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The influence of Carbon Nanotubes on the Thermoelectric Properties of Bismuth Telluride

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Introduction

Thermoelectric materials are devices that can convert waste heat to electricity. The widespread use of thermoelectric materials is currently limited by the low value their figure-of-merit (ZT). Bismuth Telluride (Bi_2Te_3) is a promising thermoelectric material in the near room temperature applications that provides a ZT value ~ 1. In order to overcome the limitation of utilizing thermoelectric materials in waste heat recovery, a ZT value > 2 is required. In this current study multi-walled carbon nanotubes (MWCNT) was incorporated into Bi_2Te_3 bulk matrix system to enhance its mechanical and thermoelectric properties through powder processing techniques.

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

Objective

To study the influence of CNT on the thermoelectric properties of Bi_2Te_3.

Methodology

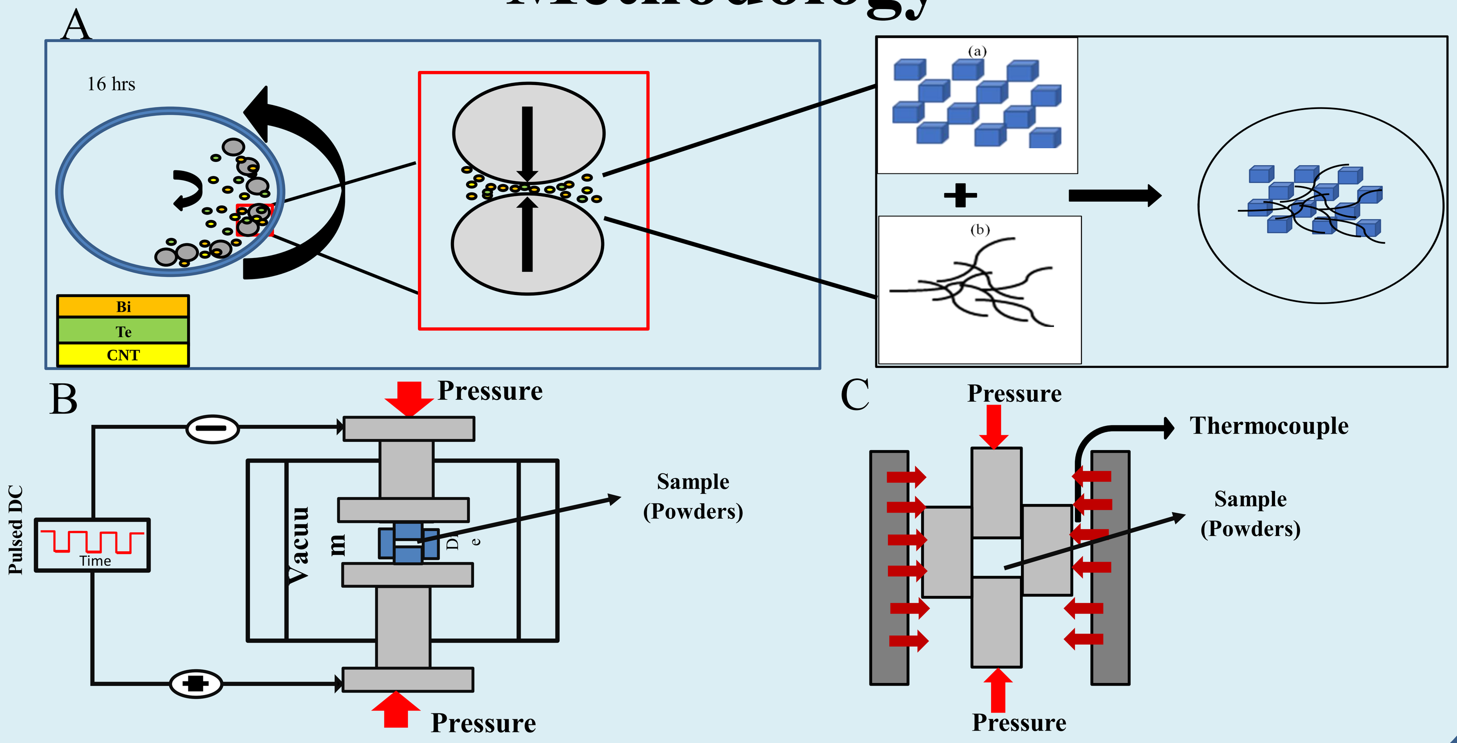


Figure 1. Schematic diagram represents the process of Bi_2Te_3/SWCNT nanocomposite by a)ball milling method; b) SPS, c) HIP .

