Multi-scale and In-situ Characterization of Phase Transformations in Metals

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Material structure directly affects properties and performance. Advanced characterization techniques allow better understanding of structure evolution from the atomic- to the macro-length scale and the influence of processing variations on phase transformations. We present recent atom probe tomography and transmission electron microscopy results from quench and tempered medium carbon steel. We link local element concentrations and phases with processing and the resultant properties. We also highlight real-time imaging results of metallic alloy melting and solidification using x-rays and protons. These techniques enable in-process studies of structure evolution from the micro-to the macro- length scale in small (x-rays) and large (protons) volumes of metals in 2D and 3D. In-situ characterization also enables the development of more efficient processing pathways and the control of structure and property evolution. Direct interrogation of metals during processing will permit the development of experimentally informed, predictive multi-scale models. These capabilities will facilitate process-aware manufacturing studies.