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Editorial

Additive Manufacturing: Materials, Processing, Characterization and Applications

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The current Special Issue collected 19 original articles reporting the results of theoretical and experimental studies that provide new insights into this fascinating new generation manufacturing process, additive manufacturing (AM). This collection is inspired by the recent developments in this area and comprises 19 research articles from research groups from seven different countries worldwide. Most of them focus on microstructure control and its resultant mechanical property [1,2]. This trend is reflected in the current collection, in which 11 articles [3–13] deal with the process–microstructure–property relationship. Four papers [14–17] establish the model of AM process, reflecting the demand for a fundamental understanding of the mechanism behind AM process. Three papers [18–20], however, discuss the lattice design and the created functional parts, which is indicative of the growing interest of researchers in design for manufacturing [21]. One [22] paper creates the bimetallic and evaluated its corrosion property.

Most of the articles in this collection explore the microstructure control of powder bed fusion (PBF) AM part. Kitano et al. [3] develop a framework to determine the appropriate process parameter range by conducting a single-track test and thermal elastoplastic analysis in the laser powder bed fusion (L-PBF) process. Their developed framework considers defects and cracks. Ikeda et al. [4] construct a process map for optimizing process parameters and optimizing the CoCrFeNiTi-based HEAs' fabrication condition. Gokcekaya et al. [5] consider scan length effects on the densification and crystallographic texture of L-PBF pure Cr, offering new insight into the L-PBF processing of metals with high ductile–brittle transition temperature characteristics. Hibino et al. [6] demonstrate by Hastelloy-X that it is possible to control the crystallographic textures using the L-PBF process by appropriately choosing the process parameters. The mechanical properties corresponding to the crystallographic textures can be designed and obtained. Takase et al. [7] systematically and quantitatively investigate phase evolution of Ti-6Al-4V and residual stresses in the final parts by considering L-PBF and electron beam (EB) PBF and their process parameters.

Based on Hunt's columnar-to-equiaxed transition (CET) criterion, columnar grains preferably form in the solidification front of a high-temperature gradient (G). However, Miyata et al. [8] report the opposite tendency for CET in the solidification microstructure. They study EB-PBF stainless steels and suggest that solidification microstructures formed in the EB-PBF process are intricately related to various factors such as temperature gradient, solidification rate, and flow velocity.

Some other researchers tried to fabricate new materials by modifying the powder materials: Guo et al. [9] prove a strategy to remove oxides in L-PBF builds a Mo-based composite using acid-treated carbon nanotubes as a carbon source and H_2 as reduction. The feedstock, CNT/Mo composite particles, is fabricated from a freeze-dried pulsated orifice ejection method.

On the other hand, post-processing is also essential and has been investigated in the current collection. Pereira et al. [10] propose new customized heat treatments for L-PBF parts in IN718 alloy to achieve its best mechanical properties. Liu et al. [11] clarify the effect of annealing on the microstructure evolution of Al–12%Si alloy fabricated by the L-PBF process and rationalize the change in anisotropic tensile properties during the annealing at various temperatures. Cho et al. [12] perform a two-step heat treatment on EB-PBF β-containing TiAl alloy rods and evaluate its microstructure evolution and high-temperature tensile property. It should be highlighted that this resultant microstructure in its final property should not only be investigated experimentally, and Zeng et al. [13] perform molecular dynamics simulations to investigate the mechanical deformation of cellular structures in the L-PBF of aluminum.

The fundamental understanding of the mechanism behind AM process is critical to predicate the forming part. Therefore, the researchers also pay attention to this field. Li et al. [14] establish a 3D model to accurately simulate the internal and external powder stream characteristics of the coaxial discrete three-beam nozzle for laser direct energy deposition (L-DED). Li et al. [15] also prove that optical signals can simultaneously reflect the deposition height and width in L-DED. In addition, they establish a laser reflection model to explain the correlation between reflected laser and accumulated deposition height. Additionally, Liu et al. [16] derive some important analytical expressions of the geometric characteristics of the powder stream in L-DED. Shcherbakov et al. [17] develop a computer model for investigating the processes of heat and mass transfer under the influence of concentrated energy sources on materials.

AM should not only just be considered as a forming process, but should also open design freedom for lightweight structures and lattices because of the layer-by-layer feature. Therefore, some novel structures can be fabricated. Ikeo et al. [18] provide a novel 3D puzzle structure by arranging the powder and solid parts and creating it in the AM process. The 3D puzzle structure has an anisotropic Young's modulus, making it suitable for bioimplants. On the other hand, through EB-PBF and subsequent heat treatment, Ikeo et al. [19] also design a novel powder/solid composite with a uniaxially anisotropic and hierarchical structure. Santiago et al. [20] comprehensively analyze the mechanical property and dimensional accuracy of carbon fiber PEEK lattice structures fabricated by fused filament fabrication with high-temperature support.

In addition to the abovementioned progress, AM can also produce bimetallics for better properties with a combination of the benefits of both metals. Therefore, it has become more prevalent in recent years. For example, Hu et al. [22] fabricated bimetallics by wire-arc additive manufacturing and studied their microstructure and corrosion resistance.

Reflecting from the contents of the collection, the feedstock's preparation and characterization, microstructure control by AM process and post-heat treatment, computational studies of the interaction of powder and energy beam and its functional part design and fabrication provide new, interesting data about AM. These works advance the understanding of the state of the art in the AM process. We expect that the current collection will stimulate the idea exchange, encourage the concept development and theoretical investigations of various classes of AM process and its feedstocks, as well as motivate newcomers to initiate exciting research in AM domain.

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