Results and discussions

SEM

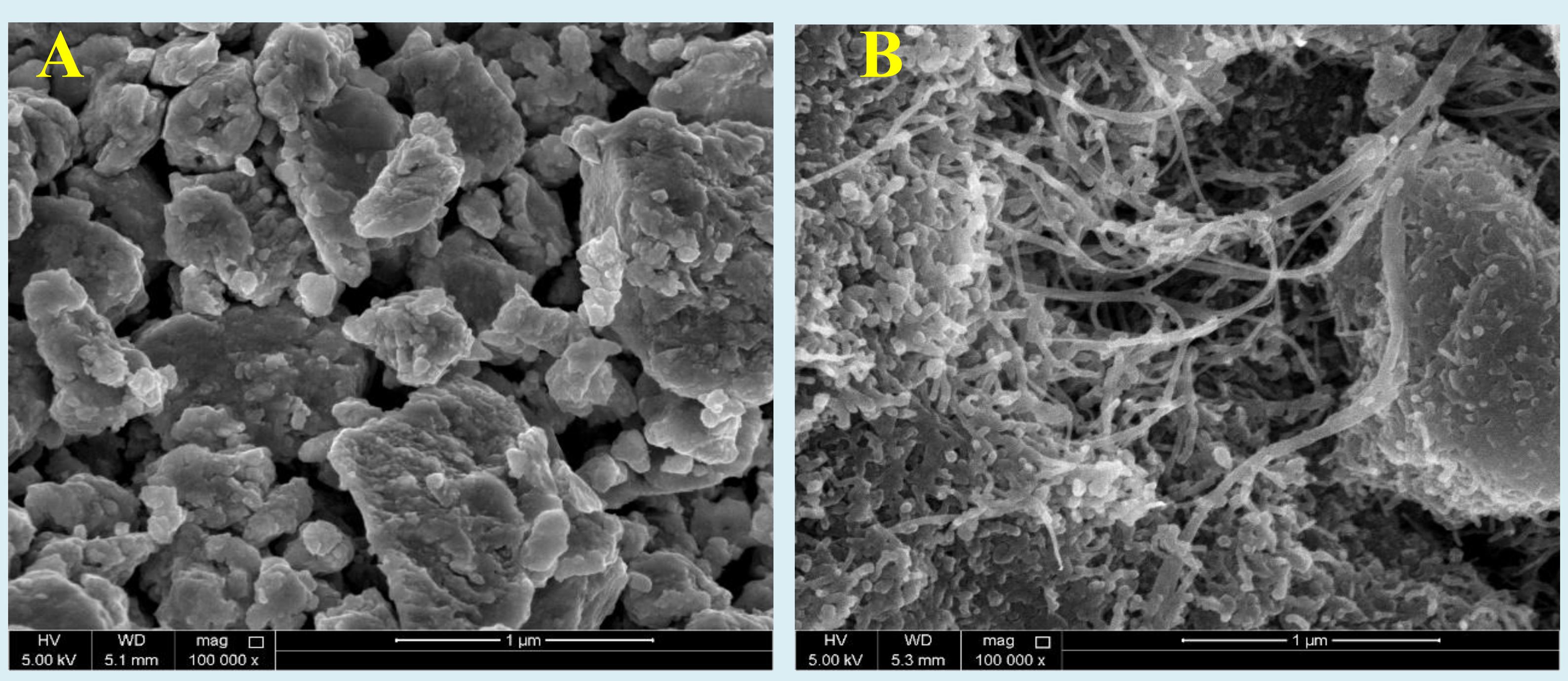


Figure 2. Shows SEM images of alloys a) Bi_2Te_3, b) MWCNT.

