Stanford

Leora Dresselhaus-Marais

Assistant Professor of Materials Science and Engineering, of Photon Science and, by courtesy, of Mechanical Engineering

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, and a term appointment in Photon Science at the SLAC National Accelerator Lab. Leora was also appointed as a Precourt Center Fellow and a Gabilan Fellow at Stanford University, and was selected for a Young Investigator Research Program (YIP) Award from the AFOSR in 2023. 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
- Assistant Professor (By courtesy), Mechanical Engineering
- Principal Investigator, 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)

HONORS AND AWARDS

- Young Investigator Research Program Award, Air Force Office of Scientific Research (2023-2026)

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

2025-26

- Kinetics of Materials Synthesis: MATSCI 145 (Spr)
- Metalheads of Modern Science: MATSCI 86N (Aut)
- Optics of Microscope Design for Materials: MATSCI 324 (Win)

2024-25

- Kinetics of Materials Synthesis: MATSCI 145 (Spr)

2023-24

- Kinetics of Materials Synthesis: MATSCI 145 (Aut)
- Materials Science Colloquium: MATSCI 230 (Aut, Win, Spr)
- Optics of Microscope Design for Materials: MATSCI 324 (Spr)

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)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

Aaron Altman

Orals Chair

Ashton Aleman

Postdoctoral Faculty Sponsor

Sophie Parsons, Zipeng Xu

Doctoral Dissertation Advisor (AC)

Tz-En Chang, Ernest Cubit, Cesar Diaz-Caraveo, Andy Fong, Anirudh Hari, Edem Honu, Sara Irvine, Brinthan Kanesalingam, Dorian Luccioni, Lauren Moghimi, Isabella Ortolan, Dayeeta Pal, Subhechchha Paul, Tharun Reddy, Zane Taylor

Publications

PUBLICATIONS

- **Advances in artificial intelligence-based approaches to enhance dark field X-ray microscopy analysis** *MRS COMMUNICATIONS*
  Kanesalingam, B., Yildirim, C., Dresselhaus-Marais, L.
  2025
- **Laser, vacuum and gas reaction chamber for operando measurements at NSLS-II's 28-ID-2.** *Journal of synchrotron radiation*
  Moghimi, L. Y., Johansson, P. K., Paul, S., Wang, Y., Irvine, S., Graham, R., Dominguez, D., Taylor, Z., Martinez, A. A., Markert, J. T., Trunk, J., Zhong, H., Bai, et al
  2025
- **A percolating path to green iron.** *Cell reports. Physical science*
  Paul, S., Kanesalingam, B., Ma, Y., Villanova, J., Requena, G., Akpu, S. C., Raabe, D., Battiato, I., Dresselhaus-Marais, L.
  2025; 6 (8): 102729
- **Oblique diffraction geometry for the observation of several non-coplanar Bragg reflections under identical illumination.** *Journal of applied crystallography*
  Detlefs, C., Henningsson, A., Kanesalingam, B., Cretton, A. A., Corley-Wiciak, C., Frankus, F. T., Pal, D., Irvine, S., Borgi, S., Poulsen, H. F., Yildirim, C., Dresselhaus-Marais, L. E.
  2025; 58 (Pt 4): 1439-1446
- **High-resolution in situ characterization of laser powder bed fusion via transmission X-ray microscopy at X-ray free-electron lasers.** *Journal of synchrotron radiation*
  Taylor, Z., Reddy, T., Fang, L., Oppermann, P., Kramer, P. L., Decker, F. J., Seaberg, M., Chollet, M., van Driel, T., Halavanau, A., Hart, P., Dayton, M., Seiboth, et al
  2025
- **Computing virtual dark-field X-ray microscopy images of complex discrete dislocation structures from large-scale molecular dynamics simulations** *JOURNAL OF APPLIED CRYSTALLOGRAPHY*
  Wang, Y., Bertin, N., Pal, D., Irvine, S. J., Katagiri, K., Rudd, R. E., Dresselhaus-Marais, L. E.
  2025; 58: 458-468
- **Formalism to image the dynamics of coherent and incoherent phonons with dark-field X-ray microscopy using kinematic diffraction theory** *JOURNAL OF APPLIED CRYSTALLOGRAPHY*
  Chalise, D., Wang, Y., Trigo, M., Dresselhaus-Marais, L. E.
  2025; 58: 469-483

- **Dark-field x-ray microscopy for 2D and 3D imaging of microstructural dynamics at the European x-ray free-electron laser** *JOURNAL OF APPLIED PHYSICS*

  Irvine, S. J., Katagiri, K., Raeder, T. M., Boesenberg, U., Chalise, D., Stanton, J. I., Pal, D., Hallmann, J., Ansaldi, G., Brausse, F., Eggert, J. H., Fang, L., Folsom, et al

  2025; 137 (5)

- **X-ray induced grain boundary formation and grain rotation in Bi2Se3** *SCRIPTA MATERIALIA*

  Katagiri, K., Kozioziemski, B., Folsom, E., Goede, S., Wang, Y., Appel, K., Chalise, D., Cook, P. K., Eggert, J., Howard, M., Kim, S., Konopkova, Z., Makita, et al

  2025; 256

- **Measuring the Burgers vector of dislocations with dark-field X-ray microscopy** *JOURNAL OF APPLIED CRYSTALLOGRAPHY*

  Pal, D., Wang, Y., Gurunathan, R., Dresselhaus-Marais, L.

