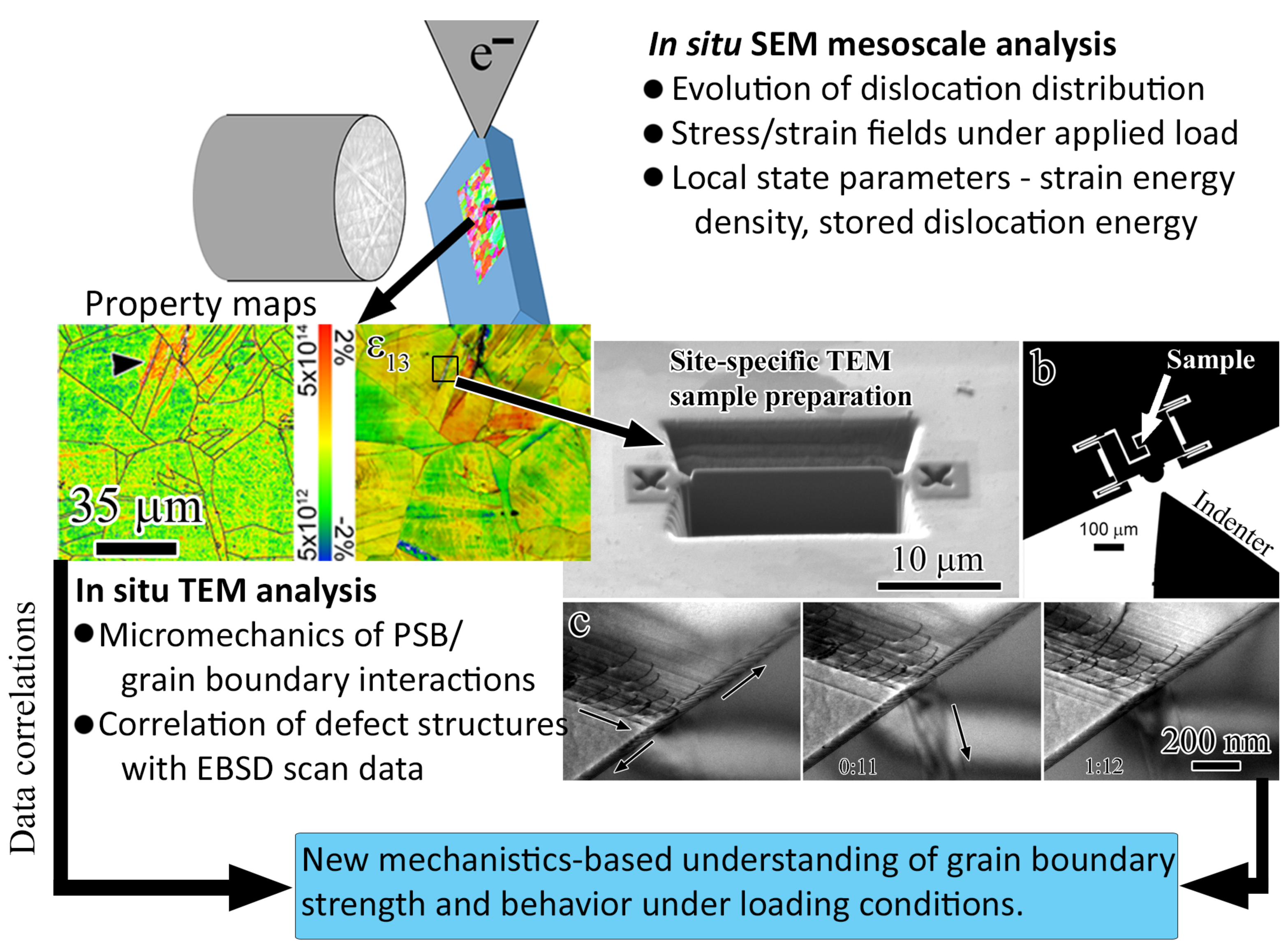
Kacher Lab

Group Overview

As a lab, we focus on microstructure-scale design and understanding materials behavior for metals and alloys in extreme environments. We combine data-rich mesoscale characterization with advanced *in situ* transmission electron microscopy to better understand both the statistics and mechanics of degradation and failure.

Two key focuses we have going forward are incorporating AI and automated analysis into materials characterization for autonomous instrument operation and designing advanced *in situ* TEM experiments to better capture real-world degradation phenomena.

