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Microstructure and Mechanical Properties Evaluation of Graphene-Reinforced AlSi10Mg Matrix Composite Produced by Powder Bed Fusion Process

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Abstract : Since the last decade, graphene achieved great attention toward the progress of multifunction metal matrix composites, which are highly demanded in industries to develop energy-efficient systems. This study covers the two advanced aspects of the latest scientific endeavor, i.e., graphene as reinforcement in metallic materials and additive manufacturing (AM) as a processing technology. Herein, high-quality graphene and AlSi10Mg powder mechanically mixed by very low energy ball milling with 0.1 wt. % and 0.2 wt. % graphene. Mixed powder directly subjected to the powder bed fusion process, i.e., an AM technique to produce composite samples along with bare counterpart. The effects of graphene on porosity, microstructure, and mechanical properties were examined in this study. The volumetric distribution of pores was observed under X-ray computed tomography (CT). On the basis of relative density measurement by X-ray CT, it was observed that porosity increases after graphene addition, and pore morphology also transformed from spherical pores to enlarged flaky pores due to improper melting of composite powder. Furthermore, the microstructure suggests the grain refinement after graphene addition. The columnar grains were able to cross the melt pool boundaries in case of the bare sample, unlike composite samples. The smaller columnar grains were formed in composites due to heterogeneous nucleation by graphene platelets during solidification. The tensile properties get affected due to induced porosity irrespective of graphene reinforcement. The optimized tensile properties were achieved at 0.1 wt. % graphene. The increment in yield strength and ultimate tensile strength was 22% and 10%, respectively, for 0.1 wt. % graphene reinforced sample in comparison to bare counterpart while elongation decreases 20% for the same sample. The hardness indentations were taken mostly on the solid region in order to avoid the collapse of the pores. The hardness of the composite was increased progressively with graphene content. Around 30% of increment in hardness was achieved after the addition of 0.2 wt. % graphene. Therefore, it can be concluded that powder bed fusion can be adopted as a suitable technique to develop graphene reinforced AlSi10Mg composite. Though, some further process modification required to avoid the induced porosity after the addition of graphene, which can be addressed in future work.

Keywords : graphene, hardness, porosity, powder bed fusion, tensile properties
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