Project Title: Silicone Ablation Phenomena in the Mars Science Laboratory Heat Shield

Adviser: Francesco Panerai (AE)

Project Description: The Mars Science Laboratory (MSL) thermal protection system (TPS) marks an important milestone in the history of Entry Descent and Landing (EDL). For the first time, in-flight temperature measurements were collected on the Phenolic Impregnated Carbon Ablator, PICA, a material technology developed at NASA and successfully flown in a series of mission including MSL (Fig. 1), Stardust, OSIRIS-REx and SpaceX Dragon. Since the 2012 flight, the impact of MSL data on aerothermal sciences has been substantial. The measurements collected by the MSL Entry Descent and Landing Instrumentation, MEDLI, suite have become an established reference to assess the performance of engineering models of PICA and to validate hypersonics computational fluid dynamics (CFD) tools for entry systems. NuSil CV-1144-0, a room-temperature vulcanizing silicone, was applied as sprayed coating on the MSL PICA heat shield. The coating was used as a contamination control to minimize the particulate matter shedding from PICA from interfering with cruise-stage navigation sensors. Evidence from arc jet experiments on NuSil-coated PICA shows that, while NuSil had no adverse effect on the performance of the heat shield, it did affect the near-surface response of PICA at high temperatures.

An effort is underway at NASA to upgrade ablator response models of PICA to account for NuSil-related effects, neglected during the original design of MSL. This is a critical step to revisit prior analysis of MEDLI data, and to support the design of the MEDLI-2 sensor suite for the forthcoming Mars 2020 mission. This project aims at contributing to the analysis of NuSil samples to be tested in NASA arcjets using the advanced material characterization facilities of the Beckman Institute and of the Material Research Laboratory (MRL) at the University of Illinois. The ultimate goal is to understand the underlying phenomena of silicon ablation at extreme temperatures.

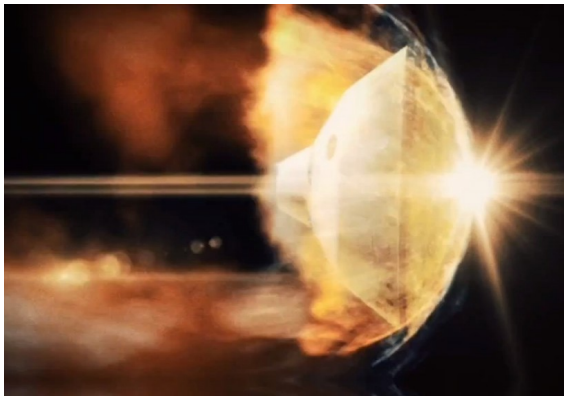

Figure 1.Impression of the MSL entry vehicle blasting through the Mars' atmopshere.

Student background and expected research activities: We are looking for an enthusiastic and ambitious student who has an interest in hypersonic aerothermodynamics and high temperature materials. The project will require utilizing microscopes and X-ray tomography facilities at Beckman and MRL. While prior hands-on laboratory experience will be a plus, eagerness to learn laboratory practice and techniques and data analysis is a fundamental recipe for the success of the project.

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