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Electrodeposition of thermoelectric materials for 21st century applications

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Nowadays, there is an increasing demand of energy resources to cope with the needs of our society. Moreover, there is a growing concern about how these resources make an impact to our environment, and therefore, alternative ways of obtaining the higher efficiency with the less damage are being developed. It is in this scenario where thermoelectric generators stand as a quite promising alternative to improve the efficiency of our energy system by obtaining electricity from the heat produced by transport, motors, etc, that would be, otherwise, wasted.

The efficiency of any thermoelectric material is given by the so-called Figure of Merit $ZT=S\cdot\sigma/\kappa$, where S is the Seebeck coefficient, σ the electrical conductivity and κ the thermal conductivity. Given that in classical physics these quantities are related, it is not possible to increase this ZT at will. Nevertheless, after the theoretical predictions presented by Dresselhaus in 1993 [1] in which it was showed that when the dimensions are reduced and quantum physics start to play a role in the equations, it is possible to tailor separately S, σ, and κ and obtain more efficient thermoelectric materials. Therefore, much research is being carried in 1D nano-structures, such as nanowires, or nanotubes, to prove this point. For the moment, an effective enhancement of the ZT has been achieved in these structures, although they are not due to quantum effects but to a decrease of the thermal conductivity of the lattice, due to the nano-structuring itself that causes phonon scattering in the increasing number of interfaces, walls, etc.

In our group, we prepare template-assisted growth of nanostructures of thermoelectric materials via electrodeposition. The templates are porous alumina fabricated in our laboratory, which combine a high tunability of the pore diameters (from ten to hundreds of nanometers) with densities of $>10^{10}$ nanowires/cm^2 and high aspect ratio. Prior to the nano engineering the thermoelectrics by electrochemical techniques, films of different thermoelectric materials are prepared [2], the electrodeposition mechanism studied, and the growth conditions optimized as in references [3], [4], and [5]

References:

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