Synthesis and Spark Plasma Sintering of Bi_2Te_3 Nanoplates with a Single Nanopore

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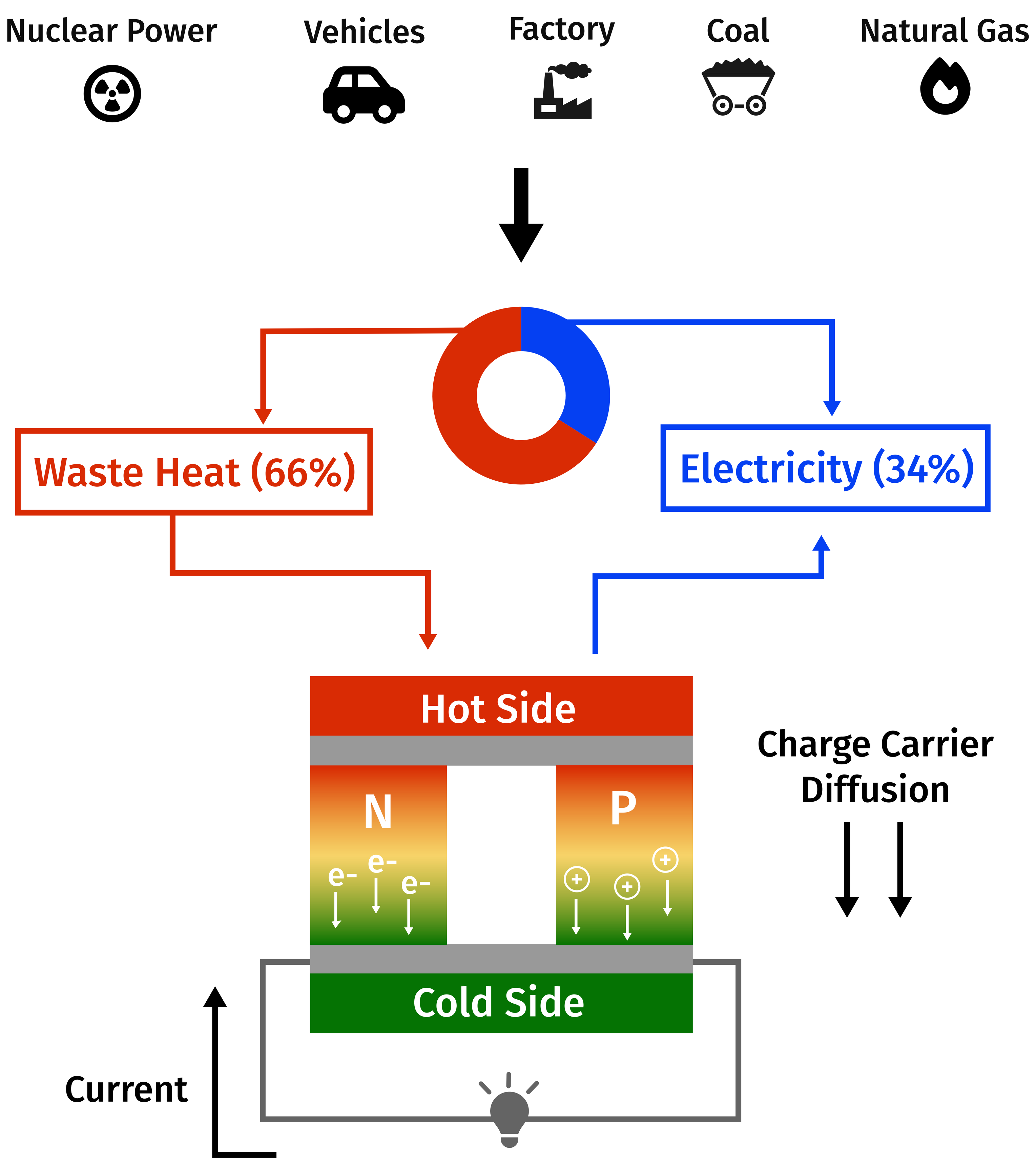
Thermoelectric Materials

