Growth of Gray Tin epilayers on insulating (001)-CdTe/GaAs substrates and its Angular Resolved Photoemission Spectroscopy studies

B. Turowski[1]*, R. Rudniewski[1], M. Rosmus[2], M. Aleszkiewicz[3], T. Wojciechowski[1], W. Zaleszczyk[1], Z. Muhammad[1], N. Olszowska[2], T. Wojtowicz[1], V. V. Volobuev[1]

[1] International Research Centre MagTop, Institute of Physics, Polish Academy of Sciences, Aleja Lotników 32/46, PL-02668 Warsaw, Poland

[2] National Synchrotron Radiation Centre SOLARIS, Jagiellonian University, Czerwone Maki 98, PL- 30392 Kraków, Poland

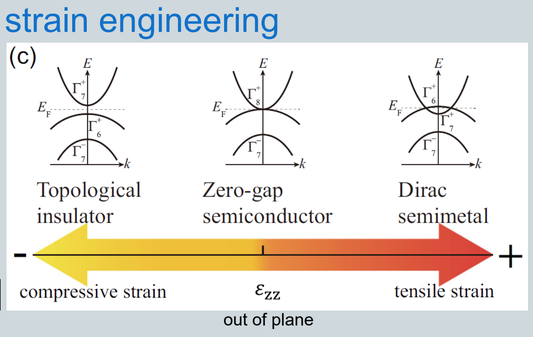
[3] Institute of Physics, Polish Academy of Sciences, Aleja Lotników 32/46, PL-02668 Warsaw, Poland

*e-mail: turowski@magtop.ifpan.edu.pl

Introduction & Motivation

Fundamental point

Phase transitions realized by strain engineering



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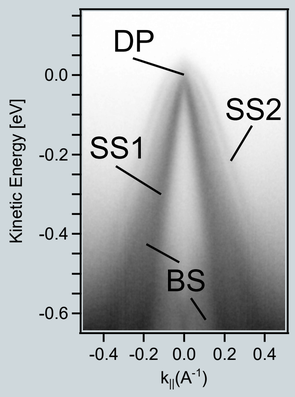
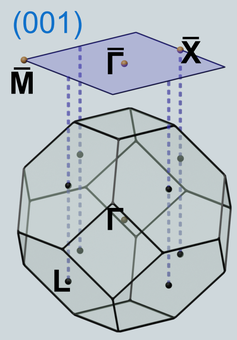
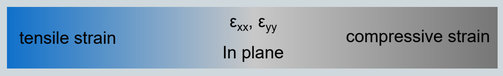
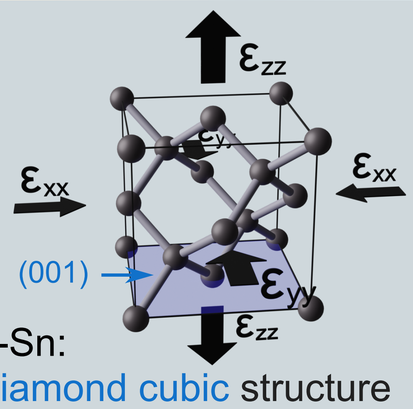


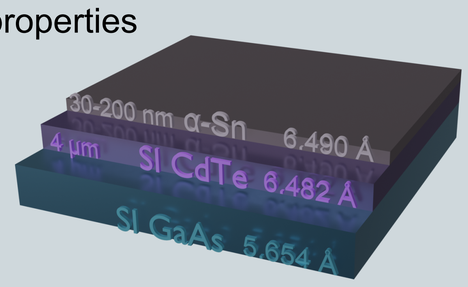






α-Sn:
Diamond cubic structure
Compressive in-plane strain

MBE growth on semi insulating (SI) substrates to study transport properties



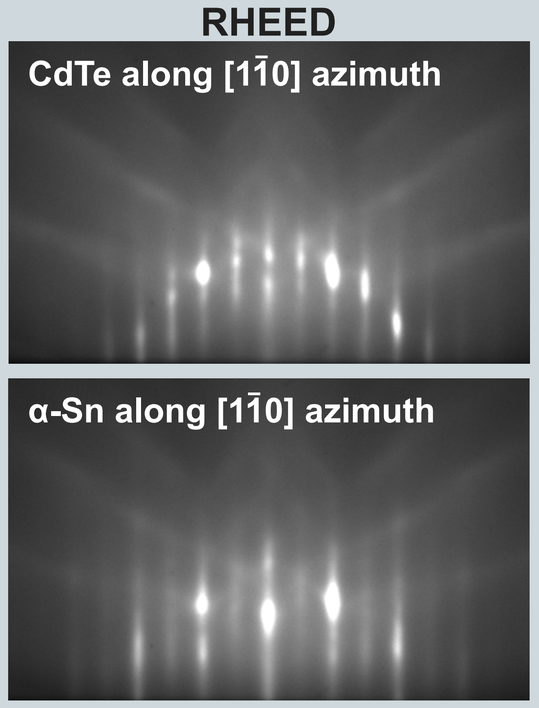
Compressive in-plane strain **-0.1%** due to lattice mismatch

