MA 24: Electronic Structure: Surface Magnetism and Spin Phenomena

Time: Tuesday 18:15–20:30 Location: Poster E

MA 24.1 Tue 18:15 Poster E

High-Mobility Sm-Doped Bi2Se3 Ferromagnetic Topological Insulators and Robust Exchange Coupling — •Taishi Chen — Max Plank Institute for Chemical Physics of Solids, 01187 Dresden, Germany

Magnetically doped topological insulators (MTIs) are emerging as a new platform of dilute magnetic semiconductors (DMSs) as a result of growing interest in topological magnetoelectric effect, the quantum spin/anomalous Hall Effect, and Dirac fermion-mediated magnetic coupling physics [1]. However, the traditional transition metal magnetic elements doped topological insulators are often hindered by the inadequate material quality, which is demonstrated by the low mobility of the samples [2-4]. In this work [5], we show the successful preparation of a series of new Sm-doped Bi2Se3 MTIs, which exhibit ferromagnetism up to about 52 K and a suppressed bulk electron carrier concentration as low as 1018 cm*3 in order. Clear Shubnikov*de Haas oscillations are observed in these samples. All evidence suggests that Sm-doped Bi2Se3 is a candidate high-mobility MTI.

MA 24.2 Tue 18:15 Poster E

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References [1] X. L. Qi, et al., Physical Review B 78, 195424 (2008). [2] C. Z. Chang, et al., Science 340, 6129, (2013). [3] C. Z. Chang, et al., Nature Materials 14, 5, (2015). [4] Y. L. Chen, et al., Science 329, 5992, (2010). [5] T. S. Chen, et al., Advanced Materials 27, 33, (2015).

MA 24.3 Tue 18:15 Poster E

Laser induced DC photocurrents in a Topological Insulator thin film — •Nina Meyer[1], Thomas Schumann[1], Dagmar Butkovicová[2], Eva Schmoranzerová[2], Helena Reichlová[3], Gregor Mussler[4], Petr Nemec[2], Detlev Grützmacher[4], and Markus Münzenberg[1] — [1]Institute of Physics, Ernst-Moritz-Arndt University, Greifswald,Germany — [2]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic — [3]Institute of Physics ASCR v.v.i., Prague, Czech Republic — [4]Peter Grünberg Institute (PGI-9), Jülich, Germany

Recent experiments give evidence that the optical excitation of spin-polarized surface states of topological insulators (TI) can launch electron currents along the surface whose direction can be controlled by varying the polarization of the driving light [1]. We generated a photocurrent by illuminating TI $(Bi, Sb)_2Te_3$ thin films with laser light whose polarization changes periodically. The laser light was focused to a 6 μm spot on the device by an objective. We found and will discuss that the photocurrent has at least two parts on different time dynamics. Furthermore we determined different Parameters like [1] and show their dependence on polarization and additional experimental parameters. The films with a thickness of 20 nm were structured to Hall bar devices.

We acknowledge funding through DFG priority program SPP "Topological Insulators" and DAAD PPP Czech Republic "FemtomagTopo". [1] J. W. McIver, D. Hsieh, H. Steinberg, P. Jarillo-Herrero and N. Gedik, Nature Nanotechnology 7, 96-100 (2012)

MA 24.4 Tue 18:15 Poster E

W(110) and Ta(110): A Playground for Spin-Orbit-Induced Effects on Surface States — •H. Wortelen[1], K. Miyamoto[2], H. Mirhosseini[3], B. Engelkamp[1], A.B. Schmidt[1], J. Henk[4], and M. Donath[1] — [1]Universität Münster — [2]HSRC, Hiroshima University — [3]MPI für Mikrostrukturphysik Halle — [4]Universität Halle-Wittenberg

The influence of spin-orbit effects on the surface electronic structure of W(110) and Ta(110) was investigated with spin- and angle-resolved photoemission and inverse photoemission experiments and electronic-structure calculations. We present a comprehensive $E(\mathbf{k}_\parallel)$ picture of the electronic states and their spin texture in the occupied and unoccupied regime.

