TT 39: Spintronics (Joint session of DS, HL, MA, O and TT organized by O)

Time: Tuesday 14:00–16:00 Location: S051

TT 39.1 Tue 14:00 S051

Skyrmion à la carte: Engineering magnetic skyrmions at transition-metal multilayers — •Bertrand Dupé[1], Gustav Bihlmayer[2], Marie Böttcher[1], Stefan Blügel[2], and Stefan Heinze[1] — [1]Institute of Theoretical Physics and Astrophysics, University of Kiel, 24098 Kiel, Germany — [2]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany

Due to their unique topological and dynamical properties skyrmions in magnetic materials offer attractive perspectives for future spintronic applications [1]. Recently, it has been discovered that magnetic skyrmions can also occur in ultra-thin transition metal films at surfaces [2,3]. However, so far only skyrmions at interfaces with a single atomic layer of a magnetic material were reported, which greatly limits their potential for application in devices. Here, we predict the emergence of skyrmions in $[4d/Fe_2/5d]_n$ multilayers, i.e. structures composed of Fe biatomic layers sandwiched between 4*d*- and 5*d*-transition-metal layers [4]. In these composite structures, the exchange and the Dzyaloshinskii-Moriya interactions, which control skyrmion formation, can be tuned separately by the two interfaces. This allows engineering skyrmions as shown by density functional theory and spin dynamics simulations. [1] A. Fert, *et al.*, Nature Nano. **8**, 152 (2013). [2] N. Romming, *et al.*, Science **341**, 636 (2013). [3] B. Dupé, *et al.*, Nature Comm. **5**, 4030 (2014). [4] B. Dupé, *et al.*, submitted (arXiv :1503.08098).

TT 39.2 Tue 14:15 S051

Multichannel-Spin-Polarimetry for the Analysis of Spin-Transport in Metal-Organic Interfaces — •Erik Schaefer[1,2], Martin Krämer[1], Dmytro Kutnyakhov[1], Katerina Medjanik[1], Gerd Schönhense[1,2], and Hans-Joachim Elmers[1,2] — [1]Institut für Physik, Johannes Gutenberg-Universität, Mainz — [2]Graduate School Materials Science in Mainz, Mainz

Spin- and angular resolved photoemission spectroscopy has become the key technique for the investigation of electronic properties of promising spintronic materials. In contrast to conventional photon optics, an effective spin polarization analysis of a given electron beam is difficult. Since organic materials tend to degrade within a short period, a massive reduction of spin-resolved data acquisition time is crucial. The recent developed multichannel spin- and angle-resolved photoemission spectroscopy [1] solves this issue by enhancing the figure of merit by several orders of magnitudes. Ir(001) shows high potential for the use as a scattering target in multichannel spin analysis [2]. A new Ir(001) multichannel spin-detection system was constructed and the important quantities and efficiency of the system were determined. Spin- and angle-resolved photoemission spectroscopy of thin iron films on W(110) were performed.

Founded by Stiftung Rheinland Pfalz für Innovation (project 1038)

[1] M. Kolbe et al., Phys. Rev. Lett. 107, 207601 (2011)

[2] D. Kutnyakhov et al., Ultramicroscopy 130, 63-69 (2013)

TT 39.3 Tue 14:30 S051

Spin-resolved ToF momentum-microscopy of anomalous surface states on W(110) — •D. Kutnyakhov[1], S.V. Chernov[1], R. Wallauer[1], K. Medjanik[2], S.A. Nepijko[1], C. Tusche[3], M. Ellguth[3], S. Borek[4], J. Braun[4], J. Minár[4,5], H. Ebert[4], H.J. Elmers[1], and G. Schönhense[1] — [1]Institut für Physik, Uni-Mainz — [2]MAX IV Lab., Lund, Sweden — [3]MPI für Mikrostrukturphysik, Halle — [4]Dep. Chemie, LMU München — [5]University of West Bohemia, Pilsen, Czech Republic

Spin-resolved bandmapping of anomalous surface states on W(110) has been performed via time-of-flight (ToF) momentum microscopy with an imaging spin-filter using synchrotron radiation at the beamline U125-NIM at BESSY II (hν=22 eV). 3D (k_x,k_y,E_B)-maps in the full surface Brillouin zone with 3.4 Å^{-1} dia. and 4 eV binding energy range were measured simultaneously, resolving 2.5×10^5 voxels without and more than 10^4 voxels with spin resolution. Similar to our recent experiment on Mo(110) [1] the results give evidence for d-like surface resonances in the spin-orbit induced partial band gap. In agreement with previous results [2], we find the dispersing state with Dirac-like signature and Rashba spin texture crossing the bandgap at the $\overline{\Gamma}$-point and E_B=1.25 eV. A second linear band crossing occurs close to the midpoint between $\overline{\Gamma}$ and $\overline{\mathrm{N}}$ at E_B=0.8 eV. Results are compared with one-step photoemission calculations in its density matrix formulation.

