3D-printing of lunar regolith ceramics with high mechanical properties via a stereolithography-based approach

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Abstract

Lunar regolith, a material that is ubiquitously present across the surface of the Moon and has been formed over billions of years through space weathering of the lunar surface, holds immense potential as a valuable resource for the sustainable development of lunar infrastructure. Its abundance on the lunar surface makes it an ideal raw material for the implementation of the In-situ Fabrication and Repair (ISFR) strategy, particularly for long-duration crewed lunar exploration missions. In turn, additive manufacturing with lunar regolith enables future astronauts to efficiently produce a wide range of items, including spare parts, instruments, and essential infrastructure elements, on demand and at a rapid pace. This paper presents a method for producing dense ceramic components with high mechanical strength and good precision, out of LHS-1 lunar regolith simulant, using laser stereolithography. The study demonstrates that through the use of suitable grinding and sintering parameters, precise and dense ceramic parts with intricate designs can be produced via 3D printing of lunar regolith. It was found that obtained samples pose a relative density of 97% and a micro-hardness of more than 730HV. It was found that the manufactured regolith ceramics yield up to 380 MPa of compressive, 88 MPa of tensile, and 152 MPa of flexural strength, making it a perspective ceramic material for a wide range of applications on the lunar surface.