Thermoelectric properties of SnSe composite with $MoSe_2$

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1. Introduction

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

High *PF* + Low *κ* → High *ZT*

High *PF*

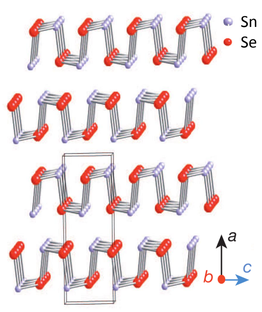
large α
- Quantum confinement
- Electron energy filtering
- Resonance levels

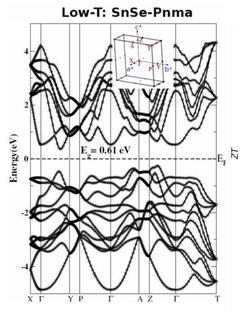
high σ
- Modulation doping
- Crystallite alignment
- Composite engineering

Low *κ*
- ◆ PGEC approach
- ◆ Nanostructuring techniques
- ◆ All-scale hierarchical structuring
- ◆ Intrinsic low κ
  Zintl phases
  Sulphur-based compound

Arash Mehdizadeh Dehkordi, *Mater. Sci. Eng. R* 97, 2015, 1–22 — Eyob K. Chere, *J. Mater. Chem. A*, 2016,4,1848-1854

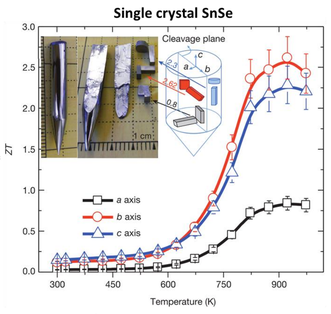
Crystal structure & electronic band structure of SnSe



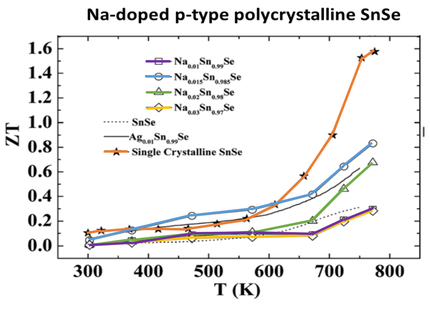


Li-Dong Zhao, *Nature* 13184,373-377(2014)

ZT of SnSe



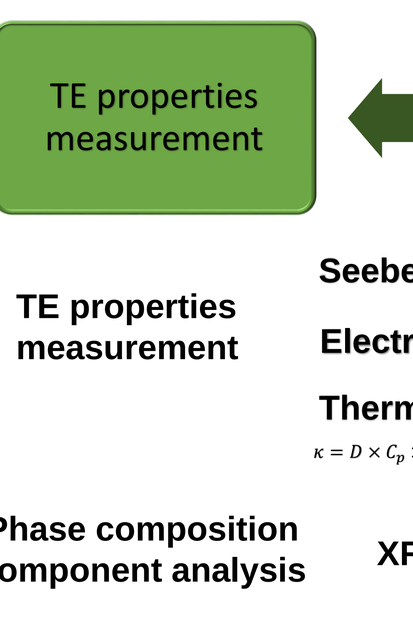
Li-Dong Zhao, *Nature* 13184,373-377(2014)



Eyob K. Chere, *J. Mater. Chem. A*, 2016,4,1848-1854

2. Motivations

SnSe and $MoSe_2$ Layered structural Isomers



Noel S. Gunning, J. Am. Chem. Soc, 2015,137,8803-8809

◆ Large cross-plane thermal resistance created by SnSe–$MoSe_2$ and $MoSe_2$ – $MoSe_2$ turbostratically disordered van der Waals interfaces

⇨ $[(SnSe)_{1.05}]_m(MoSe_2)_n$ κ ~ **0.08** W/mK @ 300

This work

➢ Search for low thermal conductivity in the bulk SnSe composite with $MoSe_2$, by conventional solid-state reaction method and densified by spark plasma sintering

3.Experimental procedures

Synthesis of SnSe+$MoSe_2$ from Sn, Se, Mo. → XRD patterns of the product has impure phases → Find another approach → Synthesis of $MoSe_2$ first → Synthesis of SnSe+$MoSe_2$ from SnSe, $MoSe_2$ → TE properties measurement

TE properties measurement

Seebeck coefficient α: Zem-3(323K~773K)

Electrical conductivity *σ*: Zem-3(323K~773K)

Thermal diffusivity *D*: Laser flash method(323K~773K)

