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METAL ALLOYS FOR ADDITIVE MANUFACTURING PLUS SILICON AND OXYGEN FROM REGOLITH

Abstract

Thermophysical processing of regolith can produce simultaneous streams of oxygen, silicon, aluminum alloy, and iron alloy, along with volatile or gaseous components. A first Joule heating produces magma, releasing water vapor, helium, and volatile carbon compounds. A second inductive heating releases oxygen which can be separated from sub-oxide mineral vapors using principles of supersonic flow. A third heating of sub-oxide minerals into a plasma state produces a beam from which individual isotopes can be separated according to their charge-to-mass ratio. This includes silicon-28 which can be crystallized via ribbon-growth and used with other elements to manufacture p-n junction solar cells. An aluminum stream containing some Mg with Si-29 and Si-30 can be extracted to produce a silumin-type alloy suitable for enclosing life support environments. Another stream of iron along with some Co and Ni makes a structural alloy intermediate between stainless steel and Telluric iron. Yield versus purity trade space is explored in this work, along with power requirements, mass leverage, and payload logistics. Means to tighten plasma beam velocities for higher purity include bunching into a pulsed beam. This is ideally suited for deposition onto a 5-axis movable platform where each packet of isotopes becomes a voxel for additive manufacturing of high-density planar and convex shapes. A stream of un-ionized compounds is also to be expected. This slag can be captured on a movable workpiece (such as an existing rock) to build up a refractory brick, useful for insulation, radiation protection, or ablation station-keeping. Taken together, these multiple outputs from a single processing stream contain most of the elements needed to fabricate and operate a human habitat or spacecraft with a breathable atmosphere. Subsystem studies of value-added outputs are collected into a system-level analysis which can be applied to various locations on the moon or various types of asteroidal bodies, suitable for comparison with other methods of in situ resource utilization.