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THERMOELECTRIC MATERIALS

The power of pores

“We have constructed a Bi_2Te_3-based thermoelectric material that shows extremely low thermal conductivity thanks to its high porosity”

Thermoelectric materials can generate electricity from heat in a quiet and reliable way, but with much lower efficiency than conventional heat engines. To achieve high performance, a thermoelectric material requires a high ‘figure of merit’ — a dimensionless quantity that is inversely proportional to the material’s thermal conductivity. A high figure of merit is achieved when a material simultaneously shows low thermal conductivity and high electrical conductivity. Now, a method for the production of porous thermoelectric nanocomposites with extremely low thermal conductivity and good electrical conductivity is reported by Yue Wu and colleagues in *Angewandte Chemie International Edition*.

Porous materials are known to have low thermal conductivities because of phonon scattering at grain boundaries. However, obtaining such materials is not straightforward. Wu and colleagues used a self-templating multistep method to make hollow nanorods that were then pulverized and re-pressed to form a nanocomposite. Because the nanorods are hollow, the nanocomposite is highly porous. “We have constructed a Bi_2Te_3-based thermoelectric material that shows extremely low thermal conductivity thanks to its high porosity,” explains Wu. “Compared with other porous Bi_2Te_3-based thermoelectric materials, ours has high electrical conductivity and exhibits the highest figure of merit among state-of-the-art Bi_2Te_3 materials.”

With the support of theoretical calculations, the researchers attribute the remarkably low thermal conductivity to a strong enhancement of the phonon scattering. This enhancement is due to the porosity and the many grain boundaries and dislocations within the material that result from the compression of the hollow precursor. In addition, the electron mobility in the material is high, possibly because of the presence of large grains and the high crystallinity of the material. Together with its good performance, this highly porous nanocomposite is lightweight, and thus opens opportunities for the material to be used in portable devices. Also, compared with conventional thermoelectrics, 30% less tellurium — a costly element — is used to fabricate the material.

To determine whether this synthetic strategy can be applied more generally to form high-performance thermoelectric materials, Wu and colleagues envisage using hollow precursors of different compositions, such as PbTe and SnSe, to make a wide range of materials. “We anticipate that applications of porous thermoelectric materials might be possible in a few years’ time,” says Wu. However, there are issues that still need to be addressed, including the production cost of the nanomaterials and the adaptation of the method for large-scale production — in the present study only 11 g were synthesized, which is far less than is required if porous thermoelectric materials are to find practical applications. Finally, an alternative raw material to replace tellurium in the precursor is needed to make these materials economically viable.

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ORIGINAL ARTICLE Xu, B. *et al.* Highly porous thermoelectric nanocomposites with low thermal conductivity and high figure of merit from large-scale solution-synthesized $Bi_2Te_{2.5}Se_{0.5}$ hollow nanostructures. *Angew. Chem. Int. Ed.* http://dx.doi.org/10.1002/anie.201612041 (2017)

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