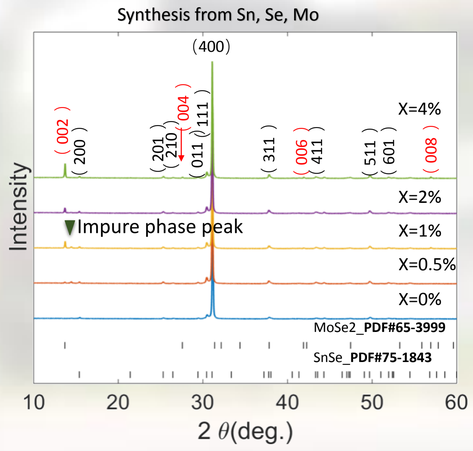
$\kappa = D \times C_p \times \rho (C_p: specific\ heat;\ \rho: density)$

Phase composition component analysis — **XRD, SEM, and EDX**

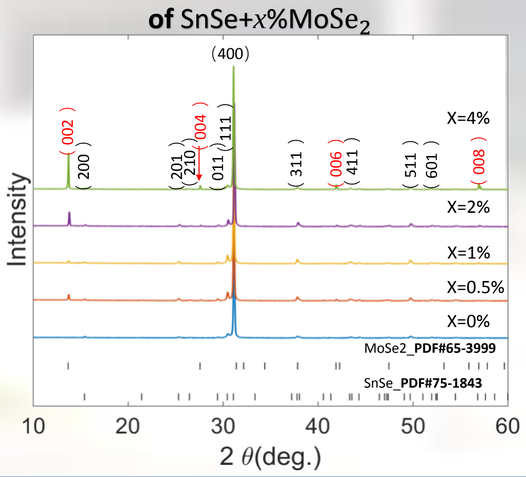
4.Results

Powder XRD-pattern of SnSe+*x*%$MoSe_2$

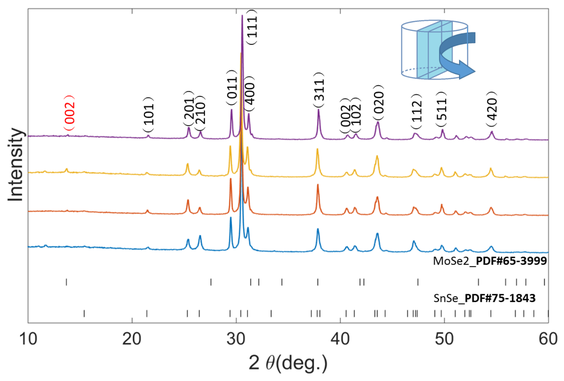
Synthesis from Sn, Se, Mo



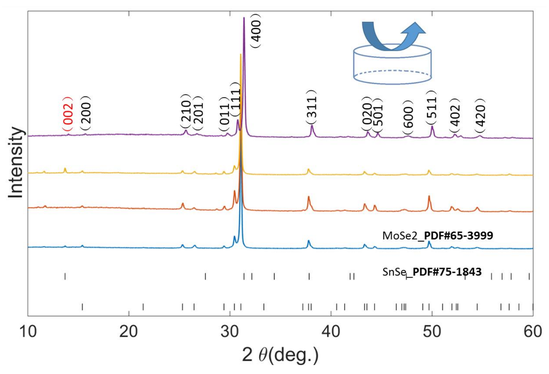
SnSe+*x*%$MoSe_2$



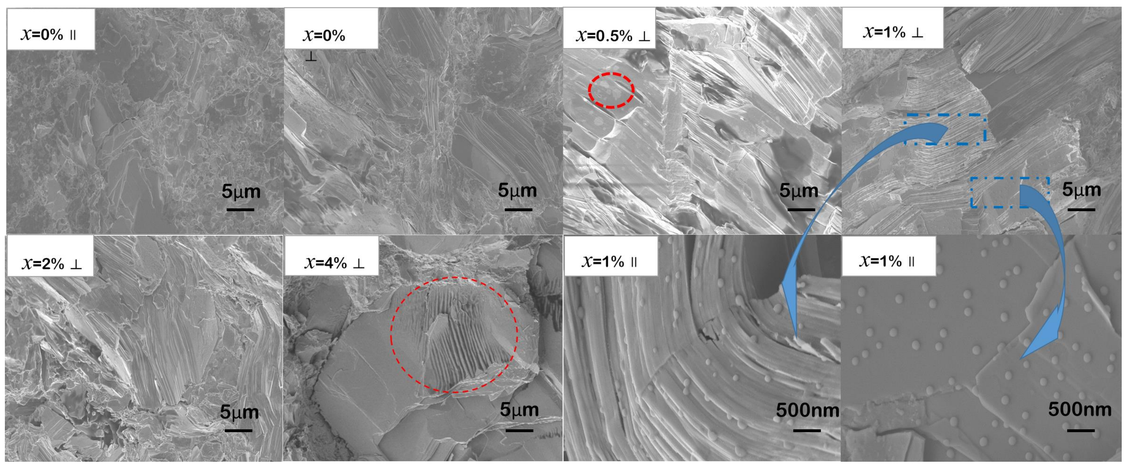
Bulk XRD-pattern ⊥



Bulk XRD-pattern ∥



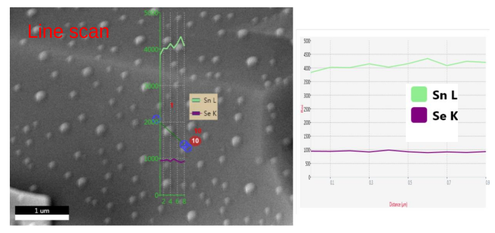
SEM images of SnSe+*x*%$MoSe_2$



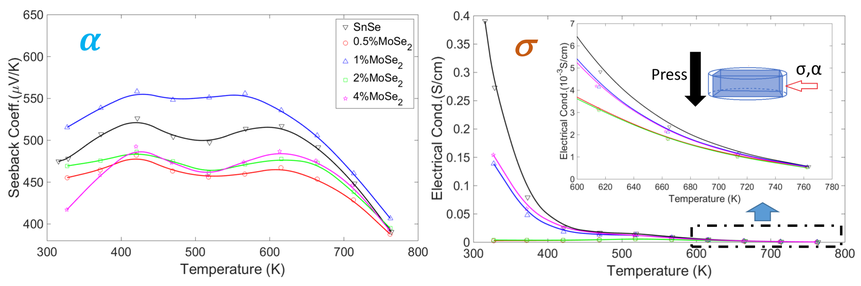
SEM: microstructure variable with the amount of $MoSe_2$ specially in⊥ direction

EDX results of SnSe+1.0%$MoSe_2$

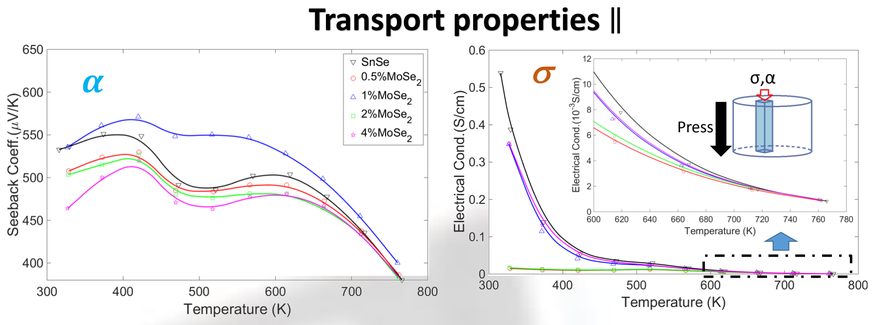
Precipitate phase consist of only Sn and Se elements indicated the same composition of main phase



