Stanford

Leora Dresselhaus-Marais

Assistant Professor of Materials Science and Engineering and of Photon Science

Bio

BIO

Leora studies how modern methods can enable new opportunities to update "old-school" materials processing and manufacturing for sustainability. This includes designing new microscopes and using them to get a deeper view into the extraction, forming, and functional properties of metallic materials. Leora's group works on thrusts in sustainable steelmaking (specifically ironmaking), metal 3D printing, and studies of the fundamental mechanisms underlying properties in materials.

Leora is an Assistant Professor in the Department of Materials Science & Engineering, with a courtesy appointment in Mechanical Engineering, a term appointment in Photon Science at the SLAC National Accelerator Lab, and an appointment as a Precourt Center Fellow. Before coming to Stanford, Leora was a Lawrence Fellow in the Physics Division of the Physics and Life Sciences Directorate at Lawrence Livermore National Labs, where she developed the tools to study time-resolved defect dynamics in bulk materials -- giving new insights into long-standing problems in materials science. Leora did her PhD in Physical Chemistry with Prof. Keith Nelson at MIT, where she demonstrated how shock waves initiate chemistry in RDX that couples to deformations in unique ways that enhance the sensitivity. Leora did her BA and MSc in Chemistry at the University of Pennsylvania.

ACADEMIC APPOINTMENTS

- Assistant Professor, Materials Science and Engineering
- Assistant Professor, Photon Science Directorate
- Member, Stanford PULSE Institute

ADMINISTRATIVE APPOINTMENTS

- Gabilan Fellow, Stanford University, (2021- present)
- Terman Fellow, School of Engineering, Stanford, (2021- present)
- Courtesy Appointment, Mechanical Engineering, Stanford, (2021- present)
- Precourt Center Fellow, Precourt Center for Renewable Energy, Stanford, (2021- present)
- Term Appointment, Photon Science, SLAC, (2021- present)

LINKS

- Group Website: https://mesoscale.squarespace.com/

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

The Dresselhaus-Marais research group develops new methods to update 19th-century manufacturing processes with modern approaches. Our approach focuses on a holistic view of metals fabrication, from the mining and extraction of ores into metals to a deep look at how specific microstructural features (e.g. dislocations and grain boundaries) during the forming and forging give rise to mechanical and thermal properties we can tune or print.

To get this deep view of modern processing, we develop and use new optical/X-ray and analytical tools to reveal how imperfections deep inside materials instigate the dynamics that transform them. Spanning length- and time-scales from bonds breaking at single atoms through long-duration dwell times in 100-m tall blast furnace reactors, these defect dynamics define complex high-dimensional problems that are difficult to reconcile at intermediate scales in order to predict or understand a material's behavior and chemistry. To address this challenge, we develop new types of time-resolved experiments aimed at the elusive "mesoscale" to directly visualize how large populations of subsurface defects drive them. With these new approaches, we tackle fundamental studies of how temperature drives materials, and applied problems.

Our applied work focuses on two important steps of the supply chain: metals extraction and metal forming. Most metals extraction processes have been perfected for centuries to millennia, but are done today at scales that make our effective processing strategies unsustainable. In cases like steel (8% of global CO2 emissions), this arises from coal-intensive steps that produce Gigatons of CO2 per year that contribute significantly to climate challenges. For metals like lithium and rare earth elements, our present mining and extraction strategies simply cannot reach a high enough throughput to sustain our current demand for the elements, making them Critical Materials. My group studies how an updated multiscale characterization and modeling approach can enable key opportunities to advance these fields.

Teaching

COURSES

2022-23

- Defects and Disorder in Materials: MATSCI 183 (Spr)
- Defects and Disorder in Materials: MATSCI 213 (Spr)
- Kinetics of Materials Synthesis: MATSCI 145 (Aut)
- Materials Science Colloquium: MATSCI 230 (Aut, Win, Spr)

2021-22

- Defects and Disorder in Materials: MATSCI 183 (Spr)
- Defects and Disorder in Materials: MATSCI 213 (Spr)
- Metalheads of Modern Science: MATSCI 86N (Aut)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

Briley Bourgeois

Postdoctoral Faculty Sponsor

Lichao Fang, Kento Katagiri, Yifan Wang

Doctoral Dissertation Advisor (AC)

Lauren Moghimi

Publications

PUBLICATIONS

- **An automated approach to the alignment of compound refractive lenses** *JOURNAL OF SYNCHROTRON RADIATION*
  Breckling, S., Kozioziemski, B., Dresselhaus-Marais, L., Gonzalez, A., Williams, A., Simons, H., Chow, P., Howard, M.
  2022; 29: 947-956

- **X-ray free-electron laser based dark-field X-ray microscopy: a simulation-based study** *JOURNAL OF APPLIED CRYSTALLOGRAPHY*
  Holstad, T., Raeder, T., Carlsen, M., Knudsen, E., Dresselhaus-Marais, L., Haldrup, K., Simons, H., Nielsen, M., Poulsen, H.
  2022; 55: 112-121

- **In situ visualization of long-range defect interactions at the edge of melting.** *Science advances*
  Dresselhaus-Marais, L. E., Winther, G., Howard, M., Gonzalez, A., Breckling, S. R., Yildirim, C., Cook, P. K., Kutsal, M., Simons, H., Detlefs, C., Eggert, J. H., Poulsen, H. F.
  2021; 7 (29)

PRESENTATIONS

- Visualizing the Dynamics of Subsurface Defects with Time-Resolved DFXM - European Synchrotron Radiation Facility