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Determination of the Cooling Rate Dependency of High Entropy Alloys Using a High-Temperature Drop-on-Demand Droplet Generator

Authors : Saeedeh Imani Moqadam, Ilya Bobrov, Jérémy Epp, Nils Ellendt, Lutz Mädler

Abstract : High entropy alloys (HEAs), having adjustable properties and enhanced stability compared with intermetallic compounds, are solid solution alloys that contain more than five principal elements with almost equal atomic percentage. The concept of producing such alloys pave the way for developing advanced materials with unique properties. However, the synthesis of such alloys may require advanced processes with high cooling rates depending on which alloy elements are used. In this study, the micro spheres of different diameters of HEAs were generated via a drop-on-demand droplet generator and subsequently solidified during free-fall in an argon atmosphere. Such droplet generators can generate individual droplets with high reproducibility regarding droplet diameter, trajectory and cooling while avoiding any interparticle momentum or thermal coupling. Metallography as well as X-ray diffraction investigations for each diameter of the generated metallic droplets where then carried out to obtain information about the microstructural state. To calculate the cooling rate of the droplets, a droplet cooling model was developed and validated using model alloys such as CuSn%6 and AlCu%4.5 for which a correlation of secondary dendrite arm spacing (SDAS) and cooling rate is well-known. Droplets were generated from these alloys and their SDAS was determined using quantitative metallography. The cooling rate was then determined from the SDAS and used to validate the cooling rates obtained from the droplet cooling model. The application of that model on the HEA then leads to the cooling rate dependency and hence to the identification of process windows for the synthesis of these alloys. These process windows were then compared with cooling rates obtained in processes such as powder production, spray forming, selective laser melting and casting to predict if a synthesis is possible with these processes.

Keywords : cooling rate, drop-on-demand, high entropy alloys, microstructure, single droplet generation, X-ray Diffractometry
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