Grain Boundary Strength



Microstructural features such as grain and phase boundaries dictate in large part dictate the mechanical properties and failure mechanisms in metals and alloys. We are currently exploring:

- Grain boundary strength as a function of grain boundary character
- Grain boundary-driven fatigue crack formation

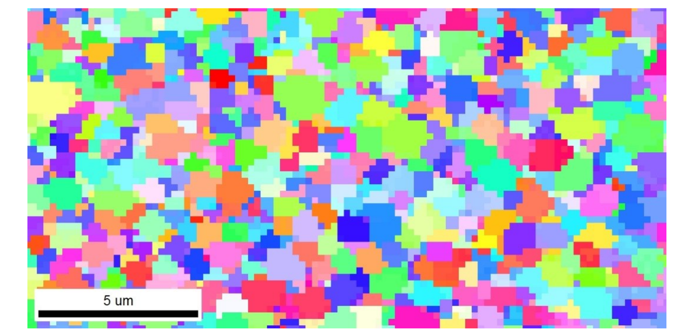
Websites

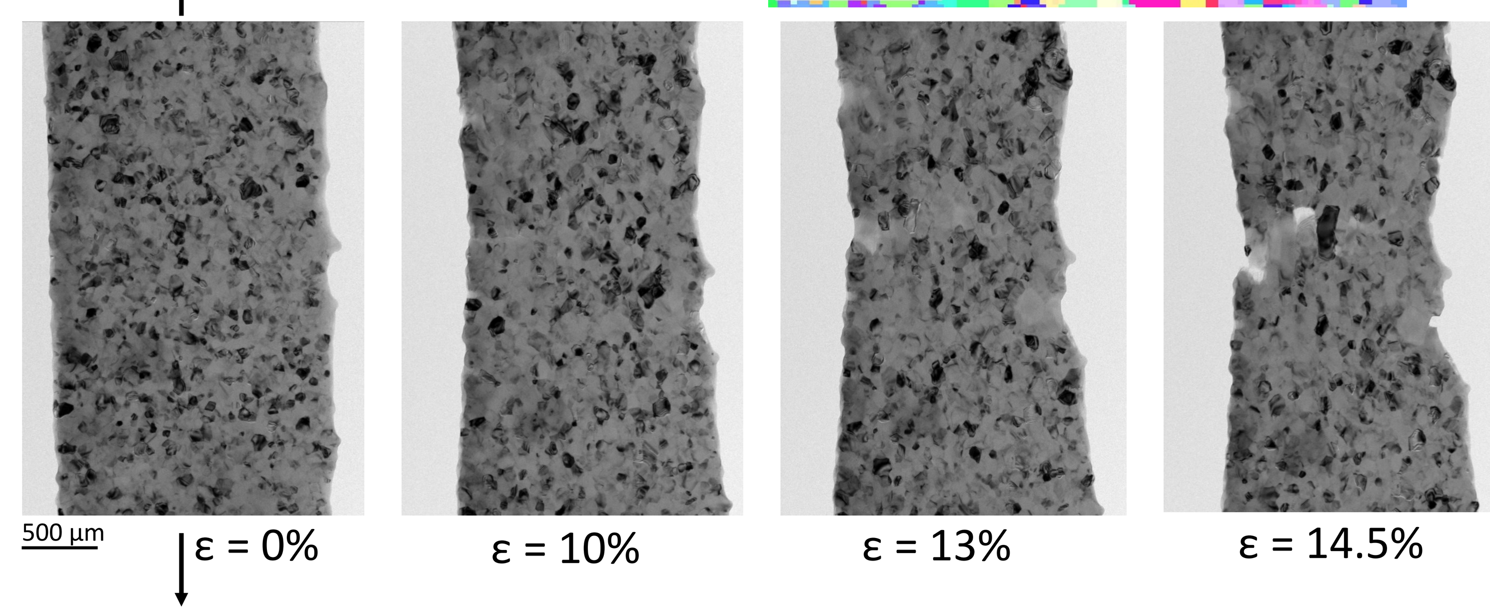
In situ TEM videos

Group website

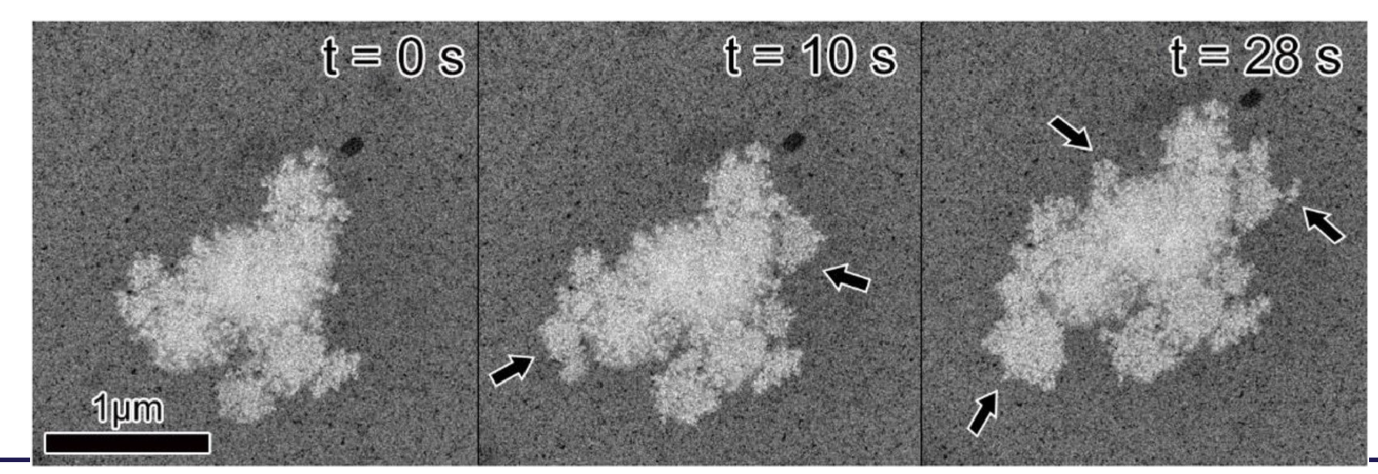
In situ Electron Microscopy

We develop *in situ* electron microscopy-based techniques to explore processes ranging from materials degradation to localized corrosion.

