# Investigation of Particle Aggregation Behavior in Anti-Dust Nanostructures

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Passive dust mitigation is one of the grand challenges for the explorations of the lunar and other extraterrestrial enviroments. The Apollo missions discovered this challenge when seals were clogged, spacesuits were damaged, and mechanical components on the craft were quickly degraded [1] [2]. The key challenge for creating passive dust mitigation is minimizing the adhesion forces, depends on surface chemistry and contact area. In prior work, we demonstrated that surface nanostructures can minimize the adhesion force of particulates and result in dust-mitigation properties [3]. Our results demonstrated that structures with a 500 nm period can reduce coverage area of lunar dust by 93.1%. However, questions regarding the particle aggregation and adhesion behavior remain, which is cruicial in designing a dust-mitigation surface that is broadly applicable.

In this work, we investigate the particle aggreation behavior and removal mechanisms in anti-dust nanostructured surfaces by controlling the particle density. The proposed nanostructures are fabricated on polycarbonate substrates using a highly scalable nanocoining and thermal nanoimprint process [4]. These structures have been fabricated with a wide array of feature sizes and periods ranging from 3 to 0.4 µm to vary the surface area. In addition, the patterned surfaces are also chemically treated to reduce their surface energy by coating a monolayer of trichloro(octyl)silane using vapor phase deposition. To examine the particle aggregation behavior, we use two methods to apply the lunar dust. The first is to apply the dust via a spoon, which results in a thick layer of dust. The second is to apply the dust via a pressure controlled spray, where a thin layer of dust can be applied. These two methods enable us to examine the particle aggregation behavior by precisely controlling the particle density on the nanostructure surfaces. The residual particles can then be analyzed using confocal and scanning electron microscopy (SEM) to quantify the particle mitigation properties.

Initial tests have been performed, and applying lunar dust simulant to the surface of a 500 nm periodic sample via spoon coating shows effective dust-mitigation properties when tilted vertically, as shown in Figure 1. Here the sample is at boundary between smooth (left) and structured (right) surfaces, where less than 10% of dust remains on the right side. However, when applying the dust by spraying, the same sample collects signifcantly more dust, as seen in Figure 2. Furthermore, spoon coating more dust onto a dust sprayed sample has shown to remove dust on the surface, resulting in the <10% dust coverage that was previously obtained. These results show that the mechanisms behind dust removal depends highly on particle density. We will present the detailed fabrication methods and the mechanisms behind dust adhesion by observing changes in aggregation and surface contact of dust particles on the surface when sprayed or spoon coated. An understanding of the cause of this coating method dependance on the effectivness of the dust mitigating nanostructures will allow for refined manufacturing techniques to broaden the potential application of such a surface. This insight will enable these highly scallable nanostructures to be implemented in applications such as space exploitation, solar panels, and anti-dust windshields.

