Photoluminescence studies of the futuristic SnSe semiconductor

M. Szot[1, 2], P. Wojnar[1, 2], J. Korczak[1, 2], W. Zaleszczyk[1, 2], L. Kowalczyk[1], S. Chusnutdinow[1, 2], R. Minikayev[1], W. Wołkanowicz[1], M. Aleszkiewicz[1], T. Story[1,2], G. Karczewski[1]

[1] Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland
[2] International Research Centre MagTop, Institute of Physics Polish Academy of Sciences, Al. Lotników 32/46, PL-02668 Warsaw, Poland

The research was partially supported by by the Foundation for Polish Science through the IRA Programme co-financed by EU within SG OP (Grant No. MAB/2017/1) and by the National Science Centre through Grant No. 2021/41/B/ST3/03651.

… about SnSe

Orthorombic structure

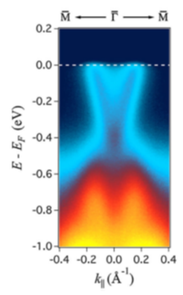
…if bulk – indirect bandgap material
Eg=0.89 eV

…if monolayer – indirect bandgap material
Eg=1.63 eV

W. Shi et al. Nano Lett. 15, 6926 (2015)

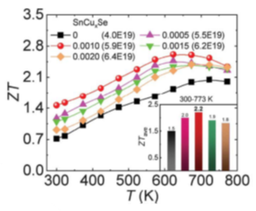
Y. Wang et al. Mat. Tod. Physics **32**, 101018 (2023)

…TCI if force cubic structure



W. Jin et al. Phys. Rev. X **7**, 041020 (2017)

- high absorption coefficient (10^5/cm)
- strong excitonic effect (10 meV →0.27 eV)
- earth-abundant material
- eco-friendly
- application-friendly



