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Combining theoretical methods and simulations to propose a novel FE-BASED bulk metallic glass composite alloy with acceptable laser powder bed fusion processability

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Fe-based bulk metallic glass composites (BMGCs) stand out because of their desirable combination of magnetic, corrosion, mechanical properties, and low material cost. The main bottleneck for producing Fe-based BMGCs is their poor glass forming-ability (GFA). The high cooling rates required to produce Fe-based BMGCs limit the size and geometry of parts made by casting. This limitation may be overcome using the additive manufacturing (AM) method of Laser Powder Bed Fusion (LPBF), which is based on locally melting powders deposited on a substrate layer by layer. Because the interaction time between the laser beam and powder is very short, high cooling rates (103-106 K/s) can be achieved, and BMGC parts with volume and geometries never obtained before can be obtained. However, selecting suitable Fe-based alloys for being processed by LPBF is still a challenge. Most of the Fe-based alloys LPBF-processed were chosen based on familiarity with other processing techniques such as casting or melt spinning. Consequently, the alloy compositions used thus far exhibited poor AM processability. The present work aimed to design, propose, and produce by LPBF BMGCs of the Fe-Mo-P-C-B system. First, GFA, liquidus temperature (TL), and primary phase formation of Fe-Mo-P-C-B alloys were investigated by theoretical methods of glassy phase formation and calculation of phase diagram (CALPHAD). The selected alloy compositions were produced using iron-alloys and steel by suction casting. The casted samples were analyzed by microscopy (OM and SEM), DSC, XRD, and Vickers microhardness. Then, the two most promising compositions were produced by Vacuum Induction Melting (VIM) and subsequently gas atomized. The powders were characterized regarding their flowability, particle size distribution, morphology, and microstructure using Carney funnel, OM, SEM, DSC, and XRD. The +20 µm – -75 µm powders were used to produce samples by LPBF using different laser power, scanning speed, laser scanning strategies, and remelting. The LPBF-ed samples were investigated using OM, SEM, XRD, DSC, and Vickers microhardness. The powders presented suitable physics characteristics to be applied in the LPBF process as good circularity and flowability. The LPBF experiments showed that suitable laser power and scan speed are in the range of 90-210 W and 300-900 mm/s, respectively. The chessboard laser strategy is more promising than single strokes for the glassy phase formation. The remelting step increases the glassy phase formation independently of the laser scan strategy used. The powders and LPBF-ed samples presented a composite microstructure based on glassy and crystalline phases. In the range of 90-210 W and 300-900 mm/s, the effect of the laser power and scan speed is decisive for the integrity of the samples but not for the glassy phase formation. Vickers microhardnesses of 1180±132 HV were obtained for the same range of parameters.