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Author: Dr. Kavya K. Manyapu
The Boeing Company, United States

Dr. Pablo De Leon
University of North Dakota, United States
Dr. Leora Peltz
The Boeing Company, United States

SELF-CLEANING SPACESUITS FOR FUTURE PLANETARY MISSIONS USING CARBON NANOTUBE TECHNOLOGY

Abstract

Lunar dust proved to be troublesome during the Apollo missions. The lunar dust comprises of fine particles, with electric charges imparted by solar winds and cosmic rays. As such, it adheres readily, and easily penetrates through smallest crevices into mechanisms. During Apollo missions, the powdery dust got into everything, abrading spacesuit fabric, clogging seals and other critical equipment. Even inside the lunar module, Apollo astronauts were exposed to this dust after they removed their dust coated spacesuits. While efforts are under way to figure out how to return astronauts to the Moon and set up habitats for long duration missions, the issue of lunar dust remains relevant. As such, NASA has identified dust as a critical environmental challenge to overcome for future long duration missions.

Several concepts were successfully investigated by the international research community for preventing deposition of lunar dust on rigid surfaces (ex: solar cells and thermal radiators). However, applying these technologies for flexible surfaces and specifically to spacesuits has remained an open challenge, due to the complexity of the suit design, geometry, and dynamics. In our research, we developed a SPacesuit Integrated Carbon nanotube Dust Ejection/Removal (SPIcDER) system to protect spacesuits and other flexible surfaces from lunar dust. SPIcDER leverages the efficient Electrodynamic Dust Shield developed at NASA for use on solar cells. It is customized for dust mitigation on flexible surfaces, using novel materials and specialized design techniques. The result is a self-cleaning spacesuit that can repel lunar dust.

This paper provides an overview of SPIcDER and showcases our working prototypes, ranging from coupons to a scaled portion of a lunar spacesuit segment. The design is supported by our parametric analysis in ANSYS Maxwell, for optimizing SPIcDER integration into the spacesuit outerlayer. The paper also emphasizes design considerations for astronaut safety, based on analysis and experimental results. We believe that SPIcDER can be optimized efficiently for potential missions to Mars and asteroids, as well as for earth based applications.