Proposal Summary Chart

Developing High-Performance Bioinspired Surface Textures for Repelling Lunar Dust

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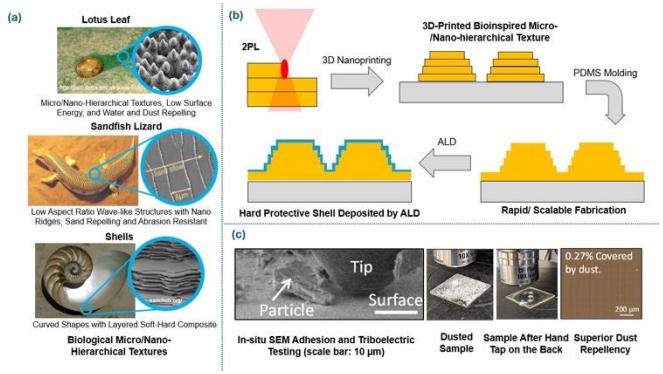

Inspired by natural surfaces (a), 3D micro/nano-hierarchical textures (MNHTs) will be fabricated via two-photon lithography (2PL) and are scalable using roll-to-roll nanoimprinting lithography. Atomic layer deposition (ALD) will provide uniform hard coatings for durable core-shell structures with low surface energy and a matching work function to lunar dust (b). Testing will demonstrate dust repellency at both macro- and micro- scales, with in-situ SEM testing revealing particle-surface interactions in vacuum and under triboelectric charges.

Research Objectives

What will be accomplished?

- Develop and optimize bioinspired surface textures to repel lunar dust and reduce adhesion.
- Study lunar dust particle adhesion and texture scratch resistance inside an SEM.
- Demonstrate dust repellency and durability in ambient air and simulated lunar environments.

What is the innovation?

- Novel micro-nano-hierarchical textures inspired by multiple natural surfaces.
- Core-shell structures with robust shells to protect against extreme lunar conditions.
- Real-time measurement of particle adhesion under vacuum and triboelectric charge using SEM.
- Compatibility with roll-to-plate and roll-to-roll production for scalability.

Comparison to State-of-the-Art (SOA):

- Current textures have limited tunability and durability, facing challenges like seasonal dependency, accessibility, and limited design flexibility.
- Our method offers precise control over texture geometry, materials, substrates, and coating thickness.
- Enables accurate single-particle adhesion quantification in vacuum and under triboelectric charge, unlike existing macroscale and qualitative measurements.

Start and End TRLs:

- *Start TRL:* 1 (initial concept and preliminary data in ambient air)
- *End TRL:* 2 (validated through testing in-situ and in simulated lunar environment)

Approach

Methods to accomplish goals:

- Create durable, complex 3D textures using 2PL and ALD, mimicking natural dust-repelling surfaces.
- Conduct in-situ SEM testing of individual particle adhesion to understand the adhesion mechanisms of lunar dust and triboelectric effects.
- Optimize textures to minimize dust adhesion and test durability using a tribometer and in-situ scratch testing.
- Leverage the collaboration and expertise of the Principal Investigator, Co-Investigator, and an external testing facility for comprehensive micro/nano-hierarchical core-shell texture evaluation under simulated lunar conditions.

Potential Impact

- Enhanced Lunar Mission Safety and Longevity: Bioinspired MNHTs will improve the reliability and reduce maintenance needs of lunar missions, ensuring greater mission safety and longevity.
- Innovative Dust Mitigation Technology: This research will set new standards in dust mitigation with novel textures and materials.
- Broad Applicability: Techniques and materials from this project will benefit other industries facing dust and particle adhesion challenges.
- Advancement in Surface Engineering: Insights gained will significantly contribute to the field of surface engineering and foster further research.
- Collaboration and Expertise Development: The project will strengthen collaboration between academic institutions and space research facilities, enhancing technical expertise.