ZT= 2.6

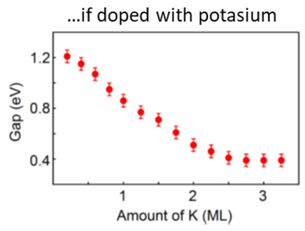
…due to low thermal conductivity

L. D. Zhao et al. Nature **508**, 373 (2014)

D. Liu et al. Science **380**, 841 (2023)

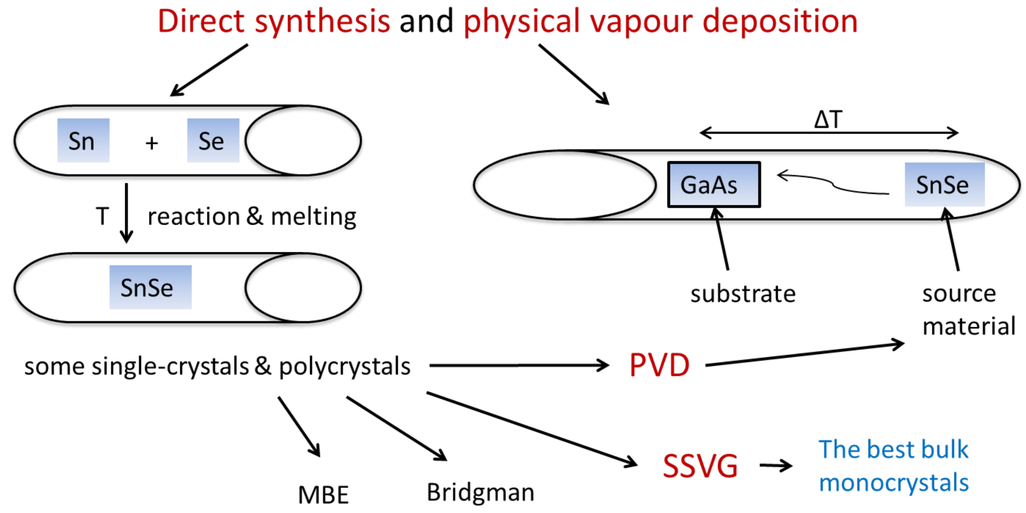
Tunable bandgap

…if doped with potasium



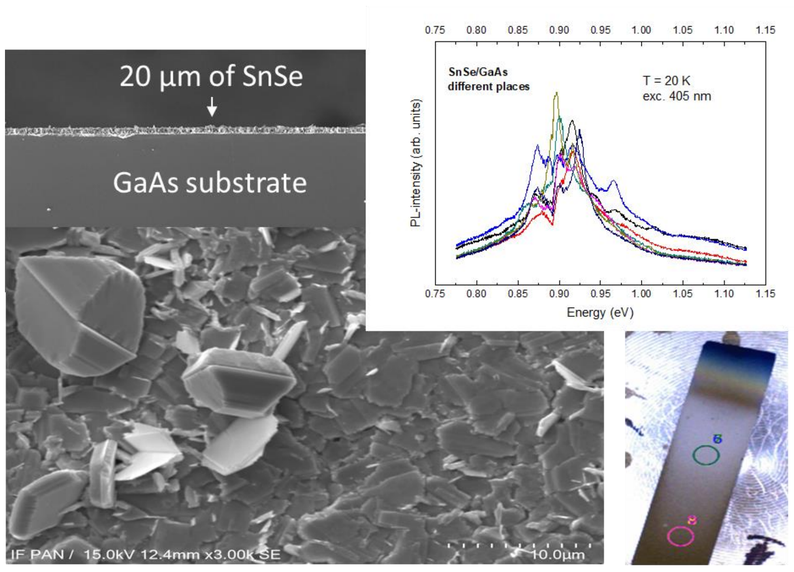
Growth methods we used

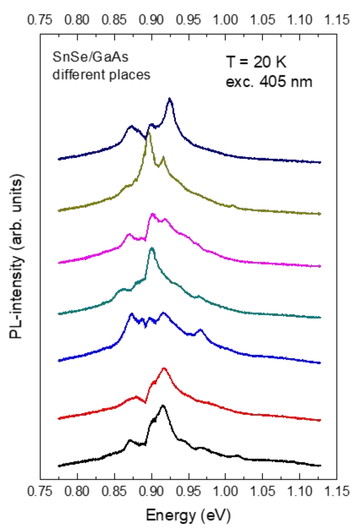
Direct synthesis and physical vapour deposition



easy exfoliation

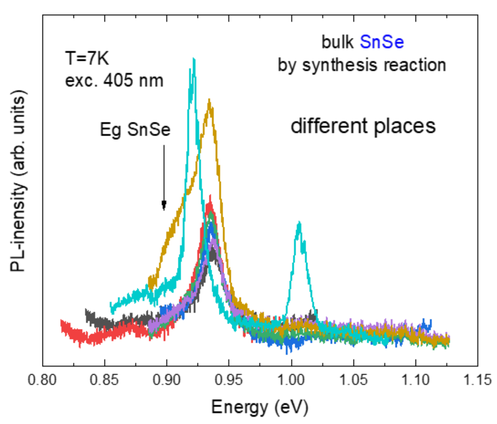
SnSe by physical vapour deposition – photoluminescence