XRD

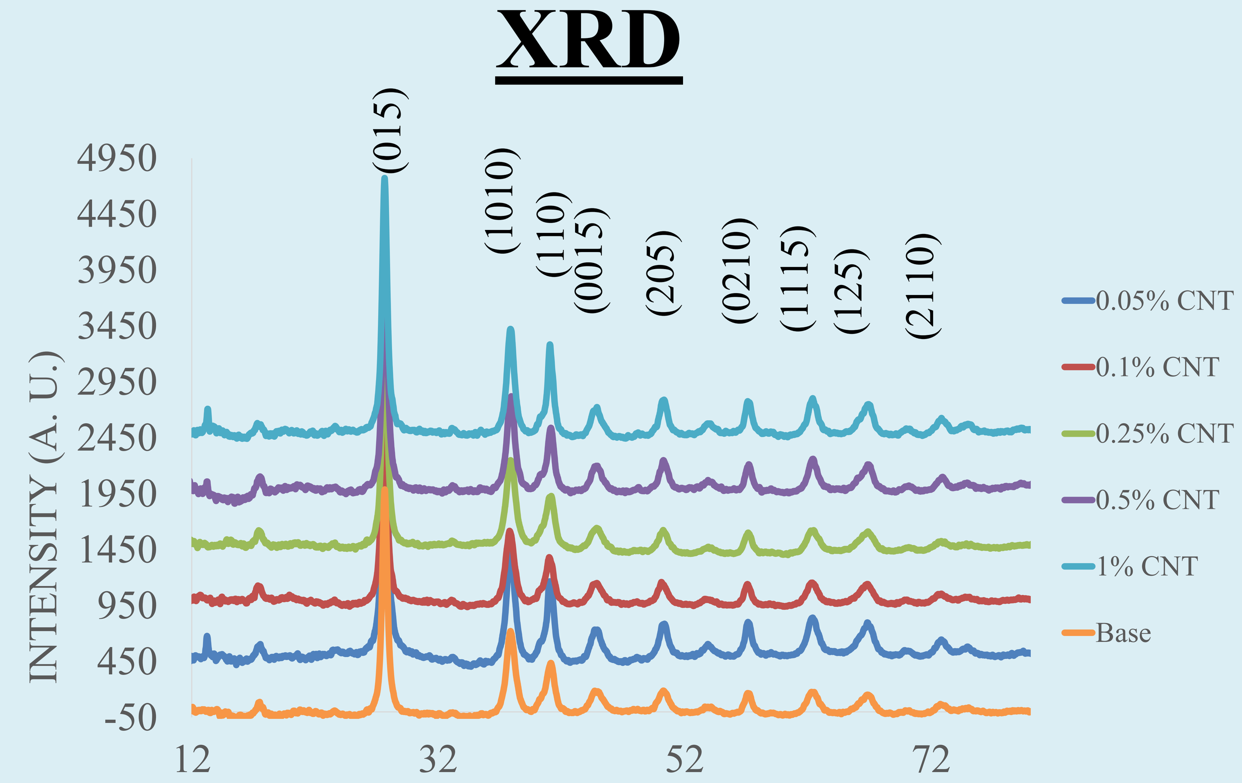


Figure 3. XRD analysis of as prepared Bi_2Te_3, Bi_2Te_3 –o.o5% SWCN, Bi_2Te_3 – 0.1% SWCNT, Bi_2Te_3 – 0.25% SWCNT, Bi_2Te_3 – 0.5% SWCNT and Bi_2Te_3 – 1%SWCNT.

