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ADDITIVE MANUFACTURING RESEARCH GROUP

ADDITIVE MANUFACTURING USING EXTRA-TERRESTRIAL MULTI-COMPONENT CERAMIC MATERIALS

INTRODUCTION

The aim of this research was to investigate the application of Laser Additive Manufacturing to process ceramic multicomponent materials into 3D layered structures. These ceramic materials matched those found on the Lunar and/or Martian surface. These indigenous extra-terrestrial materials could potentially be used for manufacturing physical assets onsite (i.e. off World) on future planetary exploration missions and could cover a range of potential applications including infrastructure, radiation shielding, thermal storage, etc. [Figure 1].

Figure 1 - European Space Agency, (2014). *Building a lunar base with 3D printing*.

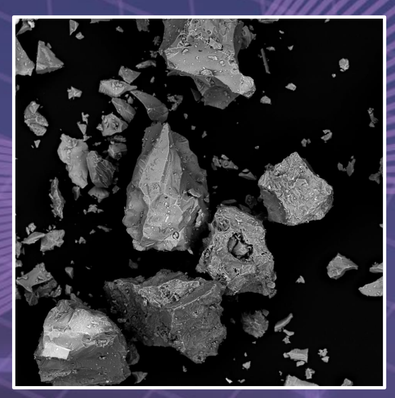


Figure 2 – SEM Micrograph of Lunar (left) and Martian (right) regolith simulant particles.

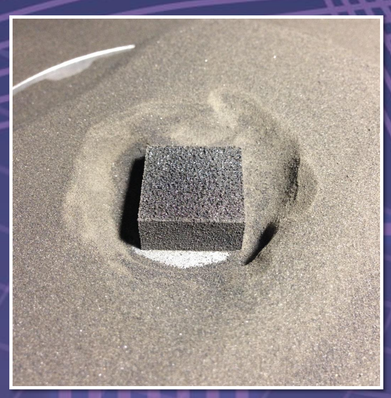
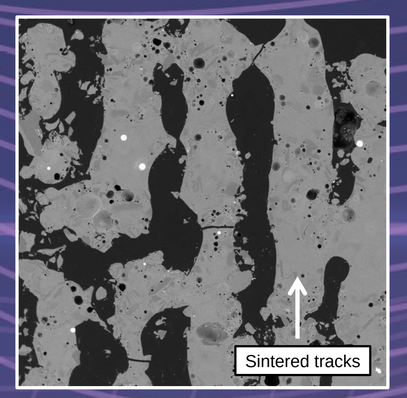


Figure 3 – 3d printed geometries out of Lunar (left) and Martian (right) regolith simulant.



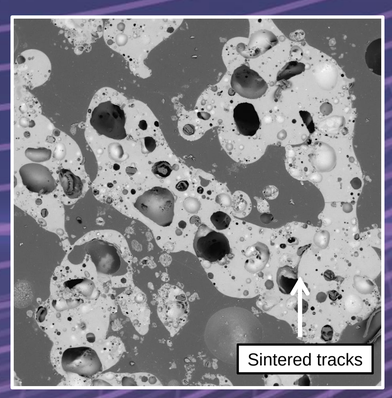
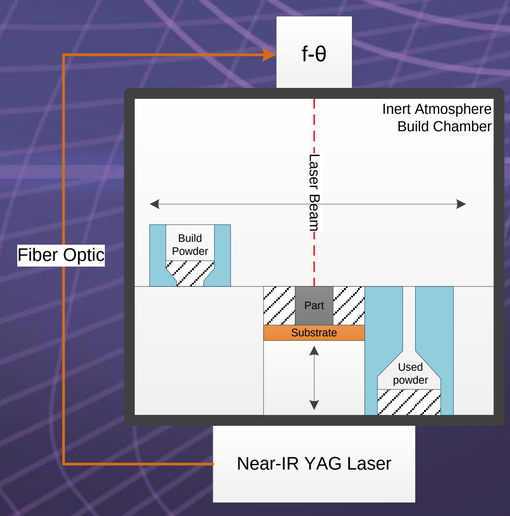


Figure 4 – SEM image cross-sections of Lunar (left) and Martian (right) sintered samples.

METHODOLOGY

An Ytterbium fiber laser (NIR) and a CO_2 (IR) laser were used to provide a range of thermal energies to selectively fuse regions of a powder bed containing the Lunar and Martian regolith materials and manufacture complex structures on a layer-by-layer strategy [Figure 5].