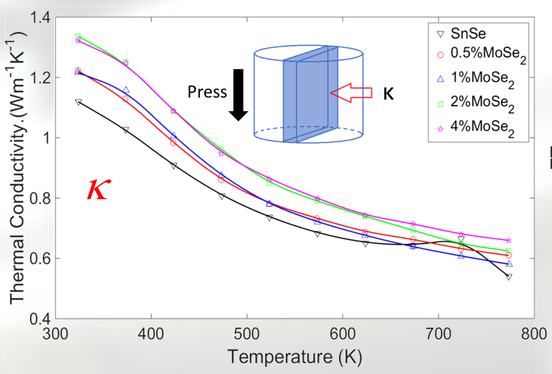
Transport properties ⊥



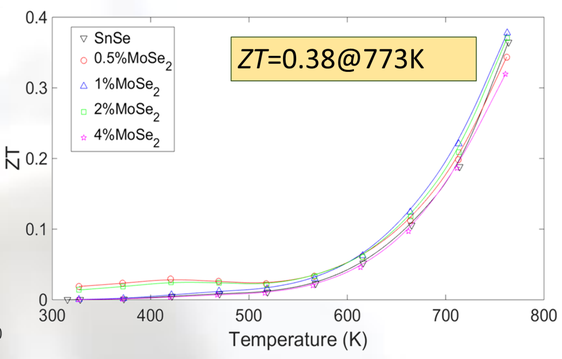
Transport properties ∥



Thermal properties ⊥



ZT values ⊥



5. Conclusions & Future plans

- SnSe+ *x*% $MoSe_2$ (*x* = 0.5, 1.0, 1.5 and 2.0) composites are prepared by were prepared by conventional solid-state reaction method followed by SPS;
- SEM images indicated that microstructure variable with the amount of $MoSe_2$;
- *ZT* values haven't changed significantly, and ZT_{max} ~ 0.38 is obtained at 773K for x = 0.10.

Future plans

For *x* = 1.0%, precipitated phase was observed in SEM which may lead to the exceptional behavior in transport properties. This encourage us to further investigate the formation mechanism of the precipitated phase.