Thermoelectric materials (TE) can convert waste heat into electricity. Roughly 50%—66% of the energy used in generating electricity is lost as waste heat. (Source: Department of Energy)



The thermoelectric performance of a material is given by the figure of merit zT:

$$zT = \frac{S^2\sigma}{\kappa}T$$

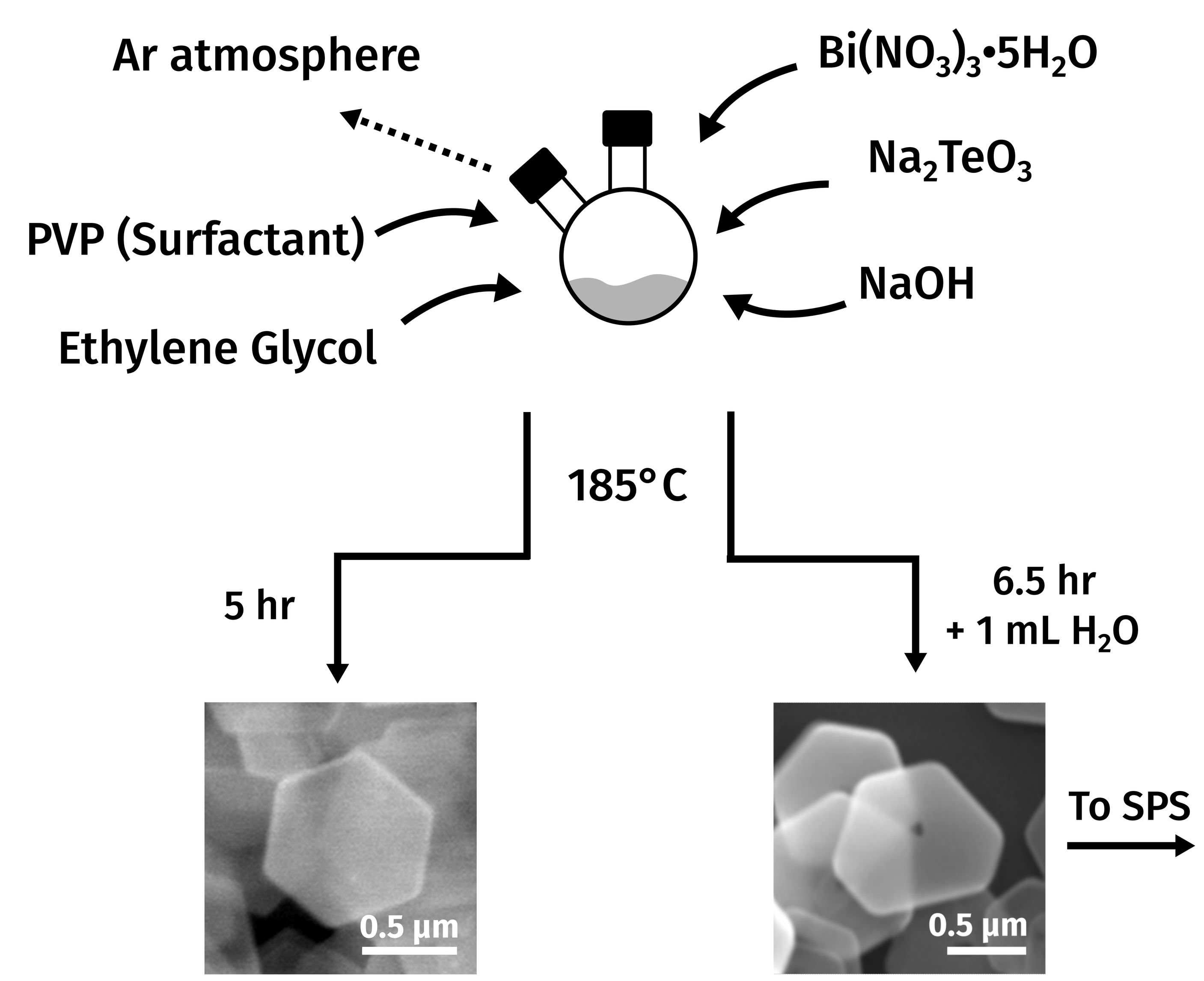
An ideal TE material at temperature (*T*) would have:

- High Seebeck coefficient (*S*)
- High electrical conductivity (*σ*)
- Low thermal conductivity (*κ*)

Bi_2Te_3 Nanoplates

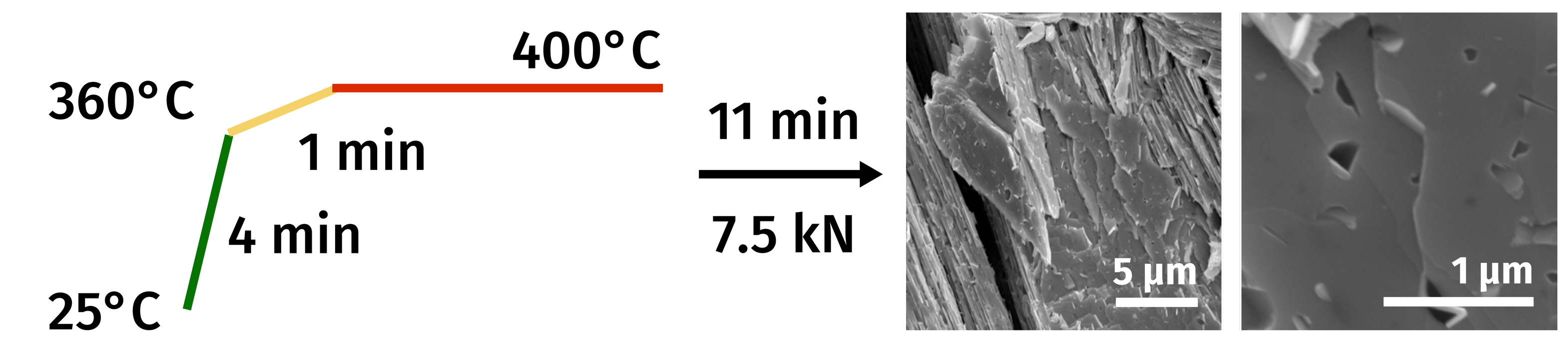
- High TE performance near room temperature (zT ≈ 1)
- High Seebeck coefficient from quantum confinement
- Low thermal conductivity from surface phonon scattering
- TE properties can be tuned by nanostructure engineering with scalable solution synthesis

