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Effects of Spark Plasma Sintering Temperature on Thermoelectric Properties of Higher Manganese Silicide

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Higher manganese silicide (HMS) is a promising *p*-type thermoelectric material. HMS samples were synthesized by a vacuum induction melting process and sintered by spark plasma sintering (SPS) at various temperatures to obtain a single phase of HMS and investigate the effect of the SPS temperature on the thermoelectric properties. A single phase of HMS was obtained, and the appearance and the amount of Mn_2O_3 and MnSi as secondary phases could be controlled via the SPS temperature. The effects of the SPS temperature on the electrical conductivity and Seebeck coefficient of the HMS samples were investigated. The changes in the electrical conductivity and Seebeck coefficient were attributed to changes in the density and the amount of Mn_2O_3 secondary phase.

Key words: Thermoelectric, higher manganese silicide, spark plasma sintering (SPS)

INTRODUCTION

Demand for alternative energy has become a major social issue due to the depletion of fossil fuels. Thermoelectric devices can directly convert thermal energy into electrical power. They have received a lot of attention as one of the promising alternative sources of electricity due to their potential for waste heat recovery from vehicles and industrial plants. The efficiency of a thermoelectric material is represented by the figure of merit $ZT = S^2\sigma T/\kappa$, where S, σ, T, and κ are the Seebeck coefficient, electrical conductivity, absolute temperature, and thermal conductivity, respectively.[1–3] The energy conversion efficiency of a thermoelectric device can be improved by increasing the thermoelectric figure of merit of materials. However, it is difficult to improve ZT because of the interrelation among the Seebeck coefficient, electrical conductivity, and thermal conductivity.

Widely used thermoelectric materials such as Bi_2Te_3 and PbTe have higher efficiency than most other thermoelectric materials. However, due to their high cost and toxicity, many studies on alternative thermoelectric materials which have high efficiency, low cost, and nontoxicity have been carried out. Higher manganese silicide (HMS) is one of the promising environmentally friendly thermoelectric materials. HMS materials are represented by Mn_4Si_7, $Mn_{11}Si_{19}$, $Mn_{15}Si_{26}$, and $Mn_{27}Si_{47}$, which are incommensurate phases with similar properties.[4] All these compounds have tetragonal crystal structure with long *c*-axis as Nowotny chimney–ladder phases with energy gap of 0.4 eV to 0.7 eV.[5–7]

It is difficult to obtain a single phase of HMS by a conventional melting process because of the slow

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