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SOLID-STATE SYNTHESIS AND THERMOELECTRIC PROPERTIES OF MAGNESIUM SILICIDE

Abstract

Powering deep space probes using photovoltaic cells is not feasible due to the vast distance travelled by the probes away from the sun. As an alternative source of energy, radioisotope thermoelectric generators (RTGs) have been used to successfully power more than 20 NASA space missions, including the Voyager, Pioneer, and Cassini missions. RTGs are capable of producing an electric voltage in response to an applied temperature gradient due to the Seebeck effect. However, current state-of-the-art RTGs have efficiencies between 6 and 7Magnesium silicide is an attractive material for thermoelectric applications due to its low toxicity, thermal and mechanical stability, low density, and high relative abundance. The large effective masses of charge carriers, high charge carrier mobility, and low lattice thermal conductivity found in magnesium silicide are expected to lead to high zT values. However, the high vapor pressure of magnesium, combined with its propensity for oxidation, makes it difficult to synthesize large quantities of high quality magnesium silicide using typical melt synthesis techniques. Here, we present a facile, scalable, and reliable technique for the synthesis of pure magnesium silicide from the constituent elemental powders. Solid-state reaction between micron-sized magnesium and silicon particles in a three-zone tube furnace is used to produce the magnesium silicide powder, which is consolidated via hot uniaxial pressing into pellets. X-ray diffractometry (XRD) and Raman spectroscopy confirm the absence of impurities and contaminants in the synthesized magnesium silicide powder. Preliminary thermoelectric characterization of the synthesized magnesium silicide pellets indicates promising thermoelectric behavior, with pellets exhibiting thermoelectric power factors comparable to those reported in the literature. The present synthesis technique is less energy intensive and simpler than several others reported in the literature. Unlike other reports on the solid-state synthesis of magnesium silicide found in the literature, the present technique is scalable. Scalability of processes for the production of materials for space applications is essential for enabling commercial space travel. Finally, the technique can be extended to the synthesis of magnesium silicide nanowires, by reaction between silicon nanowires and magnesium powder, which can further enhance thermoelectric properties.