In-situ Imaging of Solidification

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Solidification is experienced by all metals and occurs over multiple length and time scales. It provides the first opportunity to control structure and defect development, which ultimately determine a metal's performance and failure. Fundamental understanding of solidification is important for advancing casting and crystal growth technologies. It will enable the development of smart processing to produce materials with improved quality, without the need for down-stream, energy-intensive wrought processing. We use x-ray and proton imaging at DOE-BES User Facilities to understand structure, defect, and fluid flow development from the micro- to macroscopic scales during melting and solidification. We control micro- and mesoscopic structure and defect development in metals during directional solidification by managing the imposed thermal gradient and solid-liquid interface velocity and by using real-time feedback from x-ray imaging. Our goal is to integrate real-time observations of dynamic phenomena with theory and modeling to enable the prediction and control of structure and defect development in metals during solidification. Our approach will reduce the time for process development and will enable the creation of advanced materials with improved properties, performance, and reliability.