Micro-Hardness

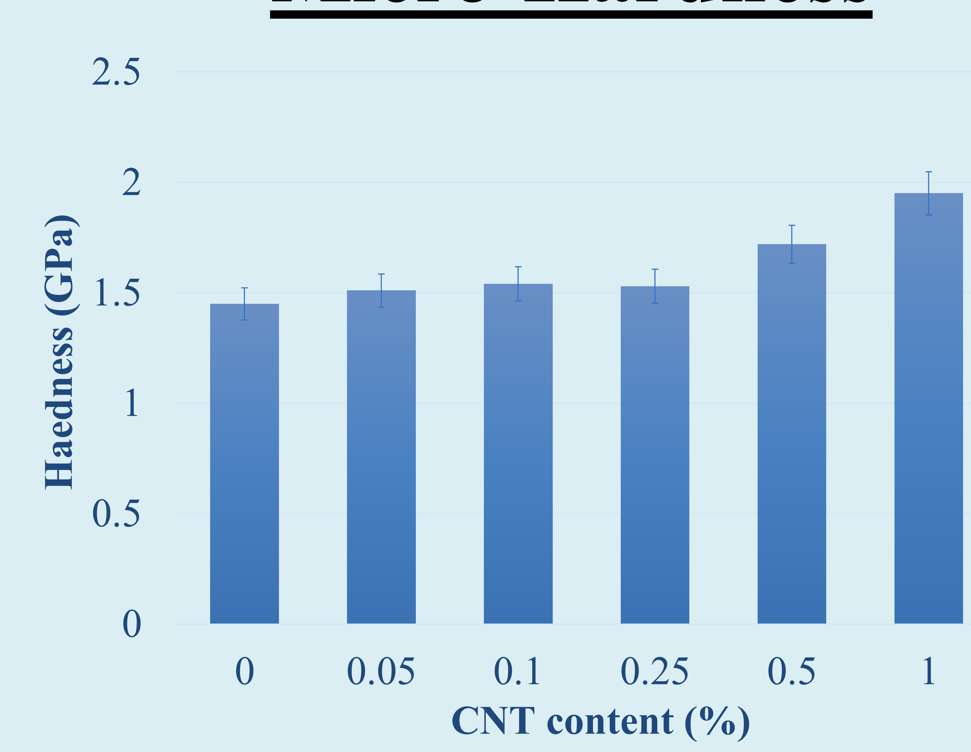


Figure 4. Shows the microhardness values (GPa) based on the SWCNT content.

