Phase II Project Summary

Research Objective:

The primary objective of this investigation was to optimize plasma reduction techniques to produce vital consumable gases and metal species from lunar regolith. A secondary goal of this investigation was to demonstrate the feasibility of producing high fidelity simulants via plasma reduction of terrestrial materials.

Research Performed:

Reduction of JSC-1A regolith simulant via plasma processing was conducted to evaluate and optimize the production of oxygen and metallic materials. Thermodynamic calculations were performed to determine optimum processing parameters. Processed materials were analyzed via X-ray diffraction, scanning electron microscopy, transmission electron microscopy, differential thermal analysis and Mossbauer. Captured gases were analyzed by gas chromatography.

Research Results:

- Thermodynamic calculations were used to predict the evolution of gases and production of metals from plasma processed JSC-1A lunar simulant.
- Several techniques were evaluated in an attempt to quantify the amount of oxygen evolved from the JSC-1A during plasma processing. Techniques included characterization of processed material, analysis of captured gases and the employment of an in-line oxygen sensor. Characterization of processed material suggested reduction occurred during processing, but quantitative results were not obtainable. Analysis of capture gases was found to be inconclusive. In-line oxygen sensor repeatedly indicated appreciable oxygen production during plasma processing of JSC-1A.
- SEM characterization indicated plasma processing of JSC-1A effectively produced agglutinate and glassy spherules analog particles similar to those found on the lunar surface. Furthermore, TEM characterization confirmed that these particles contained nano-phase iron which was precipitated directly from the original feedstock of JSC-1A. Therefore, it can be inferred that the plasma processing technique closely duplicates the glass formation mechanisms on the lunar surface.

A great need exists for oxygen-extraction innovations as NASA pursues long-duration, human and robotic exploration of the moon and Mars. Successful utilization of in-situ resources is a key element of the Vision for Space Exploration and NASA goals. During this Phase II effort, Plasma Processes, Inc. (PPI) supported this vision by investigating gas-liberation technologies to extract consumables (e.g. O_2) and metallic materials from a lunar regolith simulant. Additionally, novel processing methodologies were optimized to enhance the fidelity of current lunar regolith simulants by incorporating significant quantities of agglutinates and glassy phase spherules, similar to those found on the lunar surface.