Tungsten and tantalum, direct neighbors in the periodic table, exhibit a very similar electronic structure, yet with a shifted Fermi energy due to the one electron difference. Both elements exhibit a bcc crystal structure, however, with different lattice parameters resulting in differently pronounced hybridization of surface and bulk bands. As a consequence, a Dirac-cone-like surface state, reminiscent of a topological surface state, observed for W(110) below E_F [1,2] has no apparent equivalent on Ta(110), although it is expected above E_F [3]. Furthermore, a Rashba-split d_{z^2} surface state appears on Ta(110) [4], which has no equivalent on W(110).

[1] Miyamoto et al., Phys. Rev. Lett. **108**, 066808 (2012)
[2] Mirhosseini et al., New J. Phys. **15**, 033019 (2013)
[3] Engelkamp et al., Phys. Rev. B **92**, 085401 (2015)
[4] Wortelen et al., Phys. Rev. B **92**, 161408(R) (2015)

MA 24.5 Tue 18:15 Poster E

First-principles dynamical spin and charge currents in magnetic nanostructures — •Sascha Brinker, Filipe Souza Mendes Guimarães, Manuel dos Santos Dias, and Samir Lounis — Peter Grünberg Institut and Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, D-52425 Jülich, Germany

We investigate the spatial distribution of ground state and dynamical spin and charge currents in magnetic nanostructures from first-principles. We outline our density functional theory implementation in the Korringa-Kohn-Rostoker Green function method, in a real-space approach. Small magnetic nanostructures are considered, e.g. Fe adatoms, dimers and trimers on the Au(111) and Pt(111) surfaces. Our findings should be relevant for recent and future microscopy techniques [1].

Work funded by the HGF-YIG Programme FunSiLab – Functional Nanoscale Structure Probe and Simulation Laboratory (VH-NG-717).

[1] A. Lubk, A. Béché, and J. Verbeeck, Phys. Rev. Lett. **115**, 176101 (2015)

MA 24.6 Tue 18:15 Poster E

Bi/Ag(111) vs. Pb/Ag(111) along $\overline{\Gamma}\,\overline{\mathrm{M}}$ and $\overline{\Gamma}\,\overline{\mathrm{K}}$ – A comparative study of the unoccupied states — •Katharina T. Ritter[1], Sune N. P. Wissing[1], Anke B. Schmidt[1], Hossein Mirhosseini[2], Steven Achilles[3], Jürgen Henk[3], and Markus Donath[1] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [3]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Germany

Surface alloys of heavy metal elements on noble metal surfaces exhibit strongly Rashba-split band structures. Especially surface alloys with $(\sqrt{3}\times\sqrt{3})R30°$ reconstruction have been investigated over the last few years.

Here, we compare Bi/Ag(111) and Pb/Ag(111) systematically. We present spin- and angle-resolved inverse photoemission data for both high-symmetry directions $\overline{\Gamma}\,\overline{\mathrm{M}}$ and $\overline{\Gamma}\,\overline{\mathrm{K}}$. The experimental data is complemented by theoretical calculations.

Changing the adsorbate from Bi to Pb results in an energetic shift of the surface states and leads to a different size of the spin splitting. These changes are attributed to the adsorbate's atomic number, which is connected to the atomic spin-orbit coupling, as well as to its size, thus the relaxation of the surface.

MA 24.7 Tue 18:15 Poster E

Spin filtering in Bi superstructures on a Au(111) surface — Sebastian Jakobs[1,2], •Dominik Jungkenn[1], Christian Tusche[3], Jürgen Kirschner[3], Benjamin Stadtmüller[1], Mirko

Cinchetti[1], Stefan Mathias[4], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Erwin-Schrödinger-Str 46, 67663 Kaiserslautern, Germany — [2]Graduate School of Excellence Materials Science in Mainz, Erwin Schroedinger Straße 46, 67663 Kaiserslautern, Germany — [3]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 062120 Halle/Saale, Germany — [4]I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Spin dependent scattering of electrons at interfaces is one of the most relevant microscopic processes that determine the performance of spintronics devices. However, the scattering process itself is hard to address experimentally. Here, we use spin-resolved momentum microscopy to investigate the scattering of photoelectrons from a Au(111) surface on Bi superstructures. We will show that the Bi/Au(111) interface constitutes a simple model system to understand spin dependent electron scattering processes on the microscopic level, since the spin polarization changes with the number and direction of scattering events.

