Adv. Manuf. (2019) 7:278–287
https://doi.org/10.1007/s40436-019-00269-y

Accelerating sample preparation of graded thermoelectric materials using an automatic powder feeding system

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Received: 30 September 2018 / Revised: 14 March 2019 / Accepted: 4 July 2019 / Published online: 26 August 2019

Abstract In recent years, the development of techniques for the controlled preparation of functional graded materials (FGMs) has become a vigorous research field. In this study, to improve the efficiency and accuracy of sample preparations, an automated feeding system based on gravimetric principles for dry powder with three dosing feeders is designed and realized. The feeding rate and accuracy can be regulated by coordinating the protruded length L (mm) and rotational speed V (r/min) of the feeder stirrer. To demonstrate this automatic sample preparation system, the well-known thermoelectric material $Bi_xSb_{2-x}Te_3$ (x = 0.3, 0.4, 0.5, 0.6, 0.7 and 0.8) is selected and prepared by the developed system, and the composition distribution of the functional graded material is characterized. Experimental results show that the $Bi_xSb_{2-x}Te_3$ (x = 0.3–0.8) functionally graded material crystalizes in the rhombohedral phase after hot-pressing sintering and annealing and the prepared sample has a good gradient composition distribution. This verifies the reliability and accuracy of the feeding system. The concept of samples with a gradient component and application of the automatic powder feeding system could considerably accelerate the research and development of new materials.

Keywords Powder feeding · Automatic system · Functional graded material · Thermoelectric

1 Introduction

Thermoelectricity is currently considered as a plausible means of producing "clean" electrical energy from virtually any type of waste heat [1]. The demand for higher thermoelectric device efficiency combined with mandatory cost reductions per watt of thermoelectrically produced power helps drive upstream material research. Functional graded materials (FGMs) have primarily been studied for fabricating thermoelectric modules for assembling and welding of p- and n- legs to enhance the thermoelectric energy conversion efficiency in thermoelectrics [2]. FGMs are a useful means of improving the efficiency and usable temperature range of thermoelectrics. An FGM can undergo a continuous change in composition with annealing and other processes. Therefore, it might be used as an ideal sample to screen out the sample composition with the best thermoelectric performance. Thus, an FGM with a quasi-continuous composition distribution satisfies the sample requirement of the emerging materials genome initiative (MGI) and could lead to further research and improvements in thermoelectric conversion efficiency.

In actual operation, the precision of weighing a high-purity material powder has a great influence on the outcome of the preparation. The greatest challenge in the

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Electronic supplementary material The online version of this article (https://doi.org/10.1007/s40436-019-00269-y) contains supplementary material, which is available to authorized users.

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