IAF SPACE POWER SYMPOSIUM (C3)
Advanced Space Power Technologies (3)

Author: Ms. Emily Hitz
National Aeronautics and Space Administration (NASA), Langley Research Center, United States,
ehitz@umd.edu

ALL-SOLID-STATE LITHIUM-ION BATTERIES TOWARD OPERATION IN LOW-TEMPERATURE MARTIAN ENVIRONMENT

Abstract

The advancement of space exploration does not only rely on sensors, computers, and robotics; equally critical to the success of each mission is the ability to deliver power to these devices. Future space missions will have diverse requirements for energy storage, involving energy density, power density, safety, portability, and compatibility with extreme environments. While traditionally, batteries that use liquid electrolyte have filled this role, issues with safety and environmental robustness have driven scientists to consider a new concept of an all-solid state battery. The inherent design of an all-solid-state battery eliminates the flammability and leak hazards associated with liquid-electrolyte chemistries while offering the potential for greater energy density, power density, and ability to withstand the temperature and pressure extremes of space environments.

All-solid-state batteries composed of solid inorganic electrodes and electrolytes are inherently able to withstand extremes in temperature, exposure to flame, and vacuum environments, but further research is needed regarding their operation at low temperatures, where the movement of ions through the material is reduced and performance can be negatively affected.

For this work, we explore the challenges that accompany the design of an all-solid-state lithium ion battery, from establishing robust deposition techniques to studying its performance at low temperature. Employing a thin film all-solid-state battery fabricated by sputter deposition of solid inorganic materials including lithium manganese oxide and the solid electrolyte LiPON (lithium phosphorus oxynitride), we study the behavior of the device at temperatures approaching -60 °C, similar to the temperatures a battery would encounter on Mars. Using experimental techniques such as scanning electron microscopy, X-ray photoelectron spectroscopy, and Raman spectroscopy to characterize the microstructural and compositional features of the system and galvanostatic cycling, cyclic voltammetry, and electrochemical impedance spectroscopy to evaluate the electrochemical performance of the battery, we develop a deeper understanding of the effects that factors such as interfacial impedance and electrolyte conductivity have on the performance of a cell at low temperature.