

# PbTe-CdTe thermoelectrics: two-phase nanocomposite vs. single-crystalline $\text{Pb}_{1-x}\text{Cd}_x\text{Te}$ solid solution

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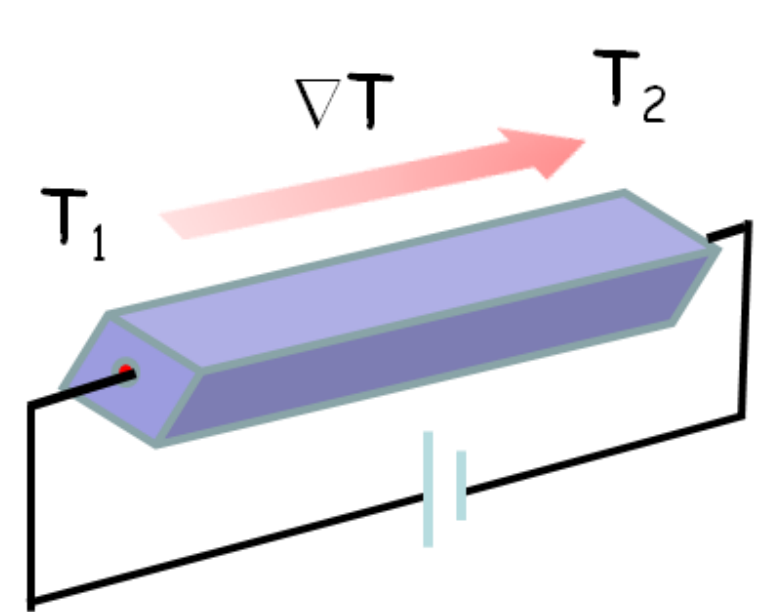
## Introduction

Thermoelectric generators and coolers are simple devices that can directly convert heat into electricity (generators) and vice versa (coolers). Such converters operate on the basis of Seebeck and Peltier effects, respectively, utilizing the ability of electrons to transfer heat and electric charge simultaneously.

### Thermoelectric effects

#### Seebeck effect

- the direct conversion of temperature difference to electric voltage



and vice versa

#### Peltier effect

### Thermoelectric efficiency

In this work we describe the preparation method of thermoelectric **PbTe-CdTe semiconductor nanocomposite** in the form of **bulk material** intended for thermoelectric generators working at mid temperature conditions.

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

disorder

$\sigma$  electrical conductivity  
 $S$  Seebeck coefficient  
 $\kappa$  thermal conductivity  
 $T$  temperature

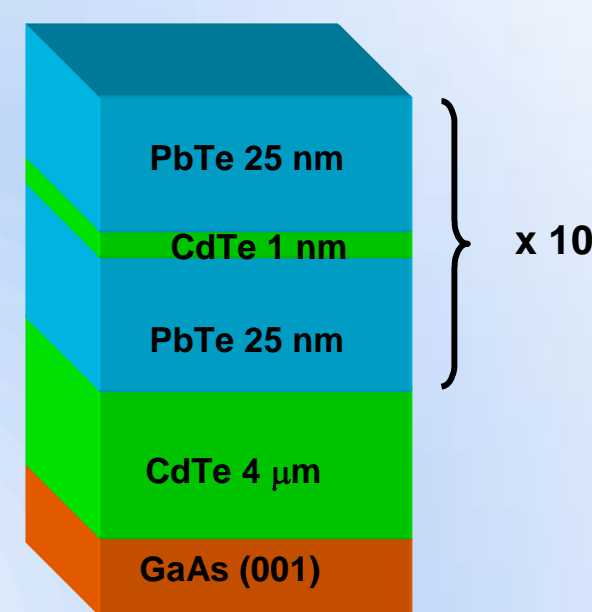
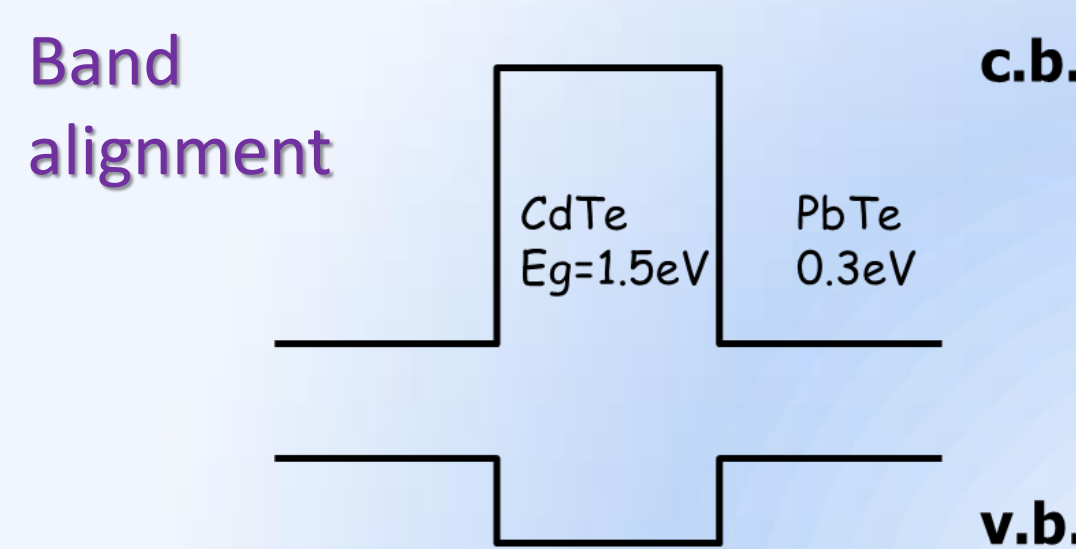
DOS  
"sharpening"

