Radiation Shielding Plasma Sprayed Coatings Heads to International Space Station for MISSE-17 Experiments

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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, Plasma Forming Laboratory (PFL) at Florida International University (FIU), in collaboration with NASA, has developed a novel multi-functional coating to protect the components synergistically against abrasion, erosion, and radiation. The titanium-boron nitride composite coatings were prepared using the 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 as a part of MISSE-17 (Materials International Space Station Experiment).

A) B)

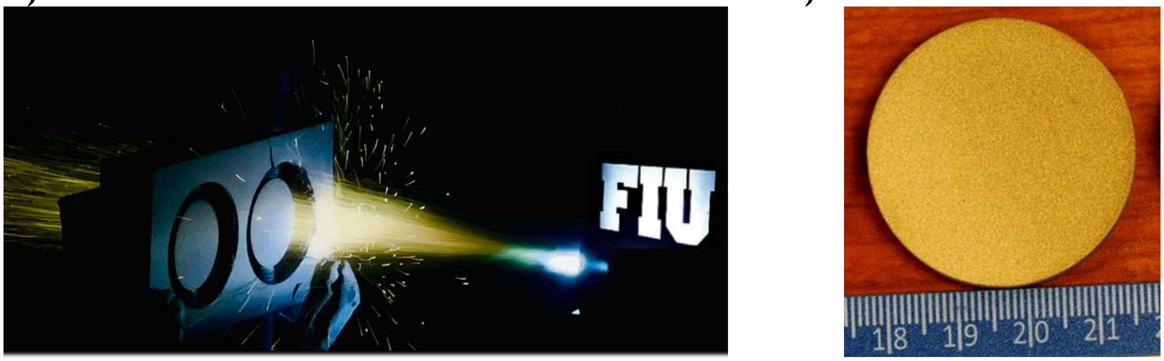

Figure 1: (A) Coating deposition using atmospheric plasma spraying at PFL, FIU (B) Ti-hBN coating on a Ti6Al4V substrate.

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 Centre, Huntsville, Alabama, and NASA Langley Research Center, Hampton, Virginia) and Plasma forming Laboratory at FIU as an academic partner and Plasma Processes, Huntsville, Alabama, 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 Plasma forming Laboratory, FIU.

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

Coating development and property analysis

The coatings were prepared at low and high vol.% of 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, 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°C to 150 °C) and impact angles. The coatings with excellent radiation shielding results will be sent to the International Space Station as a part of MISSE-17[7] (Materials International Space Station Experiment) in March 2023. The coatings will be mounted on a platform with other testing samples to be exposed to solar and intergalactic cosmic radiation.

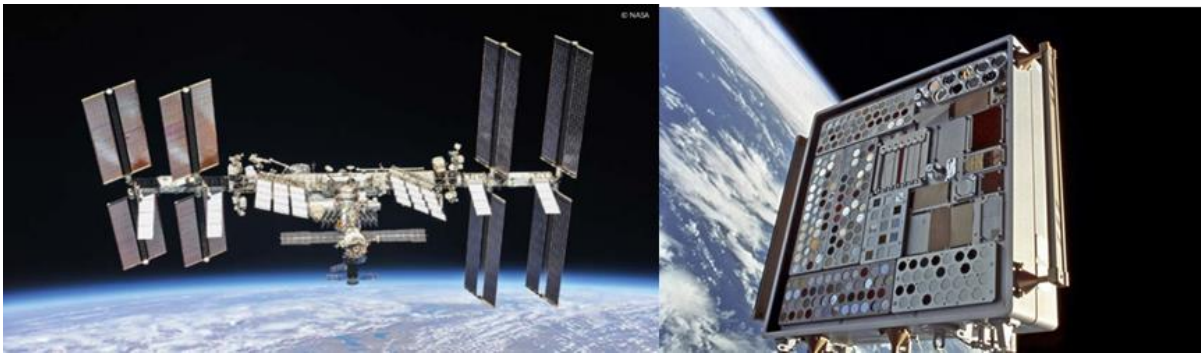

Figure 2: MISSE experimental setup on ISS[7]

After six months, a crew of astronauts will take the material back to Earth for analysis. Meantime NASA and FIU will be testing 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.

Acknowledgment

The authors gratefully acknowledge support from the National Aeronautics and Space Administration (NASA) through the 80MSFC21P0018 grant and Marshall Space Flight Center (MSFC, Huntsville, AL). The usage of facilities at the Plasma Forming Laboratory and Advanced Materials Engineering Research Institute (AMERI) at Florida International University is recognized for the research reported in this study.

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