MA 24.8 Tue 18:15 Poster E

Inelastic spin excitations and many-body effects in Fe porphins — •Laëtitia Farinacci, Nino Hatter, Sonja Schubert, Benjamin W. Heinrich, and Katharina J. Franke — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

Magnetism of 3d metals in molecules is commonly treated by crystal field theory. Nonetheless, in case of strong hybridization of the d levels with ligand orbitals this approach may be insufficient. Modification of the conjugated π system could give insight in the influence of such hybridization effects.

Using STM and STS we investigate the properties of the H2P porphins adsorbed on Au(111). After deposition, only monomers are observed on the surface. Annealing to 630 K triggers their polymerization and metalation of the molecules is achieved by Fe deposition at 300 K.

In spectroscopy, FeP monomers and dimers present various features around the Fermi energy above their Fe centers as well as above specific parts of their molecular ligand. Depending on the nature and adsorption site of the molecules, steps localized at energies up to $\pm$ 14 mV as well as a zero bias anomaly similar to a Fano-line shape can be observed. These features result from an interplay between inelastic spin excitations and many-body effects: their shape, broadening and localization cannot be fully addressed by crystal field theory and have to be related to the mixing of the Fe d levels with organic orbitals reported by theory [1] as well as to various couplings to the substrate.

[1] M.E. Ali, et al., J. Phys. Chem. B 116, 5849 (2012).

MA 24.9 Tue 18:15 Poster E

Correlation effects in the surface electronic structure of Fe(110) — •Beatrice Andres, Marko Wietstruk, and Martin Weinelt — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

Beyond one-electron mean-field theories, electronic band energies are renormalized by many-body effects. Such a renormalization can directly be observed in photoemission as a kink in the band dispersion, where the band reaches the excitation energy of a quasi particle. In laser photoemission ($h\nu = 6.2$ eV) on Fe/W(110) we find an occupied surface band crossing the Fermi level at ~ 0.1 Å^{-1} in Γ-H direction. We observe a pronounced energy renormalization in this iron minority-spin surface state at 160 meV binding energy. Following Ref. [1], we assign this to a renormalization by magnon dressing of the surface electrons.

Applying spin-resolved photoemission, we are able to track the spin polarization of the surface band and ensure that the observed kink is not a trivial crossing of two bands. Our spin detection is based on exchange scattering at a magnetized Fe/W(001) target. By switching the magnetization of sample and scattering target separately, we are able to distinguish between spin polarization and dichroic effects in the photoemission process. Thereby, we find the magnetic-linear-dichroic contrast changing sign crossing the kink as expected for spin-momentum coupling.

[1] Jörg Schäfer, *Phys. Rev. Lett.* **92**, 097205 (2004)

MA 24.10 Tue 18:15 Poster E

Non-collinear spin-states in dilute 1D chains induced by Dzyaloshinskii-Moriya interaction — •Manuel Steinbrecher[1], Alexander Ako Khajetoorians[1,2], Jens Wiebe[1], and Roland Wiesendanger[1] — [1]INF, Hamburg University, 20355 Hamburg, Germany — [2]IMM, Radboud University, 6525 AJ Nijmegen, The Netherlands

Nanostructures of coupled atomic spins are of high interest for future spintronic applications. Therefore, a deep understanding of the behavior of single magnetic atoms deposited on metallic surfaces and of the coupling between several of these spins is mandatory. By using the tip of a scanning tunneling microscope as a tool, single atoms can be moved on a surface [1] to build artificial nanostructures. Realizing bottom-up fabricated 1D spin chains so far led to simple ferromagnetic [2] or antiferromagnetic [3] ground states described by Néel states [4,5]. When using a heavy spin-orbit coupling material, like a Pt(111) surface [6], as a substrate we showed that we can tune the strength of an anisotropic, indirect exchange interaction between indidivual Fe atoms, namely the Dzyaloshinskii-Moriya interaction [7]. With this knowledge we were able to build 1D spin chains and induce non-collinear spin states in the chains, resulting in exotic magnetic behavior. [1] Eigler and Schweizer, Nature **344**, 524 (1990); [2] Gambardella *et al.*, Nature **416**, 301 (2002); [3] Hirjibehedin *et al.*, Science **312**, 1021 (2006); [4] Khajetoorians *et al.*, Science **332**, 1062 (2011); [5] Khajetoorians *et al.*, Nat. Phys. **8**, 497 (2012); [6] Khajetoorians *et al.*, PRL **111**, 157204 (2013); [7] Khajetoorians *et al.*, Nat. Commun., submitted (2015)