2D, 1D and 0D structures based on classic thermoelectrics

introduction of other phases into material

## Previous results

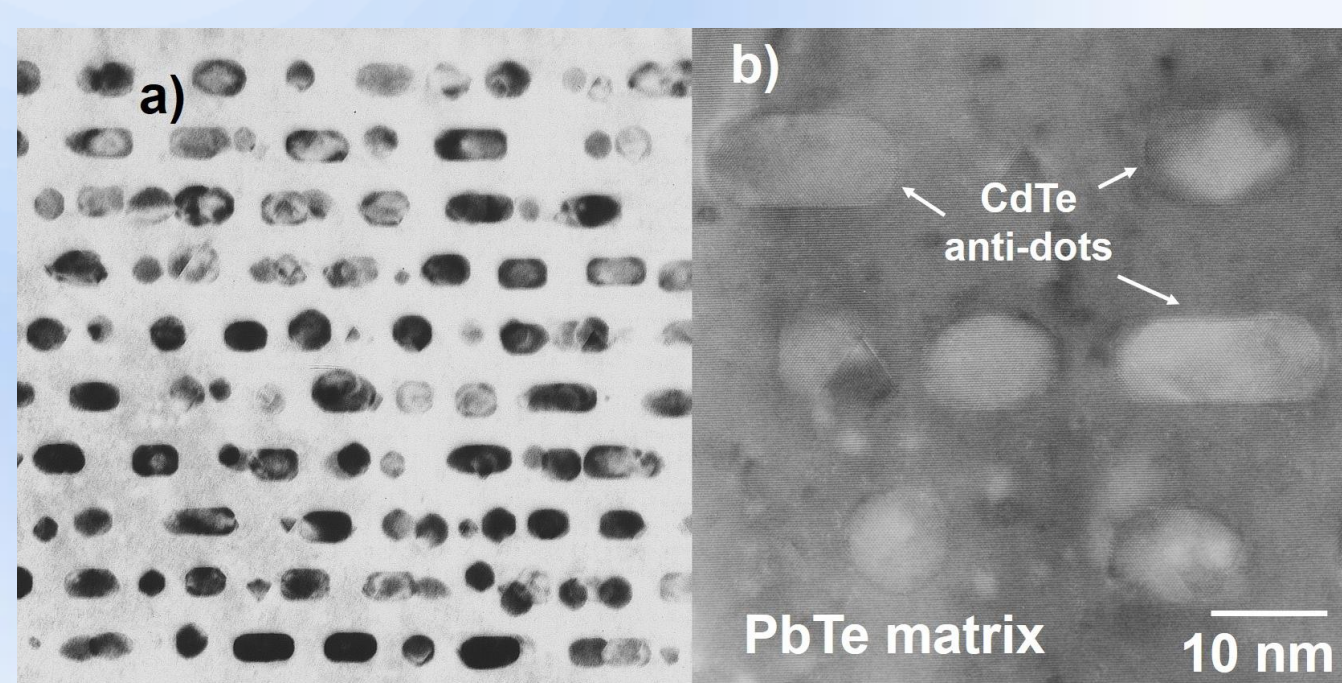
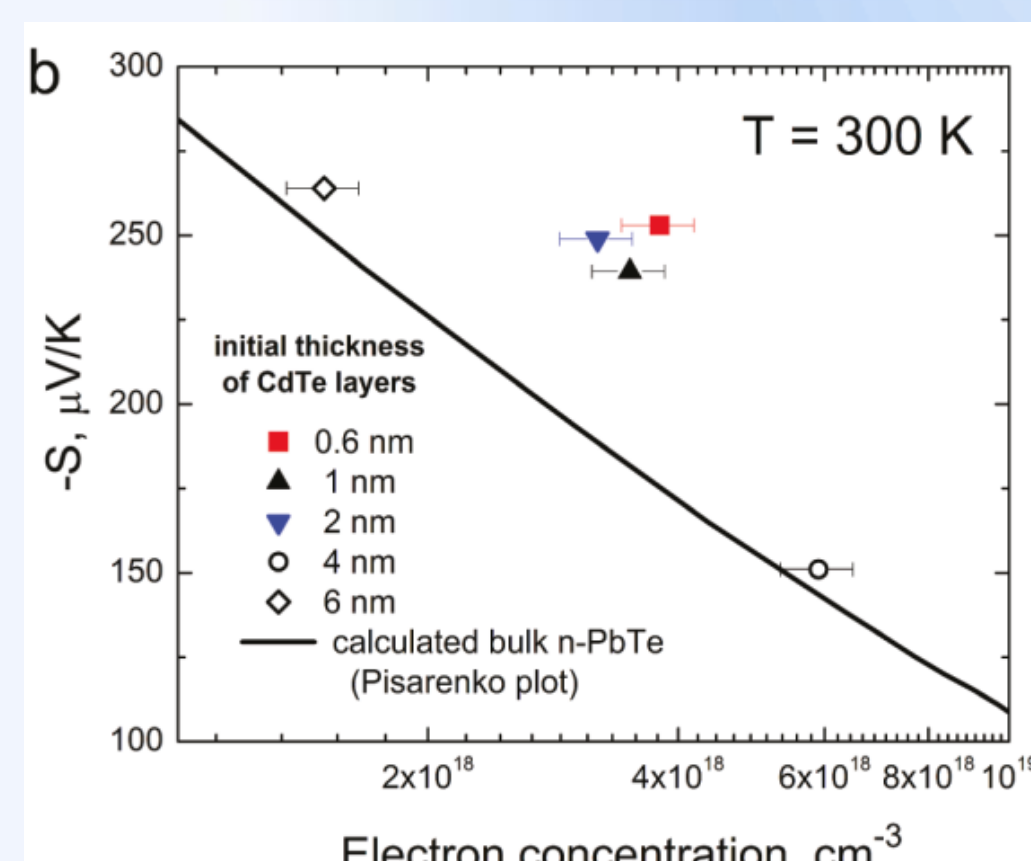
**Layered PbTe-CdTe epitaxial nanocomposite** obtained by the MBE growth method [1,2]