Transport measurements in external magnetic field

- breaks time-reversal symmetry ⟶ Weyl semimetal
- induces chiral anomaly in $\vec{B}$ parallel to current

MBE growh of thin α - Sn films

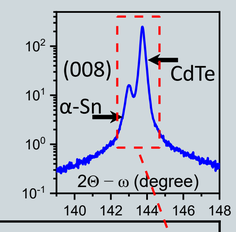
RHEED



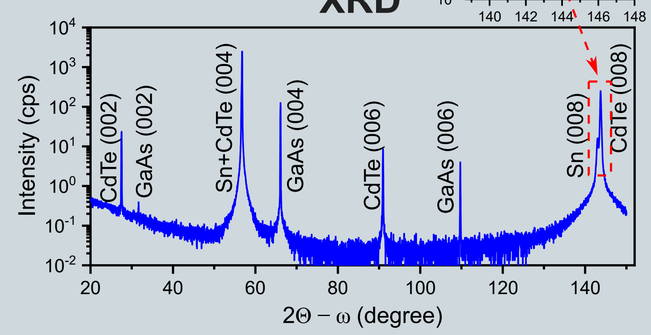
Conditions

- MBE growth below RT
- Bulk α-Sn stable only below 13.2°C
- α-Sn thin epitaxial film stable above RT [2]

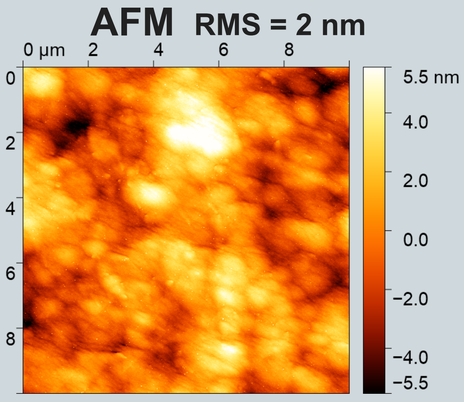
α-Sn XRD for (001) orientation present only at (00X) planes, where X is divisible by 4.

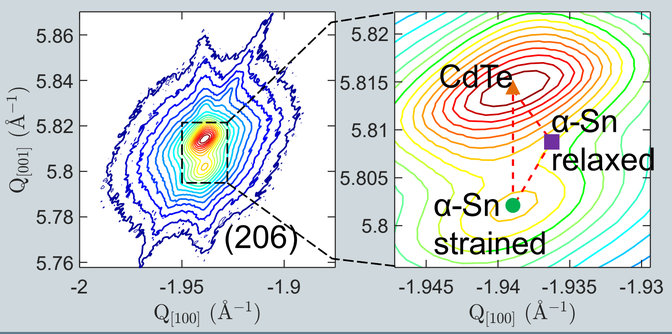


XRD



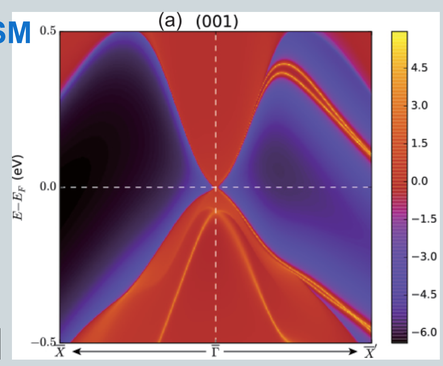
AFM RMS = 2 nm





Angular Resolved Photoemission Spectroscopy (ARPES) results

DSM



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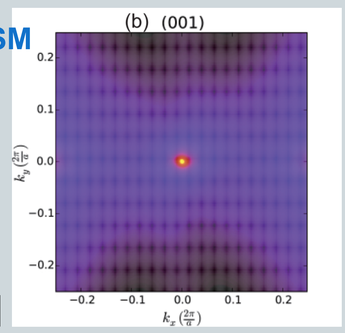
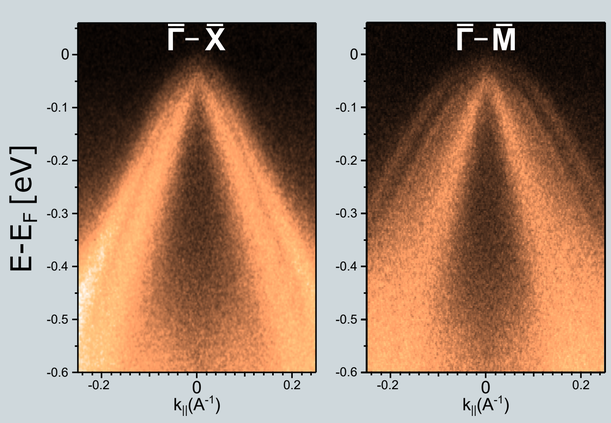
DSM



[5]

The projected surface states and corresponding Fermi surface of semi-infinite α-Sn under a compressive in-plane strain of −1% [5].



