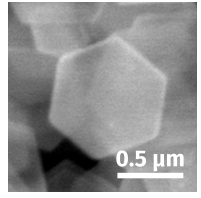
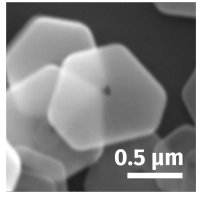
UCDAVIS
DEPARTMENT OF CHEMISTRY

Synthesis and Thermoelectric Properties of Bi_2Te_3 Nanoplates with a Single Nanopore





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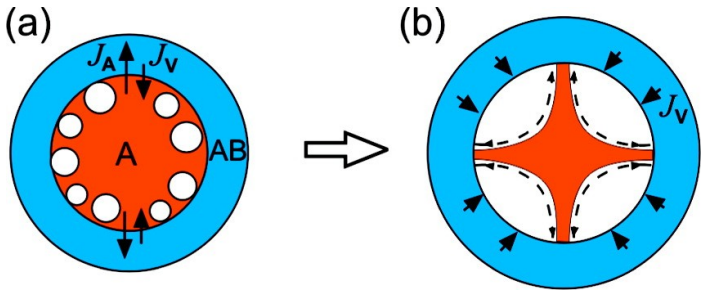
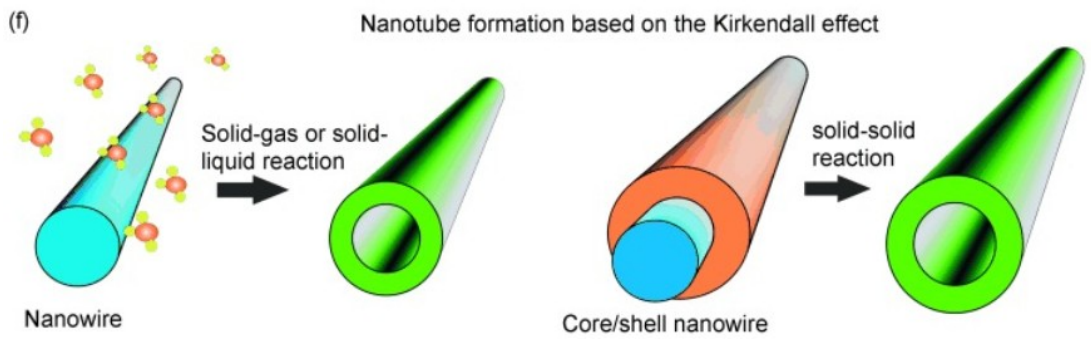
Continuing from Gustavo's Presentation...

- Thermoelectric materials can convert waste heat into electricity
- Bi_2Te_3 is a good thermoelectric material near room temperature
- Nanostructuring materials can improve their thermoelectric properties
- Nanopore morphology is influenced by:
  - ✔ Reaction temperature
  - ✔ Drying the solvent

Diffusion Mechansim (Kirkendall Voids)



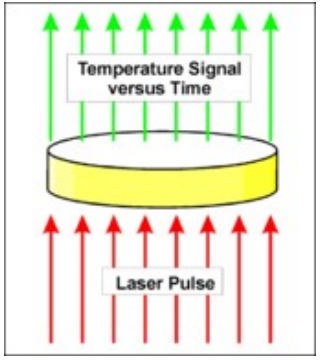


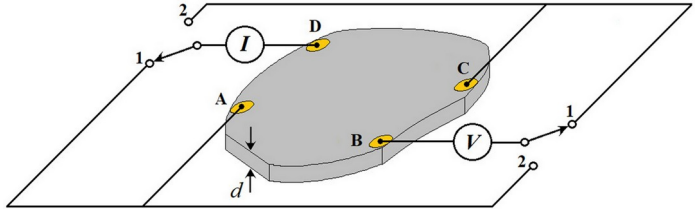
1. Homogeneous nucleation of Te into nanorods
2. Bi^{3+} nucleates heterogeneously onto nanorods
3. Bi_2Te_3 nanoplates (NP) grow by consuming the Te nanorod
4. Te diffusion continues, NP breaks away from Te nanorod
5. Kirkendall effect between Te and Bi results in vacancies
6. Pore is filled in by consuming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

Nano Lett. 2007, 7, 4, 993-997
Small. 2007, 3: 1660-1671.

