In-situ Characterization with High-speed X-ray Diffraction of Phase Evolution in Ni alloy 718 during Laser Melting

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Laser melting in metals additive manufacturing is accompanied by rapid evolution in temperature, phase, and structure due to its extreme process speed and high cooling rates. Phase evolution in Ni alloy 718 during cool-down after laser melting is examined by in-situ X-ray diffraction experiments using high energy synchrotron x-rays and a high-speed large area detector. With high temporal and spatial resolution, phase fractions can be quantified down to a fraction of a percent. By analyzing asymmetric peak shapes based on an assumption of overlapped peaks from γ, γ' and γ'', fractions of the latter two hardening precipitates are found to increase rapidly within milliseconds of re-solidification to 3.0 % and 14.8 %, respectively. The lattice parameters of the two precipitates are similar to the matrix at high temperature but diverge on cooling, suggesting that they have different coefficients of expansion. The NbC carbide phase appears almost immediately after solidification with a final fraction of 0.026 % and the Laves phase appears between 1115 ˚C and 1050 ˚C, close to where it is thermodynamically stable with a final fraction of 0.020 %, respectively. Also, the thermal history is approximated estimated by using the known coefficient of thermal expansion and the changes in the lattice spacing. Remarkably, precipitation is not suppressed except of the δ phase although the volume fractions are, unsurprisingly, smaller than can be obtained via heat treatment.