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Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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ADDITIVE MANUFACTURING WITH MOLTEN LUNAR REGOLITH UNDER VACUUM CONDITIONS

Abstract

The Moon offers a unique opportunity for space exploration and colonisation due to its proximity to Earth and abundance of resources. Additive manufacturing, also known as 3D printing, has shown promise as a technology for in-situ fabrication of structures and devices using local resources on the Moon. In the project *EDAM-R* at TU Berlin, molten lunar regolith simulant (TUBS-M mare basalt simulant) was used as a feedstock for high-temperature 3D printing under vacuum conditions.

A customised printhead was developed and used to melt the lunar regolith. The printhead is a vertical high-temperature tube furnace containing a platinum crucible with an orifice at the bottom through which the molten lunar regolith is extruded. The melt drips onto a regolith substrate that is moved by a 3-axis traverse table within a vacuum chamber. Melt viscosity, which depends on the chemical composition and the temperature, primarily determines the thickness of the manufactured parts, as the melt stream narrows with increasing fall distance. Subsequently, the melt cools down in a vacuum and solidifies. The cooling rate is an important parameter as it determines whether the melt solidifies as glass or devitrifies. Previous experiments under ambient conditions have shown that the fast cooling rates due to convection caused the printed glassy parts to crack. In a vacuum, slower cooling rates were observed as heat is mainly released by radiation, reducing the residual stress on the printed parts.

This paper presents the results of the first test campaign of *EDAM-R*, including the system design and findings from printing the molten lunar regolith simulant under vacuum conditions. The study demonstrates the potential of using molten lunar regolith for on-site construction on the Moon's surface. Relevant high-temperature properties, such as viscosity and glass transition temperature, were measured for a wide range of lunar regolith simulants.

The ability to use lunar regolith for construction on the Moon is an important step towards sustainable and cost-efficient lunar exploration and settlement. The results of *EDAM-R* provide valuable insights into the potential of 3D printing technology for lunar surface construction and pave the way for further research and development in this area.