Weak anti-localization effect in SnTe based epitaxial thick layers

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Abstract

- Certain IV-VI semiconductors (SCs) exhibit intriguing features e.g. topological surface states, room temperature ferroelectricity and giant Rashba effect which hold potential for spintronic applications.
- Polar GeTe is proposed to integrate both its intrinsic ferroelectric polarization (broken inversion symmetry) and Rashba spin splitting (*k*-dependent splitting).
- Topological crystalline insulator, SnTe possess robust metallic surface states originating from intrinsic spin-orbit interaction.
- Our preliminary work on $Ge_{1-x}Sn_xTe$ epitaxial layers demonstrate low-temperature weak anti-localization (WAL) effect below $T \sim 3.5$ K and $|B| \leq 0.2$ T.
- Similarly, $\rho_{xx}(B)$ results of α-GeTe show a small WAL effect only at lowest measured temperature of $T \sim 1.6$ K. However; the WAL effect disappears at $T = 4.2$ K for both α-GeTe and SnTe epitaxial layers.

Introduction and motivation

Choice of IV-VI semiconductors

- **Narrow band-gap** as a prerequisite to produce giant Rashba effect.
- Room temperature **ferroelectricity** up to $x = 0.7$ for $Ge_{1-x}Sn_xTe$ [1].
- Presence of **topological surface states**.
- Possibility of RT **non-volatile memory** applications [2].
- Higher charge carrier concentration.
- GeTe-SnTe as good **thermoelectric** s

Projected plans

- We are working on $Ge_{1-x}TM_xTe$ multiferroics to:

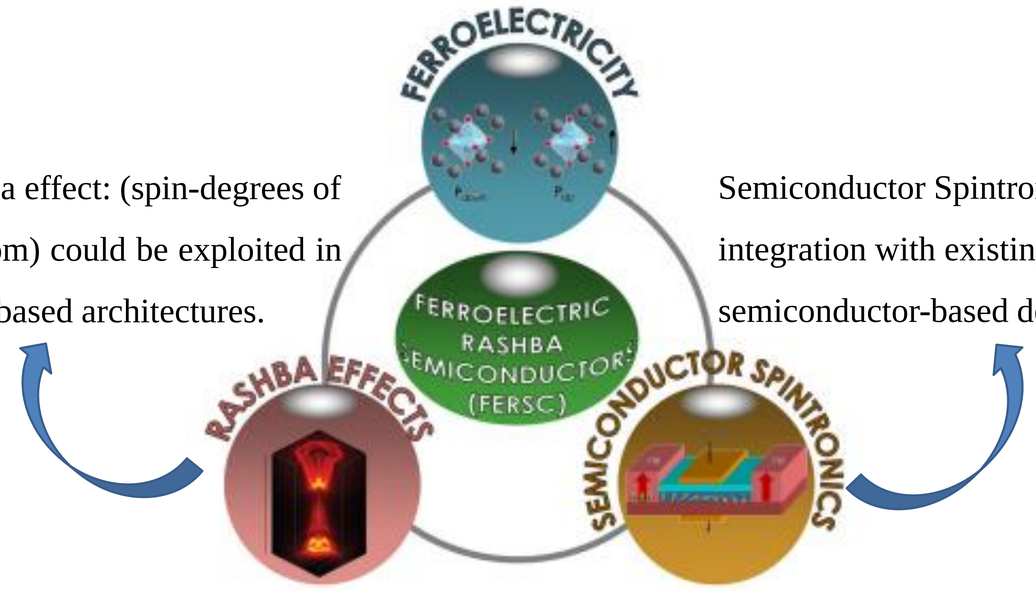
1) Correlate ferroelectricity and spin texture.
2) Inspect the Impact of Sn/Mn on low temperature scattering mechanisms.
3) Discover possible topological surface states in GeTe led ternary and quaternary alloys
4) Tune the ferroelectric domain walls with impurities and temperature.

[1] J. N. Bierly et al., *Acta Metallurgica*, 1963, **11**, 447.
[2] C. Rinaldi et al., *Nano Lett*. 2018, **18**, 2751.

