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# Exploring Electromagnetic Scattering Analysis for In-Situ Monitoring of Laser Powder Bed Fusion Additive Manufacturing

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## ABSTRACT

Laser powder bed fusion (LPBF) additive manufacturing (AM) is a promising method for fabricating complex geometries with lower cost and faster speeds compared to conventional (subtractive) manufacturing methods (e.g., computer numerical control (CNC)). However, challenges associated with AM (i.e., presence of defects, manufactured part materials properties, etc.) necessitate the development of in-situ monitoring techniques to evaluate process parameters in real-time. As LPBF is a layer-by-layer process, in-situ monitoring offers the advantage of halting the process at the first sign that a defect is likely to be generated, resulting in time and cost savings. During LPBF, the laser selectively melts the powder bed based on a pattern produced by the slicer software. Interaction of the laser with the powder bed results in the ejection of metal particles, known as spatters. It has been shown (in the literature) that these spatters behave differently depending on the processing parameters, and their behavior might be correlated with deviations from properly set processing parameters or defect generation during the AM process. In a preliminary study, we suggested employing a well-established electromagnetic (EM) model to calculate spatters' scattering behavior during LPBF. This model utilizes EM backscattering radar cross-section (RCS) analysis to distinguish between various spattering behaviors under different processing conditions. Consequently, there is a great potential for monitoring the scattering properties of spatters generated in LPBF process, serving as an indicator of changes in the spattering behavior, that in turn might become an EM signature of a potential defect. Therefore, monitoring of backscattering RCS may offer a viable online monitoring method for the LPBF process. To validate this hypothesis and confirm the results of the theoretical model, a controlled chamber where powder is ejected using a powder dispenser machine was devised. The powder is then released, and its RCS is measured in the chamber while simulating different particle distributions (i.e., spatter) and sizes within the chamber. The objective is to confirm the effectiveness of using this EM scattering analysis to distinguish between different metal powder spatter spatial distributions.

**Keywords:** Additive manufacturing, Laser powder bed fusion, Electromagnetic scattering, Radar cross-section, Spatters

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