TEM

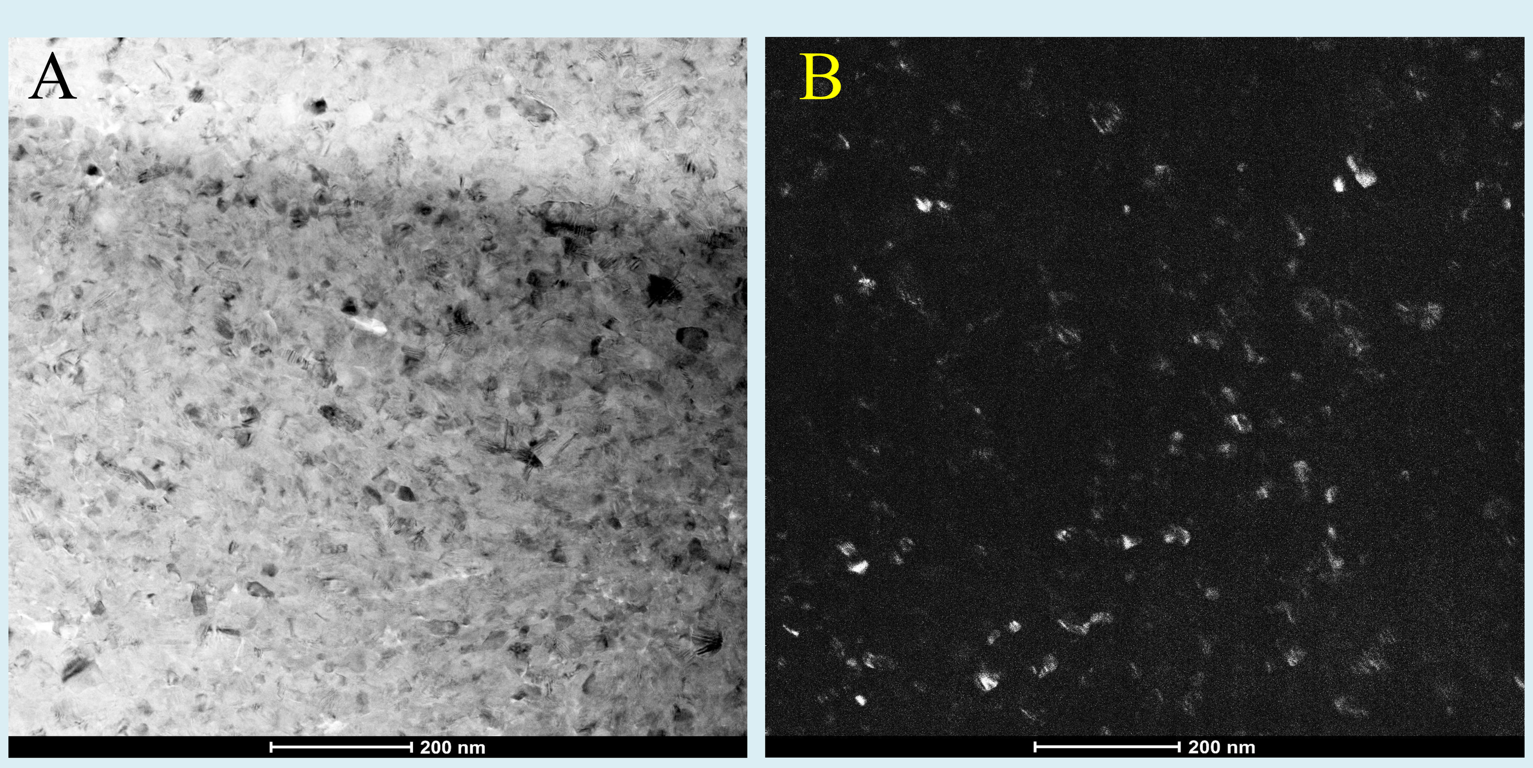


Figure 5. Shows the TEM images of the Grain size (nm) a) bright field image, b) dark field image.