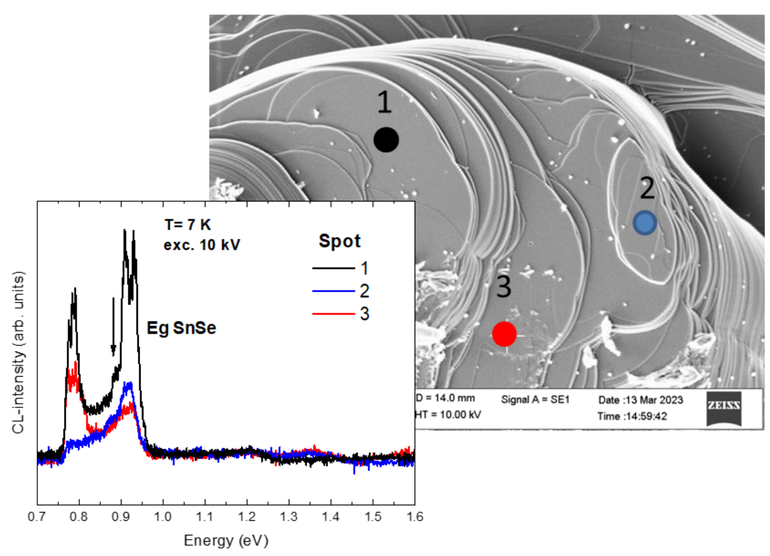


SnSe by direct synthesis - photo- and cathodoluminescence vs position

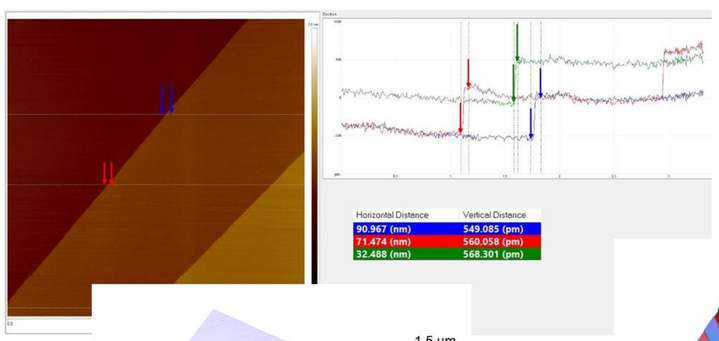
Photoluminescence

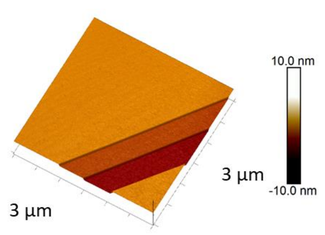


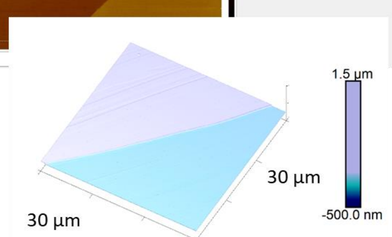
Cathodoluminescence

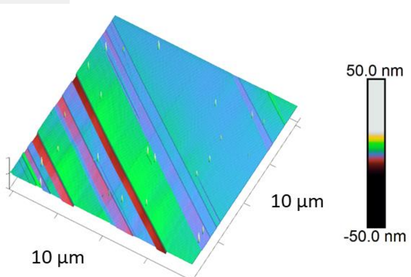


SnSe by SSVG- AFM characterization

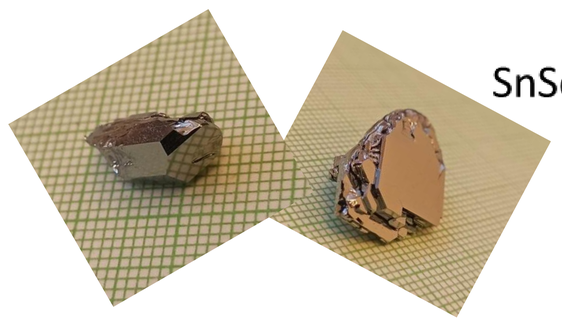


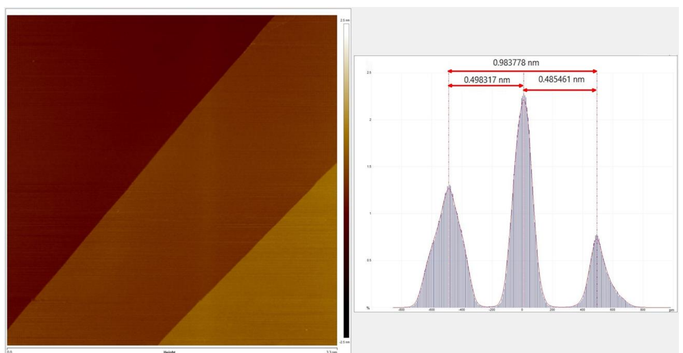




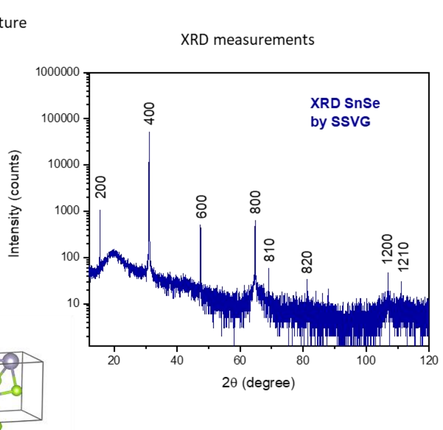


SnSe monocrytals by SSVG - XRD characterization





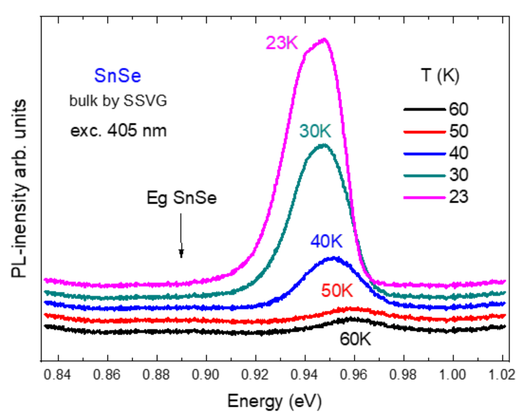
Orthorhombic structure
