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Transferable nanoporous Ca3Co4O9 thin films for wearable thermoelectric applications

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With the emergence of low power and flexible applications, e.g. to power wearable electronics, on-chip cooling etc., the demand for high performance flexible and transferable thermoelectric thin films is on rise. Here, we report the growth of high performance nanoporous Ca3Co4O9 thin films with controlled porosity by a simple and scalable sequential-sputtering-and-annealing method. Ca3Co4O9 is promising not only for its high thermopower and good electrical conductivity but also important for the nontoxicity, low cost and abundance of its constituent raw materials. Nanoporous films provide a new opportunity to tailor the phononic properties by selective scattering of phonons, but without hampering the electronic transport, leading to the enhancement of thermoelectric efficiency. Two step sputtering-annealing growth is performed by sequentially depositing the multilayered CaO/CoO films on sapphire and mica substrates by rf-magnetron reactive sputtering from metallic targets of calcium and cobalt, followed by reactive annealing in oxygen atmosphere at 700 degree Celsius. A three stage phase transformation from multilayered CaO/CoO films to the final phase of Ca3Co4O9 occurs during annealing. The thermoelectric performance of the films are tunable with the controlled pores in the films. Low electrical resistivity ~ 7 mOhm.cm near room temperature is obtained from the nanoporous films, resulting high power factor, 0.23 mW/mK2 near room temperature, which is comparable to the Ca3Co4O9 thin films without porosity. Furthermore, these nanoporous films are readily to transferable to any arbitrary platform or substrate, due to the tailored weak adhesion between the films and the substrate by formation of nanopillars in the interfacial region. With this transferability and the high power factor near room temperature, the nanoporous Ca3Co4O9 films open avenues for low-temperature use of this material.

Author: Dr PAUL, Biplab (Linköping University)

Co-authors: Dr BJÖRK, Emma (Linköping University); Mr KUMAR, Aparabal (Indian Institute of Technology, Kharagpur); Dr LU, Jun (Linköping University); Dr EKLUND, Per (Linköping University)

Presenter: Dr PAUL, Biplab (Linköping University)

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