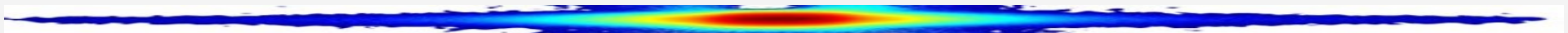


Institute of Materials Research (IMR)

Marc Weber

John S. McCloy, director

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<https://materialsresearch.wsu.edu>



Services:

- **Diagnostics:** *Xradia*, *Positrons*, Electrical, Defect spectroscopies
 - Missing atoms: Atomic-scale, voids-mesopores, nanometer to micron pores
 - 3D sub μm structures
 - Mid bandgap defects, Raman spectroscopy, FTIR, Hall
- **Crystal growth:** Czochralski, Bridgman
- **Class 1000 cleanroom:** ALD, sputtering, annealing, plasma etching



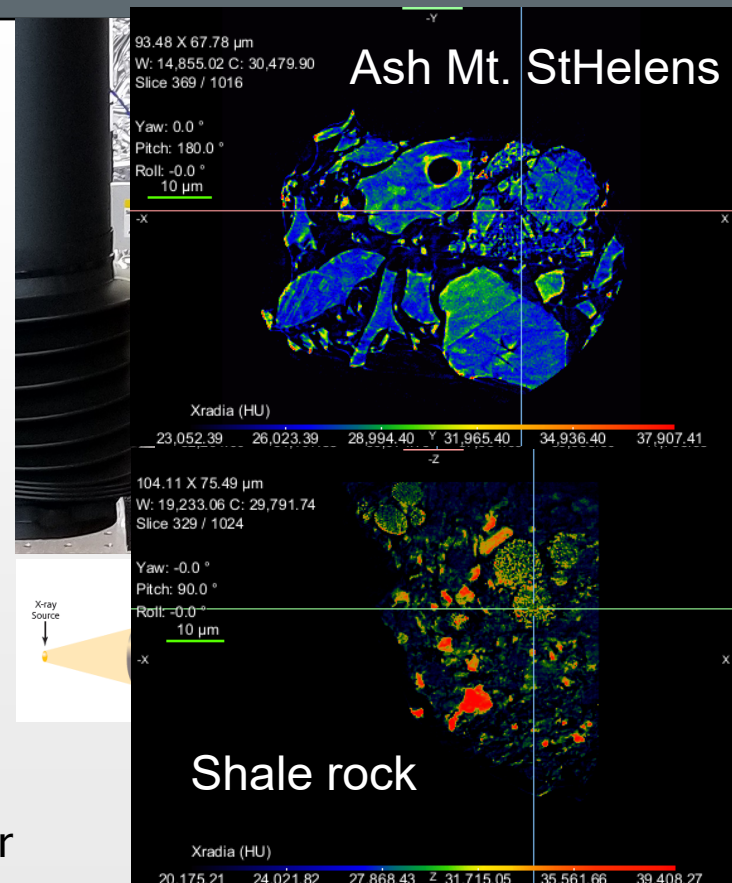
Objective

- Educate next generation engineers & scientists
- Modern/unique spectroscopic tools
- Opportunity to try ideas outside the standard process
- Establish links to broad research/industry community
- Worked with
 - Universities
 - Government national laboratories
 - Industry
 - NDAs are no problem



