# High-quality single crystalline SnSe grown by vapor phase methods for thermoelectric applications

M. Szot<sup>1,2</sup>, J. Korczak<sup>1,2</sup>, W. Wołkanowicz<sup>1</sup>, S. Chusnutdinow<sup>1</sup>, W. Zaleszczyk<sup>1,2</sup>, L. Kowalczyk<sup>1</sup>, R. Minikayev<sup>1</sup>, M. Aleszkiewicz<sup>1</sup>, Z. Adamus <sup>1,2</sup>, G. Karczewski<sup>1</sup>, T. Wojtowicz<sup>2</sup>, T. Story<sup>1,2</sup>



<sup>1</sup> Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland

<sup>2</sup> International Research Centre MagTop, Institute of Physics Polish Academy of Sciences, Al. Lotników 32/46, PL-02668 Warsaw, Poland

This research was partially supported by the Foundation for Polish Science project "MagTop" no. FENG.02.01-IP.05-0028/23 co-financed by the European Union from the funds of Priority 2 of the European Funds for a Smart Economy Program 2021–2027 (FENG) by TechMatStrateg2/408569/5/NCBR/2019 and project TERMOD of NCBR and by the National Science Centre through Grant No. 2021/41/B/ST3/03651

about SnSe			Growth methods we used	
Orthorombic structure if bulk – indirect bandgap material Eg=0.89 eV	2D Orthorhombic	easy exfoliation	Direct synthesis and physical vapour deposi	ition



### SnSe by PVD – SEM characterization top view **SnSe on GaAs**

## 20 µm of SnSe side view GaAs substrate or





### SnSe by SSVG – AFM characterization

#### SnSe by SSVG – XRD characterization

SnSe single crystals by SSVG



optical transmission

electrical characterization

Summary

#### Energy, eV 1.3 1.2 1.1 0.9 0.8 0.7 /=10μA /=1mA SnSe SSVG # 340 295 K *Ι*=10μΑ 3.0 vdP vdP 0.20 vdP sion, arb. u. 2.5 -1.0 0.15 *B*=0.5T $R_{\rm xx}(\Omega)$ $R_{xx}(\Omega)$ 2.0 -*B*=-0.5T Transr 1.5 0.9 -5 K 0.05 1.0 0.00 0.5 · 1800 1200 2000 1000 1400 1600 250 150 300 50 100 -10 200 -8 10 Wavelength, nm T(K) B(T)

- SnSe single crystals and thin films were obtained using vapor phase growth methods (PVD and SSVG)
- Crystals obtained using the SSVG method exhibit an atomically smooth surface
- Further electrical and thermoelectric characterization is necessary





