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Transport Properties of Bulk Thermoelectrics: An International Round-Robin Study, Part II: Thermal Diffusivity, Specific Heat, and Thermal Conductivity

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For bulk thermoelectrics, improvement of the figure of merit *ZT* to above 2 from the current values of 1.0 to 1.5 would enhance their competitiveness with alternative technologies. In recent years, the most significant improvements in *ZT* have mainly been due to successful reduction of thermal conductivity. However, thermal conductivity is difficult to measure directly at high temperatures. Combined measurements of thermal diffusivity, specific heat, and mass density are a widely used alternative to direct measurement of thermal conductivity. In this work, thermal conductivity is shown to be the factor in the calculation of *ZT* with the greatest measurement uncertainty. The International Energy Agency (IEA) group, under the implementing agreement for Advanced Materials for Transportation (AMT), has conducted two international round-robins since 2009. This paper, part II of our report on the international round-robin testing of transport properties of bulk bismuth telluride, focuses on thermal diffusivity, specific heat, and thermal conductivity measurements.

Key words: Thermoelectric, thermal conductivity, thermal diffusivity, specific heat, power factor, figure of merit

INTRODUCTION

In order to improve the figure of merit *ZT* of thermoelectrics, the most noticeable, recent advances have been in the reduction of thermal conductivity while maintaining the electrical properties. This is the case in both bulk and low-dimensional thermoelectrics.[1–5] In studies of bulk materials, skutterudites[6–10] and clathrates[11–14] are examples of Slack's[15] ideal thermoelectric material with phonon glass–electron crystal (PGEC) characteristics. More recent efforts have focused on nanocomposite materials,[16–22] in which nanosized precipitates or secondary phases play significant roles in scattering phonons and reducing lattice thermal conductivity. Materials processing techniques such as spark plasma sintering (SPS),[23–25] melt-spinning,[26–28] and high-energy ball milling[4,29,30] have resulted in significant improvements to many existing thermoelectrics. As a result, the maximum reported *ZT* values have increased from 1.0 to the range of 1.5 to 1.8 in recent years.

Successful decoupling of thermal transport and electronic transport properties is key to thermoelectric

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