  2025; 58: 207-220

- **Real-time tracking and analysis of gas bubble dynamics in laser powder bed fusion using in-situ X-ray characterization and machine learning** *Additive Manufacturing*

  Liu, S., Thampy, V., Quan, P., Gorgannejad, S., Nicolino, J. W., Strantza, M., Forien, J., Fang, L., Dresselhaus-Marais, L., Martin, A. A., Calta, N. P., Tassone, C. J.

  2025; 110 (2025)

- **Electrochemical Control of the Ultrafast Lattice Response of a Layered Semimetal.** *Advanced science (Weinheim, Baden-Wurttemberg, Germany)*

  de Quesada, F. A., Muscher, P. K., Krakovsky, E. S., Sood, A., Poletayev, A. D., Sie, E. J., Nyby, C. M., Irvine, S. J., Zajac, M. E., Luo, D., Shen, X., Hoffmann, M. C., Kramer, et al

  2024: e2411344

- **Precision Calcination Mechanism of CaCO₃ to High-Porosity Nanoscale CaO CO₂ Sorbent Revealed by Direct In Situ Observations** *ADVANCED MATERIALS INTERFACES*

  Martinez, J., Wardini, J. L., Zheng, X., Moghimi, L., Rakowsky, J., Means, J., Guo, H., Kuzmenko, I., Ilavsky, J., Zhang, F., Dholabhai, P. P., Dresselhaus-Marais, L., Bowman, et al

  2024

- **Static and shock compression studies of eutectic high-entropy alloy AlCoCrFeNi_{2.1} to ultrahigh pressures** *JOURNAL OF APPLIED PHYSICS*

  Katagiri, K., Irvine, S. J., Hari, A., Kodama, R., Ozaki, N., Sano, T., Ren, J., Yang, W., Chen, W., Clay, M. P., Pope, A. D., Iwan, S., Dresselhaus-Marais, et al

  2024; 135 (9)

- **Correlating chemistry and mass transport in sustainable iron production.** *Proceedings of the National Academy of Sciences of the United States of America*

  Zheng, X., Paul, S., Moghimi, L., Wang, Y., Vilá, R. A., Zhang, F., Gao, X., Deng, J., Jiang, Y., Xiao, X., Wu, C., Greenburg, L. C., Yang, et al

  2023; 120 (43): e2305097120

- **Simultaneous bright- and dark-field X-ray microscopy at X-ray free electron lasers.** *Scientific reports*

  Dresselhaus-Marais, L. E., Kozioziemski, B., Holstad, T. S., Ræder, T. M., Seaberg, M., Nam, D., Kim, S., Breckling, S., Choi, S., Chollet, M., Cook, P. K., Folsom, E., Galtier, et al

  2023; 13 (1): 17573

- **Transonic dislocation propagation in diamond.** *Science (New York, N.Y.)*

  Katagiri, K., Pikuz, T., Fang, L., Albertazzi, B., Egashira, S., Inubushi, Y., Kamimura, G., Kodama, R., Koenig, M., Kozioziemski, B., Masaoka, G., Miyanishi, K., Nakamura, et al

  2023; 382 (6666): 69-72

- **Real-time imaging of acoustic waves in bulk materials with X-ray microscopy.** *Proceedings of the National Academy of Sciences of the United States of America*

  Holstad, T. S., Dresselhaus-Marais, L. E., Ræder, T. M., Kozioziemski, B., Driel, T. v., Seaberg, M., Folsom, E., Eggert, J. H., Knudsen, E. B., Nielsen, M. M., Simons, H., Haldrup, K., Poulsen, et al

  2023; 120 (39): e2307049120

- **Dynamic optical spectroscopy and pyrometry of static targets under optical and x-ray laser heating at the European XFEL** *JOURNAL OF APPLIED PHYSICS*

Ball, O. B., Prescher, C., Appel, K., Baehtz, C., Baron, M. A., Briggs, R., Cerantola, V., Chantel, J., Chariton, S., Coleman, A. L., Cynn, H., Damker, H., Dattelbaum, et al
2023; 134 (5)

- **Opinion 35+1 challenges in materials science being tackled by PIs under 35(ish) in 2023** *MATTER*
  Allen, M., Bediako, K., Bowman, W. J., Calabrese, M., Caretta, L., Cersonsky, R. K., Chen, W., Correa, S., Davidson, R., Dresselhaus-Marais, L., Eisler, C. N., Furst, A., Ge, et al
  2023; 6 (8): 2480-2487

- **Automatic Determination of the Weak-Beam Condition in Dark Field X-ray Microscopy** *INTEGRATING MATERIALS AND MANUFACTURING INNOVATION*
  Huang, P., Coffee, R., Dresselhaus-Marais, L.
  2023

- **Extensive 3D mapping of dislocation structures in bulk aluminum.** *Scientific reports*
  Yildirim, C., Poulsen, H. F., Winther, G., Detlefs, C., Huang, P. H., Dresselhaus-Marais, L. E.
  2023; 13 (1): 3834

- **Nanolamellar phase transition in an additively manufactured eutectic high-entropy alloy under high pressures** *AIP ADVANCES*
  Pope, A. D., Iwan, S., Clay, M. P., Vohra, Y. K., Katagiri, K., Dresselhaus-Marais, L., Ren, J., Chen, W.
  2023; 13 (3)

- **Analytical methods for superresolution dislocation identification in dark-field X-ray microscopy** *JOURNAL OF MATERIALS SCIENCE*
  Brennan, M. C., Howard, M., Marzouk, Y., Dresselhaus-Marais, L. E.
  2022

- **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