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**UTILIZATION OF ADDITIVELY MANUFACTURED LUNAR REGOLITH
CERAMICS FOR IN-SITU FABRICATION OF OPTO-MECHANICAL PARTS ON
THE MOON**

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ABSTRACT

Future lunar missions will rely heavily on opto-mechanical components for both navigation and sensing, including lidars, sensors, and lasers. These opto-mechanical components will also be essential for scientific applications such as optical, infrared, and ultraviolet telescopes among other advanced instruments. Present study investigates the feasibility of utilizing regolith-based ceramics as a viable material for additive manufacturing (AM) of core opto-mechanical components for both scientific and applied instruments on the Moon. Focusing on a simplified telescope design, we present an end-to-end technology pathway in which these components can be manufactured in situ. Leveraging existing research on regolith-based ceramics, we incorporate material properties - such as density, compressive strength, and thermal stability - into quasi-static and modal analysis simulations. Specifically, PTC Creo and Ansys were employed for both the design and simulations, taking into account lunar conditions including one-sixth of Earth's gravity and relevant vibration requirements to ensure operability on the lunar surface. These simulations account for lunar-specific gravitational influences and thermomechanical conditions, deliberately omitting the launch loads typically experienced when sending hardware from Earth. By conducting finite element modeling, we assess the structural integrity and dynamic behavior of key subsystems. Our findings suggest that regolith-derived ceramic components, produced by the vat-polymerization based AM can meet critical performance requirements within the lunar environment and significantly increase the autonomy of operation and maintenance of optical instruments on the Moon. The capacity to produce opto-mechanical assemblies on-site, using in-situ mined lunar regolith, can help to expand mission flexibility and increase overall redundancy for the long-duration operations. Capacity of rapid-prototyping of complex ceramic parts directly on the Moon will contribute for in-situ fabrication and repair of diverse range of opto-mechanical parts, including mirror support structures, load-bearing bases, and positioning mechanisms. Ultimately, this work underlines the broader potential of using regolith-based ceramics in various applications beyond telescope assemblies, including scientific instrumentation, infrastructure elements and ISRU processing plants. Such an approach could significantly advance human exploration by reducing the mass of materials that must be launched from Earth, thereby simplifying mission architecture and lowering overall costs.

Comments:

Track: Technology

Slots: ISRU systems, Structures and materials, In-space manufacturing, Innovative concepts

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