Solution Synthesis



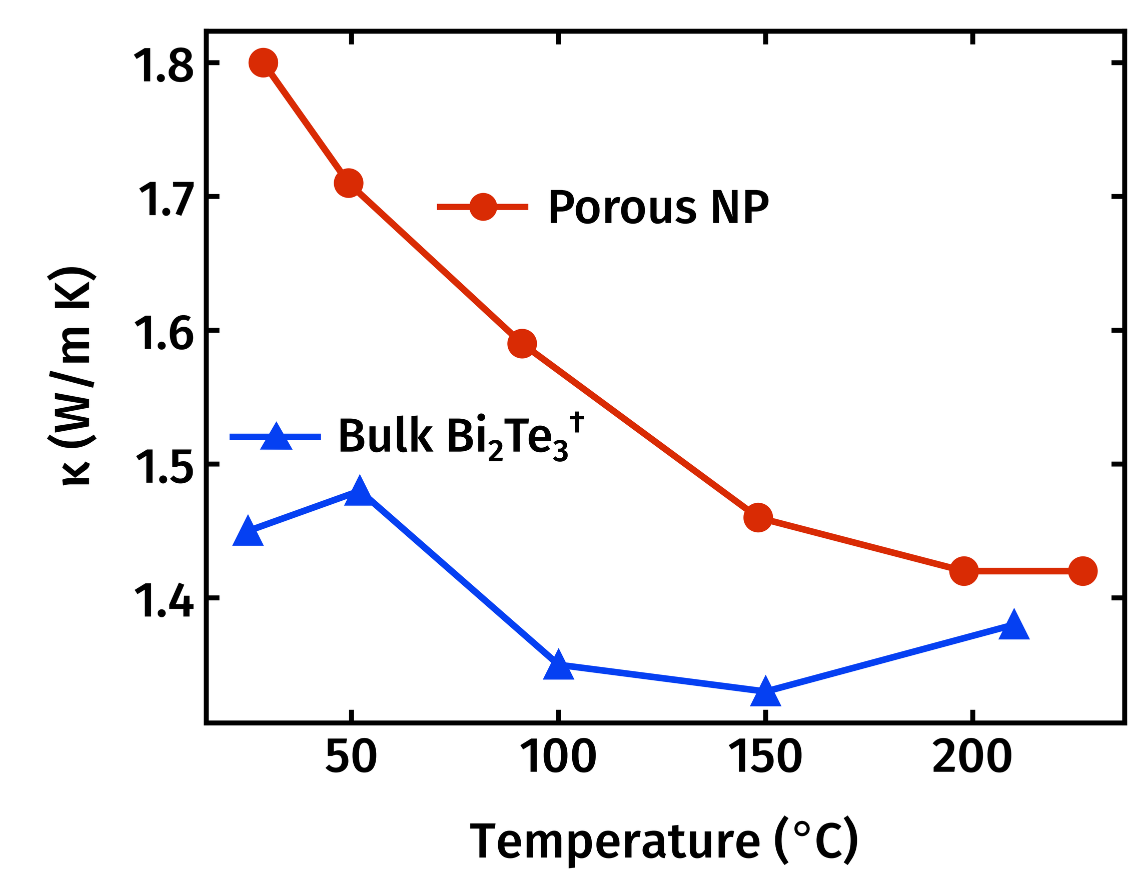
Spark Plasma Sintering (SPS)

Pressure and heat is used to compact and densify the NPs. The density after sintering was 98%.



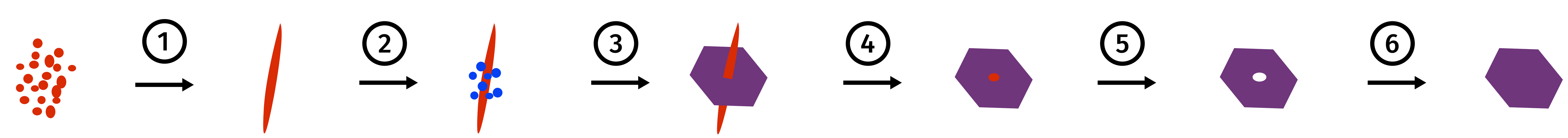
Thermal Conductivity

The thermal conductivity was comparable to bulk Bi_2Te_3, which suggests that the nanoplates had melted. The increased surface area from the pores could have lowered the melting point.



† Du, Y., Li, J., Xu, J. & Eklund, P. Thermoelectric Properties of Reduced Graphene Oxide/Bi2Te3 Nanocomposites. Energies 12, 2430 (2019).

Proposed Growth Mechanism



1. Homogeneous nucleation of Te into nanorods
2. Bi^{3+} nucleates heterogeneously onto nanorods
3. Bi_2Te_3 nanoplates (NP) grow by consuming the Te nanorod
4. Te diffusion continues, NP breaks away from Te nanorod
5. Kirkendall effect between Te and Bi results in vacancies
6. Pore is filled in by consuming smaller Bi_2Te_3 crystals