We can expect:

✓ decreased thermal conductivity

✓ increased Seebeck coefficient ( $S$ )



TEM image of CdTe anti-dots in PbTe matrix

## New results !!!

### Nanostructuring a method to improve ZT

#### Bulk PbTe-CdTe

#### polycrystalline nanocomposite

obtained by the Bridgman growth method

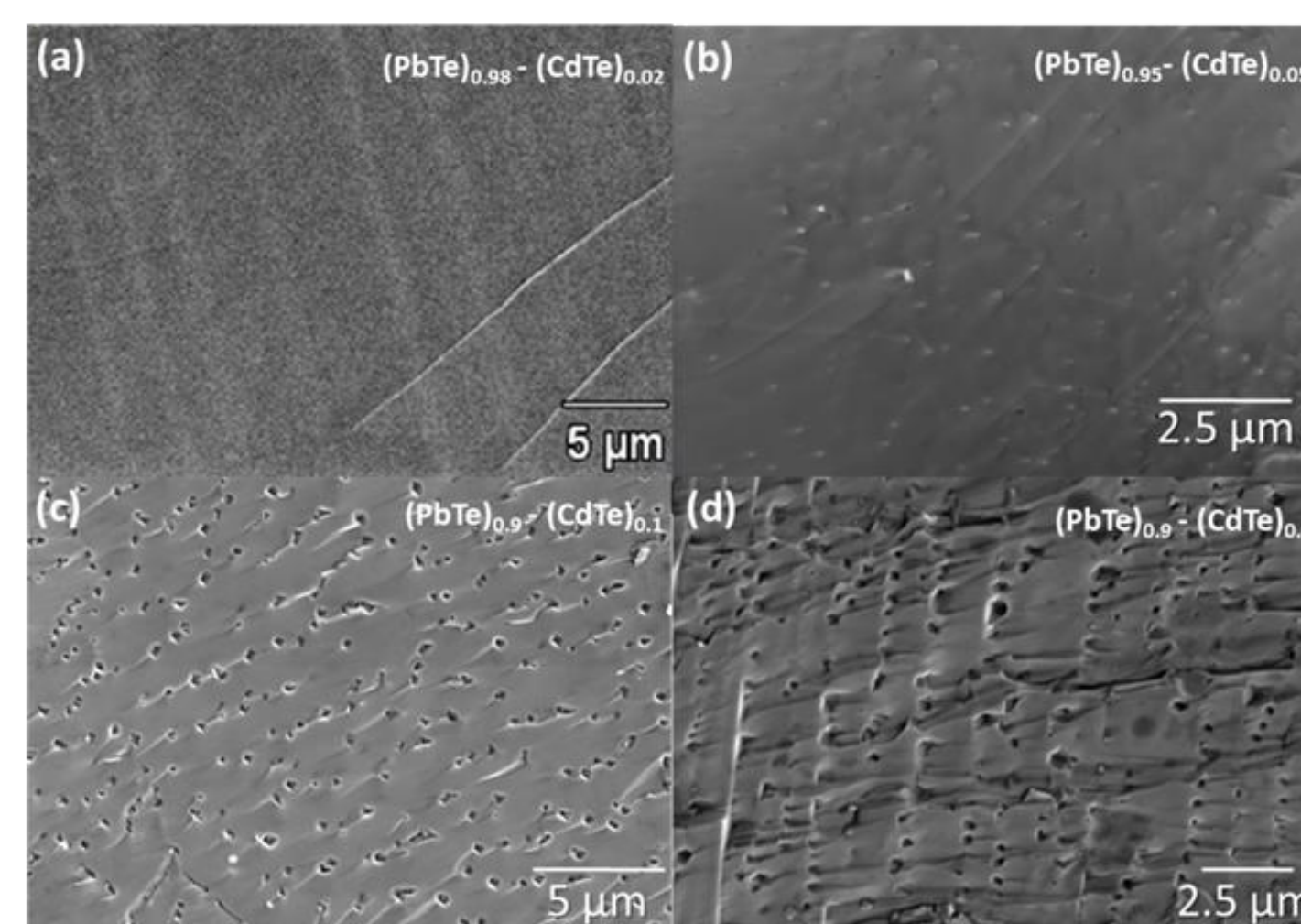
The method utilizes the **extremely low mutual solubility** of both semiconductors and is based on novel combination of the **modified Bridgman growth method** with proper preparation of constituent substances [4].



