

FALL 2022

MSE 690 SEMINAR SERIES

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ARMS 1010



B. REEJA JAYAN

Associate Professor
Mechanical Engineering
& Dean's Early Career
Fellow at Carnegie
Mellon University

“Yes, You Can Microwave Metals & Other Tales at the Interface of Materials and Electromagnetics”

Abstract: Electromagnetic (EM) fields absorbed within a material promote non-equilibrium chemical reactions and structural transformations. However, the underlying fundamental mechanisms behind these observations remain largely unknown. For the first time, we used high-resolution in-situ synchrotron x-ray total scattering tools to observe the dynamics of materials synthesis as it occurs under EM radiation. Beyond offering energy savings by lowering temperature requirements, (EM) fields (e.g., microwaves) have the unique ability to transfer energy directly to molecules via polarization effects. This preferential absorption of radiation by materials with high dielectric (and/or ohmic) loss can cause rapid and selective heating of precursor molecules in solution; leading to the formation of high temperature ceramic phases with minimal thermal input; stabilization of different atomic structural arrangements compared to conventional, high temperature synthesis. We merge exploratory experiments with computational and data-driven methods to demonstrate that externally applied fields explore regions of phase space, microstructures, and properties not accessible via conventional synthesis via defects-mediated, field-driven, non-equilibrium effects. The impacts of studying field-matter coupling can range widely from discovering energy storage materials to technological development in areas like additive manufacturing of ceramics. Finally, delivering energy in a directed fashion using EM radiation will facilitate process intensification that can meet global needs for de-carbonization of process heating used in the synthesis of materials like ceramics.

Biography: B. Reeja Jayan is an Associate Professor in Mechanical Engineering and Dean's Early Career Fellow at Carnegie Mellon University (CMU). She also holds courtesy appointments in Materials Science and Engineering, Chemical Engineering, and Electrical & Computer Engineering departments. She leads the Adaptive Experimentation Thrust at the Air Force Research Laboratory (AFRL) Center of Excellence at CMU. Her multidisciplinary lab explores ways by which electromagnetic fields can synthesize materials hitherto unavailable to conventional synthesis routes. These low temperature processed materials directly grow on flexible, lightweight substrates, enabling structurally integrated energy and sensing. Dr. Jayan is a strong believer in game-based learning methodologies that she uses extensively in her undergraduate and graduate engineering courses. Dr. Jayan is a recipient of the 2018 National Science Foundation (NSF) CAREER Award, 2017 Army Research Office (ARO) Young Investigator Award, 2016 Air Force Office of Scientific Research (AFOSR) Young Investigator Award, CMU Engineering Dean's Early Career Fellowship, the George Tallman Ladd Research Award, the Donald L. and Rhonda Struminger Faculty Fellowship, the Berkman Faculty Development Fund, and Pittsburgh Magazine's 40 Under 40 Award. Her research is also funded by the Department of Energy (DOE), Defense Advanced Research Project Agency (DARPA), and by private sponsors.



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