Manufacturability Demonstration and Assessment of Aerogel Applicability as an Insulation Replacement for eMMRTG Flight Module

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Abstract. Silica aerogels are exceptionally porous materials presenting unique properties such as high specific surface area, light weight, and extremely low thermal conductivity (0.02 W/m-K). They are very promising for many scientific and technological applications, including thermoelectrics (T/E), as insulations to effectively reduce heat losses. They provide sublimation suppression at the surface of the T/E materials as well. TESI has adapted JPL's latest technology to synthesize silica aerogel and worked on further developing and optimizing the process of fabricating silica-based aerogel by utilizing drying at room temperature and pressure, thus eliminating super-critical drying typically required by aerogel materials. Aerogel insulation contains Titania particles in a silica matrix to impede radiative heat transfer and fiber reinforcement to increase material strength and stiffness. The resulting material provides low thermal conductivity at high operating temperatures, lightweight, and high mechanical stability, with no shrinkage.

Aerogel was synthesized via hydrolysis of silicon alkoxides followed by condensation to yield a polymeric oxobridge silica network by the sol-gel process. This solution or "sol" was poured into the appropriate molds containing sublimation coupons, and allowed to solidify or "gel" and dry under ambient conditions. The critical factors for making aerogel were identified and closely monitored. The test criteria were also well defined to help improve the process control for manufacturing the high quality aerogels which were characterized by a variety of test methods to ensure implementation of requirements. To date, several iterations have been investigated in which stainless steel T/E couples which simulate the real Skutterudite n- and p-type couples were encapsulated by various forms of aerogel. The issues associated with aging and drying have been addressed in order to manufacture crack-free silica aerogel. The next step is to directly cast the aerogel around the Skutterudite couples in the modules and test them for performance and stability.

Keywords: Silica aerogel, thermoelectrics, RTG, generator, Skutterudite