Modeling Structural Relaxation and Crystallization of Bulk Metallic Glasses in Powder Bed Fusion Additive Manufacturing

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ABSTRACT

In recent years, bulk metallic glasses (BMGs) have attracted intensive interest not only in the science community but also in industry. Their amorphous structures give them many desirable properties, such as high yield stress (1-5 GPa) and high elastic strain limits (up to $\sim$2%) compared to typical crystalline metals [1]. In addition to the remarkable features of additive manufacturing, i.e. high design flexibility and near-net-shape formability, the rapid cooling rate of this technology should also be noted. The cooling rates at the solidification front can reach the order of 10^6 K/s in selective beam melting [2], which is very beneficial for glass forming. In spite of the fact that this rapid technology has been employed to fabricate BMGs [3], the knowledge about structural relaxation and crystallization in the process is still in demand. Structural relaxation brings the non-equilibrium glassy material back into the equilibrium undercooled liquid state, whereas crystallites are formed during crystallization, both of which will lead to a loss of the characteristic features of BMGs.

Understanding these phenomena and the possibility to numerically determine processing windows is the subject of current research. Phenomenological models for structural relaxation and crystallization are coupled to the existing simulation software for powder-bed-based additive manufacturing. They are the well-known Kohlrausch-Williams-Watts (KWW) model, which has been extensively used to describe the structural relaxation [4] and the Nakamura model, which has been applied to investigate the crystallization of polymers during additive manufacturing [5]. The preliminary results will be presented. The relaxation or crystallization map depicts space-distribution and its evolution with respect to time, qualitatively.

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