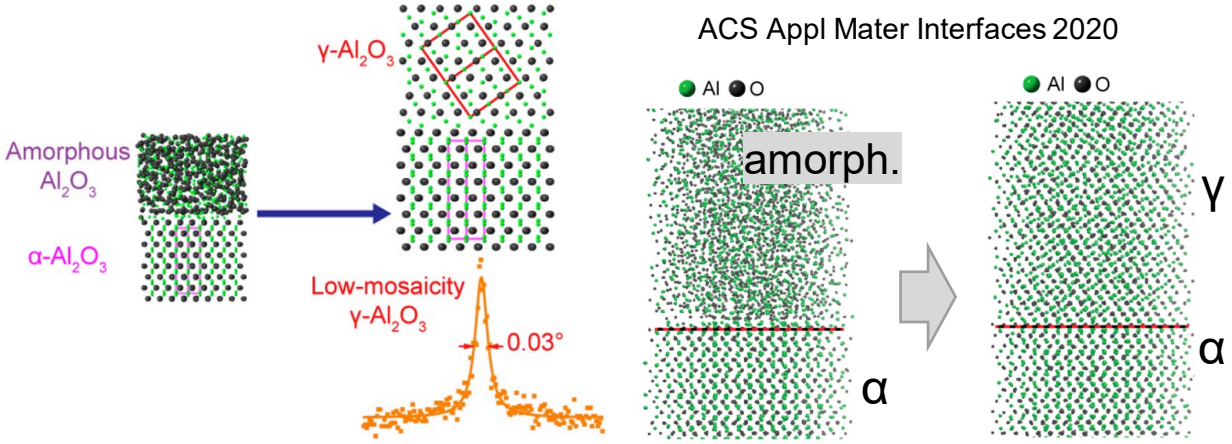
Kinetics of Complex Oxide Transformations

