Superconducting Phase of BiTe at High pressure

Manisha YADAV (Bhabha Atomic Research Centre, Homi Bhabha National Institute, India)
Pallavi MALAVI (Bhabha Atomic Research Centre, India)
S. KARMAKAR (Bhabha Atomic Research Centre, Homi Bhabha National Institute, India)

Abstract

Quasi-two-dimensional (2D) layered BiTe is a weak topological insulator having time-reversal symmetry protected conductive surface states on the side surfaces, while the layer surface is topologically protected due to the crystal mirror symmetry making it also a topological crystalline insulator [1]. Searching for superconductivity (SC) in diverse Topological insulators is of tremendous current interest for realization of topological superconducting surface states [2]. Efforts to induce SC at high pressure to obtain clean 3D topological SC without doping often lead to structural transitions into topologically trivial metallic phases prior to the emergence of SC [3,4].

Our high pressure investigations show that ambient quasi-2D trigonal ($P\bar{3}m1$) BiTe phase undergoes sequential structural transitions into various three dimensional (3D) network structures (SnTe-type) above 6 GPa and the atom-disordered bcc phase ($Im\bar{3}m$) emerges at 13 GPa through consecutive transitions to intermediate orthorhombic 3D phases ($Cmcm$) and($\gamma - Pnma$). Superconductivity emerges at 3 GPa, within the phase stability of the 2D layered BiTe phase. This also shows concurrent appearance of 2D weak anti-localization (WAL) feature in the normal state magneto-resistance, indicating the key role of the strong spin-orbit coupling in the emergence of SC in the layered phase [5]. SC T_c rapidly increases from 2.5K to 6K across the first structural transition to the 3D orthorhombic phase and further increases to 9K near 13 GPa across the structural transition to the bcc alloy phase. We identify the 2D and 3D BiTe phases with their distinct superconducting and normal state transport properties. Magneto-transport and Hall resistance measurements also indicate distinct transport behavior in the 2D and 3D phases.

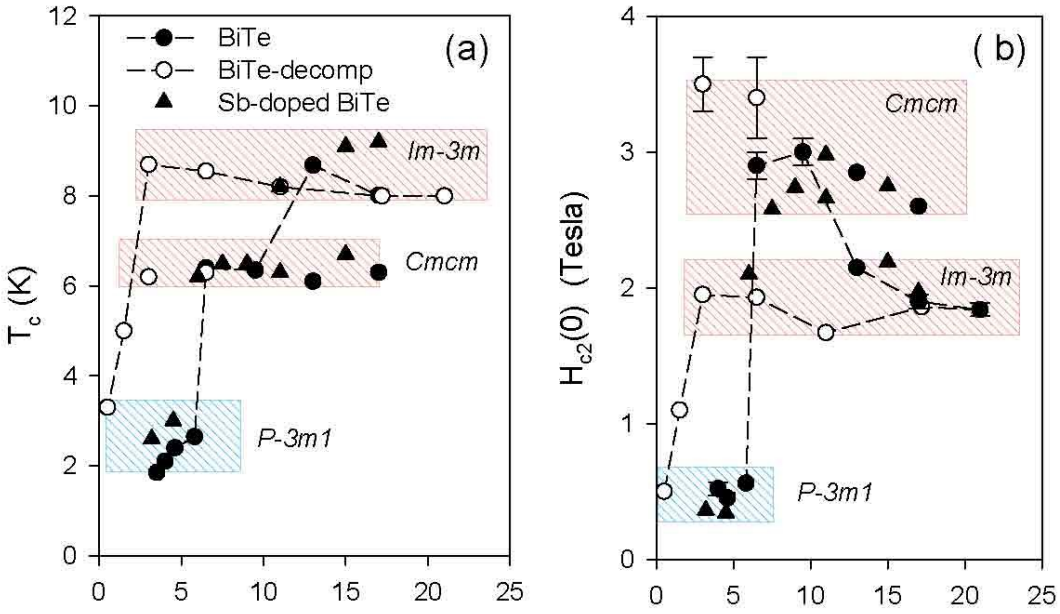

Fig. 1 *P*-variation of (a) SC T_c and (b) orbital upper critical field $H_{c2}(0)$ for BiTe and Sb-doped BiTe. The dashed lines indicate the *P*-variation of H_{c2} and T_c of the major phase at any *P*. The distinct T_c and $H_{c2}(0)$ values corresponding to the 2D and 3D phases fall in different shaded regions.

Acknowledgements: We acknowledge Prof. A. K. Sood for his support and S. Mondal and P. S. Anil kumar for providing single crystals. We thank S. Lupi, M. Zacchigna, and Veronica Stopponi for their assistance at the SISSI-Mat Science beamline and B. Joseph for his assistance at the XPRESS beamline. We gratefully acknowledge funding from ICTP (Italy) for high pressure XRD and IR measurements in Elettra Synchrotron (Italy).

Keywords: Topological Insulator, Superconductivity, X-ray diffraction, Magneto-transport measurements.

References:

1. M. Eschbach et al., Nat. Commun. **8**, 14976 (2017)
2. L. Fu and C. L. Kane, Phys. Rev. Lett. **100**, 096407 (2008).
3. K. Kirshenbaum et al., Phys. Rev. Lett. **111**, 087001 (2013).
4. K. Matsubayashi et al., Phys.Rev. B **90**, 125126 (2014)
5. M. Yadav, P. Malavi, S. Kisku, D.V.S. Muthu, V. Stopponi, M. Zacchigna, S. Lupi, P.S.A. Kumar, A.K. Sood, S. Karmakar. Phys. Rev. B 112 (2025) 214511-214526.