Microparticle Adhesion

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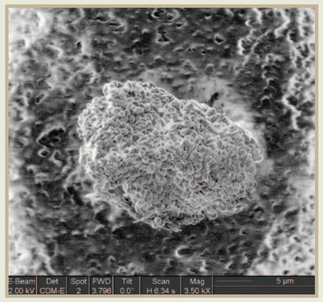
Background

- Microparticle-surface interactions have been studied extensively for ideal geometries, materials, and environmental conditions.
- Trace detection of chemical, biological, radiological, nuclear, and explosive materials (CBRNE), and particle resuspension, rarely occur under such circumstances. Thus, we have little predictive capability under real conditions.

- Anthrax agglomerate removed from the 2001 attack on Capitol Hill[1]. Detection and remediation could have been enhanced with better understanding of microparticle adhesion.



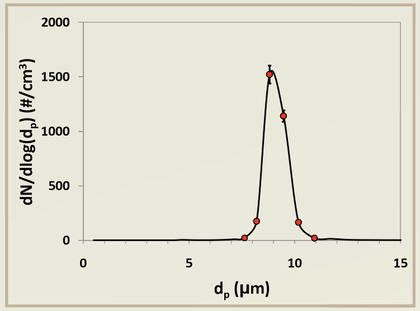
- Lunar dust particle[2] illustrates contamination hazard for mission critical systems like satellites where tenacious adhesion behavior must be prevented.

Objectives

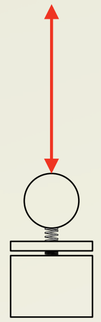
- Employ advanced diagnostic tools to make highly resolved measurements of adhesion bonds.
- Quantify effects of relative humidity (capillary bridging) and compare to van der Waal's and electrostatic forces for various surface morphologies.
- Develop and validate SNL multi-physics models to enable predictive simulation of related phenomena and applications in the interest of national security

Technical Approach

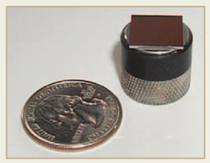
- Monodisperse polymer and glass spheres are aerosolized, charge neutralized, and uniformly deposited on wafers. Particle size distributions are measured directly.



- Wafers are excited piezoelectrically. Particle motion is measured with a high frequency laser Doppler vibrometer (LDV). This system provides ***high fidelity data*** on adhesion and represents a ***distinctive SNL measurement capability***.



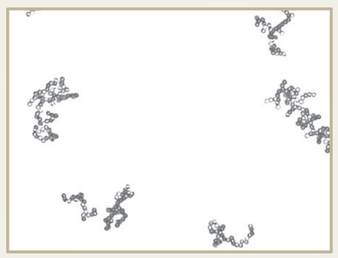
- Particle-substrate system is analogous to a spring-mass where the adhesion bond provides the restoring force.
- **Hypothesis:** capillary bonds create a damping mechanism which prevents rolling and resuspension.



Results

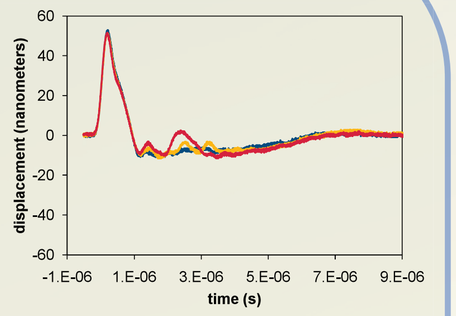
- Preliminary results show that 10 µm PMMA particles excited by 50 nanometer, 200 nanosecond, pulses "dance" on TiO_2 surfaces until they collide and form stable agglomerates which possess fractal character.

Before excitation

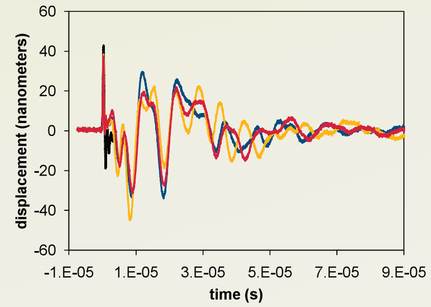


After 60 seconds

- Some particles remain isolated and stationary. These particles display subtle differential motion with respect to the substrate and undergo ***accelerations as high as 2,000,000 m/s^2***.



- Agglomerated particles appear stationary but constituent monomers oscillate with large amplitudes over longer durations.



- E***xperiments and model simulations are underway*** to investigate the outlined objective space.

Technical Collaborators

Randall Schunk, 1500, Multi-physics models
Flint Pierce, 1516, Multi-physics models
Anton Sumali, 1526, Laser Doppler Vibrometry
Rick Kellogg, 2616, Laser Doppler Vibrometry
David Moore, 1522, Surface excitation
John Brockmann, 1532, Aerosol phenomena
Carlos Sanchez, 1746, Surface preparation

References

1. FBI unveils science of anthrax investigation, 2008, https://share.sandia.gov/news/resources/releases/2008/anthrax.html.
2. Lunar dust buster, 2006, http://science.nasa.gov/science-news/science-at-nasa/2006/19apr_dustbuster

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