O-19 Optimization of bismuth telluride films and nano-wire arrays via electrodeposition for thermoelectric applications

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Due to the current world's demand for energy, there is a great interest in thermoelectricity, which offers the possibility of increasing the sustainability of our electrical system. Thermoelectric materials can convert heat into electricity and vice versa, and thus they offer a way of recovering wasted heat produced in engines, industrial processes and others into usable power. However, one of the main problems for their actual use is their low efficiency in this conversion. This efficiency is directly related with what is called the thermoelectric figure of merit, described by $ZT=(S^2\cdot\sigma\cdot T)/\kappa$,where S, σ, κ, and T stand for the Seebeck coefficient, electrical and thermal conductivities, and the absolute temperature, respectively. Given that in classical physics S, σ, and κ, are correlated, the improvement of the efficiency is not straightforward. Nevertheless, in 1993 a theoretical work suggested that the efficiency could be greatly enhanced by reducing the dimensionality of the structures under studied and working in the nano-scale. Therefore, much experimental effort has been done to achieve these kind of structures and in some cases, an enhancement of the *ZT* value has been achieved, although this has not been due to the quantum confinement to the charge carriers, as it was theoretically predicted, but to an increase of the κ due to the increased number of interface boundaries in nano-structures [1].

Among the most efficient thermoelectric materials used for applications at room temperature, bismuth telluride (Bi_2Te_3) and its different alloys stand out, with a *ZT* for $Bi_2Te_3$of around 1 at RT [2]. We present here an optimized method of obtaining films and nanowire arrays via electrochemical deposition in a conventional three-electrode cell. Different ways of improving the quality of the obtained films have been studied (working electrode, constant and pulsed potentials, different chemical baths, etc.) in order to obtain highly oriented (110) films, which are the most favorable for out-of-plane applications. Then, nanostructuration has been achieved by changing the working electrode to porous alumina templates and realizing the electrochemical deposition inside the pores. The samples produced have been characterized using SEM, EDX, AFM, XRD, and Raman spectrometry, and in the case of the films, their transport properties have also been measured.

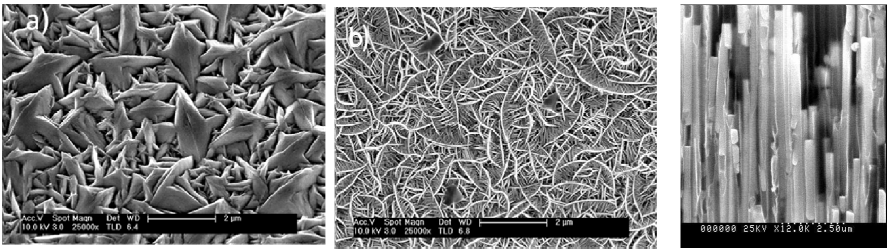

FIGURE
SEM images of a) a Bi_2Te_3 film before parameter optimization b) with optimized morphology and c) 200 nm diameter nanowires.

Notes and References

1 Martin-González, M.; Caballero-Calero, O; Díaz-Chao, P. *Renewable and sustainable Energy Reviews* **2013**, *24*, 288-305
2 Martín-González, M. Prieto, A.L; Gronsky, R; Sands, T; Stacy, A.M. *Journal of the Electrochemical Society* **2002**, *149*, C546-C554