Thermoelectric Properties

- Spark Plasma Sintering (SPS) @ 400°C, 7.5kN for 11 minutes
- X-Ray Powder Diffraction — Phase purity & Preferred Orientation
- Laser Flash Analysis — Thermal Conductivity
- Van der Pauw procedure — Room Temperature Resistivity

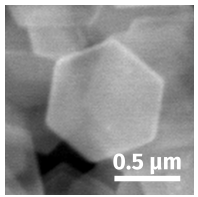




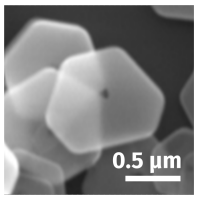
LFA: Wikipedia
Scientific Reports volume 10, Article number: 16379 (2020)

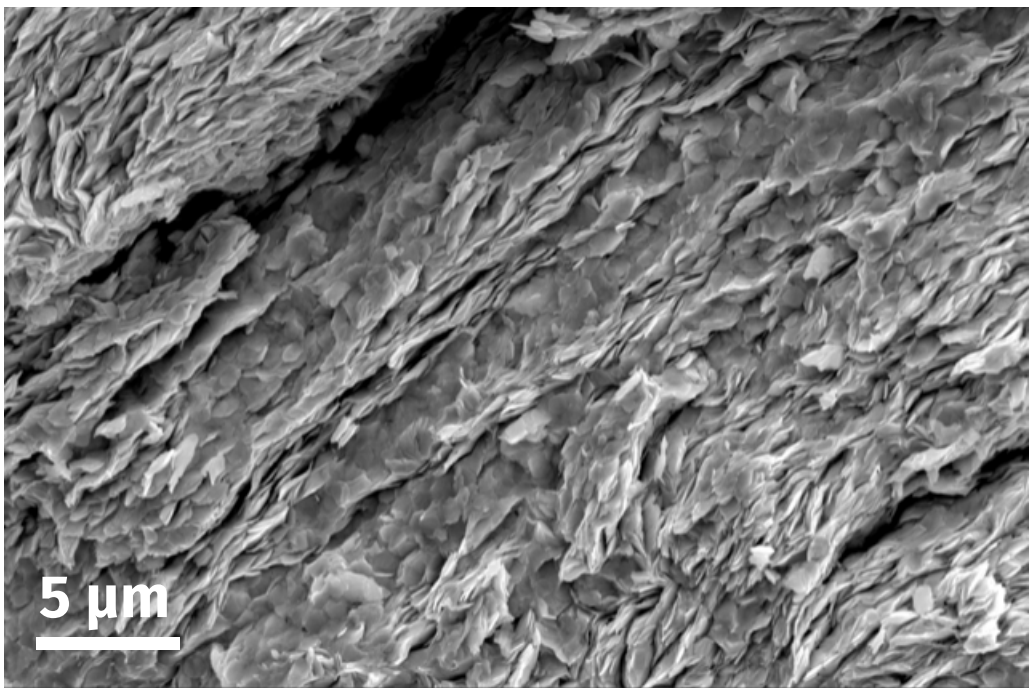
Pristine NP vs Nanopore NP (After Sintering)