Potential for spintronic applications

Ferroelectricity: switchability of ferroelectric polarization by an electric field

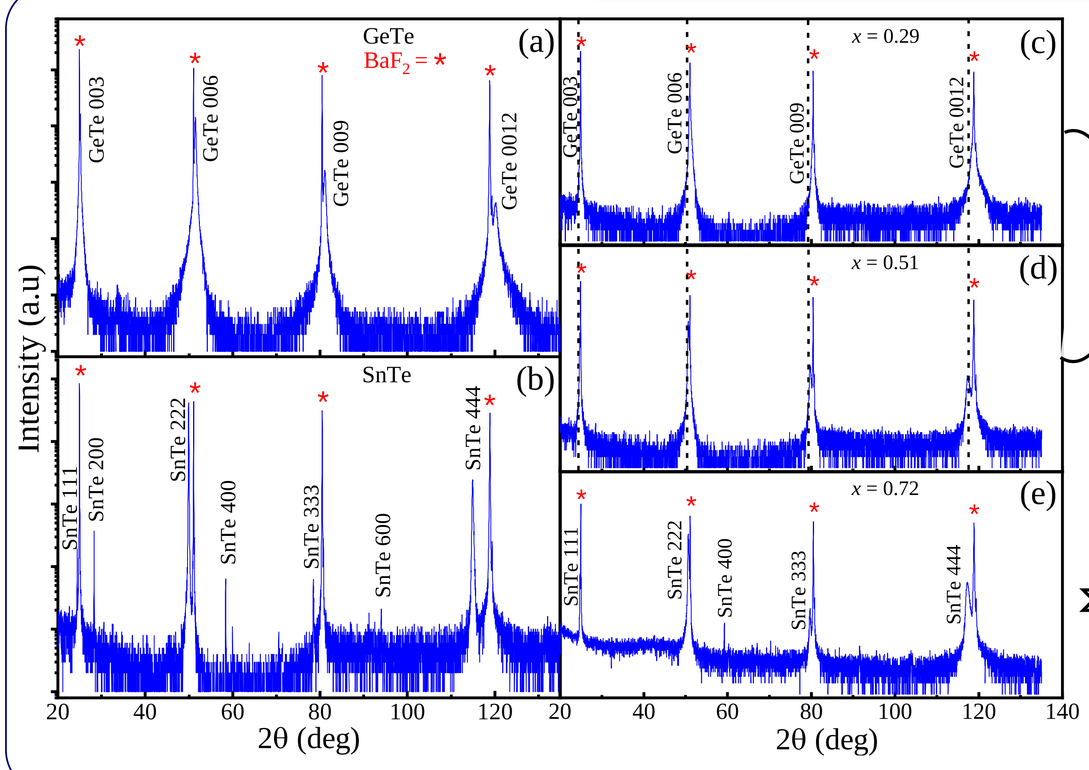
Rashba effect: (spin-degrees of freedom) could be exploited in logic-based architectures.



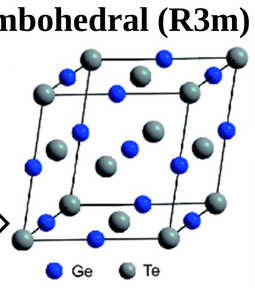
Semiconductor Spintronics: integration with existing semiconductor-based devices.

[3] S. Picozzi, *Front. Phys*., **2**: 10 (2014).

