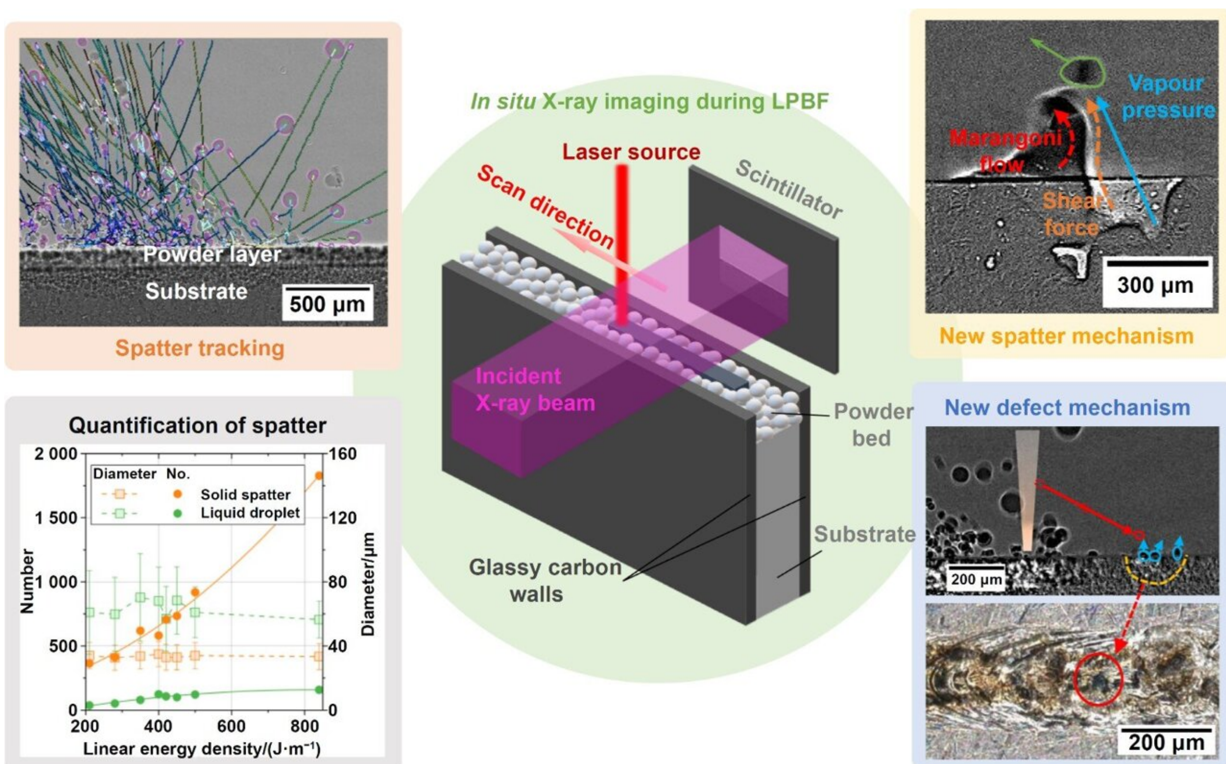
Seeing the invisible: How X-ray reveals spatter behavior during 3D printing

August 30 2024



Through high-speed synchrotron X-ray imaging, the spatter dynamic during LPBF was captured and quantified under various processing conditions, and two new spatter mechanisms were discovered. Credit: Da Guo, Rubén Lambert-Garcia, Samy Hocine, Xianqiang Fan, Henry Greenhalgh, Ravi Shahani, Marta Majkut, Alexander Rack, Peter D Lee and Chu Lun Alex Leung.

Research conducted by UCL researchers reveals and explains the links between vapor depression shape and spatter dynamics during LPBF under various industry-relevant processing conditions.

The work, reported in the *International Journal of Extreme Manufacturing*, not only quantifies the spatter and spatter-laser interactions but also proposes strategies to minimize defects, thereby enhancing the surface quality of LPBF-manufactured parts.

Spatter during LPBF can induce surface defects, impacting the fatigue performance of the fabricated components.

"Spatter is one of the main concerns in industrial 3D printing applications that can contribute to porosity formation and rough surface," said Chu Lun Alex Leung, the corresponding author on the paper and Associate Professor of UCL Mechanical Engineering.

"Adoption of LPBF for safety critical applications is hindered by the challenge of achieving defect-lean, high surface quality metallic components."

Professor Peter D. Lee, also a corresponding author and Professor of UCL Mechanical Engineering, emphasized, "Currently, research on spatter during LPBF is limited, and our goal is to improve our understanding of spatter formation mechanisms using high-energy synchrotron X-ray sources."

LPBF is a leading metal 3D printing technology, with the potential to produce components that surpass traditional castings in defect levels and mechanical properties when appropriate process parameters are used.

However, they may not currently reach the surface quality and defect levels of components machined from wrought products. Reduced defects (or roughness) in the surface regions should bring further improvements on the fatigue performance of the LPBF components.

The surface defects are often associated with spatter formation during LPBF. Oversized spatter can adhere to the surface of AM parts, increasing both surface defects and roughness; they can also be trapped in the powder bed in subsequent build layers, leading to lack-of-fusion porosities.

Spatter may undergo oxidation, which lowers the recyclability and reusability of powder. The surface oxides can inhibit particle fusion and promote the formation of porosity, decreasing the density of the LPBF parts. Hence, a deeper understanding of spatter evolution is therefore essential to mitigate these issues.

The experiments were performed using a bespoke AM machine, called the Quad-laser in situ and operando process replicator (Quad-ISOPR). The Quad-ISOPR comprises four lasers and the industrial scan head system combined with a custom-built environmental chamber filled with argon shielding gas.

A substrate with a 1 mm through-thickness and 15 mm height is mounted in the chamber, onto which a thin layer of the powder is automatically deposited.

Using in situ high-speed synchrotron X-ray, both spatter and melt pool dynamics during LPBF can be captured at exceptional spatial and temporal resolution. The in situ experiments were carried out at the European Synchrotron Radiation Facility's (ESRF) high-speed imaging beamline ID19, using polychromatic hard X-ray beam with a mean energy of ~30 keV and a high-speed camera at a framerate of 40 kHz.

"Our work predicts the number of spatters formed during LPBF of an Al-Zr-Fe alloy system," said first-author Da Guo, post-doc in the school.

"This prediction can be used for future model validation and minimizing spatter."

The researchers are continuing their efforts to deepen the understanding of spatter formation across various commercial materials in 3D printing applications, with the goal of achieving higher surface quality LPBF parts for real-world use. Through these advancements, they hope to contribute significantly to the broader adoption of LPBF in industry, particularly in applications where component integrity is critical.

More information: Da Guo et al, Correlative spatter and vapour depression dynamics during laser powder bed fusion of an Al-Fe-Zr alloy, *International Journal of Extreme Manufacturing* (2024). DOI: 10.1088/2631-7990/ad4e1d

Provided by International Journal of Extreme Manufacturing

Citation: Seeing the invisible: How X-ray reveals spatter behavior during 3D printing (2024, August 30) retrieved 31 August 2024 from https://techxplore.com/news/2024-08-invisible-ray-reveals-spatter-behavior.html