Study of thin films of the filled skutterudite $Sm_y(Fe_xNi_{1-x})_4Sb_{12}$

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Devices based on thermoelectric (TE) technology could play a significant aspect in the future global requirement of energy as a result of their dual role in power generation (TEG) and cooling (TEC). Our team was lately involved in the characterization of dense skutterudites belonging to the $Sm_y(Fe_xNi_{1-x})_4Sb_{12}$ system, finding a complex dependence from stoichiometry and applied pressure.

The present-day interest in microelectronics led to the need for miniaturizing components. TE thin films could be a remarkable power source as TEG for wearable or biomedical devices or coolers as TEC for microchip applications. Regarding skutterudites, only a limited number of research papers on binary $CoSb_3$ and $IrSb_3$ thin films have been published in the early 2000s, then films of filled skutterudites doped with Fe at the Co site were studied in the most recent years.

In this work, we present our results on thin films of skutterudites $Sm_y(Fe_xNi_{1-x})_4Sb_{12}$ with x = 0.63 (crossover n/p type). Films were prepared by pulsed laser deposition (PLD) on fused silica substrates focusing on dense pellets prepared by SPS a laser beam (YAG, λ = 266 nm) under the following conditions: frequency 10 Hz, $d_{sub\text{-}target}$ = 35 mm, T_{dep} = 20~300 ºC, t_{dep} = 20~60 min, in P_{Ar} = 20~1000 mTorr or high vacuum (P = 10^{-4} Pa). We also examined the difference between as-deposited and annealed thin films (T = 150-300°C for 2h).

As a preliminary investigation, under SEM, the surface of the films appeared granular, and the size of grains decreases with the reduction of P_{Ar}. The XRD exposed that the films are amorphous and may require post-annealing. The transport and thermoelectric properties of as-deposited samples were measured between 300 K ~500 K using a home-made apparatus. The best sample so far (T_{dep} = 20 ºC and t_{dep} = 60 min, in high vacuum), with a thickness of 264 nm shows σ = 0.85 mOhm/cm, S = -24 μV/K and power factor σS^2 = 70 $\mu W/mK^2$ at 500K.