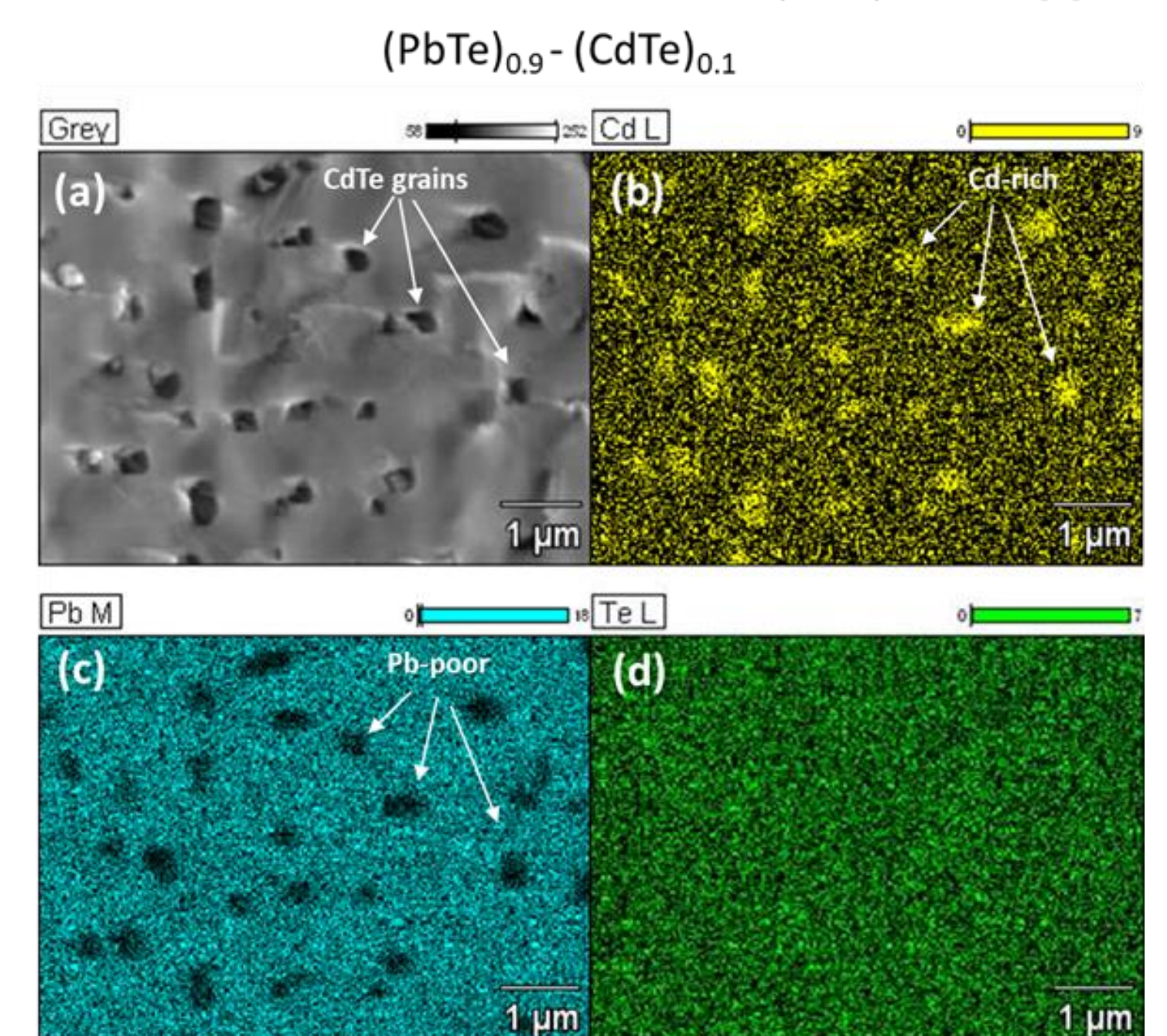
PbTe-CdTe nanocomposite sample cut from an ingot



