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Pulsed-Continuous Dual-Beam Selective Laser Melting of Ceramics

A novel dual-beam laser method significantly improves ceramic additive manufacturing, producing high-density, low-roughness parts with minimal cracking for aerospace and medical applications.

Researchers at Purdue University have proposed a new method intended to successfully produce ceramic parts through selective laser melting (SLM). SLM is a type of competitive additive manufacturing (AM) technology with the advantages of rapid production and good flexibility in terms of part composition and geometry. It is the major AM technology capable of directly manufacturing ceramic parts largely in a single step with high geometrical accuracy, complexity and theoretically achievable density. Although extensively used with metals, SLM for ceramics often faces challenges due to the relatively high melting point, low thermal conductivity and fracture toughness of ceramics. This leads to issues such as frequent thermal cracking, high surface roughness, balling, and/or insufficient densification. Purdue researchers have proposed to address these challenges through their innovative pulsed continuous-SLM method. The key innovation of the method is the unique combination of a "melting laser beam" in the pulsed mode with a "heating laser beam" in the continuous-wave (CW) mode. The pulsed "melting beam" can potentially induce full melting of targeted ceramic particles for high part densification without an overlarge melt pool or molten-state duration that may cause a rough part surface. The continuous "heating beam" can potentially reduce the temperature gradient in the powder bed, suppressing thermal cracks. As a result, the new method can potentially produce high-quality ceramic parts largely in a single step with high density, low surface roughness and no (or few) cracks.

Technology Validation:

Preliminary experimental results on single-track SLM provided support for the advantages of the PC-SLM method. Compared with other SLM methods using two CW beams, a single CW beam or pulsed beam, the PC-SLM method can produce a ceramic track (chromium carbide), which appears much more continuous and densified, and has high nanohardness of the

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cross-section, under the conditions studied. Further research is still needed and expected to be conducted by Prof. Wu's team to understand the underlying mechanisms and further investigate the performance of PC-SLM of ceramics.

Advantages:

-Rapid production of ceramic parts largely in a single step with no or little post-processing.

-High flexibility in part composition and geometry

-Potentially high achievable part quality with high density, low surface roughness and no (or few) cracks.

Applications:

-Additive manufacturing, specifically selective laser melting, of ceramics

-Medical and dental industries

-Aerospace industry

Publications:

Wu, Mengchen and Wu, Benxin, 2025. A Ceramic Additive Manufacturing Process via Pulsed-Continuous Dual-Beam Laser Powder Bed Fusion.â€¯Journal of Manufacturing Science and Engineering,â€¯147(10), p.101010.

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