Systematic Measurements of Reduced Transmissivity of Optical Windows Coated by a Cured Phenolic Compound

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1 Introduction

Ablation refers to the removal or destruction of a material from an object, this can be accomplished through erosive processes, vaporization, excessive heat, etc. This process can be particularly useful in its application for space flight; by using ablative materials, parts that would otherwise be damaged by the extreme temperatures are kept cool and protected. It is ablators like, phenolic impregnated carbon ablator (PICA) or super light-weight ablator (SLA), that are used in the thermal protection system (TPS). TPS refers to the materials applied to the outer surfaces to maintain acceptable temperatures, it maintains the temperature by melting and shedding off for new layers, as the material falls off the heat is also taken with it. The TPS choice depends on the entry conditions and/or the mission, meaning that SLA might be the best TPS choice for some missions and PICA for others. Due to the high temperature and low-pressure conditions during entry, the ablative material is deposited on surfaces like a radiometer window. This causes a significant reduction in transmissivity; therefore, it is necessary to study to determine the affects of deposited ablative materials on transmissivity. Through the use of a pulse laser deposition (PLD) technique in a vacuum chamber, the cured phenolic compound will be deposited on the glass substrate as it would during entry. From there, the deposition will be monitored using optical spectroscopic ellipsometry to obtain information such as thickness and surface roughness and a grating-type spectrometer will measure the optical transmissivities of the samples.

2 Procedure

We will evaporate the NASA space mission-relevant material, the cured phenolic compound, onto optical windows using a pulsed laser deposition (PLD) technique in a vacuum chamber. PLD allows us to test various materials with no major instrumental changes or additional investments in equipment. With that we will monitor the deposition using in-situ, real-time optical spectroscopic ellipsometry with a spectral range of wavelengths from 210 nm to 1000 nm (i.e., 1.2 eV – 6.0 eV in photon energies) (Woollam M-2000X-210). Not only will we obtain optical refractive indices of the deposits, but also useful information such as their thickness and surface roughness via spectral model analyses. We will measure the optical transmissivities of various samples as a function of spectral wavelength from 180 nm to 3300 nm using a grating-type spectrometer (Perkin-Elmer Lambda-950). If necessary, we will also measure at longer wavelengths (up to 22000 nm) using a Fourier-transform infrared spectrometer