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RADIATION SHIELDING PLASMA SPRAYED COATINGS FOR SPACE STATION

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RADIATION SHIELDING PLASMA SPRAYED COATINGS HEAD TO INTERNATIONAL SPACE STATION FOR MISSE-17 EXPERIMENTS

Titanium boron composite coatings with superior wear performance were selected for use in materials experiments on the International Space Station.

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NASA's Artemis program aims to return to the moon in search of scientific discoveries and establish a habitat using in-situ resource utilization. However, the past lunar explorations presented challenges, such as thermal cycles, solar and intergalactic cosmic radiation, and severe abrasive interaction of sharp lunar regolith particles[1-4]. Dust mitigation and radiation shielding have become the most important concerns for lunar structural components and rovers which can fail abruptly without a protective solution. To counter these threats, the Plasma Forming Laboratory (PFL) at Florida International University (FIU), in collaboration with NASA, has developed a novel multifunctional coating to protect the components synergistically against abrasion, erosion, and radiation. The titanium-boron nitride composite coatings were prepared using an atmospheric plasma spray technique from engineered composite powders[5,6]. The coatings were subjected to extensive characterization and tribological study with lunar mare simulant JSC-1A, which shows tremendous improvement in the wear performance. The coatings subjected to neutron radiation shielding experiments at NASA Langley Research Center exhibited significantly improved neutron attenuation capacity compared to the substrate. The coating is selected to undergo radiation exposure on the International Space Station (ISS) as a part of MISSE-17 (Materials International Space Station Experiment).

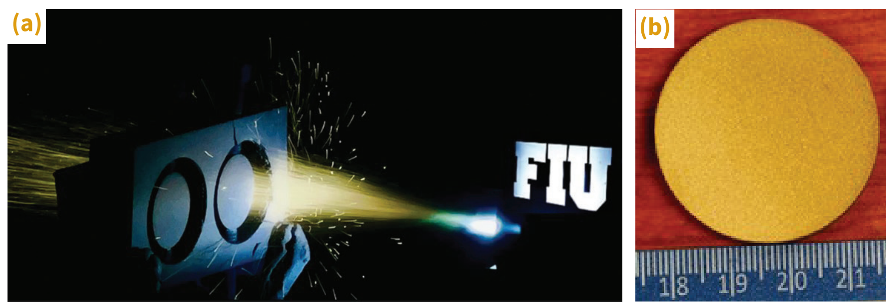

Fig. 1 — (a) Coating deposition using atmospheric plasma spraying at PFL, FIU. (b) Ti-hBN coating on a Ti6Al4V substrate.

COATING DEVELOPMENT AND PROPERTY ANALYSIS

The coatings were prepared at low and high vol% of hexagonal boron nitride (hBN). The composite powder was prepared using the cryo-milling technique at NASA Langley Research Center. The composite coatings were deposited on Al 6061 and Ti6Al4V disk substrates (Fig. 1a and b). The process parameters were optimized to achieve the highest densification in the coating and good interfacial bonding with the substrates. All coatings were deposited at a minimum thickness of 200 microns.

PROMISING PRELIMINARY RESULTS

Compared to the conventional titanium CM substrate, the microhardness of the coatings was increased 3 times and 1.5 times, respectively, for low and high hBN concentrations. The significant increase in hardness and lubrication effect of boron nitride is expected to increase the coatings' abrasive and erosive wear performance. The abrasion performance will be analyzed in atmospheric and vacuum tribometers in collaboration with NASA MSFC. The high-velocity regolith impact tests will be conducted in a custom-made erosion test rig capable of generating high particle velocities (up to 150 m/s), lunar temperature range (-196° to 150°C) and

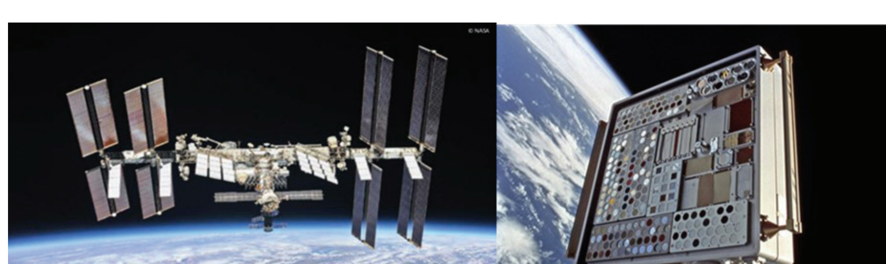

Fig. 2 — MISSE experimental setup on ISS[7].

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impact angles. The coatings with excellent radiation shielding results were sent to the International Space Station as a part of MISSE-17 (Materials International Space Station Experiment) in March 2023[7]. The coatings, mounted on a platform with other testing samples are being exposed to solar and intergalactic cosmic radiation.

After six months, a crew of astronauts will bring the material back to Earth for analysis. In the meantime, NASA and FIU will test the coatings against the harsh erosive environment and thermal vacuum cycles. The findings from this study will help develop and construct materials and systems that will be used in Human Landing Systems (HLS) in future lunar explorations, including Artemis missions. **~iTSSe**

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THE TEAM

The coatings were developed as a part of NASA's Metallic Environmental Resistant Coatings Rapid Innovation Initiative (MERCRII) project. The MERCRII team consists of two NASA centers (NASA Marshall Space Flight Center (MSFC), Huntsville, Ala., and NASA Langley Research Center, Hampton, Va.; the Plasma Forming Laboratory at FIU as an academic partner; and Plasma Processes, Huntsville, Ala., as a private partner.

The project is led by Ms. Sara Rengifo, Tribology and Metrology engineer at NASA MSFC and PFL alums. The project is mentored by subject matter experts, including Dr. Cheol Park from NASA Langley Research Center and Dr. Arvind Agarwal from the Plasma Forming Laboratory, FIU.

The APS coatings were developed and characterized at FIU's Plasma Forming Laboratory and the Advanced Materials Engineering Research Institute (AMERI) by Ph.D. candidate Abhijith Sukumaran under the supervision of Professor Arvind Agarwal.