DMSE Semester Colloquia Series
Tuesday, February 26, 2019
White 411 at 4:00pm

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Nano-scale Spatiotemporal Resolution Transmission Electron Microscopy of Multicomponent Alloy Microstructure Evolution During Rapid Thermal Transients

In laser and electron beam processing of materials, e.g. melting based additive manufacturing (AM) and high-energy density welding, microstructures evolve during sequences of micro- to millisecond heating-cooling cycles. The attendant microstructural changes are governed by metallurgical phenomena at sub-micrometer length scales under non-isothermal and non-equilibrium conditions. The initial transient establishes rapid solidification (RS) microstructures. RS can produce metastable phases, extreme solute segregation, and modifications of the microstructural spatial length scales, crystal orientation or texture relative to those familiar from more conventional conditions closer to equilibrium. In layer-by-layer AM the RS microstructures are modified in subsequent thermal cycles by series of solid-state transformations. It is essential to interrogate the materials microstructure evolution during these processes by experimentation at the requisite spatiotemporal scales to support development of mechanistically accurate understanding and models of the respective irreversible transitions and determine associated processing-microstructure and microstructure property relationships. Using thin-film based alloy platforms we combine unique nano-scale spatiotemporal resolution *in situ* observations with the dynamic transmission microscope (DTEM) with quantitative*post mortem* S/TEM. Hypo- and hypereutectic Al-Cu binaries are selected as model systems in quantitative studies of the microstructural evolution after pulsed-laser-induced melting and annealing. *In situ* experiments revealed crystal growth mode changes at composition dependent critical crystal growth rates that are responsible for establishing characteristic morphologically distinct microstructural zones. Quantitative measurements of locally resolved instantaneous and average transformation interface velocities during the solidification have been attained. Using the thin film platforms enabled direct observation based mechanistic and quantitative insights of the non-equilibrium processes responsible for microstructure development in the Al-Cu model multicomponent alloys during rapid thermal cycles involving transformations under conditions driven far-from-equilibrium. *Support from the National Science Foundation, DMR 1105757, 1607922, is gratefully acknowledged. Work at Lawrence Livermore National Laboratory (LLNL) was performed under the auspices of the U.S. Department of Energy, and supported via DE-AC52-07NA27344 and FWP SCW0974.*

Bio:

Jörg Wiezorek, Professor of Materials Science and Engineering in the Department of Mechanical Engineering and Materials Science (MEMS) at the University of Pittsburgh (Pitt), holds degrees in physics from the Westphalian Wilhelms-University Münster, Germany, and a Ph.D. in materials science and metallurgy from the University of Cambridge, UK. Prior to joining the faculty of the University of Pittsburgh in late 1998 he was a post-doctoral researcher at The Ohio State University. While at Pitt he has held appointments as National Center for Electron Microscopy Visiting Scientist Fellow at the Lawrence Berkeley National Laboratory, the William-Kepler-Whiteford Faculty Fellow at Pitt, Visiting Professor at the Swiss Federal Institute of Technology (ETH) in Zürich, and Visiting Senior Engineer at the Westinghouse Electric Corporation. Dr. Wiezorek is associate editor of Advances in Materials Science and Engineering, and served as Director of MSE, Graduate Program Coordinator for MSE, and Director of the Materials Micro-Characterization Laboratory.

Dr. Wiezorek's research interests and expertise include physical metallurgy and advanced quantitative micro-characterization by electron microscopy with a focus on the study of phase transformations, mechanical and magnetic properties, and elucidating processing-microstructure-property relationships in metallic and intermetallic materials. He has published over 170 journal and proceedings papers, and edited two books. He teaches on structure of materials, crystallography, diffraction, electron microscopy, phase transformations and microstructure evolution, and physical metallurgy.