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Influence of Annealing Temperature in Thermoelectric Materials for Thermal Energy Harvesting

Thermoelectric (TE) device appear as an alternative solution to one of the major problems in this XXIth century concerning the energy crisis and environment deterioration. The big advantage of this technology lies with the vast availability of power supply where the heat is a common source of energy in our daily life. Moreover has the capability in converting waste heat into the electricity thus contributing to a sustainability system [1].
TE alloys exhibit interesting properties to use in TE energy conversion such as: zero emissions, vast scalability, low maintenance, and long operating lifetimes. However, nowadays the TE devices are still the limited application mainly because of its low energy-conversion efficiency and corresponding high material cost. Recent investigations have shown that nanostructuring these materials can enhances the thermoelectric figure of merit (ZT) due the enhancement of phonon scattering at nanodomains, which lies with the concept of "Phonon-Glass-Electron-Crystal". ZT is defined as $ZT=(S^2\sigma/\kappa)T$, where S, σ, κ and T are the Seebeck Coefficient, electrical conductivity, thermoelectric conductivity and absolute temperature, respectively [1]. Thus, increasing the ZT through nanoscale reduction, it may increase the energy-conversion efficiency.
The main goals of the present work are the production of efficient n-*type* Bi_2Te_3 and p-*type* Sb_2Te_3 thin films with nanometre thickness in order to be below the phonon mean free path of these materials. The films are deposited by Ion Beam Deposition in different substrates (flexible ad rigid). Towards the efficient nanodevices, the aim of this work is to growth TE thin films in Glass and Si substrates, and in flexible substrates such as PET and Kapton to support low temperatures working operation (from RT to 100 ºC). In order to improve the Seebeck coefficient and increase the phase of the deposited films, they were submitted to an annealing process under a nitrogen flux to avoid oxidation. For Bi_2Te_3 thin films the results (Figure 1) evinced that the annealing process enhanced the quality of the films, being T = 250ºC the optimum temperature, leading to the theoretical resistivity values $\sigma = 1.08\times10^{-5}$ Ωm, and a Seebeck coefficient of $S = -42.9\ \mu V\ K^{-1}$, rising one order of magnitude of the Power Factor to 170.4 $\mu W\ K^{-2}\ m^{-1}$ [2].

References

[1] W. He, G. Zhang, X. Xhang, J. Ji, G. Li, X. Zhao, "Recent development and application of thermoelectric generator and cooler" Applied Energy, 143, (2015), 1-25.
[2] J. Lin, Y. Chen, and C. Lin, "Annealing Effect on the Thermoelectric Properties of Bi2Te3 Thin Films Prepared by Thermal Evaporation Method" Journal of Nanomaterials, 2013 (2013), 1-6

Figures

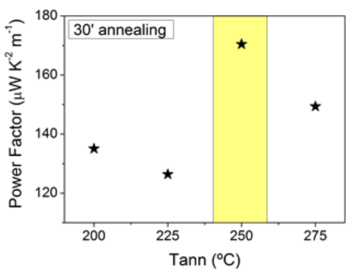

Figure 1: Power Factor of the annealed Bi_2Te_3 thin films.