

O 101: Topology and Symmetry-protected Materials (joint session O/TT)

Time: Friday 10:30–12:15

Location: H25

O 101.1 Fri 10:30 H25

Topological material in the III–V family: heteroepitaxial InBi on InAs — ●L. NICOLAÏ¹, J. MINÁR¹, M.C. RICHTER^{2,3}, O. HECKMANN^{2,3}, J.-M. MARIOT⁴, U. DJUKIC², J. ADELL⁵, M. LEANDERSSON⁵, J. SADOWSKI⁶, J. BRAUN⁷, H. EBERT⁷, J.D. DENLINGER⁸, I. VOBORNIK⁹, J. FUJII⁹, P. ŠUTTA¹, G.R. BELL¹⁰, M. GMITRA^{11,12}, and K. HRICOVINI^{2,3} — ¹University of West Bohemia — ²CY Cergy-Paris Université — ³Université Paris-Saclay — ⁴Sorbonne Université — ⁵Lund University — ⁶Polish Academy of Sciences — ⁷LMU München — ⁸ALS — ⁹Istituto Officina dei Materiali, CNR — ¹⁰University of Warwick — ¹¹Pavol Jozef Šafárik University in Košice — ¹²Slovak 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 \bar{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.

O 101.2 Fri 10:45 H25

Hidden spin-texture in an inversion-symmetric Dirac crystal — KENTA HAGIWARA^{1,2}, PETER C. SCHMITZ¹, PHILIPP RÜSSMANN¹, XIN LIANG TAN^{1,2}, YING-JIUN CHEN³, KUI-HON OU YANG⁴, RAMAN SANKAR⁵, CHIEN JING⁴, YI-HSIN SHEN⁴, MAHMOUD ZEER¹, DONGWOOK GO⁶, IULIA COJOCARIU¹, DANIEL BARANOWSKI¹, VITALIY FEYER¹, MINN-TSONG LIN^{1,6}, STEFAN BLÜGEL¹, CLAU M. SCHNEIDER^{1,2}, YURIY MOKROUSOV^{1,5}, and ●CHRISTIAN TUSCHE^{1,2} — ¹Peter Grünberg Institut, Forschungszentrum Jülich, — ²Faculty of Physics, University of Duisburg-Essen — ³Ernst Ruska-Centre, Forschungszentrum Jülich — ⁴Department of Physics, National Taiwan University, Taipei, Taiwan — ⁵Academia Sinica, Taipei, Taiwan — ⁶Johannes-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 NiTe₂. 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.

O 101.3 Fri 11:00 H25

Edge spectroscopy of the quantum spin Hall insulator indenene — ●JONAS ERHARDT^{1,2}, MATTIA IANETTI³, GIANNI PROFETA³, DOMENICO DI SANTE⁴, GIORGIO SANGIOVANNI^{2,5}, SIMON MOSER^{1,2}, and RALPH CLAESSEN^{1,2} — ¹Physikalisches Institut, Universität Würzburg — ²Würzburg-Dresden Cluster of Excellence ct.qmat — ³Department of Physical and Chemical Sciences, University of L’Aquila — ⁴Department of Physics and Astronomy, University of Bologna — ⁵Institut 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)

O 101.4 Fri 11:15 H25

Bismuthene at the Graphene/SiC Interface: A Protected Quantum Spin Hall Insulator — ●NICLAS TILGNER¹, SUSANNE WOLFF¹, SERGUEI SOUBATCH², ANDRES D. P. UNIGARRO¹, SIBYLLE GEMMING¹, F. STEFAN TAUTZ², CHRISTIAN KUMPF², THOMAS SEYLLER¹, FABIAN GÖHLER¹, and PHILIP SCHÄDLICH¹ — ¹Institute of Physics, Chemnitz University of Technology, Germany — ²Peter 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 $(\sqrt{3} \times \sqrt{3})R30^\circ$ periodicity relative to the substrate. We identify the Bi adsorption site using x-ray standing wave imaging, a method which determines 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.

O 101.5 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. SETESCAK¹, IRENE AGUILERA², ADRIAN WEINDL¹, MATTHIAS KRONSEDER¹, ANDREA DONARINI¹, and FRANZ J. GISSLER¹ — ¹University of Regensburg, Regensburg, Germany — ²University 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.

O 101.6 Fri 11:45 H25

Revealing higher-order topological bulk-boundary correspondence in Bi crystals with spin-helical hinge state loop and proximity superconductivity — ●DONGMING ZHAO¹, YANG ZHONG¹, TIAN YUAN¹, HAITAO WANG¹, TIANXING JIANG¹, YANG QI¹, HONGJUN XIANG^{1,2,3}, XINGAO GONG^{1,2,3}, DONGLAI FENG^{2,3,4}, and TONG ZHANG^{1,2,3,4} — ¹Fudan University, Shanghai, China — ²Collaborative Innovation Center for Advanced Microstructures, Nanjing, China — ³Shanghai Research Center for Quantum Sciences, Shanghai, China — ⁴Hefei 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.

O 101.7 Fri 12:00 H25

Simultaneous Atomic-Scale Imaging and Electronic Characterization of Wet-Chemically Prepared Bi₂Se₃ 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 Bi₂Se₃ nanoplatelets deposited on Au(111). We reveal the atomic and electronic structure of the surface of colloidal synthesized Bi₂Se₃ 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 Bi₂Se₃ nanoplatelets and I will show their influence on the electronic structure.