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A machine-learning assisted optimization approach and microstructure characterization method for laser powder bed fusion

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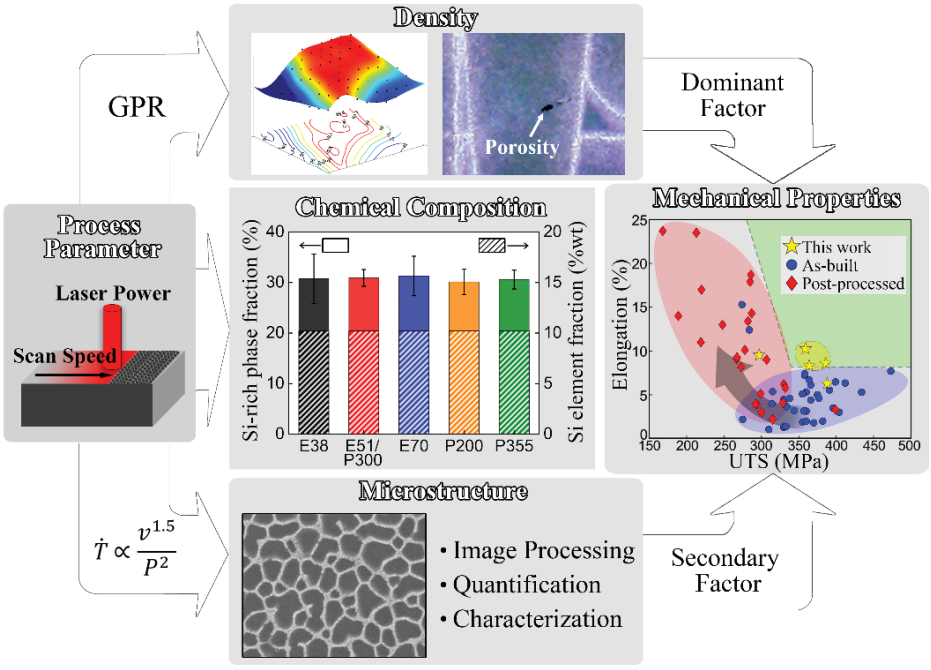
Laser powder bed fusion (LPBF) technique, as one of the most popular metal additive manufacturing (AM) techniques, has been employed for various materials fabrication due to its excellent advantages (e.g., freedom of design) compared to the traditional fabrication methods. However, a wide range of fabrication process parameters make it difficult to develop materials with this technique because corresponding suitable parameters usually rely on a costly trial-and-error process and a large number of experiments. In this work, we propose a new paradigm of LPBF process optimization for AlSi10Mg alloy based on Gaussian process regression (GPR) and limited experimental data. Our work found a new and much larger optimized LPBF processing window than was reported before for fabricating fully dense LPBF AlSi10Mg samples. More optimized manufacturing parameters make us possible to achieve previously unattainable combinations of desirable mechanical properties (high strength and ductility). Besides, in order to better manipulate the microstructure for desired mechanical properties in LPBF AlSi10Mg alloy, we introduced image processing technique and generated two newly defined morphology indices (i.e., dimensional-scale index I_d and shape index I_s) for microstructure characterization based on several key microstructural features obtained from SEM images. This proposed approach enables quick identification of the optimized LPBF processing window and the establishment of process-structure-property relationship for AlSi10Mg, which is believed to be applicable to other widely used metals and alloys or newly designed LPBF materials.

Keywords: Additive manufacturing, Gaussian process regression (GPR), Aluminum alloy



Investigated process-structure-property (PSP) link in Al-Si alloy in LPBF