TT 48: Transport: Topological Insulators I (organized by TT)

Time: Tuesday 14:00–16:00 Location: HSZ 304

TT 48.1 Tue 14:00 HSZ 304

All in-ultra-high-vacuum study of thin film topological insulators: Bi_2Te_3 — •Katharina Hoefer, Diana Rata, Christoph Becker, and Liu Hao Tjeng — Max Planck Institute for Chemical Physics of Solids

Thin films of topological insulators offer the possibility for the experimental study of the expected specular phenomena occurring at the surface or interface with these materials due to the increased surface to bulk ratio in comparison to bulk crystals. Bulk materials are always defective which leads to extra contributions in conductance.

To protect the surface integrity an all in- ultra-high-vacuum study is crucial. High quality thin films of Bi_2Te_3 were grown on well lattice matched $BaF_2(111)$ substrates using Molecular Beam Epitaxy. The preparation, characterization by RHEED, LEED, XPS and ARPES and especially transport measurements, were performed all in-situ under ultra-high-vacuum conditions.

Results of this study and the effect of air exposure on the electronic structure and transport properties will be presented.

TT 48.2 Tue 14:15 HSZ 304

Finite width effect on weak antilocalization in MBE grown Bi_2Te_3 thin films — •Christian Weyrich[1,2], Tobias Merzenich[1,2], Igor E. Batov[3], Gregor Mussler[1,2], Jörn Kampmeier[1,2], Jürgen Schubert[1], Thomas Schäpers[1,2], and Detlev Grützmacher[1,2] — [1]Peter Grünberg Institute (PGI-9) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Virtual Institute for Topological Insulators (VITI), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [3]Institute of Solid State Physics, Russian Academy of Sciences, Chernogolovka, 142432, Moscow Distr., Russia

The weak antilocalization effect is measured in Bi_2Te_3 layers under various tilt angles of the magnetic field with respect to the layer surface. The investigated Bi_2Te_3 layer was prepared by molecular beam epitaxy. For a magnetic field oriented perpendicularly to the layer the weak antilocalization effect at different temperatures can be well-fitted by the Hikami-Larkin-Nagaoka model. From the fit a phase coherence length of about 200 nm is obtained at a temperature of 2 K. A clear signature of weak antilocalization is also observed when the magnetic field is oriented parallel to the Bi_2Te_3 layer. This effect is compared to classical models as well as a recently developed theory, which takes into account the finite penetration depth of the surface or interface states into the bulk.

TT 48.3 Tue 14:30 HSZ 304

Band structure and magnetotransport in strained HgTe — •Jan Böttcher and Ewelina M. Hankiewicz — Universität Würzburg, Faculty for Physics and Astronomy, Am Hubland, D-97074 Würzburg

Strained mercury telluride is a 3D topological insulator with negligible bulk conductivity [1]. Here we report on band structure calculations using a six-band Kane model with a self-consistent Poisson solver. We find that while the surface states lie within the band gap, the Dirac point lies deep in the heavy hole subbands. We study this system as a function of gate voltage and give possible explanations of exciting experimental observations of the Landau level structures in high magnetic fields as well as oscillations in the Shubnikov-de Hass data at low magnetic fields.

We acknowledge financial support via grant HA 5893/4-1 within SPP 1666.

[1] C. Brüne, C. X. Liu, E. G. Novik, E. M. Hankiewicz, H. Buhmann, Y. L. Chen, X. L. Qi, Z. X. Shen, S. C. Zhang, and L. W. Molenkamp, Phys. Rev. Lett. 106, 126803 (2011)

TT 48.4 Tue 14:45 HSZ 304

Photoemission investigation of the predicted topological Kondo insulator behavior of SmB_6 — •Peter Hlawenka[1], Emile Rienks[1], Konrad Siemensmeyer[1], Eugen Weschke[1], Andrei Varykhalov[1], Natalya Shitsevalova[2], Slavomir Gabani[3], Karol Flachbart[3], and Oliver Rader[1] — [1]Helmholtz-Zentrum Berlin — [2]Institute for Problems of Material Science, Kiev, Ukraine — [3]IEP, Slovak Academy of Science, Kosice

The system SmB_6 is known for its unusual resistivity which increases exponentially with decreasing temperature and saturates below 3 K [1]. This has recently been attributed to topological-Kondo-insulator behavior where a topological surface state is created by Sm4f-5d hybridization and is responsible for the transport [2]. The local-density-approximation + Gutzwiller calculations of the (100) surface predict the appearance of three Dirac cones in the surface Brillouin zone [2]. We perform angle-resolved photoemission (ARPES) below 1 K and do not observe the predicted Dirac cones at $\overline{\Gamma}$ or $\overline{X}$. Moreover, the Fermi surface is made up of steeply dispersing bulk Sm5d states. The Sm^{2+} 4f band and the hybridization gaps where the surface states are expected [2] are too far ($\sim$ 20 meV) below the Fermi energy in order to contribute to the transport. These results will be discussed in comparison to other ARPES studies.

