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IN SITU SYNCHROTRON X-RAY ANALYSIS OF LASER ADDITIVE MANUFACTURING OF LUNAR REGOLITH SIMULANT

Abstract

Additive Manufacturing (AM) using in situ resource utilisation (ISRU, i.e. using local resources) has been identified as a key technology for on-demand component fabrication on the moon and extra-terrestrial planets. Laser powder bed fusion (LPBF) has received increasing attention to produce components made of fine lunar grey soil - Regolith. On earth, LPBF is a key AM technology; however, obtaining the optimal parameters to AM rich oxidised metals such as Regolith powders requires extensive characterisation and understanding of the key mechanisms. Here, we use fast synchrotron x-ray imaging to observe real-time laser interactions and to analyse the melt pool morphology at different process conditions. These datasets will enable the validation of multiphysics models that replicate lunar environmental conditions, leading to the definition of new printing strategies for enhanced parts densification and mechanical performance. The processability window is experimentally defined by assessing defects density and mechanical performance. As different Regolith simulants spreadability and laser interactions were noticed during the printing experiments campaign, a comprehensive characterisation of the two simulants: the European Astronaut Centre lunar regolith simulant (EAC-1A) from ESA and the commercially available lunar mare simulant (LMS -1) from Exolith Lab ltd is carried out. These novel results can drive activities to the formulation of an internationally accepted classification schemes of simulant materials for manufacturing applications. Further investigations will focus on the definition of the processability window depending on different Regolith mineralogy. These findings contribute to the identification of methods for additively manufacturing Regolith components in space, elucidating on the feasibility and adaptability of designing a printing system for ISRU.