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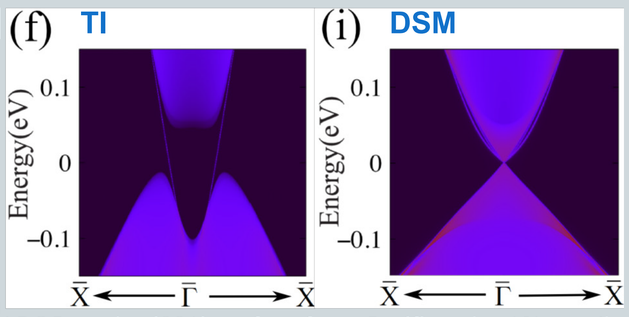
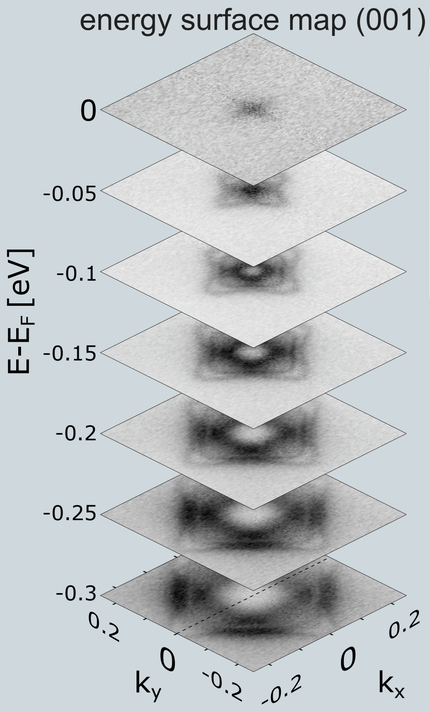
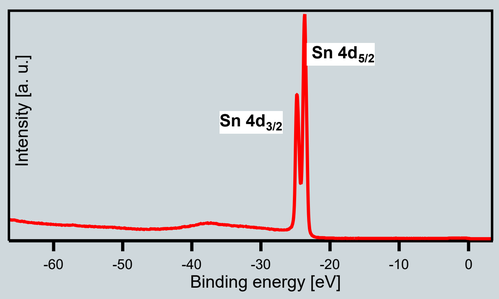


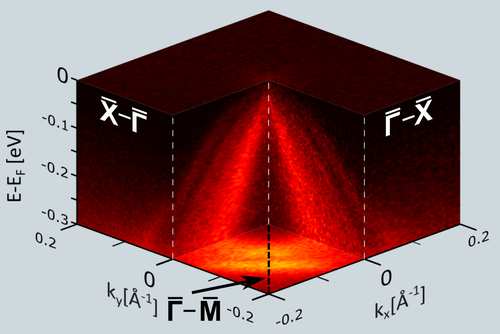
LDOS on the (001) surface for α-Sn (f) under 1% tensile strain and (i) under 1% compressive strain [1].

150nm α-Sn:Constant energy surface map (001)



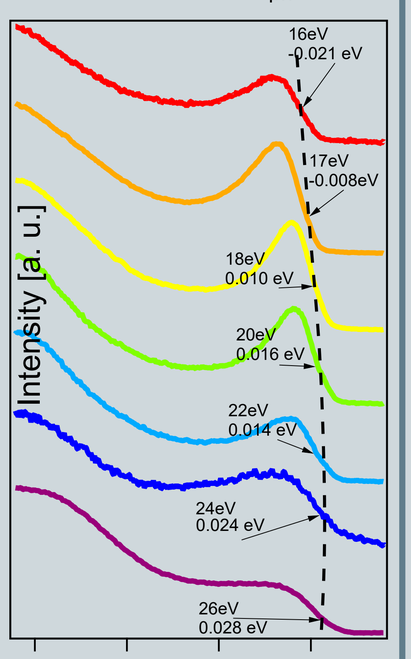
Core levels of 150nm α-Sn





3D ARPES map of 150nm α-Sn at $\bar{\Gamma}$ point (001)

Energy Dispersion Curves in function of E_{ph}



Summary

- Good quality grey Sn thin films obtained on semi insulating substrate shown by RHEED, AFM and XRD data.
- -0.1% compressive strain by XRD measurements - DSM phase [1,5]
- ARPES spectra show DSM phase as predicted theoretically in [1]
- Negative longitudinal magnetoresistance (NLMR) - additional signature of DSM phase from transport measurements

ARPES spectra of grown grey Sn thin films are in agreement with theoretical predictions [1] of DSM phase presence for compresively strained α-Sn. Growth on hybrid insulating CdTe/GaAs substrate allowed for further transport measurements that show NLMR and suggests transition of α-Sn DSM to Weyl semimetal (WSM) under magnetic field.

α-Sn is a promissing material with possibble applications such as spin to charge conversion by spin pumping or employement in high-speed electronics and spintronics (e.g. spin-filter transistor with a controllable spin polarized current) as WSM.

References

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Acknowledgements

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