Tesia Janicki

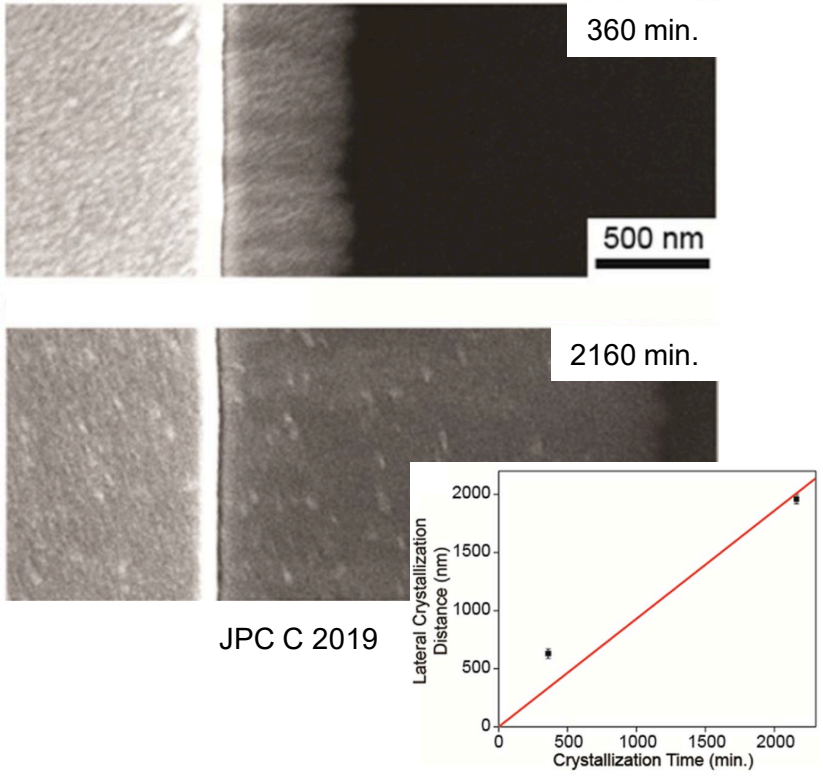


Yajin Chen

kinetic selection of metastable polymorph γ-Al_2O_3



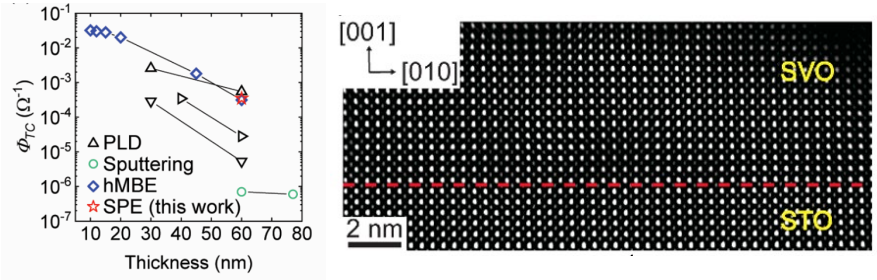
$SrTiO_3$ lateral epitaxy



JPC C 2019

stabilization of V^{4+} in $SrVO_3$ in solid phase epitaxy

submitted



- Interplay of interface bonding and configurational similarity guide phase selection
- Stabilization of specific (often metastable) phases
- Applications as substrates, transparent conductors

- Low rate of nucleation within amorphous layer and at interfaces
- Lateral epitaxy and three-dimensional structures are kinetically accessible

J. R. Schmidt, P. G. Evans, T. F. Kuech, S. E. Babcock, M. Holt (Argonne), D. Fong (Argonne)

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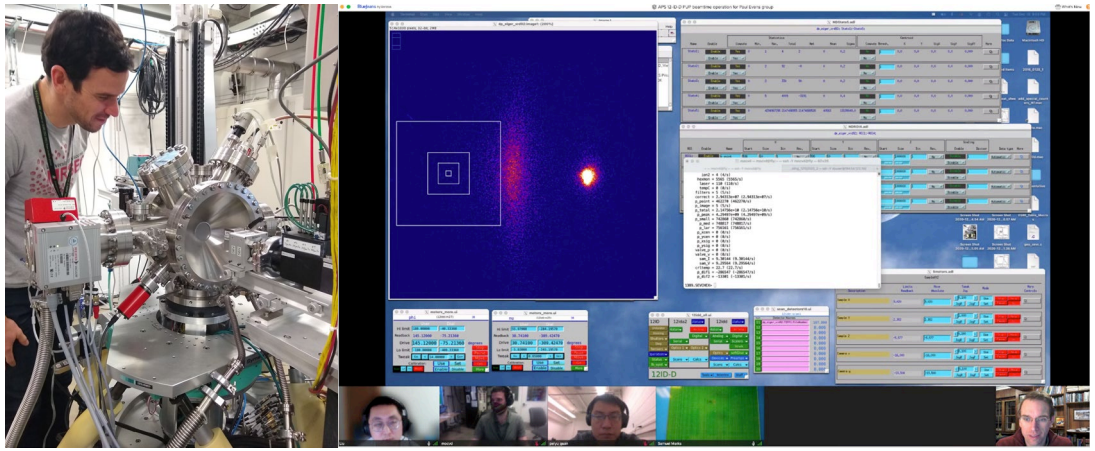
Developing Unique Instrumentation

Shared instrument facilities supported 43,000 hours of use by 484 users per year.

