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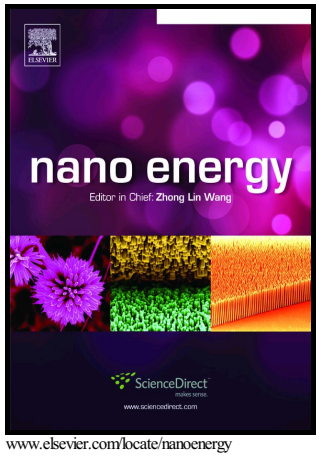

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Spontaneous solid-state foaming of nanocrystalline thermoelectric compounds at elevated temperatures

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Abstract

Nanocrystalline thermoelectric materials have improved properties, but are difficult to process to full density. During routine thermal processing operations such as powder consolidation and annealing, such compounds can spontaneously form pores, thus degrading their thermoelectric and mechanical properties. We systematically investigate pore formation during heat treatment of cold-pressed compacts of nanocrystalline Bi_2Te_3, combining dilatometry and electron microscopy to quantify pore morphology and the rate of pore growth. Pores are found to nucleate on Te-rich precipitates, which are ultimately attributable to a non-equilibrium solubility shift associated with defects in the nanostructured compound, and they grow by diffusional creep under the driving force of Te vapor pressure. This mechanistic insight reveals that, ironically, the same nonequilibrium processing and nanostructure desirable for improved thermoelectric performance also encourage foaming and challenge the formation of stable high density material. With an improved mechanistic understanding, however, we are also able to suggest strategies for improved materials design and processing.