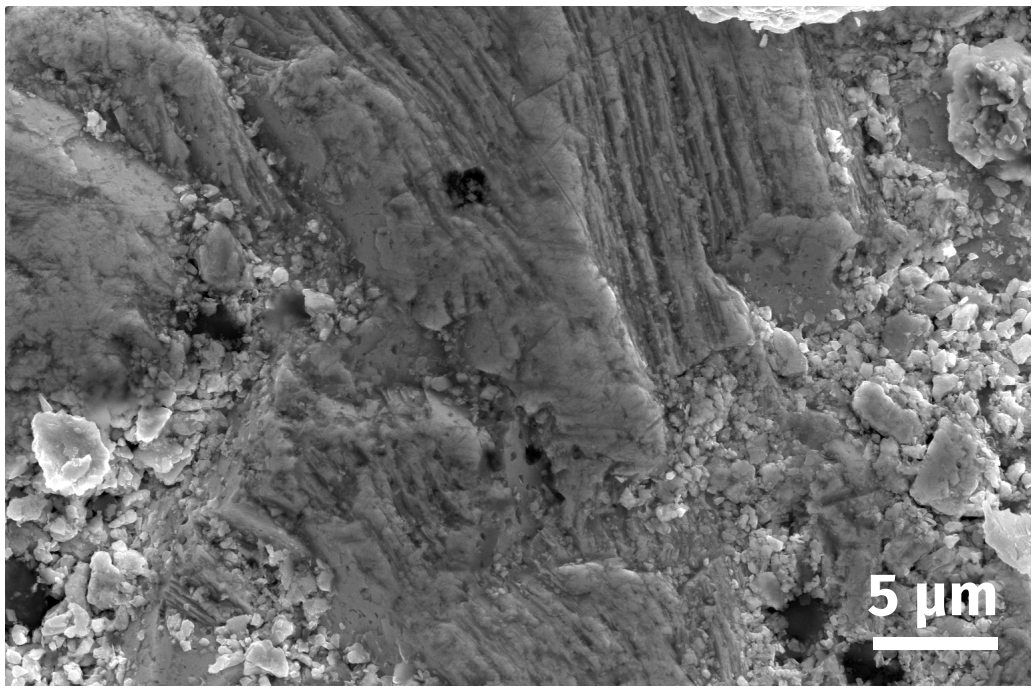
Pristine



Nanopore







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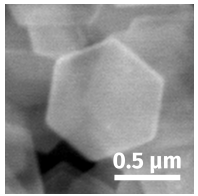
