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# DEVELOPMENT OF REFRACTORY METAL MANUFACTURING TECHNOLOGY BY LASER POWDER BED FUSION

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## ABSTRACT

Refractory metals, and most specifically tungsten and molybdenum alloys, possess specific properties that make them appealing for elevated temperature applications. However, obtaining complex shapes with these materials using conventional manufacturing processes is difficult and costly. In this work, Laser Powder Bed Fusion (LPBF) is considered as a prospective way to shape refractory metals. Since optimizing the LPBF parameters, such as laser power, scanning speed, hatching space and layer thickness, using the trial-and-error approach is time- and resource-consuming, a physics-based numerical model of the process was used to establish an efficient plan of experiments. Specimens were successfully printed using pure tungsten and molybdenum commercial powders and a custom-made Mo8Re (wt.%) plasma spheroidized powder. To find an adequate set of process parameters for each material, the printed specimens were characterized in terms of their density, microstructure and compression behavior in the 20-1000 °C temperature range. Highly dense (up to 93% for tungsten and 97% for the Mo and Mo8Re) crack-free specimens with ultimate compression strength of up to 860 MPa for tungsten and 500 MPa for Mo and Mo8Re were obtained (data provided for 20 °C). Next, the application of the Hot Isostatic Pressing (HIP) post-treatment to Mo8Re specimens allowed to reach a compression strength of 900 MPa at 20 °C (440 MPa at 600 °C) and a compression strain of 30% at 20 °C (15% at 600 °C), which represent an almost twofold increase in the compression strength and a 2 to 3 times increase in the compression strain as compared to the as-built pure Mo specimens in the 20-600 °C temperature range. Finally, complex geometry artifacts, namely 0.3 mm-width walls/gaps, and 50%-density gyroid and diamond lattice structures with 0.3 mm-thick struts were successfully printed with all the materials studied. The results of this study confirm the potential of LPBF to manufacture complex geometry refractory alloy parts with mechanical properties concurrent to their conventionally-manufactured counterparts.