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HIGH STRENGTH FIBER REINFORCED SYNTACTIC FOAM COMPOSITES AS INTERPLANETARY THERMAL PROBE MATERIAL

Abstract

The Moon's surface thermal environment is among the most extreme of any planetary body in the solar system. The lunar soil or regolith medium is in near-vacuum condition, subjecting to very large diurnal temperature variation of greater than 300K and has extremely low thermal conductivity (0.03W/mK). Resolving questions on the science of the Moon pertaining to its thermal and geological evolution demands further geophysical measurement by placing the geophysical instruments on or beneath the lunar surface operated from lunar Lander/Rover platforms. One such key instrument is the thermal probe to measure lunar thermo-physical properties. Such instruments can, in principle, be placed and operated on the lunar surface from a lunar Lander platform. Low density materials such as syntactic foams exhibiting high specific strength and inherent thermal insulation characteristics are attractive for various space applications. An experiment has been planned with primary objective of in-situ investigation of thermal behaviour of outermost layer of the lunar surface by deploying a thermal probe. Hence the selection and development of proper material for the temperature probe demanded many conflicting requirements i.e., the probe material should have very low thermal conductivity to enable accurate measurement of the thermal characteristics of lunar regolith owing to the extremely low thermal conductivity of the regolith medium and should have sufficient strength to penetrate the regolith. Towards this, the present paper reports the processing and characterisation of a new syntactic foam composite derived from cyanate ester resin, urethane modified epoxy resin, glass fibres and organic fillers. To control the density and strength parameters, glass microballoons with different thicknesses (varying from 0.5 to1.5 m) and true densities (0.1 to 0.4 g/cc) were attempted which resulted in composites with varying densities (0.8 to1.5 g/cc). The optimised composition exhibited compressive strength of 30-40 MPa and modulus of 2-3 GPa. The material is thermally stable up to 250 C. The syntactic foam composites exhibited thermal conductivity in the range of 0.1-0.13 W/mK. The low thermal conductivity, low density and high modulus render these syntactic foams as candidates for planetary science experiments such as exploring the thermal characteristics of lunar regolith/ planet surfaces.