Space Group: *Pnma*
Lattice parameters:
a = 11.5033(3) Å
b = 4.1535(1) Å
c = 4.4446(1) Å
α = 90.0 °
β = 90.0 °
γ = 90.0 °



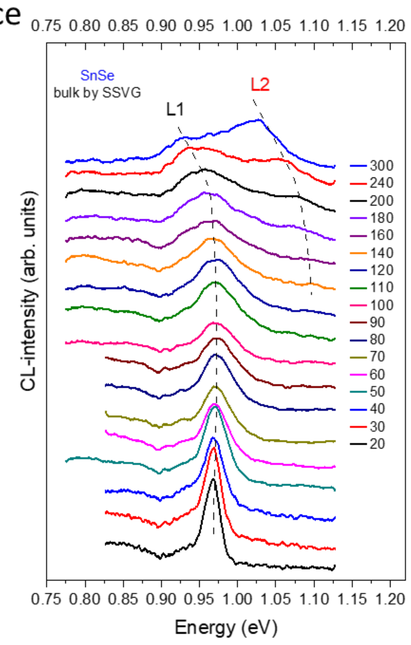
2θ/θ curve with marked Miller indices of reflections for (100) oriented the SnSe monocrystalline sample

SnSe by SSVG – photo - and cathodoluminescence vs temperature

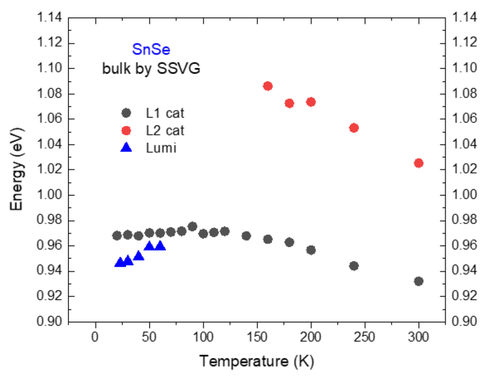
Photoluminescence
exc. 3 eV



Cathodoluminescence
exc. 20 kV

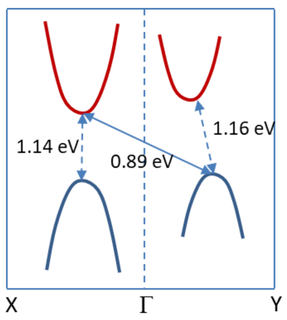


luminescence summary



SnSe by SSVG – luminescence summary and interpretation

bands diagram



W. Shi et al. Nano Lett. **15**, 6926 (2015)