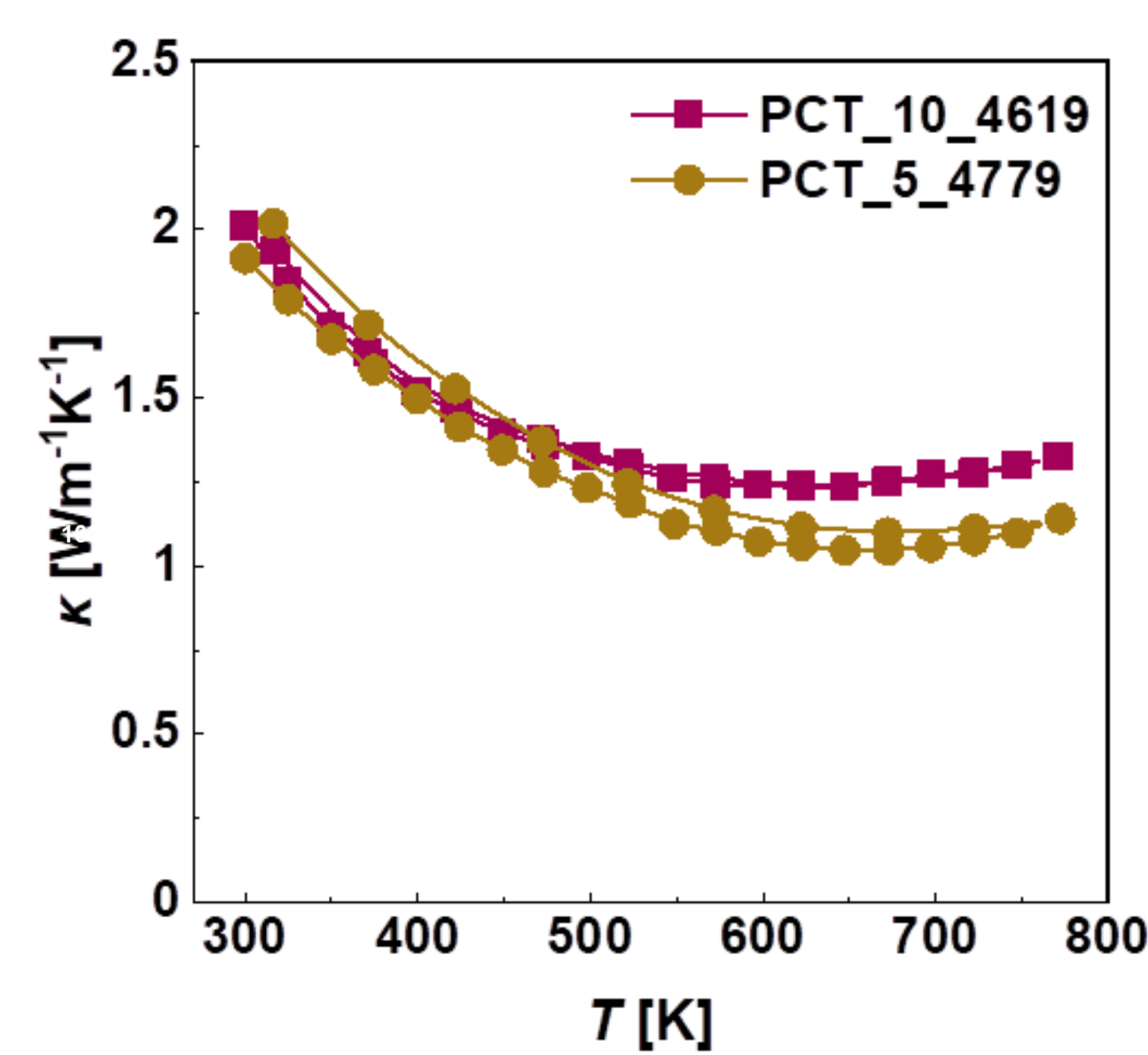
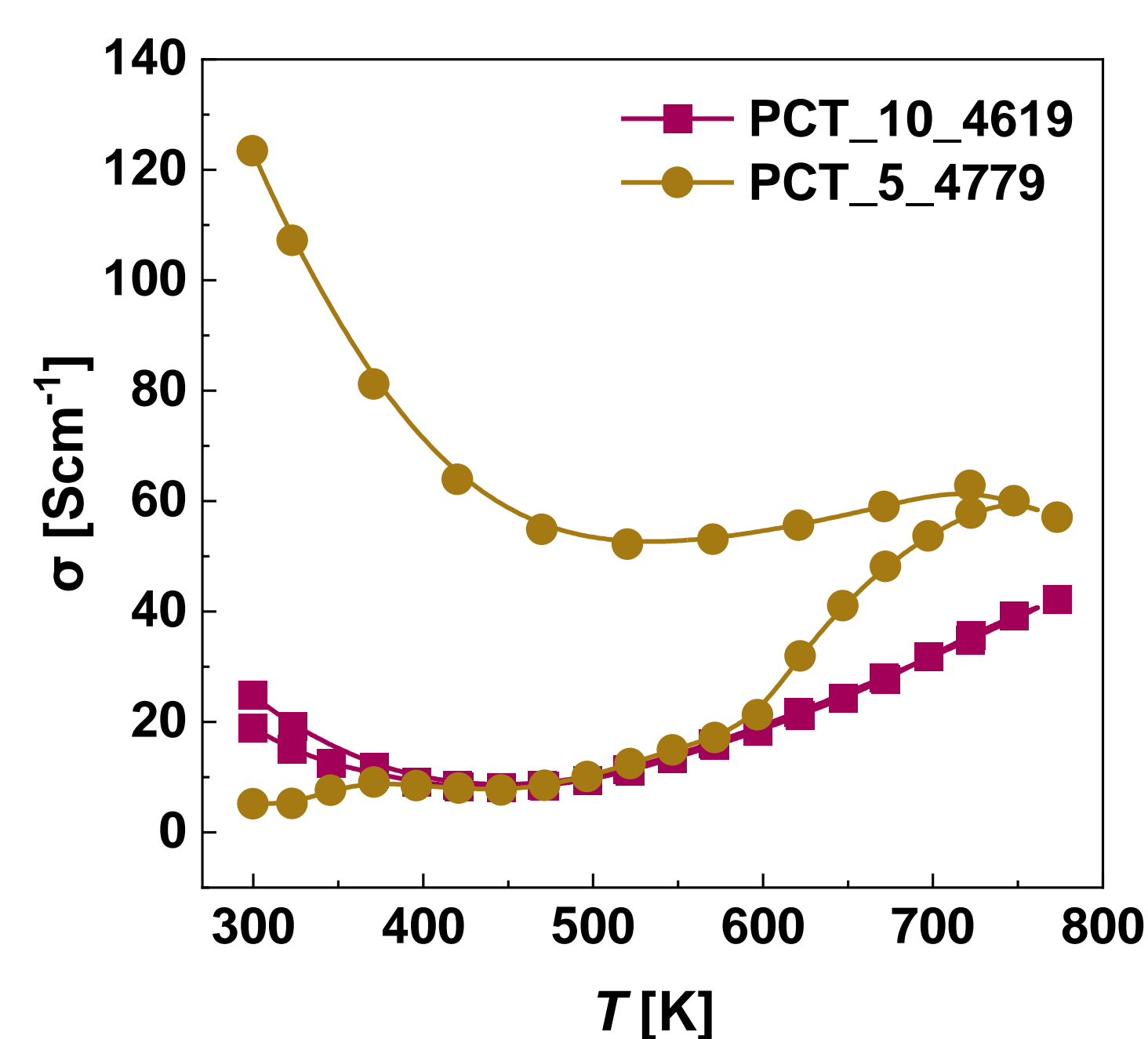
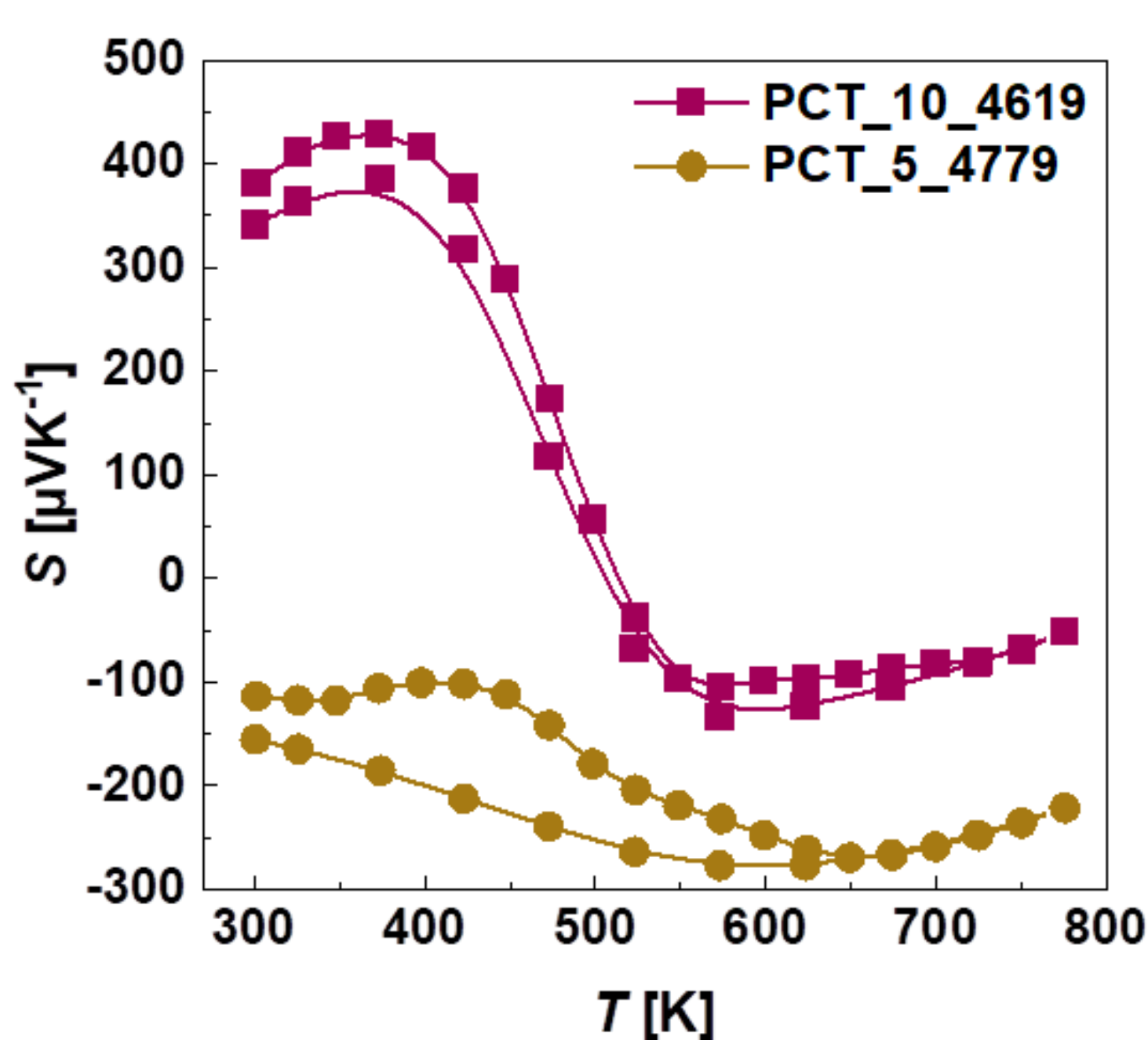
Pb<sub>1-x</sub>Cd<sub>x</sub>Te solid solutions monocrystal with high Cd content obtained by self-selecting vapor growth (SSVG) method [3]



