Colloidal Approach to Nanostructured Thermoelectric Materials for Improved Performance

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Thermoelectric materials account to compound classes that can be used to generate an electric current from a temperature difference (Seebeck-Effect) and vice versa, creating a temperature gradient (hot and cold interface) when applying an electric current (Peltier-Effect). Possible fields of application can be in space engineering as reliable energy sources, in waste-heat recovery through energy conversion (e.g. in cars), and in cooling devices.

Yet, their usability is limited due to their currently low efficiencies. Different strategies can be employed to improve their performance. Nanostructuring has proven to effectively reduce the thermal conductivity of the material while maintaining high electrical conductivity and enhancing the Seebeck-coefficient.[1] Theoretical calculations show that the thermal lattice conductivity is caused mostly by mid-energy phonons which can be effectively scattered by nano-sized grain boundaries.[2]

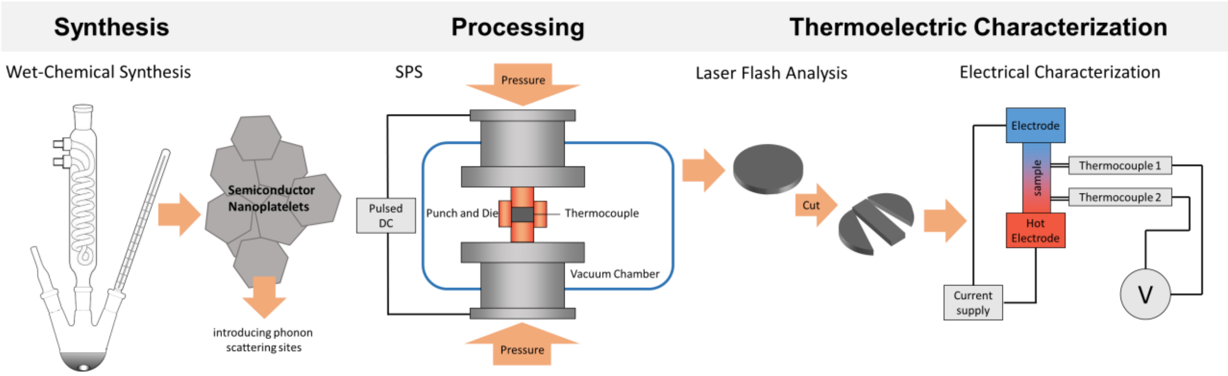

Fig. 1 Synthesis, processing and characterization of 2D bismuth chalcogenide-based thermoelectrics.

2D nano-engineered materials can be easily produced via colloidal synthetic approaches. In this work we use strategies of a facile wet-chemical nanoparticle synthesis to obtain 2D nanostructured thermoelectric materials Bi_2Te_3, Bi_2Se_3, and their alloys. These materials were processed into nanostructured bulks via spark plasma sintering (SPS) technique (Fig. 1). Comprehensive characterization of their thermoeletric properties (such as electric and thermal conductivity, Seebeck coefficient) revealed that pure Bi_2Te_3 nanocrystalline bulks composed of sintered nanosheets exhibited a remarkably high ZT value. At the same time, the mixture of Bi_2Te_3/Bi_2Se_3 (9/1) showed a maxmimum ZT higher than 1.0. Thus, these characteristics are one of the highest values ever measured for this system either in the form of bulk or nanostructured solid. Further investigations which include doping and alloying, as well as optimization of the sintering parameters can result in even better performance of these thermoelectrics.

1) M. S. Dresselhaus *et al*., *Adv. Mater.*, **2007**, *19*, 1043.
2) M. Hong *et al*., *ACS Nano* **2016**, *10*, 4719.