Erosion of Glass Substrates due to Microparticles

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Abstract

Electromagnetic (EM) window and dome material performance suffers from inadequate fracture resistance to sand particles and rain drops. Airborne sand particle impacts cause local damages that manifest themselves as radial and lateral cracking. Increased roughness through damage on the surface of the EM structures degrades the transmission properties and may lead to loss of communication. Specifically, lateral cracking is suspected of playing a larger role in loss of transmission due to surface damage on EM window and dome materials. In order to mitigate such transmission problems due to sand impact damage, in-depth understanding of the origins of distinct fracture modes is necessary. Previous work involves theoretical approaches utilizing elasticity and plasticity formulations, as well as experimental work.
While it is valuable to understand the erosion resistance of different materials when impacted by specific size erodents, the previously mentioned studies did not explore a direct relationship between impacting particle shape and subsequent damage modes. Not many studies have been published to assess the effect of impacting geometry on damage quantities and mechanisms. The limited research found in a literature survey pertained more to drop-weight impact on composite materials

In order to further the understanding of erosion due to irregularly shaped particles, first impact experiments were performed. Impacting velocity, rebound velocity, and particle volume were estimated from high-speed video footage. Impact events were also correlated to damage sites, and damage was characterized using optical and scanning electron microscopy. To explore the effect of impact geometry, bond-based peridynamic simulations were carried out. Sand particles were characterized using x-ray micro-CT. Particles from the virtual library were matched to particles from specific impacts in the experiments, and PD simulations were performed using those particles at different orientations at impact. Also, further PD simulations were conducted using sphere and cylinder impacters, to show ideal contact geometry: a perfectly round surface for the sphere, and a perfectly at surface for the cylinder face. Damage quantified from the results of the PD simulations was compared to the corresponding damage from impact experiments.

Keywords: impact, damage, fracture, modeling, experiments, characterization, peridynamics

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