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GRAPHENE AS A STIMULUS FOR NANOSTRUCTURAL CHANGES IN SILICON OXYCARBIDE CERAMICS AND ITS INFLUENCE ON THERMOELECTRIC PERFORMANCE

Abstract

Thermoelectric energy conversion has enabled the aerospace industry to explore the mysterious depths of our solar system for over 50 years. However, current thermoelectric systems have nearly reached their limit in terms of output performance. Current systems are limited by low efficiencies while using expensive and hazardous materials. With the goal of establishing an extended human presence in space and supporting the manned exploration of deep space, it is necessary to reassess thermoelectric systems to develop more efficient, less hazardous, and lighter technologies. One of the current challenges in the development of new thermoelectric technologies stems from the need to decouple the electron and phonon transport within a single material; two properties known to historically rise and fall with each other. However, advances in the understanding of quantum confinement indicates that nanostructured materials may be able to achieve this complicated feat of decoupling. Polymer derived ceramic (PDC) nanocomposites offer one possibility to address the needs of future thermoelectric systems through utilizing these quantum confinement principles. In this work, highly conductive and porous graphene fillers are introduced to a silicon oxycarbide (SiOC) ceramic matrix. Graphene is a two-dimensional nanomaterial that has revolutionized the electronics industry due to its outstanding electrical, thermal, and mechanical properties. While SiOC ceramics are not inherently tuned to operate as a thermoelectric material, graphene offers the possibility of tuning the nanostructure of SiOC to introduce a favorable structure for electron transport while keeping thermal transport at a minimum. Here, the development of the SiOC nanostructure is monitored as a function of graphene content and processing temperature. In order to investigate the details of such development and to understand the interfaces forming, techniques such as x-ray scattering, Raman spectroscopy, and atomic force microscopy are employed. The SiOC structure is then correlated to the ceramic's electrical, thermal, and thermoelectric behavior by analyzing the electrical resistivity, thermal diffusivity, and Hall coefficient. The results discussed will try to elucidate the key factors controlling the potential thermoelectric responses in such polymer-based systems. Successful design of such a system would lead to an easily fabricated, low-cost thermoelectric material that could further our reach in space.