Radioisotope thermoelectric generators (RTGs) have been an enabling technology for the exploration of deep space since the dawn of the Space Age. Such devices have provided a maintenance-free source of electrical power to a spacecraft by converting heat into electrical energy. However, current state-of-the-art devices are limited by their low efficiencies and use of hazardous and expensive materials. Attempts to nanostructure materials has been shown to improve the efficiency of thermoelectric devices by maintaining a large thermal gradient across its surface (i.e. low thermal conductivity) while simultaneously promoting efficient electrical flow through the entire system (i.e. high electrical conductivity). This thesis looks into the prospects of using nanostructure polymer-derived ceramic systems for such applications. As one of the first studies of its kind, this work looks into the structure-property relationships of graphene-loaded silicon oxycarbide ceramic nanocomposites. These relationships were by varying graphene content (0 - 2.6 vol%), altering the method of graphene network inclusion (replica or aerogel), and refining the annealing conditions (up to 1500°C). The electrical conductivity, thermal conductivity, Hall mobility, and Seebeck coefficients were measured in this work and indicate the thermoelectric potential of these material systems. However, this early stage research shows many areas of improvement that can be addressed in future design iterations to make this material system competitive with current state-of-the-art.