9th International Workshop on Electrodeposited Nanostructures

Influence of different parameters on the electrodeposition of Bismuth Telluride films and nano-wires for thermoelectric applications.

O. Caballero-Calero*, B. Abad, P. Díaz-Chao, M. Muñoz Rojo, J. Martín, M. S. Martín-González

IMM-Instituto de Microelectrónica de Madrid (CNM-CSIC), Isaac Newton 8, PTM, E-28760 Tres Cantos, Madrid, Spain *email: olga.caballero@imm.cnm.csic.es

Thermoelectricity is the effect of heat conversion into electricity and vice-versa. Therefore, this field is of great interest as an alternative way of obtaining energy, because it offers a way of recovering the wasted heat produced in motors and machines [1]. Nevertheless, the main disadvantage of thermoelectric materials for their application in actual devices is that they present low efficiencies for this conversion. A way of measuring this efficiency is the thermoelectric figure of merit $ZT=(S^2 \cdot \sigma \cdot T)/\kappa$,where S, σ, κ, and T stand for the Seebeck coefficient, electrical and thermal conductivities, the absolute temperature, respectively. The improvement of their efficiency has a fundamental drawback, which is that S, σ, and κ, are correlated in classical physics. In 1993 a theoretical work suggested that this entanglement could be avoided if one went to the nano-scale and obtained quantum confinement of the electron charge carriers [2]. Then, much effort has been done to demonstrate experimentally this end, and an effective reduction of κ in nano-scale structures has been achieved, producing an enhancement of the ZT in some cases [3].

Bismuth telluride (Bi_2Te_3) is one of the most used bulk materials for thermoelectrical applications at room temperature (RT), with a ZT of around 1 at RT. In order to achieve the nano-structuring of this material, Bi_2Te_3 has been synthesized by electrodeposition. A conventional three-electrode cell and a nitric acid solution have been used, as described in [4]. In order to improve the power factor, the orientation and the crystal quality of the deposit different approaches has being studied (type of working electrode, applied potential, surfactants, etc). With that, highly oriented (110) films and nanowires has being achieved (which is the most conductive direction for this phase). The samples have been characterized using SEM, XRD, energy dispersive X-Ray (EDX), AFM, XRF, and their transport properties have been also measured.

Acknowledgements: The authors would like to acknowledge financial support from different projects: NANOTHERMA (FCCI), ERC StG NanoTEC 240497. O.C.C. wants to acknowledge CSIC for JAE-Doc.

References:

1. Kawamoto, H., *R&D Trends in High Efficiency Thermoelectric Conversion materials for Waste Heat Recovery.* Science & Technology Trends, Quarterly Review, 2009. **30**: p. 15.
2. Hicks, L.D. and M.S. Dresselhaus, *Effect of quantum-well structures on the thermoelectric figure of merit.* Physical Review B, 1993. **47**(19): p. 12727-12731.
3. Majumdar, A., *Thermoelectricity in Semiconductor Nanostructures.* Science, 2004. **303**(5659): p. 777-778.
4. Martin-Gonzalez, M.S., et al., *Insights into the Electrodeposition of Bi_2Te_3.* Journal of The Electrochemical Society, 2002. **149**(11): p. C546-C554.