Multiferroic and topological properties of thin layers of IV-VI semiconductors

Gunther Springholz

Institut für Halbleiterphysik, Johannes Kepler Universität, A-4040 Linz, Austria

The narrow gap IV-VI compound semiconductors have attracted considerable interest due to their large variability in structure, electronic and magnetic properties that can be tuned by alloying with various magnetic and nonmagnetic elements. Their applications range from infrared optoelectronics, thermoelectrics, phase change materials for active electronic and photonic devices. Moreover, the heavy IV-VI elements support very large spin-orbit couplings that give rise to giant Rashba effects, and alloying with SnTe or SnSe induces a band inversion due to level repulsion that formed the basis for discovery of a novel class of topologic materials, called topological *crystalline* insulators. These TCIs feature an intrinsic metallic 2D surface state with Dirac-like dispersion and peculiar spin-momentum locking that may be of interest for spintronic devices. Structural distortions and magnetic doping also allow to attain multiferroicity due to coexisting *ferroelectric* and *ferromagnetic* behavior.

In this talk, I will describe our recent results on molecular beam epitaxy of multiferroic and topological insulator films and their investigation using a wide range of spectroscopic techniques, including x-ray absorption and angle resolved photoemission spectroscopy (EXAFS, ARPES). The latter provides unique access to the full 3D dispersion of the electronic band structure in energy and momentum space. Example will be presented for PbSnSe and PbSnTe TCI films – illustrated by Fig. 1 – as well as for multiferroic GeMnTe where we demonstrate the giant Rashba and Zeeman effect by spin-resolved measurements.

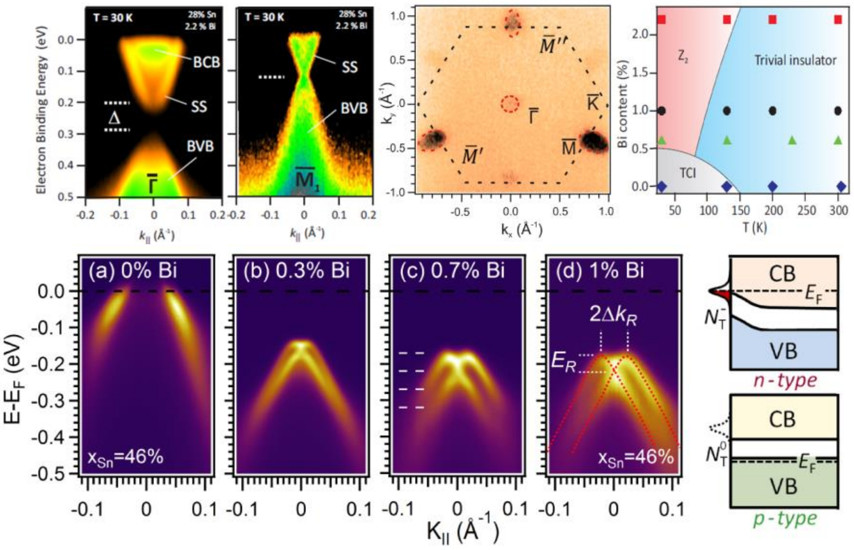

Figure 1: ARPES studies of topological crystalline insulator films of PbSnSe (top) and PbSnTe (bottom) doped with Bi. Top: Gap opening and lifting of the valley degeneracy in PbSnSe:Bi. Bottom: Giant Rashba effect in PbSnTe (111) controlled by bulk Bi-doping and surface Fermi level pinning.

For recent work see, e.g.,:

[1] J. Sánchez-Barriga et al. Nature Comm. **7**, 10559 (2016).

[2] J. Krempasky et al., Nature Communications 7, 13071 (2016).

[3] V. V. Volobuev et al., *Adv. Mater.* (2017).

*) **Collaborators**: V. V. Volobuev, S. Wimmer, A. Ney, W. Jantsch, G. Bauer (JKU-Linz), P. Mandal, J. Sanchez-Barriga, E. Golikas, A. Varykhalov, O. Rader (BESSY-Berlin), H. Przybylinska, M. Galica, P. Kacman, R. Buczko (IFPAN Warzawa), V. Holy, D. Kriegner, O. Caha (Prague/Brno), J. Krempasky, S. Muff, F. Bisti, M. Fanciulli, N. Pilet, P. Warnicke, A. Weber, H. Dil, V.N. Strocov (PSI), H. Volfova, H. Ebert, J. Braun, J. Minar (LMU-Munich). B. Assaf, T. Phuphachong, L.A.Vaulchier,Y. Guldner (ENS-Paris).