ULTRA-LOW THERMAL CONDUCTIVITIES IN LARGE-AREA Si₀.₈Ge₀.₂ NANOMESHES GROWN BY DC-SPUTTERING FOR THERMOELECTRIC APPLICATIONS

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In this work, we measure the structural, morphological, compositional, thermal and thermoelectric properties of large-area Si₀.₈Ge₀.₂ nanomeshed films manufactured by DC-sputtering of Si₀.₈Ge₀.₂ on highly ordered porous alumina matrices [1]. The Si₀.₈Ge₀.₂ film replicated the porous alumina structure resulting in nano-meshed films. Very good control of the nanomesh geometrical features (pore diameter, pitch, neck) was achieved through the alumina template, with pore diameters ranging from 294 ± 5 nm down to 31 ± 4 nm. The method that we developed is able to provide large areas of nano-meshes in a simple and reproducible way, being easily scalable for industrial applications. Most importantly, the thermal conductivity of the films was reduced as the diameter of the pores became smaller to values that varied from $\kappa = 1.54 \pm 0.27 \text{ W K}^{-1}\text{m}^{-1}$, down to the ultra-low $\kappa = 0.55 \pm 0.10 \text{ W K}^{-1}\text{m}^{-1}$ value. The latter is well below the amorphous limit, while the Seebeck coefficient and electrical conductivity of the material were retained. These properties, together with our large area fabrication approach, can provide an important route towards achieving high conversion efficiency, large area, and high scalable thermoelectric materials. Using this approach, it is possible to control thermal transport of these films through nano-engineering.

References: