Simulated Space Weathering: Interaction between micron sized SiO₂ particles on a reduced graphene oxide polymer composite target at high velocities and strain rates. I. Dowding¹, B. Jones², T. M. Orlando³
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Introduction: In outer space, micron sized particles, hereafter referred to as meteoroids, can travel with significant velocities (> 3 km/s) [1]. Meteoroids can be divided into three main categories, with the largest being stony meteorites, mainly composed of silicate minerals. Traditional studies on high velocity particle impacts in space have been done using either a gas gun or a laser ablation with a high power pulsed laser irradiation, which is purported to simulate impact events. Though the thermal spike and melting can be simulated with lasers, the momentum transfer, initial electronic excitations, and subsequent chemistry involving the impactor may not be simulated with this approach. It is therefore useful to compare the results of experiments using laser irradiation and particle impact approaches directly using the same “table-top” apparatus and the same sample.

To do this we have built a laser induced particle impact tester (LIPIT), that allows for the acceleration of 1 to 100+ particles at a time. Using this information in conjunction with post impact characterization, we can develop a complete understanding of the target material response when impacted at high velocities. These experiments involved impacts onto a reduced graphene oxide polymer composites which may have useful properties for space-suit applications.

Experimental Details: Laser-based techniques that can dynamically accelerate particles exist [2-4]. Specifically, a laser induced microparticle accelerator (LIMA) or laser induced particle impact testing (LIPIT). As shown in Figure 1, the system utilizes a high energy pulsed 1064 nm Nd:YAG laser to irradiate the backside of a thin foil target or a thin metal foil/film covered with an elastic polymer. Silicate microbeads are deposited on the front face and are launched off the substrate toward a target of interest, e.g. a reduced graphene oxide polymer composite. The velocity of the particles are measured either directly using a fast-frame camera or optically using a stroboscopic approach. The latter utilizes a second 532 nm laser that passes through an optical delay.

Figure 1: Left side: photo of the LIPIT set-up showing the YAG laser (1064 nm) used to launch particles (A), part of the beam path for the second laser (532 nm) used for velocity measurements (B), main chamber with the launching substrate inside (C), the ancillary camera (D) used to image the substrate through a dichroic mirror, and the detection camera to photograph the moving particles (E).

Results: Preliminary results indicate that SiO₂ particles ~4 μm in size are leaving craters in the polymer composite 3-4 times the size of the particle. The material has shown to stop the majority of the particles, however it is currently unclear if some particles are damaging the materials mechanical integrity or electrical conductivity. Further characterization of the material needs to be done in order to get a complete picture of what is happening upon impact.


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