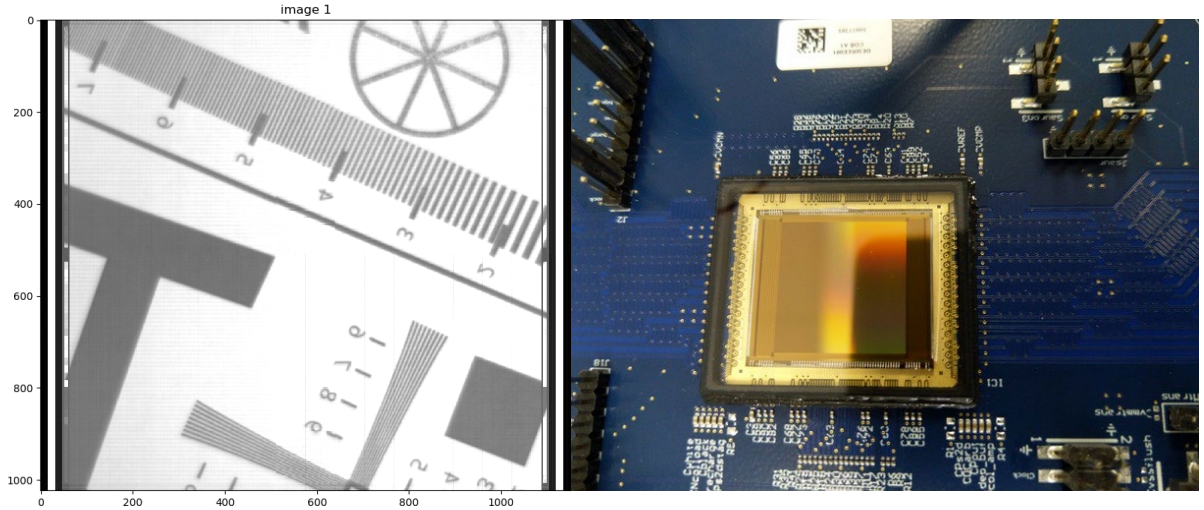
X-ray endstation for APS



Rev Sci Inst in press; Arxiv: 2021.00516

- *In situ* complex oxide deposition and crystallization
- Unique hard x-ray nanobeam and coherent scattering capabilities
- Available via MRFN now!

Ultrafast TEM camera



- At 120,000 fps, the fastest TEM camera in the world
- Time-resolved studies of materials, including motion of atoms in liquids & crystal growth
- Coming to MRFN soon!

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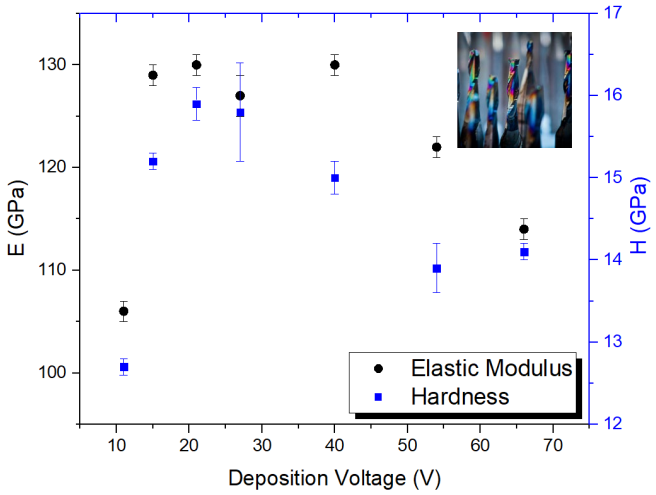
Center-wide Activities

Industry – student seed projects

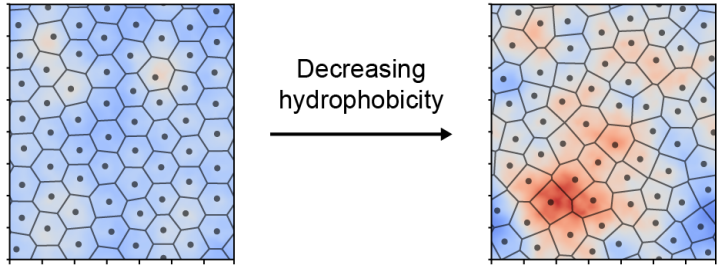
nanoindentation study of nanocrystalline diamond coatings



Sachin Muley

- Center industrial consortium funds collaborative student seed projects
- Students lead the project from conception to final reporting as the PI
- Gain experience with the project lifecycle and industrial R&D

Open science prize



Bradley Dallin

- Nanoscale structure in interfacial water near SAMs
- *Langmuir 2019, DOI:* 10.1021/acs.langmuir.8b03287
- https://zenodo.org/record/3345942#.XpkV9chKguV for MD data and python analysis tools

- Recognize excellence by students and postdocs in FAIR data and open science
- Increase impact of Center research through data and code reuse
- Promote best practices

Education, Outreach, and Diversity

Vision: We will motivate people to engage with science and engineering for their careers and everyday lives by designing experiences inspired by research.

Free digital games

Field trips

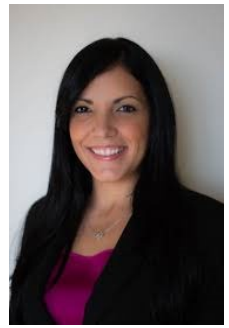
Public outreach

Cross-cultural RET

Wisconsin – Puerto Rico PREM: developing URM research leaders

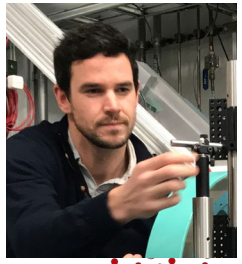
- UPRM ugrads
- UW REU
- UW PhD
- UPRM faculty
- PREM leaders

Yomaira J. Pagán-Torres IRT 1 co-lead



Claribel Acevedo-Vélez IRT 2 co-lead

Karin Riascos-Rodriguez (UPRM) Sam Marks (UW) collaborate on *in situ* x-ray measurements of porous coordination polymers



K. Riascos-Rodriguez, **S. D. Marks**, *et al.* Cryst. Growth Des. (2020).
S. D. Marks, **K. Riascos-Rodriguez**, *et al.* submitted (2020).