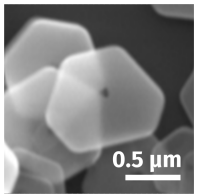
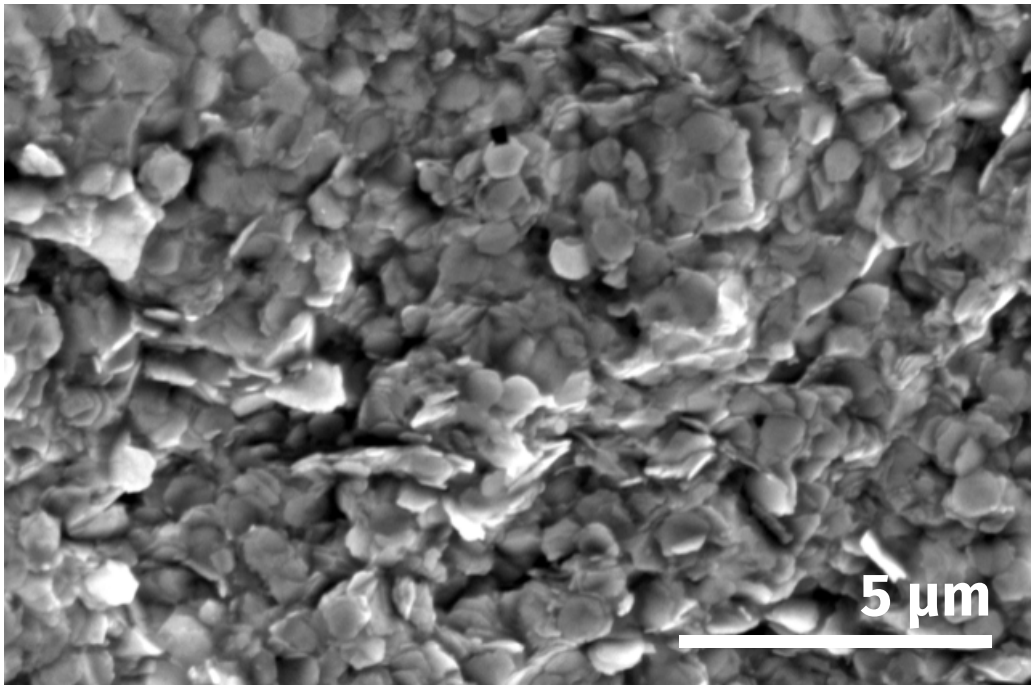
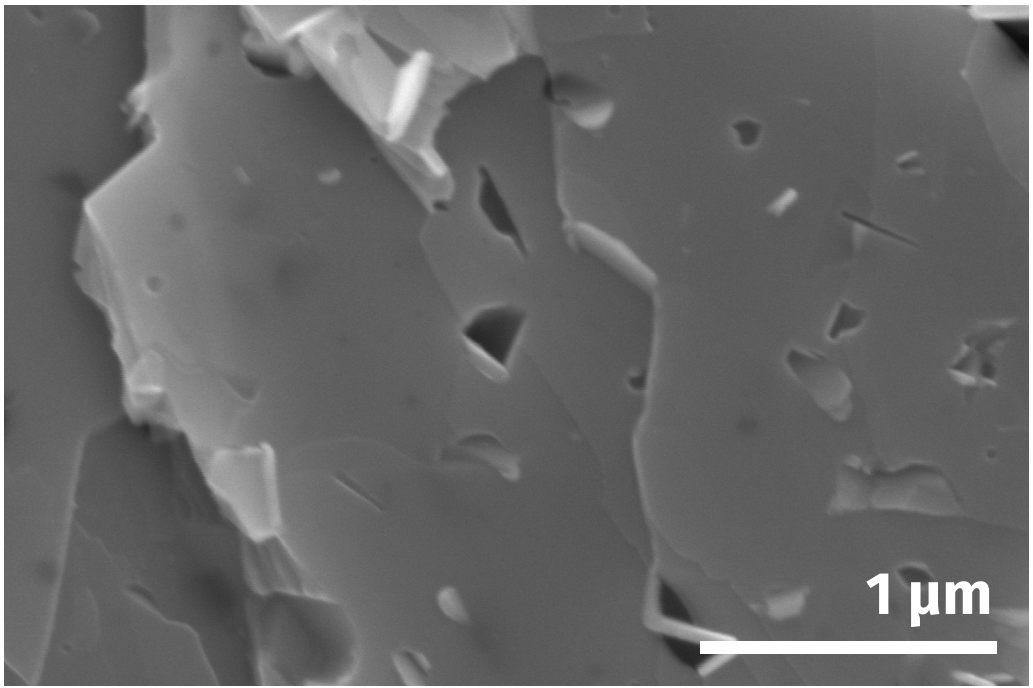
Pristine



