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Effect of laser beam shaping on the crystallographic texture and residual stress distribution of 316L stainless steel manufactured using Laser Powder Bed Fusion

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Laser Powder Bed Fusion (PBF-LB) has attracted significant attention in aerospace, automotive, and biomedical applications due to its highly flexible and near-net-shape fabrication capabilities for complex structures. While PBF-LB overcomes the limitations of conventional manufacturing methods by enabling lightweight and functionally integrated designs, traditional Gaussian laser-based L-PBF suffers from low productivity and high residual stresses due to small melt pools, rapid cooling rates, and steep thermal gradients. Laser beam shaping techniques, such as ring-mode lasers, offer improved energy distribution, enhanced melt pool stability, and potentially higher build rates. However, their effects on residual stress, microstructural texture, and mechanical properties remain unclear. This study systematically investigates the influence of Gaussian versus ring-mode lasers on the as-built microstructure (e.g., dislocation structures, elemental segregation), crystallographic texture, and residual stress in 316L austenitic stainless steel using advanced characterization techniques, including electron backscatter diffraction (EBSD) and neutron diffraction. The findings aim to optimize process parameters for superior mechanical performance, providing critical insights for the potential application of beam-shaped PBF-LB on fusion energy and nuclear industrial components.

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