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Application of In-situ Diffraction Experiments to Understand Nonequilibrium Phase Transformations in Structural Alloys

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It has been a challenge to measure phase transformation kinetics in structural alloys under rapid thermal cycles under in-situ conditions with good time resolution in the past. However, by using high-brightness synchrotron sources that deliver sufficient photon fluxes, in-situ time-resolved X-ray diffraction measurements with millisecond time-resolution are now possible. This technique was used to track nonequilibrium austenite formation in a Fe-C-Al-Mn steel weld during solidification. This solidification mode is contrary to the equilibrium ferrite solidification mode. Subsequent to solidification, during cooling splitting of austenite diffraction peaks with two different lattice parameters was observed. Continued cooling led to the decomposition of low volume austenite into bainite first which was followed by the decomposition of large volume austenite to martensite. A similar phenomenon was also observed in austenite in a high-carbon Fe-C-Si-Mn steel before bainitic transformation. Possible mechanisms will be discussed based on computational thermodynamic and kinetic models.

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