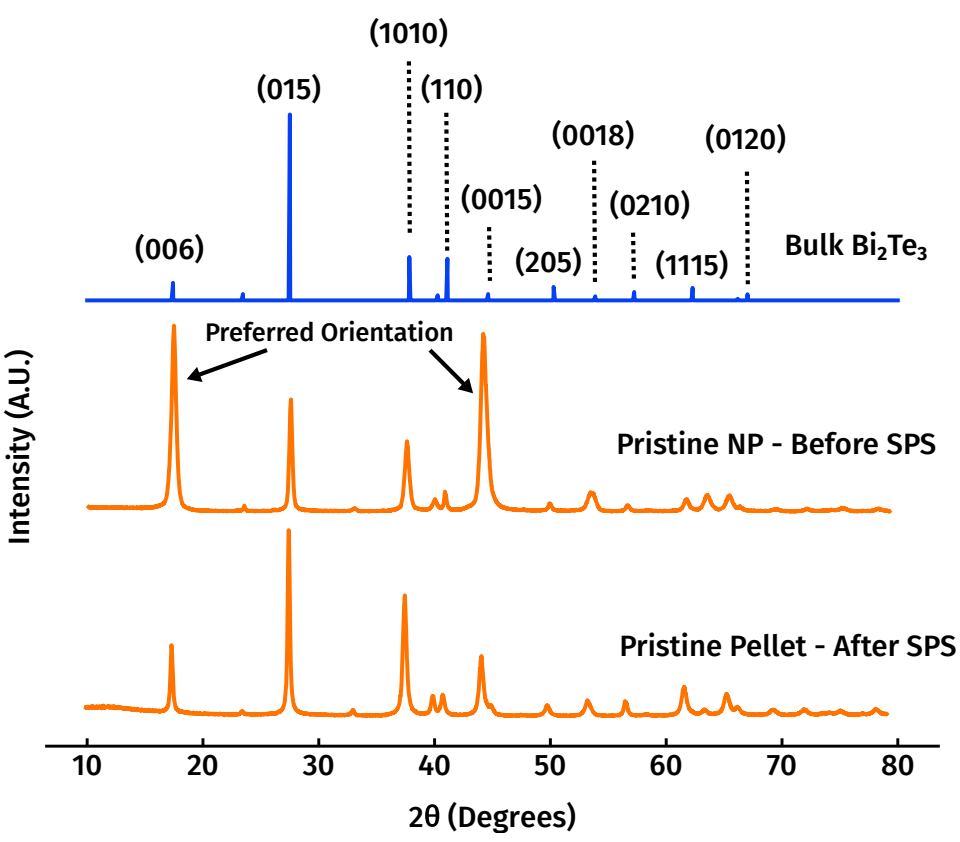
Nanopore

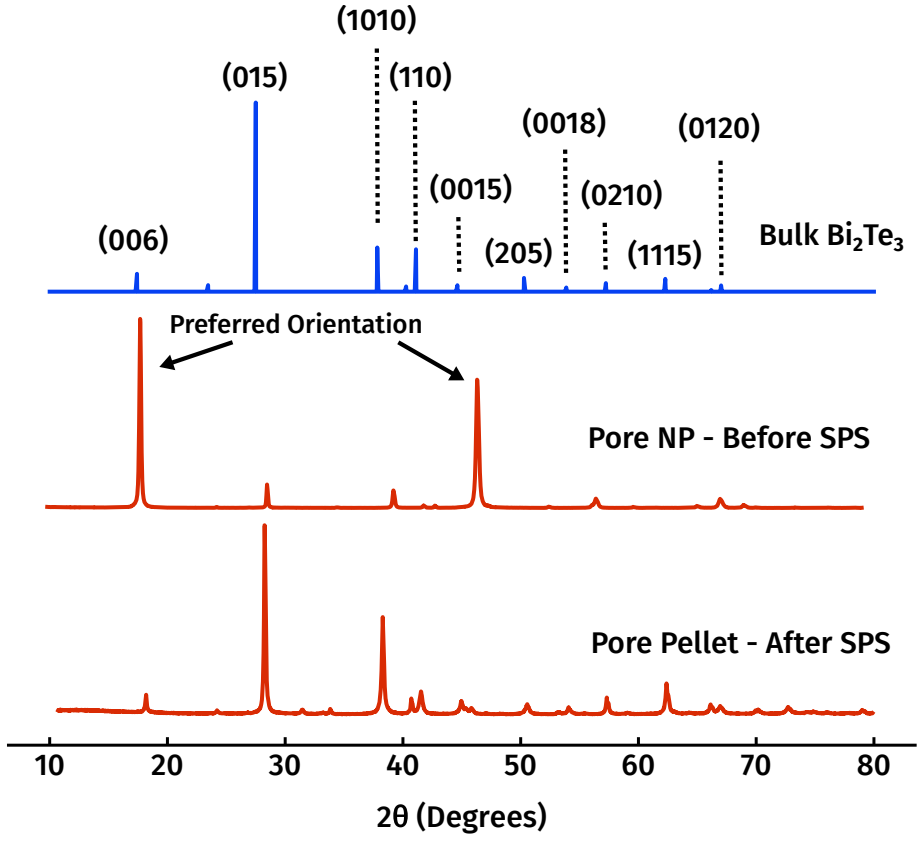




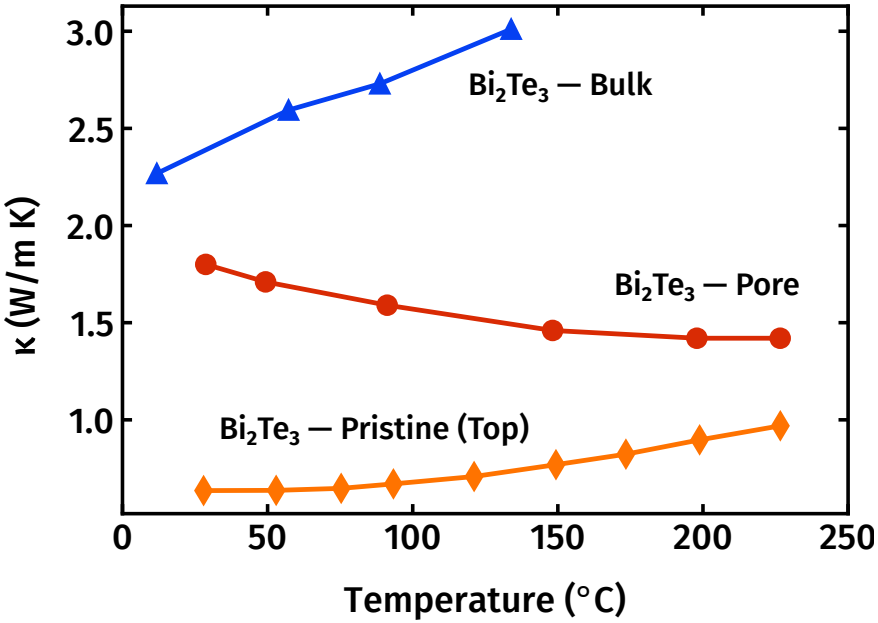


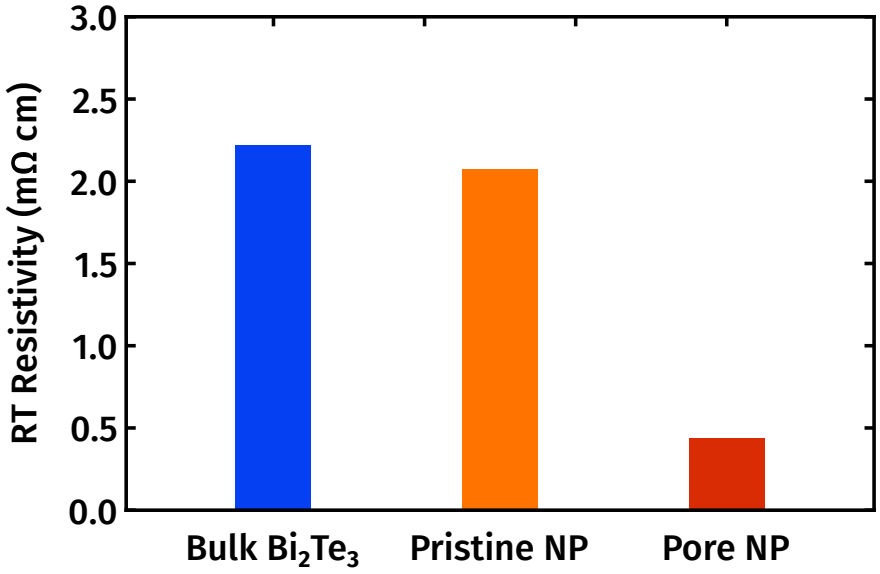
X-Ray Powder Diffraction





Thermal Conductivity & Room Temperature Resistivity





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

J. Phys. Chem. Solids 1962. Vol. 23, pp. 1209-1217
DukSoo Kim et al. 2020 Nanotechnology 31 365703

Conclusion

- Nanopore morphology is influenced by different synthetic conditions
- Proposed diffusion based mechanism
- Morphology and XRD results suggest that the pellet melted
- Thermal conductivity lower than bulk Bi_2Te_3, but higher than pristine nanoplates
- RT resistivity was found to be lower than bulk and pristine NP

Future Work

- Verify melting point with DSC (Differential Scanning Calorimetry)
- Characterize other thermoelectric properties (S, σ, zT)
- Verify proposed mechanism for pore formation
- Further nanostructuring (e.g. decorating with nanoparticles)

Acknowledgement is extended to Tanner Kimberly and Susan Kauzlarich for their support and encouragement throughout this project