DSC

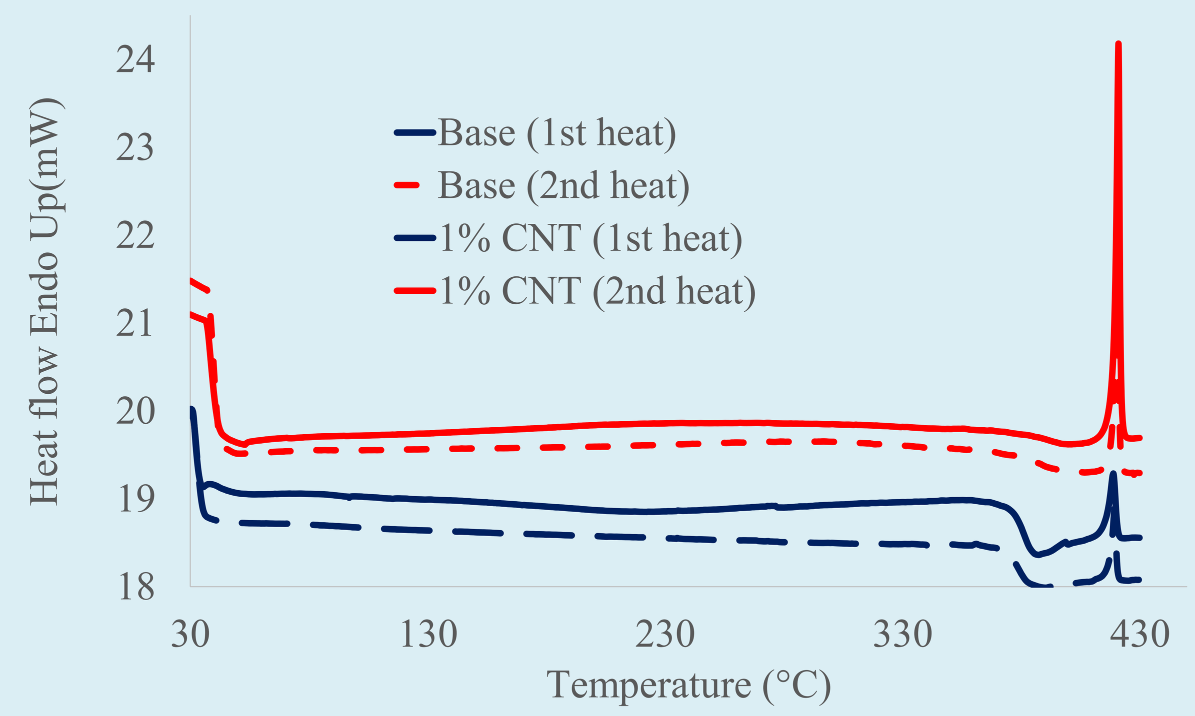
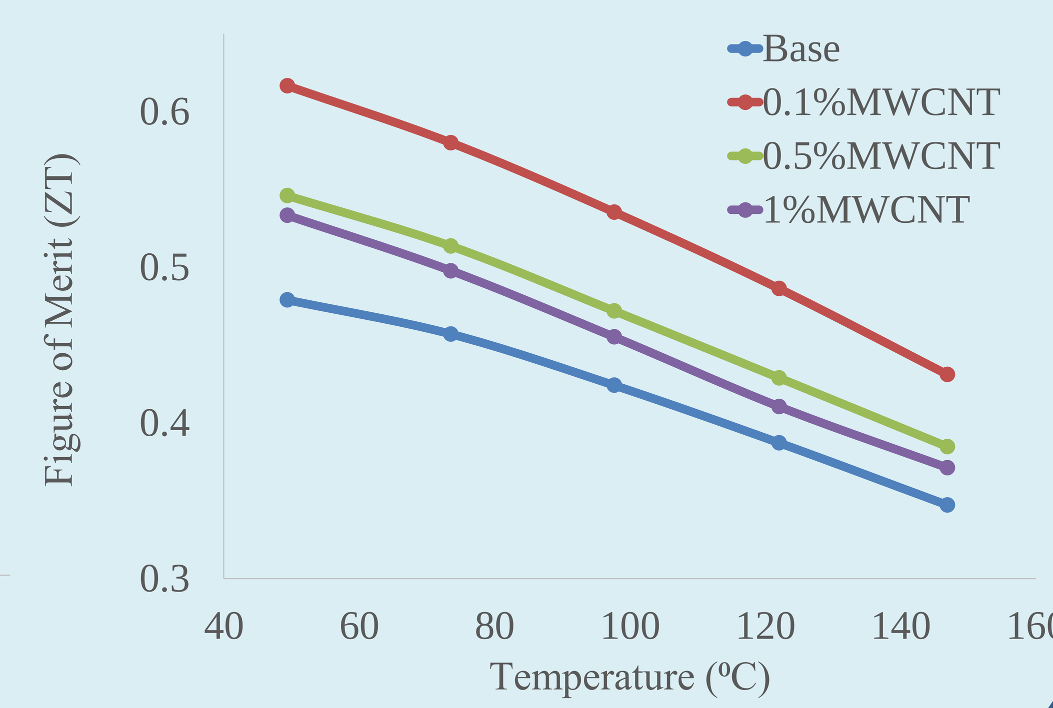


Figure 6. DSC curve of the 1st and 2nd heat cycles analysis of Bi_2Te_3 and 1% MWCNT/ Bi_2Te_3

ZT



Conclusion

- In the SEM images the MWCNT could not be seen clearly as Bi2Te3 is shielding it.
- Microhardness increases as a result of increasing MWCNT content
- The average grain size based on averbatch is 13 nm and the strain was 0.2
- DSC analysis reveals the grain growth (exothermic) temperature range 370~400ºC, $T_{m.p}$= ~416 ºC.
- Based on TEM analysis the average grain size distribution was found to be between 6 ~10 nm.
- 24% enhancement in the final ZT values at 150ºC increased from 0.35 to 0.43 and 30% enhancement at T_{RT} from 0.48 to 0.61.

References

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