TT 57: Topology and Symmetry-protected Materials (joint session O/TT)

Time: Friday 10:30–12:15 Location: H25

TT 57.1 Fri 10:30 H25

Topological material in the III–V family: heteroepitaxial InBi on InAs — •L. Nicolaï[1], J. Minár[1], M.C. Richter[2,3], O. Heckmann[2,3], J.-M. Mariot[4], U. Djukic[2], J. Adell[5], M. Leandersson[5], J. Sadowski[6], J. Braun[7], H. Ebert[7], J.D. Denlinger[8], I. Vobornik[9], J. Fujii[9], P. Šutta[1], G.R. Bell[10], M. Gmitra[11,12], and K. Hricovini[2,3] — [1]Univiversity of West Bohemia — [2]CY Cergy-Paris Université — [3]Université Paris-Saclay — [4]Sorbonne Université — [5]Lund University — [6]Polish Academy of Sciences — [7]LMU München — [8]ALS — [9]Istituto Officina dei Materiali, CNR — [10]University of Warwick — [11]Pavol Jozef Šafárik University in Košice — [12]Slovak Academy of Sciences

InBi(001) is formed epitaxially on InAs(111)-A by depositing Bi on to an In-rich surface. ARPES measurements reveal topological electronic surface states, close to the $\overline{M}$ high symmetry point. InBi surprisingly shows coexistence of Bi and In surface terminations. For the Bi termination, the study gives a consistent physical picture of the topological surface electronic structure of InBi(001) terminated by a Bi bilayer rather than a surface formed by splitting to a Bi monolayer termination. Theoretical calculations based on relativistic DFT and the one-step model of photoemission clarify the relationship between the InBi(001) surface termination and the topological surface states, supporting a predominant role of the Bi bilayer termination. Furthermore, a tight-binding model based on this Bi bilayer termination with only Bi–Bi hopping terms gives a deeper insight into the spin texture[1]. [1] Nicolaï *et al.* Phys. Rev. Research 6.4 (2024): 043116.

TT 57.2 Fri 10:45 H25

Hidden spin-texture in an inversion-symmetric Dirac crystal — Kenta Hagiwara[1,2], Peter C. Schmitz[1], Philipp Rüssmann[1], Xin Liang Tan[1,2], Ying-Jiun Chen[3], Kui-Hon Ou Yang[4], Raman Sankar[5], Chien Jing[4], Yi-Hsin Shen[4], Mahmoud Zeer[1], Dongwook Go[6], Iulia Cojocariu[1], Daniel Baranowski[1], Vitaliy Feyer[1], Minn-Tsong Lin[1,6], Stefan Blügel[1], Claus M. Schneider[1,2], Yuriy Mokrousov[1,5], and •Christian Tusche[1,2] — [1]Peter Grünberg Institut, Forschungszentrum Jülich, — [2]Faculty of Physics, University of Duisburg-Essen — [3]Ernst Ruska-Centre, Forschungszentrum Jülich — [4]Department of Physics, National Taiwan University, Taipei, Taiwan — [5]Academia Sinica, Taipei, Taiwan — [6]Johannes-Gutenberg University Mainz

A hidden spin polarization refers to a local spin polarization caused by apparent symmetry breaking and offers new perspectives for spintronics applications. Transition metal dichalcogenides can host various topological phases depending on the symmetry of their crystal structure. Here, by means of spin-resolving momentum microscopy, we reveal the spin texture of both topologically and symmetrically distinct surface and bulk Dirac cones in the inversion symmetric Dirac semimetal $NiTe_2$. We discovered a "hidden" spin polarization the bulk Dirac cone, localized at the different Te layers of the inversion symmetric bulk unit cell, such that the overlap of the two states results in a topologically trivial Dirac cone enforced by the global crystal symmetry. This work establishes a link between topology, spin-texture, and symmetry, enabling control by external perturbations.

TT 57.3 Fri 11:00 H25

Edge spectroscopy of the quantum spin Hall insulator indenene — •Jonas Erhardt[1,2], Mattia Ianetti[3], Gianni Profeta[3], Domenico Di Sante[4], Giorgio Sangiovanni[2,5], Simon Moser[1,2], and Ralph Claessen[1,2] — [1]Physikalisches Institut, Universität Würzburg — [2]Würzburg-Dresden Cluster of Excellence ct.qmat — [3]Department of Physical and Chemical Sciences, University of L'Aquila — [4]Department of Physics and Astronomy, University of Bologna — [5]Institut für Theoretische Physik und Astrophysik, Universität Würzburg

The non-trivial topology of the quantum spin Hall insulator indenene was recently demonstrated through bulk probes that reveal its topological band ordering [1,2]. According to the bulk-boundary correspondence, this ensures the existence of robust metallic states confined to the edge of this triangular indium monolayer. In this study, we employ scanning tunneling spectroscopy to investigate all three edge types of indenene for this correspondence. Our results demonstrate metallic edge density of states with suppressed backscattering near the bulk band gap, providing strong evidence for the existence of topologically protected edge states in indenene.
[1] M. Bauernfeind, J. Erhardt, and P. Eck *et al.*, Nat. Commun. **12**, 5396 (2021)
[2] J. Erhardt *et al.*, Phys. Rev. Lett. **132**, 196401 (2024)

TT 57.4 Fri 11:15 H25

Bismuthene at the Graphene/SiC Interface: A Protected Quantum Spin Hall Insulator — •Niclas Tilgner[1], Susanne Wolff[1], Serguei Soubatch[2], Andres D. P. Unigarro[1], Sibylle Gemming[1], F. Stefan Tautz[2], Christian Kumpf[2], Thomas Seyller[1], Fabian Göhler[1], and Philip Schädlich[1] — [1]Institute of Physics, Chemnitz University of Technology, Germany — [2]Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich, Germany