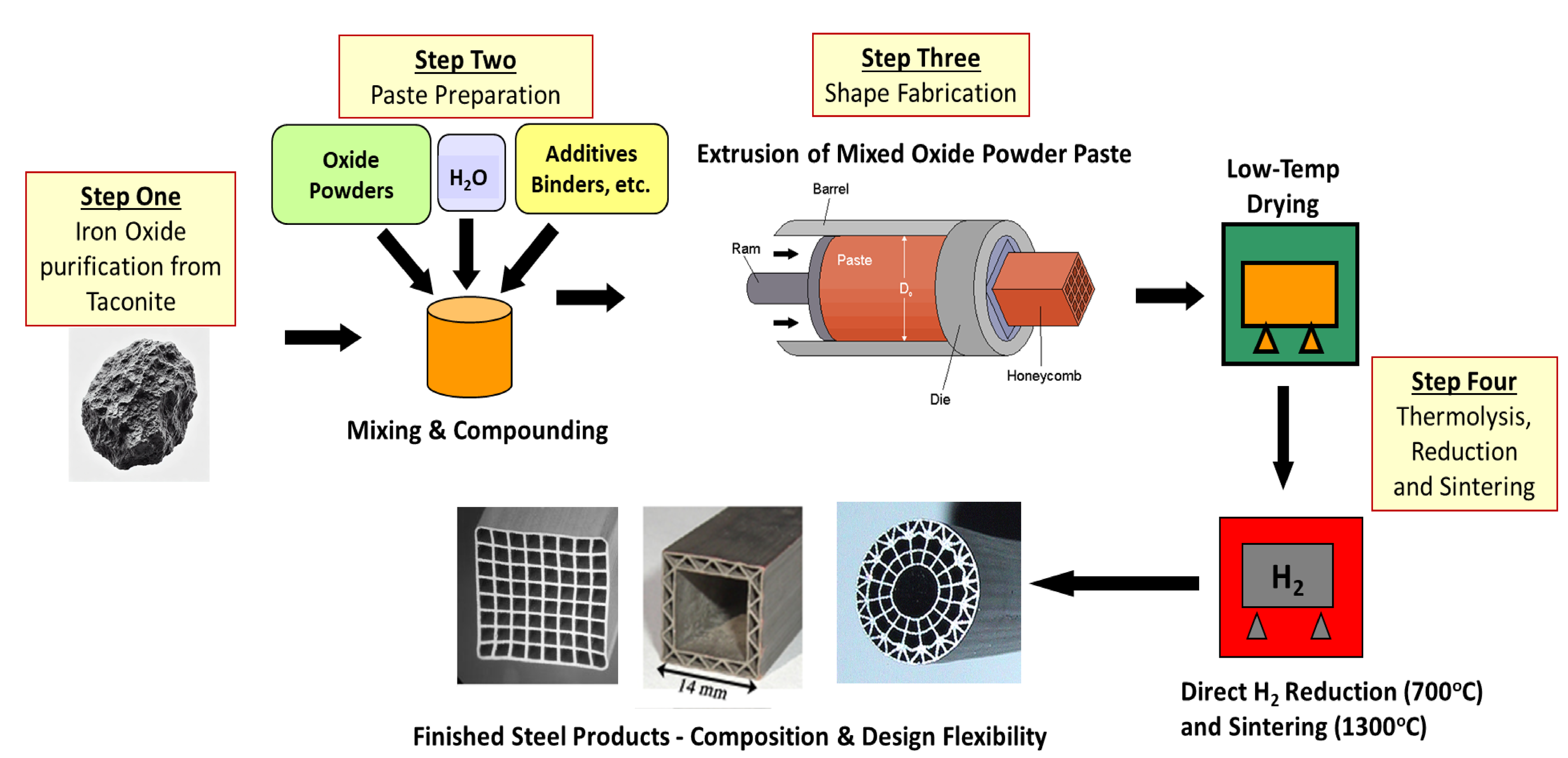




In situ deformation of Al (above) and corrosion of Fe (below).