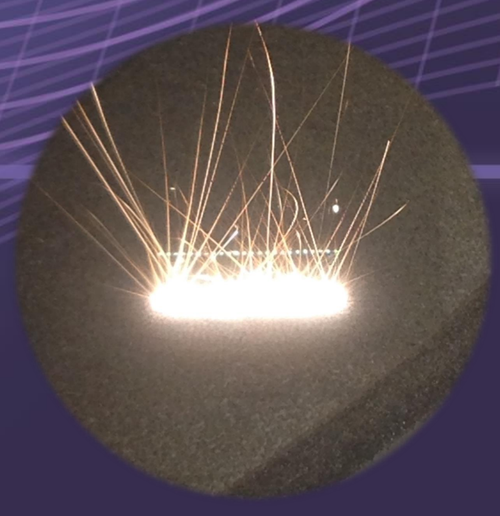


Figure 5 – Laser Additive Manufacturing of Lunar/Martian Regolith Simulants

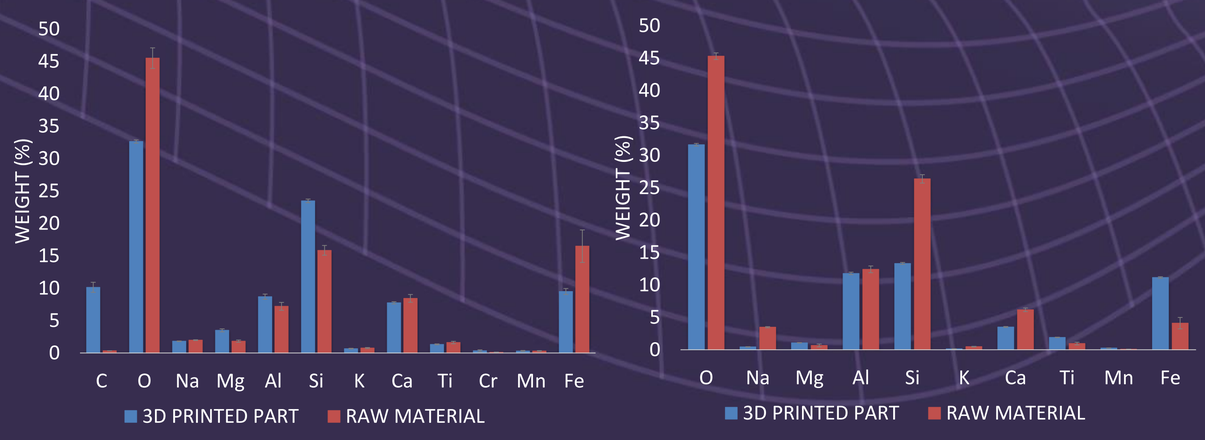


Figure 6 – Elemental concentrations (Wt%) between 3d printed Lunar (left) and Martian (right) regolith samples and raw material powders acquired via Electron Dispersive X-Ray Spectroscopy (EDS).

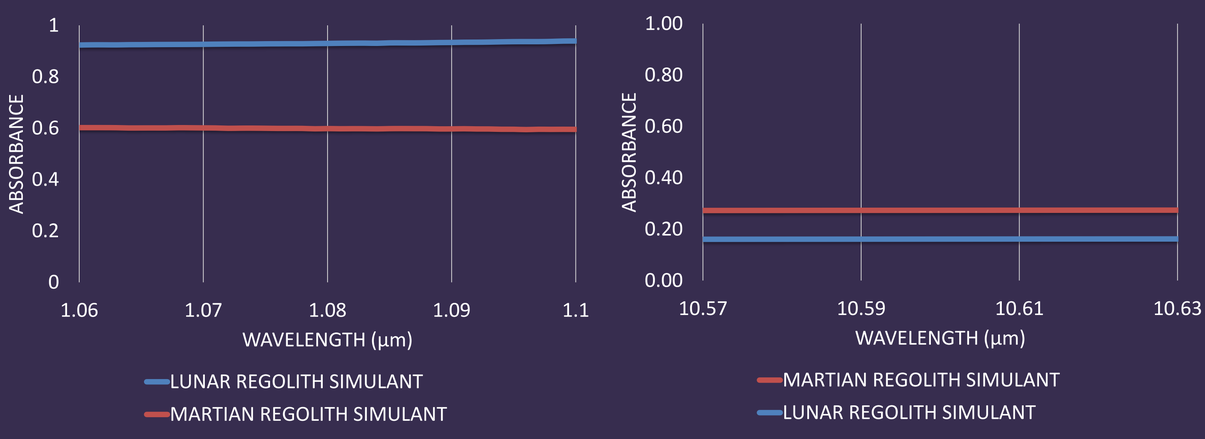


Figure 7 – Absorbance characteristics of Lunar and Martian regolith simulants in Infrared (right) and Near Infrared Spectra (left).

FINDINGS

- Identification of a suitable process window that allowed successful fabrication of three dimensional specimens from the multi-component Lunar and Martian regolith ceramic materials.
- Material Hardness for sintered Lunar regolith identified as **660 ± 2 VHN,** harder that common soda lime glass.
- Internal relative porosity of **40%** (Lunar) and **59%** (Martian) were observed [Figure 4].
- Substantial change in the particular element concentration due to the laser processing was identified [Figure 6].
- Both materials showed better laser absorption characteristics when the NIR laser was used [Figure 7].

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