Laser Additive Manufacturing with Bismuth Telluride and Magnesium Silicide

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Abstract

Additive manufacturing offers the possibility of overcoming challenges such as limited geometries and material waste associated with traditional thermoelectric device manufacturing. In particular, laser additive manufacturing (also known as laser powder bed fusion or selective laser sintering/melting) has recently been applied to inorganic thermoelectric materials. This work describes our recent progress in laser processing of bismuth telluride and magnesium silicide. A custom-built laser processing setup enabled laser additive manufacturing of thermoelectric material powders in a layer-by-layer approach applied to loose powders – the same approach used in commercial additive manufacturing equipment. Three dimensional, bismuth telluride parts were built with relative densities \_\_85-88\%. The thermoelectric properties were characterized and compared to reference samples made via a traditional hot pressing technique, and X-ray diffraction results confirm the Bi\textsubscript{2}Te\textsubscript{3} crystal structure is preserved during laser processing. Scanning electron microscopy confirmed complete through-thickness melting with no separation between fabrication layers although some micropores were present. The results indicate the rapid melting and re-solidification of the laser fabrication approach caused different effects of crystalline point defects compared to traditionally processed materials, causing a p- to n-type transition during annealing or characterization at elevated temperatures. Initial process-structure relationships for laser processing of magnesium silicide powders are also presented, and they constitute the first results of this additive manufacturing technique applied to Mg\textsubscript{2}Si, a lower cost thermoelectric material for mid- to high-temperature applications.

Keywords: additive manufacturing, bismuth telluride, magnesium silicide, laser processing

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