ABSTRACT

Historical and Current Development of Powder Bed-Based Additive Manufacturing using Lasers

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Laser Beam Powder Bed Fusion of Metals (LB-PBF-M) is an additive manufacturing (AM) technology that enables the production of complex metal components with relatively high precision. The process involves the selective melting of fine metal powder layer by layer using a high-powered laser, enabling intricate geometries and lightweight structures that are otherwise difficult to achieve through conventional manufacturing. LB-PBF-M originated in the 1990s with key contributions from the Fraunhofer Institute for Laser Technology (ILT) and companies such as EOS, Concept Laser and SLM Solutions. Over the past few decades, advances in laser technology, such as multi-laser systems and beam shaping, have led to significant improvements in part quality, production speed and scalability. Despite these advancements, challenges remain, including process-induced defects, residual stresses, and the need for extensive post-processing. Research efforts continue to focus on optimizing process parameters, enhancing powder material properties, and integrating real-time monitoring and control systems to improve reliability and repeatability. Additionally, the adoption of LB-PBF-M is expanding across various industries, including aerospace, medical, and automotive sectors, where high-performance materials and complex geometries are critical. As the technology evolves, further developments in machine learning, in-situ process monitoring, and hybrid manufacturing approaches are expected to drive the next generation of LB-PBF-M, pushing the boundaries of precision, efficiency, and material capabilities.