***Thermoelectric materials: Principle, characterization and modern applications***

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***Abstract***

Due to concerns over resource conservation and climate change, the world is looking for alternatives to fossil fuels. Among technical solutions, thermoelectric devices allow the conversion of waste heat energy into electricity. Its physical principles are known since the 19th century, but first energy applications date from the middle of the 20th century. These converters were during a long time restrained to some niche markets, especially spatial applications for their high reliability with no moving parts. A too low transformation yield has prevented its large-scale deployment. Since the end of the 20th, this field has regained momentum when it was predicted that nanostructures could enhance the conversion efficiency [1, 2].

Thermoelectric researchers are focus on a main objective: increasing the figure of merit directly related to the energy conversion efficiency. The dimensionless figure of merit is given by [3]:

$$ZT=\frac{σ S^{2}}{κ}T,$$

where the transport parameters *σ*, *S* and *κ* are respectively the electrical conductivity, the Seebeck coefficient and the total thermal conductivity. *T* is the averaged working temperature alongside the device into consideration. Improving a thermoelectric material consists of increasing *σ*, *S* and decreasing *κ.* However, these transport parameters are physically interrelated, consequently fostering one parameter is usually detrimental to the other ones. In this talk, we will focus on the different strategies applied to lower the thermal conductivity without impacting negatively (too much) the two other transport parameters [3].

Material performances can be assessed from their figure of merit values. So, measuring properly the transport parameters values entering the definition of *ZT* and estimating their associated uncertainties is of main importance. Potentialities of some techniques used to characterize the transport properties of thermoelectric materials will be discussed. Finally, some modern applications of thermoelectric materials will be presented.

[1] Hicks, L. D., & Dresselhaus, M. S. (1993). Effect of quantum-well structures on the thermoelectric figure of merit. *Physical Review B*, *47*(19), 12727.

[2] Dresselhaus, M. S., Chen, G., Tang, M. Y., Yang, R. G., Lee, H., Wang, D. Z., ... & Gogna, P. (2007). New directions for low‐dimensional thermoelectric materials. *Advanced materials*, *19*(8), 1043-1053.

[3] Rowe, D. M. (2018). *Thermoelectrics handbook: macro to nano*. CRC press.