Quantum spin Hall insulators (QSHIs) hold the potential to revolutionize next-generation technologies. Kane and Mele identified 2D honeycomb structures of heavy atoms with strong spin-orbit coupling as promising candidates for these materials. To realize this potential, however, the QSHI must be shielded from environmental influences. Previous research has demonstrated the intercalation of 2D Bi layers beneath graphene on SiC, resulting in the formation of two distinct phases. Among those, the β-phase exhibits a $(\sqrt{3} \times \sqrt{3})R30°$ periodicity relative to the substrate. We identify the Bi adsorption site using x-ray standing wave imaging, a method which deterimes the element specific, 3D atomic distribution with respect to the bulk unit cell. After subsequent hydrogen intercalation, the Bi position changes significantly from hollow to top site adsorption. Further measurements with angle-resolved photoelectron spectroscopy reveal the band structure of the QSHI bismuthene with a pronounced Rashba splitting and slight p-type doping. We propose that the initial β-phase has to be considered as an electronically inactive layer of bismuthene, whose electronic structure can be established by subsequent hydrogen intercalation.

TT 57.5 Fri 11:30 H25

Probing the Electronic Structure at the Boundary of Topological Insulators in the Bi2Se3 Family by Combined STM and AFM — •Christoph S. Setescak[1], Irene Aguilera[2], Adrian Weindl[1], Matthias Kronseder[1], Andrea Donarini[1], and Franz J. Giessibl[1] — [1]University of Regensburg, Regensburg, Germany — [2]University of Amsterdam and European Theoretical Spectroscopy Facility (ETSF), Amsterdam, The Netherlands

We develop a numerical scheme for the calculation of tunneling current I and differential conductance dI/dV of metal and CO terminated STM tips on the topological insulators Bi2Se3, Bi2Te2Se and Bi2Te3 and find excellent agreement with experiment. The calculation is an application of Chen's derivative rule, whereby the Bloch functions are obtained from Wannier interpolated tightbinding Hamiltonians and maximally localized Wannier functions from first-principle DFT+GW calculations. We observe signatures of the topological boundary modes, their hybridization with bulk bands, Van Hove singularities of the bulk bands and characterize the orbital character of these electronic modes using the high spatial resolution of STM and AFM. Bare DFT calculations are insufficient to explain the experimental data, which are instead accurately reproduced by many-body corrected GW calculations.

TT 57.6 Fri 11:45 H25

Revealing higher-order topological bulk-boundary correspondence in Bi crystals with spin-helical hinge state loop and proximity superconductivity — •Dongming Zhao[1], Yang Zhong[1], Tian Yuan[1], Haitao Wang[1], Tianxing Jiang[1], Yang Qi[1], Hongjun Xiang[1,2,3], Xingao Gong[1,2,3], Donglai Feng[2,3,4], and Tong Zhang[1,2,3,4] — [1]Fudan University, Shanghai, China — [2]Collaborative Innovation Center for Advanced Microstructures, Nanjing, China — [3]Shanghai Research Center for Quantum Sciences, Shanghai, China — [4]Hefei National Laboratory, Hefei, China

Topological materials are typically characterized by gapless boundary states, known as bulk-boundary correspondence. Recently, this concept has been generalized in higher-order topological insulators (HOTIs). E.g., a 2nd-order 3D TI hosts 1D topological hinge states winding around the crystal. A complete verification of HOTI will require probing all crystal boundaries. Here we studied a promising candi-

date of 2nd-order TI, Bi, in the form of mesoscopic crystals grown on superconducting V3Si. Using low-temperature STM, we directly observed dispersive 1D states on various hinges. Upon introducing magnetic scatterers, new scattering channels emerged selectively on certain hinges, revealing their spin-helical nature. Combining first-principle calculation and global symmetry analysis, we find these hinge states topological and formed a closed loop encircling the crystal. This provides direct evidence on the HOTI in Bi. Moreover, proximity superconductivity is observed in the topological hinge states serving as a promising platform for realizing topological superconductivity.

TT 57.7 Fri 12:00 H25

Simultaneous Atomic-Scale Imaging and Electronic Characterization of Wet-Chemically Prepared Bi_2Se_3 Nanoplatelets — •Auke Vlasblom, Victor Wesselingh, Jara Vliem, Daniel Vanmaekelbergh, and Ingmar Swart — Utrecht University, Utrecht, The Netherlands

Colloidal semiconductor nanoparticles are of great interest for various optoelectronic applications, such as integration in displays, solar cells and electronics. For applications, the surface of nanoparticles is of critical importance. However, until now, no technique exists to simultaneously investigate the atomic structure (e.g. the presence of defects) and the electronic properties of a nanoparticle, foremost limited by the presence of ligands that prevent direct access to the surface with a local probe. Here, we present a new and widely applicable procedure that allows investigation of the surface of a nanoparticle with a local probe. Using this method, nanoparticles are transferred to an atomically clean substrate under ultra-high vacuum conditions. We demonstrate the procedure for topological two-dimensional Bi_2Se_3 nanoplatelets deposited on Au(111). We reveal the atomic and electronic structure of the surface of colloidally synthesised Bi_2Se_3 nanoplatelets with scanning tunneling microscopy and spectroscopy measurements. In this talk, I will highlight the various types of defects that occur at the (sub-)surface of Bi_2Se_3 nanoplatelets and I will show their influence on the electronic structure.