Paper ID: 38415
student

SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations (IP)

Author: Mr. Jesus Dominguez
Florida Institute of Technology, United States

Dr. Jonathan Whitlow
Florida Institute of Technology, United States
Mr. Jonathan Elm
Florida Institute of Technology, United States

STUDY ON SELF-MIGRATION OF EXTRATERRESTRIAL MOLTEN REGOLITH AND ITS POTENTIAL IN-SITU USE IN TRANSFORMING OUTER SPACE RESOURCES

Abstract

This research work is aimed to explain and explore potential utilization of self-migration phenomenon experimentally observed on JSC-1A regolith simulant as it melts under certain thermal and vacuum conditions. A meniscus is formed at the three-phase junction between the wall of the ceramic-made crucible, regolith melt, and vacuumed space. The melt loosely clings to the surface of the crucible's wall and moves upward 3 inches throughout the wall coating its surface entirely with a thin film of molten regolith. The authors discuss in this paper the origin of the force that forms and transports a uniform thin front of molten regolith along a vertical wall overcoming gravity. The authors also present analysis results (regolith component distribution via SEM/EDS and crystallization characterization via X-ray crystallography) on different points of the thin film formed along the crucible's wall. This phenomenon has multiple potential in-situ use in transforming outer space resources into valuable products, such as thin films, 3D printing feedstock, semiconductor substrate, micro-electro-mechanical systems (MEMS), and metal/alloy extraction. This molten regolith vertical self-migration phenomenon observed in this study has a close similarity with the "tear of wine" phenomenon in which ethanol concentration gradient between the meniscus clinging the glass's wall and the free wine's surface generates a surface tension large enough to move the meniscus up the walls of the glass until gravity overcomes the surface tension letting tears of wine run down the glass and back into the bulk of the wine. As in the "tears of wine" case, Marangoni effect in the presence of an additional coupled effect, the Soret effect, might be the mechanism that explains the observed uniformed transportation of a molten thin-film front starting at the meniscus formed at the contact zone of the melt's free surface with crucible's wall and ending 3 inches above the melt's bulk surface. Temperature gradient within the melt and crucible's wall (verified by the authors) leads to gradient in surface tension (Marangoni effect) and diffusion of the species within the melt (Soret effect). Marangoni effect yielding current flow within melts has been demonstrated and used in industrial production of single crystals. Soret effect also has been observed at high-temperature greater than 1400 C at ambient pressure in silicate melts. This is the first time self-migration of lunar simulant regolith is reported and its prospective mechanism discussed. Self-migration on molten regolith opens multiple potential in-situ use in transforming outer space resources.