Earth Abundant High Temperature Materials for Radioisotope Power Conversion System

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ABSTRACT

This proposal focuses on breakthrough efficiencies in segmented radioisotope thermal generators (RTG) as the power conversion system through high temperature materials development while reducing reliance on single-purpose supply chains for materials. Thermoelectric devices convert thermal energy directly into electrical energy, require minimal maintenance, and can be operated over a large temperature range (room temperature to 1275 K). Thermoelectric materials are described by a figure of merit, zT, which measures how well a material converts heat flow to electricity – and is directly related to the efficiency, the higher the zT the greater the efficiency. Radioisotope thermal generators for space and terrestrial applications have been designed and developed by the Space and Defense Power Systems programs for over fifty years. Plutonium-238 provides the heat through its decay process for the hot side of the thermoelectric couple to induce direct current electricity flow. While these devices have proven to be highly effective in applications where solar photovoltaics is not an option, new materials for breakthrough thermoelectric couples that produce electricity more efficiently than current start of the art are needed. As new multi-element containing materials with high zT are discovered the potential for further increases in efficiencies can be realized. The p-type Zintl phase, $Yb_{14}MnSb_{11}$, has been an important component for increasing efficiencies to 15% for advanced power generation devices at the Jet Propulsions Laboratory (JPL). This is a significant accomplishment and more than doubles the current RTG efficiency. Zintl phases have shown great potential with zT's of higher than 1 at relevant temperatures (800-1275 K). The stability of their thermoelectric properties, stable metallization and sublimation suppression barriers/coating have been demonstrated. This proposal outline a plan to increase efficiencies to 20-30% through solid state alloying and composites of high temperature materials focusing on earth abundant elements, thereby improving RTG systems performance without the need to invest in a single-purpose supply chain.