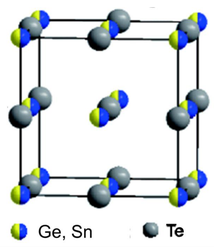
Lattice structure and phase transition



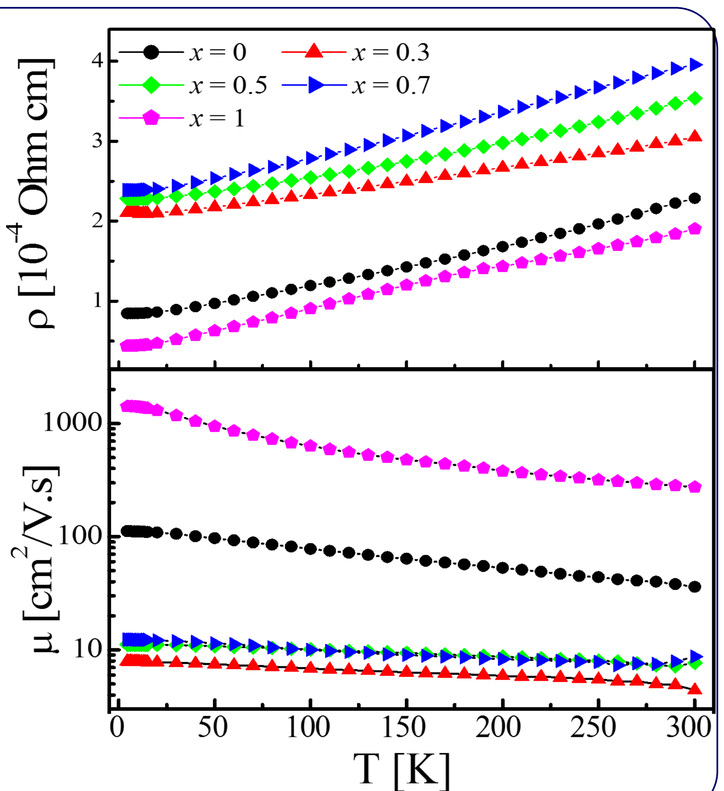
Rhombohedral (R3m)