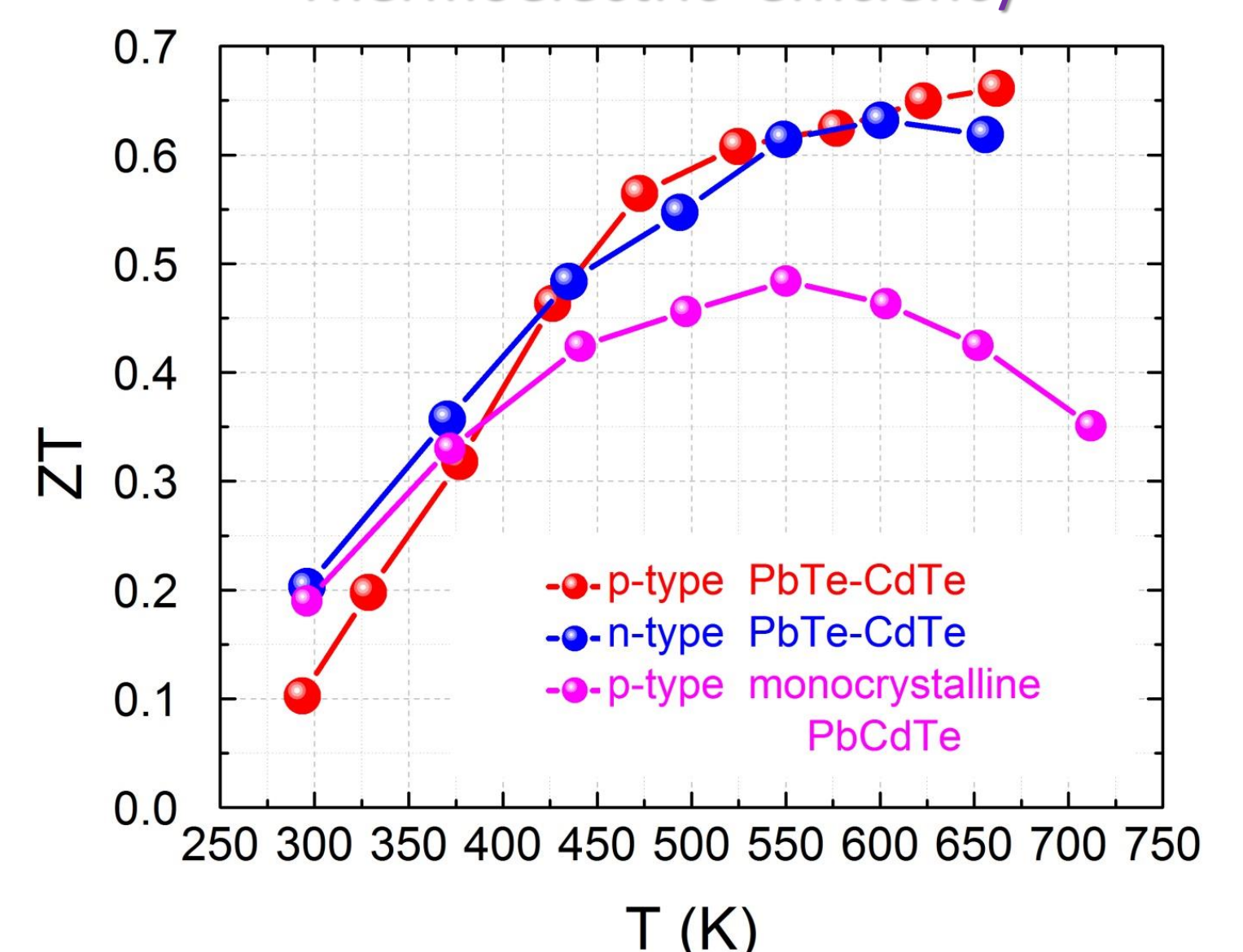
EDX analysis of PbTe-CdTe nanocomposite



## Thermoelectric characterization



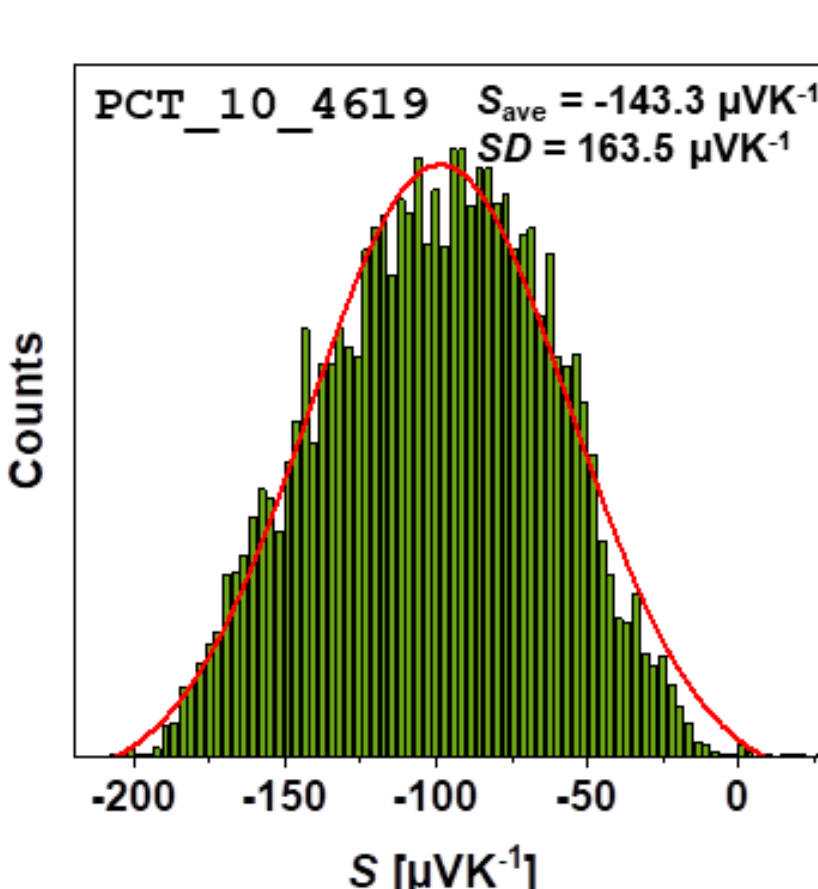
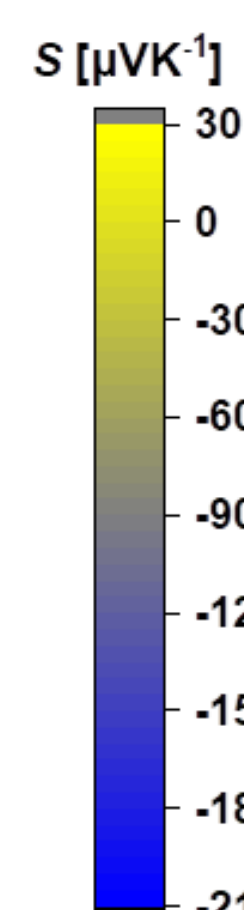
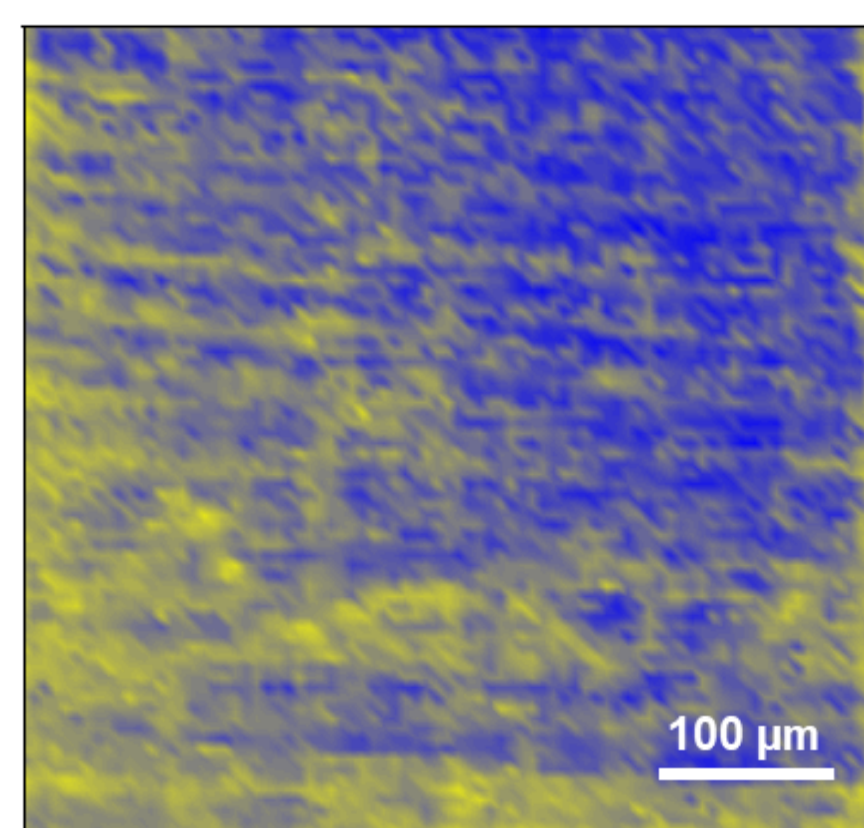
### Thermoelectric efficiency



## Summary

- Bulk PbTe-CdTe nanocomposite was obtained by the modified Bridgman method
- For PbTe-CdTe nanocomposite, an improvement in the thermoelectric efficiency was observed compared to the monocrystalline  $\text{Pb}_{1-x}\text{Cd}_x\text{Te}$  samples

Scanning Thermoelectric Microscope (SThM) maps and Seebeck coefficient histogram



### References

- [1] M. Szot et al., *Cryst. Growth Des.* 11, 4794 (2011)
- [2] G. Karczewski, M. Szot et al., *Nanotechnology* 26, 135601 (2015)
- [3] M. Szot et al., *Phys. Rev. Materials* 4, 044605 (2020)
- [4] M. Szot, K. Dybko, T. Story, A. Mycielski, European patent EP4036057A1, *European Patent Bulletin*, 2022, 49



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