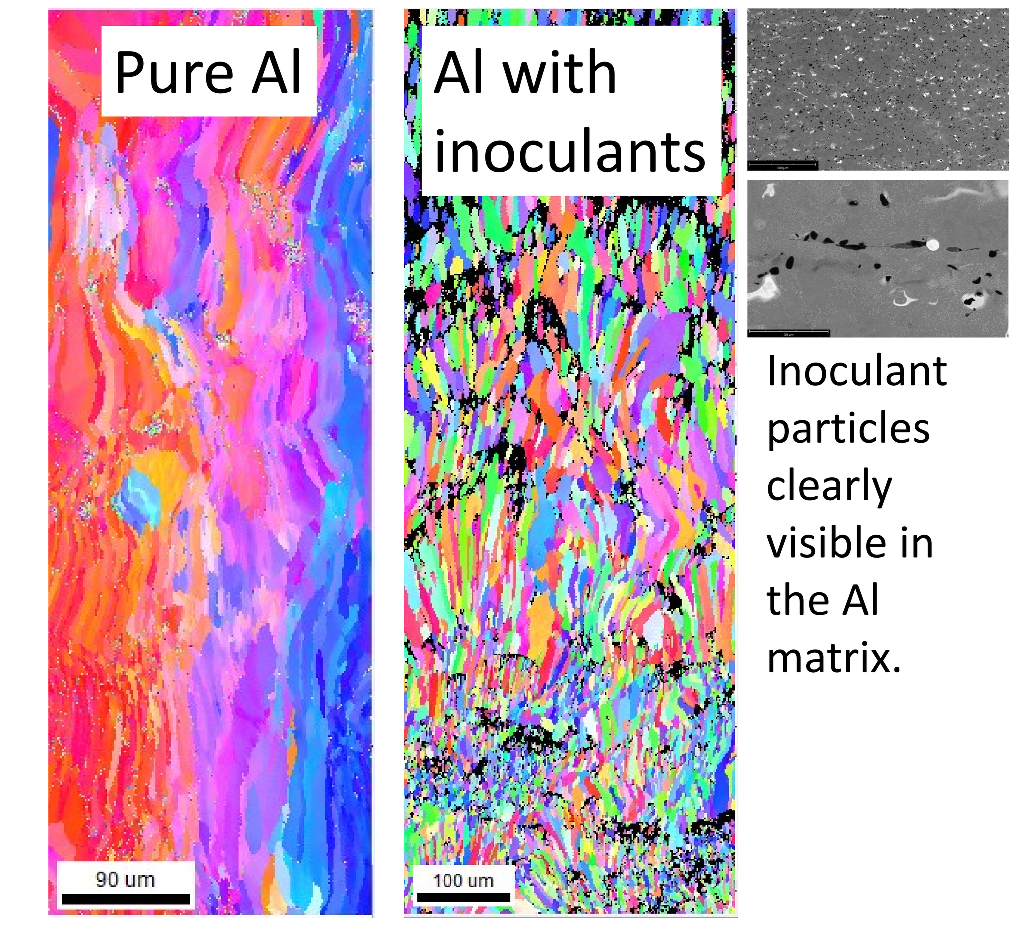
Green Steel



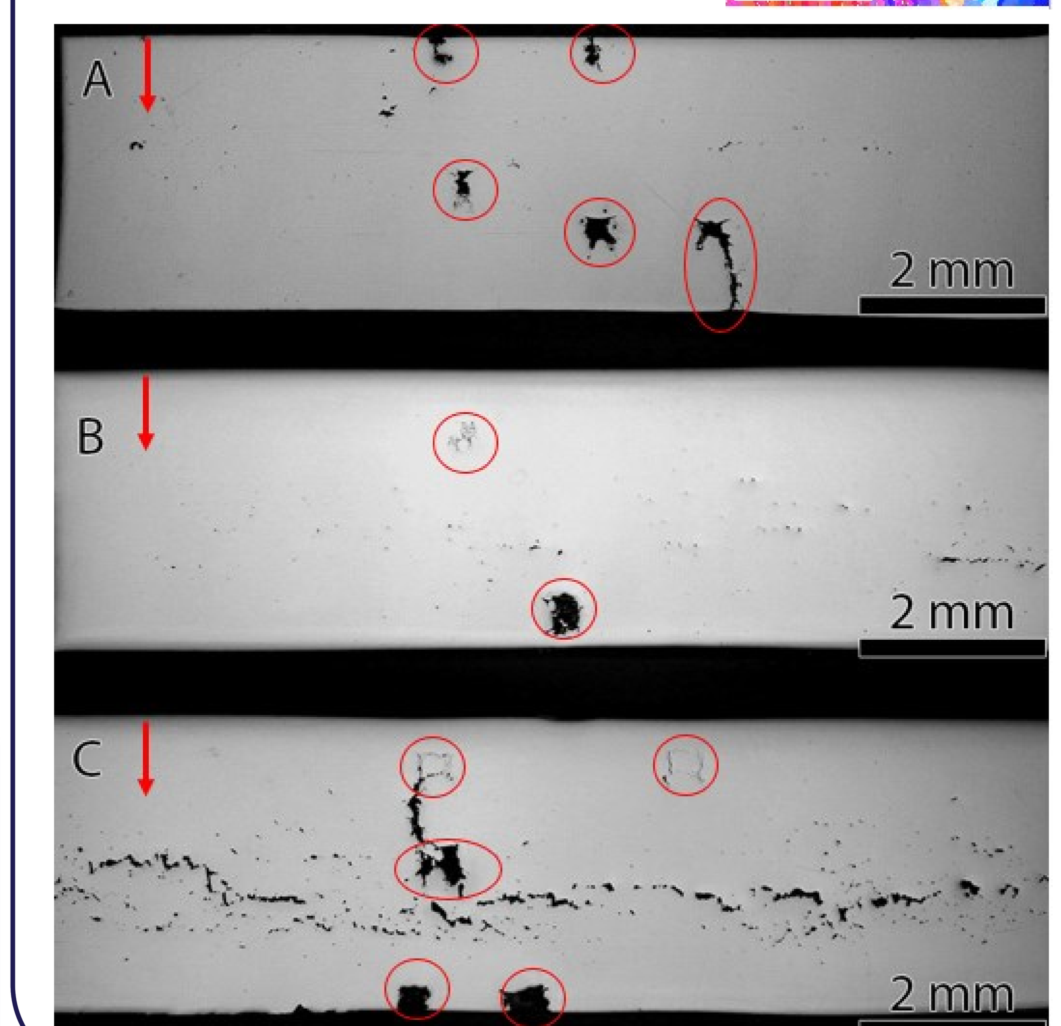
We are working on new processing and fabrication approaches to manufacture steel parts directly from refined iron ores. This approach uses hydrogen reduction, eliminating CO_2 emissions, and enabling the manufacturing of parts with complex internal geometries.

Metal 3D printing

We are working with industry partners to develop and better understand approaches for printing Al metal matrix composites. Ceramic inoculants provide heterogeneous nucleation sites during printing, resulting in significantly reduced grain sizes and more distributed residual strains. Using a data analytics approach, we are combining high throughput fabrication, characterization, and testing to further develop these materials



Inoculant particles clearly visible in the Al matrix.



We are also working on better understanding how additive manufacturing can be used to tailor the material response to extreme environments. This could be through integrating internal structuring in the form of pores or compositional gradients. Currently, we are exploring the high-strain rate deformation behavior of phase transforming and compositionally graded materials.

Current Group Needs

- Exploring the high strain rate deformation behavior of additive manufactured metals and alloys. This project is in collaboration with Los Alamos and Lawrence Livermore national labs and will explore how phase transformations and internal phase boundaries affect shock propagation and failure in additive manufactured materials.
- Understanding the deformation mechanisms governing the mechanical properties of thin films. This project uses quantitative *in situ* transmission electron microscopy deformation platforms to resolve how materials deform and fail and the nanoscale.