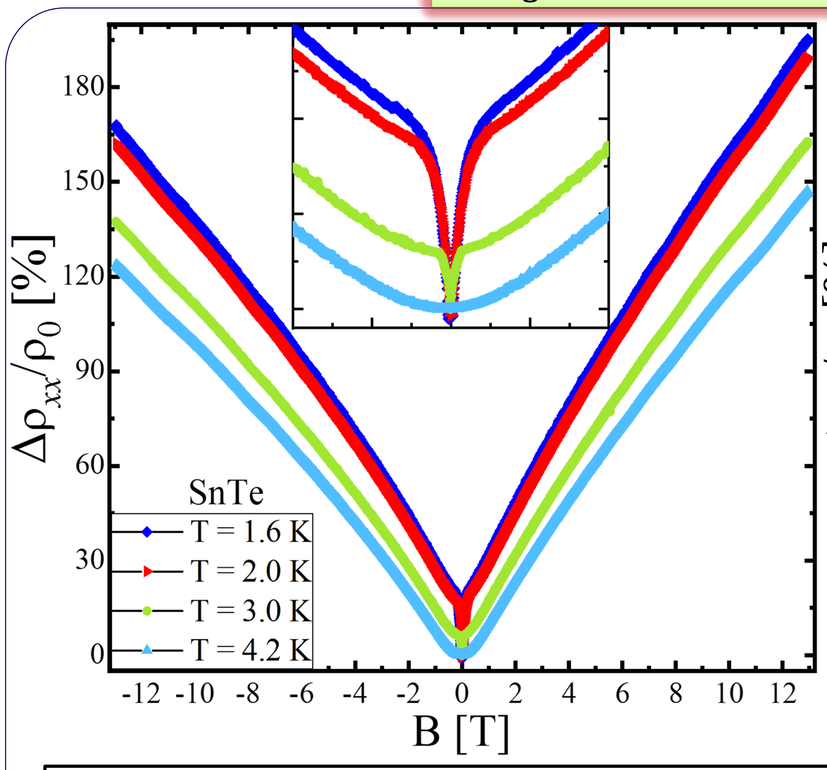
Cubic (Fm-3m)
Sn ≈ 0.7

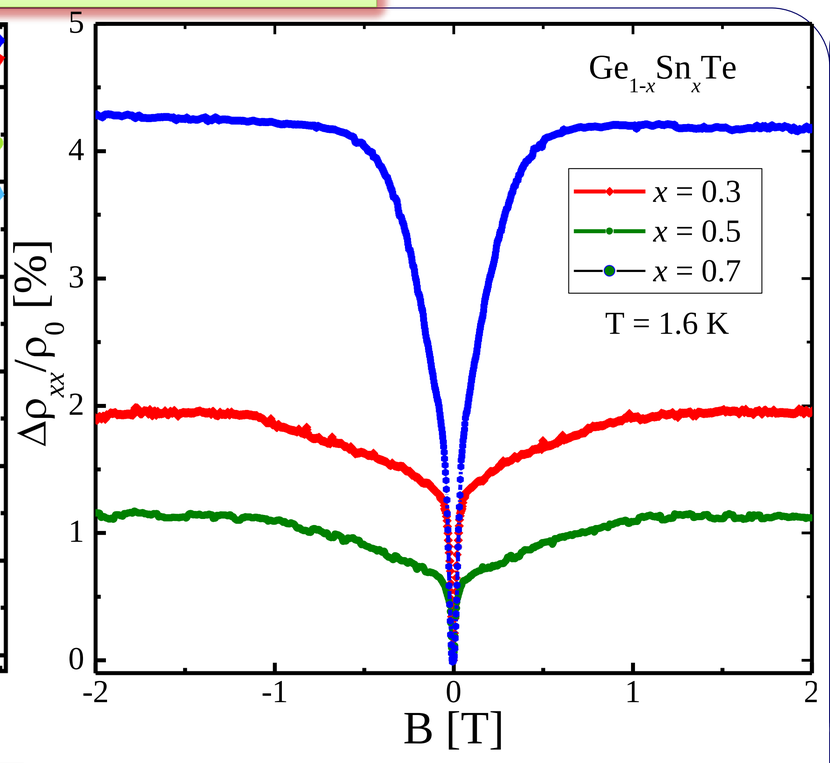


- ✓ $\rho(T)$ stays constant between $T \sim 4.3$–15 K.
- ✓ At $T \geq 20$ K, $\rho(T)$ shows dominant phonon contribution.
- ✓ The $\mu(T)$ results show similar depend ence as $\rho(T)$.



Magnetoresistance and Weak anti-localization

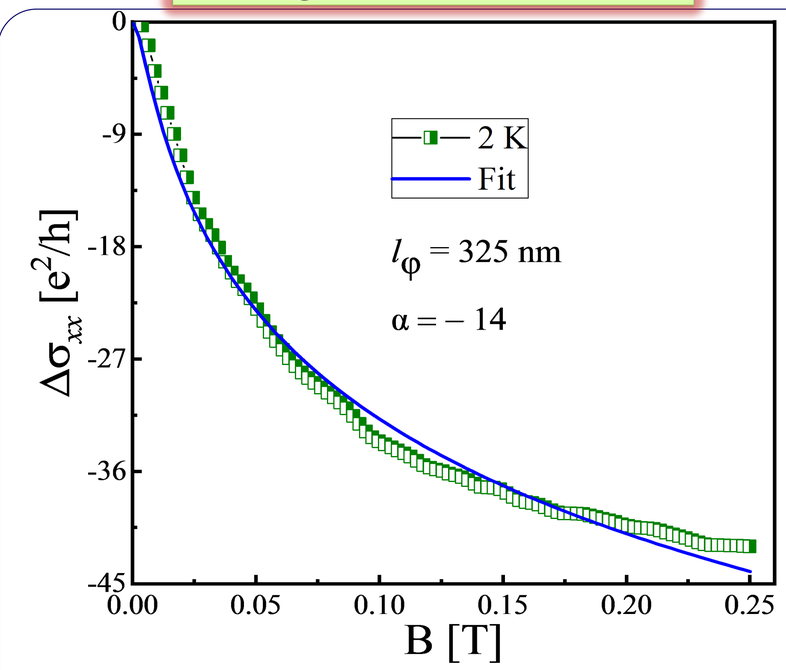




- ☼ Longitudinal resistivity graphs of SnTe layers measured at $|B| = 13$ T and T = 1.6 – 4.2 K.
- ☼ SnTe layers manifest a prominent Weak anti-localization effect at $|B| \leq 0.2$ and $T \leq 3$ K.

- ☼ Large WAL effect in Sn doped GeTe layers.
- ☼ Largest magnitude of WAL is recorded at Sn ~ 0.7.
- ☼ WAL vanishes at $T = 4.2$ K (not shown here).

Fitting of WAL to HLN model



Magnetoconductance of SnTe layers was fitted at $T = 2$ K using Hikami–Larkin–Nagaoka model.

Conclusion

- ❖ $Ge_{1-x}Sn_xTe$ ferroelectric Semiconductors show a rhombohedral to cubic phase transition at $x \approx 0.7$.
- ❖ The resistivity, $\rho(T)$ and mobility, $\mu(T)$ results show dominant phonon scattering at $T \geq 15$ K..
- ❖ SnTe and Ge1-xSnTe layers manifest large WAL effect below $T \sim 3$ K..
- ❖ The WAL cusps were fitted to HLN model which yield bulk conductivity channels in the layers.

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