X-ray nanoCT microscope

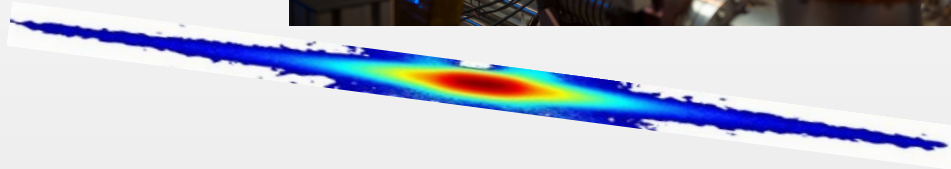
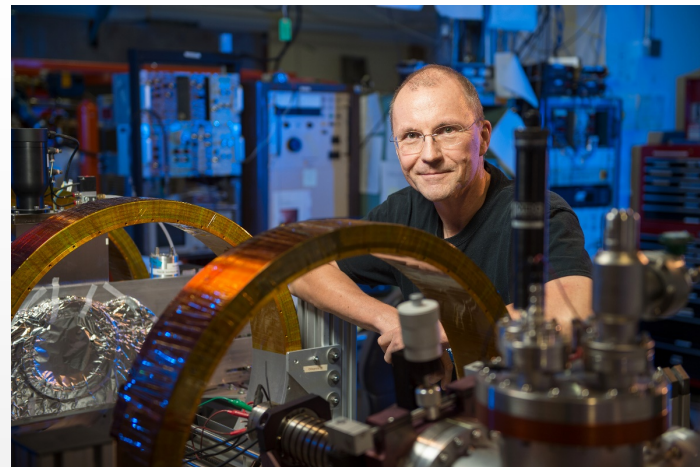
- Computed tomographic images from X-rays
 - 3D absorption reconstruction
 - 5.4 kV X-ray nano-CT microscope
 - 50nm or 150nm spatial resolution up to 65 μm samples
 - Optimized for low Z low density matter
- Examples
 - Non woven fibers, graphite fibers, catalysts,
 - battery membranes
 - Shale rock (porosity)
 - Biologic materials, structural fibers
- Students/Vistors are welcome to work on their own projects
- WSU undergrads won NASA grant to study lunar dust removal





Vacancy ID and depth profile

- Atomic to nm damage near surfaces
 - Depth profiles
 - Residual damage from cutting polishing
 - Vacancy characterization
 - Non-destructive
- Finds places in matter where atoms are missing
 - Vacancies up to 10 nm porosity
 - Isolated pores vs. interconnected pores
 - Identify impurities next to missing atoms
- Research topics
 - Metals: vacancy formation enthalpy
 - Solar cell materials: Si, CdTe, perovskites
 - Novel semiconductors: GaN, ZnO, Ga₂O₃, SiC
 - Porous thin film layers: low-k dielectrics, membranes, filters
 - Ceramics and glasses: for nuclear waste management



How? Missing atoms are detected with anti-electrons, positrons. Annihilation photons deliver information



Want to try different doping?

- Methods
 - Czochralski (pulling from melt)
 - Bridgman (vertical, high pressure)
 - Zone refining
- Examples/ Variations
 - Ruby, YAG, CdTe, $\text{Cd}_{1-x}\text{Zn}_x\text{Te}$, Ga_2O_3
 - Unique doping: Ce, Nd, Ti, Cu, Cr, Zr, Hf, In
 - Rotating crucible, w. acceleration
- Research topics
 - Ce:YAG Ce:GGG for scintillation radiation detectors
 - $\text{Cd}_{1-x}\text{Zn}_x\text{Te}$: Solar cell material, radiation detectors
 - Ga_2O_3 : wide bandgap semiconductor single crystals



CdTe



Sapphire, ruby, YAG(Ce, Er, Nd)



Ga_2O_3



Growth / processing

Thin film deposition

- Atomic layer deposition
- RF/DC magnetron sputtering
- Spin coating

Electronics fabrication

- Photolithography
- Wire bonding
- Wet/Dry etching (plasma, reactive ion)

Thermal processing

- Oxidation
- Boron diffusion
- Vacuum annealing

Measurement

- Profilometry
- Ellipsometry

Cleanroom / Microfabrication

Thin film deposition

- Atomic layer deposition
- RF/DC magnetron sputtering
- Spin coating

Electronics fabrication

- Photolithography
- Wire bonding
- Wet/Dry etching (plasma, reactive ion)

Thermal processing

- Oxidation
- Boron diffusion
- Vacuum annealing

Measurement

- Profilometry
- Ellipsometry

Characterization

Electrical measurements

- Hall, I-V, C-V

Defect spectroscopy

- TEES/TSC
- DLTS/ODLTS/PICTS
- TL/TSL, PL/PLE

Detector testing

- resolution, μr , PMTs, light output, lifetime

Standard

- Raman imaging (3 color)
- X-ray diffraction (3 energies)
- FTIR
- UV-VIS-NIR
- MMW
- IR and VIS imaging microscopes
- Lab-based X-ray absorption