Paper ID: 51513
oral
student

17th IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Systems and Infrastructures to Implement Sustainable Space Development and Settlement - Technologies (2B)

Author: Mr. Nicholas Schmidtke
Faculty of Engineering, Carleton University, Canada, NicholasSchmidtke@cmail.carleton.ca

IN SITU RESOURCE UTILIZATION - ANALOGUES FOR A LUNAR CONSTRUCTED MAGNETRON VIA 3D PRINTING AND MICROWAVE CASTING

Abstract

We are developing a microwave investment casting process as a means of fabricating magnetron parts using lunar resources. Since a magnetron is the core part of a microwave oven, this work is the first step towards a self-replicating fabricator. Lunar-like resources are used wherever possible at each stage of the process (with potential for material re-use otherwise), so this work also paves the way for development of an entire lunar infrastructure from a single seed fabrication unit. Magnetrons also have potential for other components of lunar and space infrastructure: they demonstrate the potential for vacuum tube electronics for rad-hard systems and could be used as microwave generators for solar power satellites.

Our microwave investment casting process comprises four steps: 1) 3D printing of a ‘positive’ of the part, 2) encapsulation of the positive in a silicon carbide and calcium-aluminate based hydraulic cement mould, 3) removal of the positive, and 4) casting, using either metal powder, metal oxide with carbon as a reducing agent, or precursors to ferrite magnetic materials.

3D printing of the positives allows for flexibility in part shaping, with little restriction imposed by the casting process itself. The actual positive material is not of great consequence so long as it is water resistant – we have used positives of spirulina (via an inkjet process), PLA, HIPS, and PVA (in spite of its water solubility). Positives are vibration set into the cement, which cures for 24 h. They are then either burned out (spirulina, PLA, HIPS) or dissolved in water (PVA). Powdered metal (or other material) is then poured into the cavity (which includes additional ‘crucible’ volume for shrinkage as required), and the filled mould is fired in a conventional home microwave oven.

To date cubes of copper, iron, and nickel have been successfully cast, with no apparent porosity, while attempts with barium ferrite, strontium ferrite, and nickel ferrite have been less successful. We plan to additionally cast cobalt and AlNiCo, as well as actual magnetron parts. This has demonstrated the principle of casting metal magnetron parts in 3D print-formed moulds. This technology looks promising for application on the Moon in extending 3D printing beyond regolith processing to a wide range of in-situ sourced metals.