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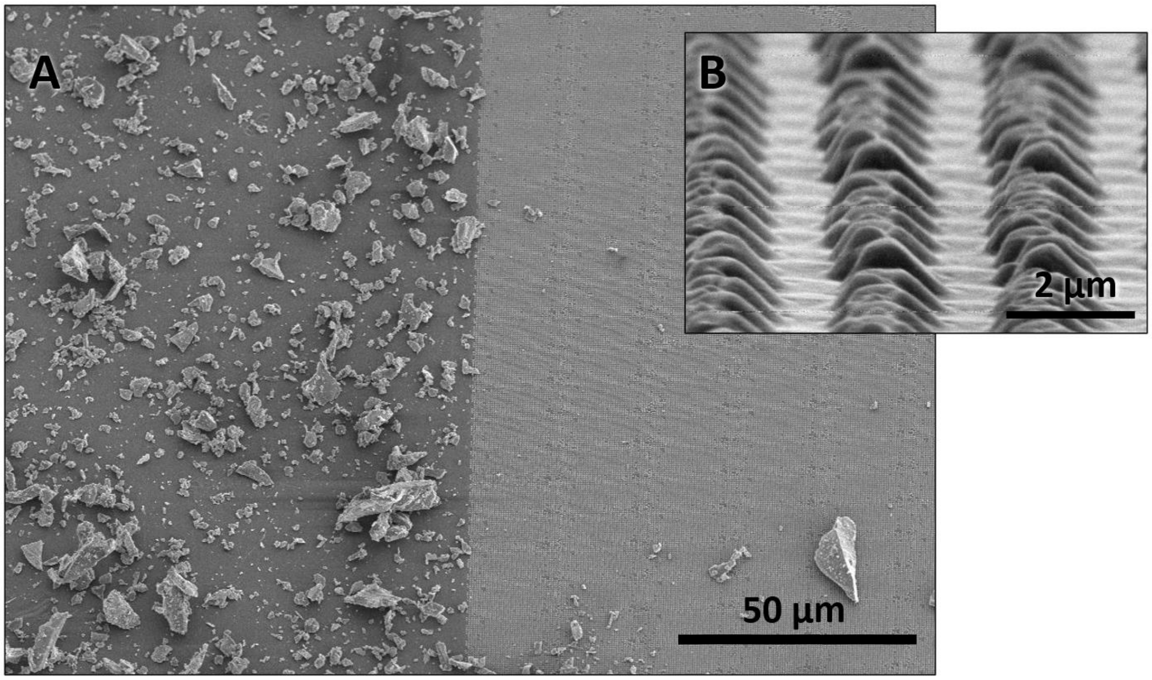


**Figure 1.** (a) SEM image of dust spoon coated on planar surface (left) and 500 nm periodic nanostructures (right), showing effective dust-mitigation property on the structured surface. (b) Close up SEM of nanostructures

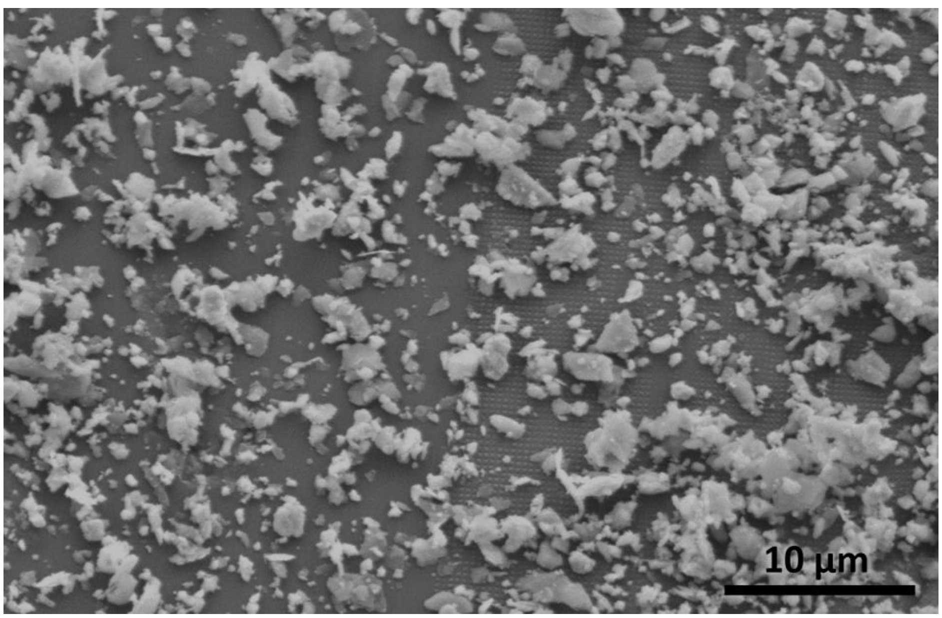


**Figure 2.** SEM image of dust spray coated on planar surface (left) and 500 nm periodic nanostructures (right), showing significant particle adhesion on both surfaces.

**References:**

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