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A Comparison Between the Mechanical and Thermoelectric Properties of Three Highly Efficient *p*-Type GeTe-Rich Compositions: TAGS-80, TAGS-85, and 3% Bi_2Te_3-Doped $Ge_{0.87}Pb_{0.13}Te$

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Since the 1960s, the TAGS system, namely $(GeTe)_x(AgSbTe_2)_{1-x}$, with two specific compositions $x = 0.8$ and 0.85, known as TAGS-80 and TAGS-85, respectively, was identified as containing highly efficient *p*-type thermoelectric materials. Recently, another highly efficient *p*-type GeTe-rich composition, namely 3% Bi_2Te_3-doped $Ge_{0.87}Pb_{0.13}Te$, achieving thermoelectric properties comparable to TAGS-based solid solutions, was also reported. Since all of these compositions were obtained by different manufacturing approaches, a comparison between the transport and mechanical properties of these alloys, prepared by the same manufacturing techniques, is required to identify the advantages and disadvantages of these compositions for practical thermoelectric applications. In the current research, the thermoelectric and mechanical properties of three highly efficient GeTe-rich alloys, TAGS-80, TAGS-85, and 3% Bi_2Te_3-doped $Ge_{0.87}Pb_{0.13}Te$, following hot pressing, were investigated and compared. Maximal ZT values of ~1.75, ~1.4, and ~1.6 at 500°C were found for these compositions, respectively. Improvement of the mechanical properties was observed by increasing the GeTe content. The influence of the GeTe relative amount on the transport and mechanical properties was interpreted by means of the phase-transition temperatures from the low-temperature rhombohedral to the high-temperature cubic phases.

Key words: TAGS, thermoelectrics, phase transition, lead germanium telluride, efficiency, figure of merit

INTRODUCTION

The development of practical thermoelectric devices for energy conversion from heat to electricity offers a major potential for overcoming the global energy crisis and atmospheric pollution, usually associated with fossil fuels. In addition, thermoelectric converters, without the involvement of any moving parts, are considered as suitable for long-term operation with minimal maintenance involvement. For this reason, such devices have been successfully used in deep-space missions, with minimal properties degradation, over several decades. The main disadvantage of such devices is their low thermal to electrical conversion efficiency. This has been the main motivation, during the last few years, for the development of highly efficient thermoelectric materials, capable of enhancement of the relevant efficiency, Ψ_{opt}, at least theoretically up to ~15% (Eq. 1), under normal operating conditions.

$$\Psi_{\text{opt}} = \frac{\Delta T}{T_{\text{H}}} \frac{\left(\sqrt{1+Z\overline{\overline{T}}}-1\right)}{\sqrt{1+Z\overline{\overline{T}}}+\frac{T_{\text{C}}}{T_{\text{H}}}}, \tag{1}$$

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