FALL 2025

MSE 690 SEMINAR SERIES

MONDAY, SEPTEMBER 8TH | 3:30 REFRESHMENTS | 3:45PM SEMINAR

ARMS 1010

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Deciphering 2D Interfacial Phases: From Computing Grain Boundary Phase Diagrams to Exploring Novel Processing and Compositionally Complex Ceramics

Abstract: Grain boundaries (GBs) can be treated as interfacial phases (also known as “complexions”) that are thermodynamically two-dimensional (2D) [see, e.g., a perspective article: Science 368, 381 (2024)]. Studies of 2D interfacial phases shed light on several long-standing mysteries in materials science, including the origins and atomic-level mechanisms of “solid-state” activated sintering of refractory metals and ceramics, liquid metal embrittlement in Ni-Bi, and GB embrittlement in Ni-S. Since phase diagrams are arguably one of the most useful materials science tools, a focus of this seminar is to discuss a series of studies to compute GB “phase” diagrams via thermodynamic models, atomistic simulations, and machine learning [see a review/perspective article: Interdisciplinary Materials 2, 137 (2023)]. Analogous 2D surface phases have also been studied and utilized to improve various materials for energy-related applications. After briefly discussing two other ongoing studies on (i) novel materials processing (ultrafast sintering with vs. without electric currents in specimens and electric field effects on microstructural evolution) and (ii) 5- to 21-component high-entropy and compositionally complex ceramics, nascent topics at the intersections of these emergent areas and interfacial science will be discussed. For example, we demonstrated that applied electric fields can induce GB phase-like transitions via electrochemical coupling [Nature Communications 12, 2347 (2021)], thereby opening a new window to tailor microstructures [Materials Today 73, 66 (2024)]. In addition, we showed that a premelting-like GB disordering transition in compositionally complex perovskite oxide solid electrolytes can trigger abnormal grain growth and be utilized to improve lithium ionic conductivities [Matter 7, 2395 (2023) and J. Adv. Ceram. 3, 9221047 (2025)].

Biography: Jian Luo graduated from Tsinghua University with dual Bachelor's degrees: one in Materials Science and Engineering and another in Electronics and Computer Technology. After receiving his M.S. and Ph.D. degrees from M.I.T., Luo worked in the industry for more than two years with Lucent Technologies Bell Laboratories and OFS. In 2003, he joined the Clemson faculty, where he served as an Assistant/Associate/Full Professor of Materials Science and Engineering. In 2013, he moved to the University of California San Diego as a Professor of Chemical and Nano Engineering and Professor of Materials Science and Engineering. Luo group’s current research focuses on interfaces in metals and ceramics, high-entropy and compositionally complex ceramics, ultrafast sintering and other novel ceramic processing technologies, and advanced materials for energy-related applications and sustainability. Luo received a National Science Foundation CAREER award in 2005 (from the Ceramics program) and an AFOSR Young Investigator award in 2007 (from the Metallic Materials program). He was a Vannevar Bush Faculty Fellow (2014) and a Minerals, Metals & Materials Society Brimacombe Medalist (2019). Luo is a Fellow of the American Ceramic Society (2016), a Fellow of the ASM International (2022), and an Academician of the World Academy of Ceramics (2021).

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