MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Specialised Technologies, Including Nanotechnology (8)

Author: Ms. Elizabeth Barrios
University of Central Florida (UCF), United States, eab143@knights.ucf.edu

INTEGRATING GRAPHENE AEROGELS INTO POLYMER DERIVED CERAMICS: A QUEST FOR UNDERSTANDING THERMOELECTRIC INTERFACIAL PHENOMENA

Abstract

For many decades, thermoelectric devices have provided long-duration, low-maintenance power to space vehicles. However, there is currently a deficiency in obtaining highly efficient and affordable materials for the construction of the thermoelectric modules. Current state-of-the-art technologies utilize expensive and hazardous materials with an operating efficiency capped at around 6-7%. Recent research has shown that the efficiency can be improved through controlled nanostructuring of thermoelectric materials through means of quantum confinement. The present studies showcase a step in the work to provide a new class of thermoelectric materials while providing more fundamental understandings of the phenomena that take place at the nanointerfaces. In this work, graphene aerogels fabricated with anisotropic thermal and electrical behavior are used as a filler material in a SiCO polymer derived ceramic (PDC) matrix. While these types of nanocomposites have been demonstrated in the past, their thermoelectric properties and their interfacial behavior have yet to be realized.

The anisotropic graphene aerogels are achieved through freeze-drying graphene oxide solutions prior to being reduced in hydrazine and hydrogen gas. The resulting aerogels are then backfilled with a preceramic polysiloxane under vacuum prior to being cross-linked and pyrolyzed to convert the materials into their ceramic counterparts. The anisotropic behavior of these potential thermoelectric materials were characterized based on their electrical and thermal conductivities, charge carrier densities, and charge mobility. Investigation into the interfacial phenomenon has been carried out through microscopic techniques including SEM and AFM equipped with Kelvin Probe (KPFM) capabilities. Current data suggests that anisotropic electrical conduction was imparted into the ceramic matrix through the incorporation of the graphene aerogels due to the percolated conductive network enabling charge transport through the composite. However, electrical conductivity was inhibited in the transversal direction due to the inability for electrons to jump between the aligned graphene sheets. Additionally, thermal conductivity was only minimally affected through the addition of the aligned graphene aerogels. It is presently assumed that this minimal increase is due to the increase of phonon scattering sites within the composite; however, current data collection is ongoing to investigate this further. Data collection into the charge carrier densities and mobilities is ongoing and will be presented during this presentation. Current data shows promise for the creation of thermoelectric capable materials through the usage of graphene loaded polymer derived ceramics; however, it is hypothesized that further modification to the graphene surface will further promote the thermoelectric performance of these materials.