[1] J. C. Cooley, M. C. Aronson, Z. Fisk, P. C. Canfield, Phys. Rev. Lett. 74, 1629 (1995)
[2] F. Lu, J. Zhao, H. Weng, Z. Fang, Xi Dai, Phys. Rev. Lett. 110, 096401 (2013)

TT 48.5 Tue 15:00 HSZ 304

Excitations of surface and bulk states in spin orbit dominated materials — •Peter Lemmens[1], Vladimir Gnezdilov[1,2], Dirk Wulferding[3], Patrik Recher[4], Helmuth Berger[5], Yoichi Ando[6], R Sankar[7], and Fang-Cheng Chou[7] — [1]IPKM, TU-BS, Braunschweig — [2]ILTPE, Kharkov, Ukraine — [3]POSTECH, Korea — [4]IMAPH, TU-BS, Braunschweig — [5]EPFL, Lausanne, Switzerland — [6]ISIR, Osaka, Japan — [7]CCMS, National Taiwan Univ., Taipei, Taiwan

Using Raman scattering experiments we probe inelastic processes in the giant Rashba material BiTeI, the topological semimetal Cd_3As_2 and several topological insulators. By comparing surface with bulk scattering processes we notice the dominance of quantum well states. With exception to Cd_3As_2 all materials show pronounced resonances in the Raman scattering cross section.

TT 48.6 Tue 15:15 HSZ 304

Josephson Effect in Topological Insulator Planar, Nanostep and Edge Junctions — •Jennifer Nussbaum, Rakesh Tiwari, Thomas Schmidt, and Christoph Bruder — University of Basel, Switzerland

Topological insulators are states of quantum matter which are characterized by a full insulating gap in the bulk and gapless surface states which are protected by time-reversal symmetry. By using the superconducting proximity effect on a Bi_2Se_3 topological insulator, a topological superconductor - topological insulator - topological superconductor (SIS) junction can be engineered. By solving the Dirac-Bogoliubov-De-Gennes equation in such a junction the maximal supercurrent that can flow through the surface of the Bi_2Se_3 topological insulator with heavily doped superconducting electrodes is calculated. In this manner, short and wide nanostep Josephson junctions involving different side surfaces of the 3D topological insulator are investigated. The results are compared to the Josephson response of a junction involving only one side surface. The comparison reveals, for example, that a step setup leads to a non-trivial scaling of the Josephson current.

TT 48.7 Tue 15:30 HSZ 304

Parity measurement in topological Josephson junctions — •François Crépin and Björn Trauzettel — Institute for Theoretical Physics and Astrophysics, University of Würzburg, 97074 Würzburg, Germany

We study the properties of a topological Josephson junction made of both edges of a 2D topological insulator. We show that, due to fermion parity pumping across the bulk, the global parity of the junction has a clear signature in the periodicity and critical value of the Josephson current. In particular, we find that the periodicity with the flux changes from 4π in a junction with an even number of quasi-particles to 2π in the odd sector. In the case of long junctions, we exhibit a rigorous mathematical connection between the spectrum of Andreev bound-states and the fermion parity anomaly, through bosonization. Additionally, we discuss the rather quantitative effects of Coulomb interactions on the Josephson current.

TT 48.8 Tue 15:45 HSZ 304

PN junctions of Topological Insulators — •Sourin Das[1] and Disha Wadhawan[2] — [1]MPIPKS, Dresden, Germany & University of Delhi, India — [2]University of Delhi, India

Spin textures of surface states of topological insulators (TI) open up possibilities for designing ultra fast electrically controllable spin transistor. In this context I will discuss spin-valve effect associated with a gating induced PN junction designed on the surface state of 2D and 3D TI. I will show that *conduction to conduction* and *conduction to valence* band transport in a PN junction is topologically distinct resulting in asymmetric electrical transport. The topological distinction is shown to be quantifiable in term of the Pancharatnam geometric phase.