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Facile Synthesis and thermal analysis of Antimony Telluride Nanostructures

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Abstract

Fabrication of nano-sized thermoelectric (TE) semiconductors like Antimony chalcogenides and study of their properties is a growing interest among the inorganic thermoelectric (TE) materials, which leads to the increase in the efficiency of energy conversion. The demand for fabricating high performance Thermoelectric (TE) materials in large quantity is very high. A facile synthesis was carried out for nanostructures of Sb_2Te_3 material trough chemical precipitation and solvo-thermal route. Both these chemical synthesis routes are not complicated and are suitable for expeditious way of synthesizing Nano crystallites, but have their own advantages. The structural and morphological studies of the prepared nanostructure material were carried out by X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM). The thermal studies were carried by Non destructive Thermal Analysis. Measurements of the thermal conductivity of the prepared nanostructured powders indicate that these synthesized Sb2Te3 material can be tuned to enhance the thermoelectric (TE) behavior as they possess considerably low thermal conductivity than that of bulk Sb_2Te_3.

Keywords: Nanostucture; Solvothermal; Thermoelectric Material;Thermal Conductivity.

1. Introduction

Thermoelectric (TE) materials have attracted attention because of their ability to convert a heat gradient directly into electricity and to transform applied power into a heating or cooling effect[1]. Such materials are able

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Nomenclature	
D	Particle Size diameter.
K	shape factor = 0.9
λ	X-Ray wavelength = 0.1541 nm
B	Full width at half max (Intensity)
Θ	Bragg or diffraction angle

to forage waste heat from the environment, thus increasing the fuel conversion efficiency of engines and generators[2].

Nanoprocessingis the adaptive way to enhance the figure-of- merit (ZT) of thermoelectric materials. The work carried out theoretically has given that small size and structurally oriented materials can exhibit a good figures of merit [3,4]. Moreover, many studies have shown that the thermoelectric properties can be enhanced by processing the materials, such as ($Bi_{2,}$Sb2) Te3to the low dimensional level (Nano) [5], PbSeTe based quantum dot superlattice structures [6] and incorporating nanoscale constituents within bulk materials to form nanocomposites [7,8].

In this work, we focused on to fabricate nanostructured Sb_2Te_3 by Chemical Precipitation Method and Solvothermal synthesis and to study their morphology and thermoelectric properties.

2. Material Fabrication Process

The material farication process is carried out in two types i) Chemical Precipitation Method and ii) Solvothermal Method. In the first process, the required metal cations from a common medium are co-precipitated usually as hydroxides, carbonates, oxalates, formates or citrates [9-11]. These precipitates are subsequently calcined at appropriate temperatures to yield the finalpowder. For achieving high homogeneity, the solubility products of the precipitate of metal cations must be closer [12-13]. Co-precipitation results in atomic scale mixing and hence, the calcining temperature required for the formation of final product is low, which lead to lower particle size [14,15]. However, each synthesis requires its own special conditions, precursor reactions, etc. Also, co-precipitation process required to control the concentration of the solution, pH, temperature and stirring speed of the mixture in order to obtain the final product with required properties. However, solvo-thermal synthesis method received greater attention because of its stability, simplicity, and cost-effectiveness.

2.1. Whychemical Synthesis?

1. Homogeneous mixing of reactant precipitates reduces the reaction temperature.
2. Simple direct process for the synthesis of fine metal oxide powders, which are highly reactive in low temperature sintering.
3. But Slovo-Thermal method is a very efficient method when compared to other methods to synthesize at low temperatures.

2.2. Materials Required

- Antimony trichloride(SbCL3)
- Tellurium dioxide (TeO2)
- Sodium Borohydride(NaBH4)
- CTAB (cetyltrimethylammonium bromide; hexadecyltrimethylammonium bromide)
- Poly vinylalchol (PVA)
- Nitic Acid (HNO3)
- Sodium Hydroxide (NaOH)