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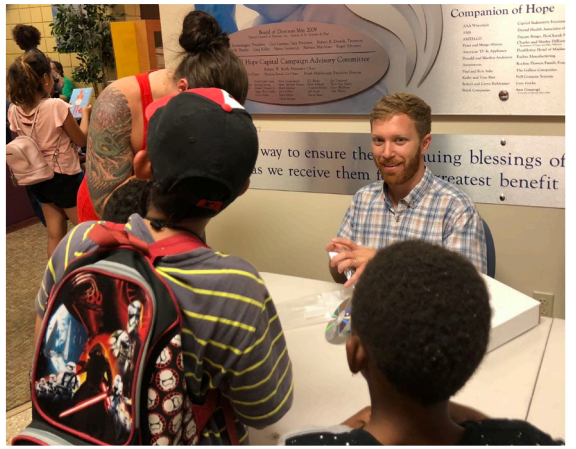
Reaching Underserved Populations

Taking the Center's outreach activities to disadvantaged members of our community where they are, not where we are, through outreach at a local food pantry.



Before COVID:

- 23 in-person visits between 2018-2020
- Impacted 146 people (85% URM, all economically disadvantaged)
- Interaction time ranged between 20 and 90 minutes

During COVID:

- Zero in-person interactions
- Distributed >200 Science Activity Kits
- Improvements:
  - English/Spanish Instructions
  - Supplies increased 3-fold for multi-child families

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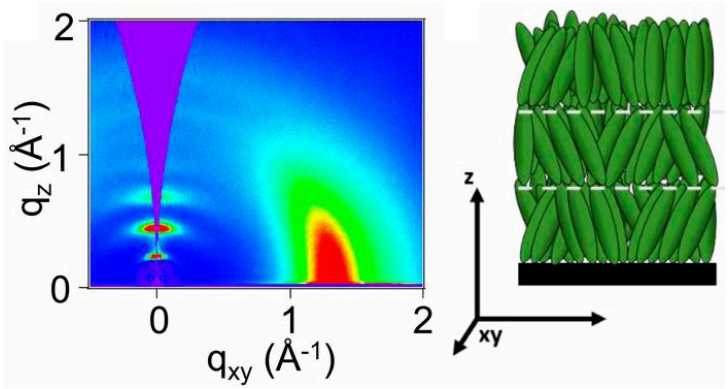
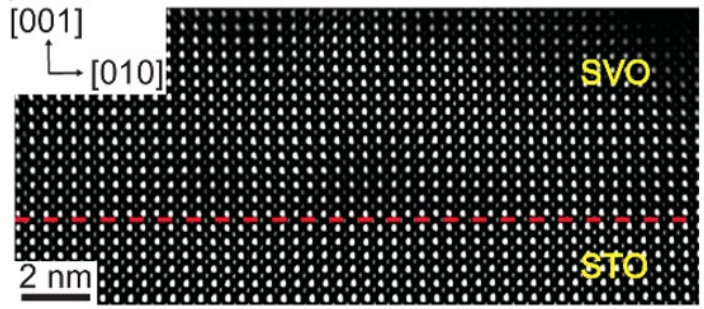
Wisconsin MRSEC Impact

Research

- New understanding of glass surface mobility and oxide crystallization kinetics
- Development of new anisotropic molecular glass thin films and pyrochlore iridates with novel magnetic properties
- Development of unique instruments for *in situ* characterization of oxide growth with x-rays and high-speed electron microscopy





Education, Outreach, and Human Resources

- Graduated 16 PhDs and transitioned 5 postdocs in total
- Implicit bias training for Center faculty, students, and postdocs, URM-focused REU program, and cross-cultural RET with U. Puerto Rico
- Reached thousands of people through in person outreach and hundreds of thousands through online outreach every year

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