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Laser welding and powder bed fusion of uranium-6 wt. pct. niobium[1]

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The metals laser powder bed fusion process is known for creating structures with architectural complexity through the use of thin layers (<100 m), fine powder and small laser spot size. Builds are often custom and the different scanning strategies, part geometries, number of builds per plate, layer size, laser parameters and material properties all contribute to complex, unique thermal conditions and solidification behavior from part to part. In alloys, crystallographic structure is dependent upon composition, which is dependent upon cooling rate. Understanding the degree of segregation which occurs during processing is critical to the development of post-processing solutionizing heat treatments. We address this issue in uranium-6 wt. pct. niobium (U-6Nb), which forms various metastable phases as a function of Nb concentration, through (1) performing laser welding of as-cast U-6Nb, (2) employing conductive and convective heat transfer models to calculate cooling rate across these welds, (3) building the microstructure (cell spacing/secondary arm spacing)-cooling rate relationship for this alloy, and (4) identifying the degree of segregation in multiple welds. The laser powder bed fusion microstructures are examined and the cooling rates which resulted in such microstructural development and resulting segregation are determined, using relationships built through the as-cast welding study. We demonstrate various heat treatments and their effect on homogenization, with a view of discussing microstructure-property behavior. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 and has been assigned the document release ID#LLNL-ABS-767978.

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