Funded by BMBF (05K13UM1, 05K12EF1, 05K13WMA). [1] Chernov et al., Ultramicroscopy, (2015), doi:10.1016/j.ultramic.2015.07.008; [2] Miyamoto et al., PRL 108, 066808 (2012)

TT 39.4 Tue 14:45 S051

Spin-polarized electron energy loss spectrometer with detection of final state spin polarization — •Dmitry Vasilyev and Jürgen Kirschner — Max-Planck Institut für Mikrostrukturphysik, Halle, Germany

Spin polarized electron energy loss spectroscopy (SPEELS) allows to investigate Stoner excitations, as was demonstrated 30 years ago. Based on theory one should expect structured energy loss spectra with features on the scale of less than 1 eV. The spectra should change with varying the incidence angle by a few degrees, and the primary energy of electrons by less than 1 eV. However, this was not observed at that time. We have developed a new SPEELS apparatus with the detection of final state spin polarization. The new spectrometer allows us to see all the expected features. Spin-polarized electrons are generated via photoemission from GaAs-based superlattice. The direction of the electron spin can be changed by varying the light helicity. Additionally the magnetization of the target can be reversed. A multichannel spin detector is used for the measurement of the spin-polarization of the outgoing electrons. It is based on spin dependent reflection from pseudomorphic Au on Ir (001). This system provides high polarization sensitivity, up to 80%, and more that 8 months lifetime in ultrahigh vacuum. The measurement of intensity asymmetries for opposite magnetization directions allows to distinguish between spin-orbit asymmetry and exchange asymmetry. Together with detection of the spin-polarization of the outgoing electrons it allows to determine relative transition probabilities for each of the four partial intensities.

TT 39.5 Tue 15:00 S051

Ab initio investigation of a novel spin-filter: Graphene on Ir(111) — •Christian Mende[1], Stephan Borek[1], Jürgen Braun[1], Gustav Bihlmayer[2], Dima Kutnyakhov[3], Hans-Joachim Elmers[3], Gerd Schönhense[3], Jan Minár[1,4], and Hubert Ebert[1] — [1]Ludwig-Maximilians-Universität München — [2]Forschungzentrum Jülich — [3]Johannes-Gutenberg-Universität Mainz — [4]University of West Bohemia Pilsen

For the determination of the spin-polarized band structure in angle-resolved photoemission (ARPES) experiments an application of materials as reflection mirrors is recommended. For this purpose one uses the spin-dependent scattering of photoelectrons from suitable surfaces based on either exchange or spin-orbit induced scattering. We present our calculations of spin-polarized low energy electron diffraction (SPLEED) patterns for the clean Ir(111) and the Graphene covered Ir(111) surface. For these materials the electron scattering is strongly influenced by spin-orbit interaction whereas the Graphene layer provides a longer lifetime of the spin-polarizing mirror due to its inert properties concerning surface contamination. Based on ab initio calculations of the electronic structure we obtained diffraction patterns over a wide range of kinetic energies and polar angles to determine the applicability of the Ir(111)+Graphene system as spin-polarizing mirror. Additionally we investigated ARPES spectra to connect the electronic structure calculations to the corresponding experiment.

TT 39.6 Tue 15:15 S051

Ab initio calculation of SPLEED patterns for the Ir(111) surface — •Stephan Borek[1], Jürgen Braun[1], Jan Minár[1,2], Dima Kutnyakhov[3], Hans-Joachim Elmers[3], Gerd Schönhense[3], and Hubert Ebert[1] — [1]Ludwig-Maximilians-Universität München — [2]University of West Bohemia Pilsen — [3]Johannes-Gutenberg-Universität Mainz

Recent investigations have shown that the Ir(100) surface is a promising candidate for spin-filter application [1]. In our studies we investigated the Ir(111) surface and its applicability for spin-filter purposes. Accordingly, diffraction patterns of spin-polarized electrons scattered on the surface have been calculated for a wide range of polar angles and kinetic energies. The calculated diffraction patterns show more suitable working points in comparison to the standard Ir(100) surface extending the spin-filter versatility. In addition we looked for deviations of the scattering plane from high symmetry directions $\overline{\Gamma}\,\overline{M}$ and $\overline{\Gamma}\,\overline{K}$ in the surface Brillouin zone and its impact on the diffraction patterns. To complement the SPLEED calculations we calculated angle-resolved photoemission spectra to characterize the underlying electronic structure.

[1] D. Kutnyakhov et al. Ultramicroscopy **130**, 63 (2013)

TT 39.7 Tue 15:30 S051

Determining excitation pathways at the Cobalt/Alq3 interface — •Philip Thielen[1,2], Anna-Katharina Mahro[1], Benjamin Stadtmüller[1], Mirko Cinchetti[1], and Martin Aeschlimann[1] — [1]Fachbereich Physik and Research Center OPTIMAS, Technische Universität Kaiserslautern, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern, Germany — [2]Graduate School of Excellence Materials Science in Mainz, Gottlieb-Daimler-Str. 47, 67663 Kaiserslautern, Germany

One of the fundamental questions in molecular spintronics consists in understanding the properties of hybrid interfaces between molecules and ferromagnetic metals. Recently, it was shown that the interface state between a thin layer of the metalorganic complex tris(8-hydroxyquinolinato)aluminium (Alq3) and a cobalt surface acts as a spin filter due to the prolonged spin-dependent trapping of electrons [1]. The excitation of spin-polarized electrons into such hybrid interface states can take place either directly from the cobalt in a coherent process or in an indirect, incoherent process, e.g. via charge transfer. We show that we can disentangle coherent and incoherent excitation pathways using a phase-stabilized two-pulse correlation experiment. We discuss the possible implications of our findings regarding the optical control of spin-polarized electrons at hybrid interfaces.

References: [1] S. Steil, N. Großmann, M. Laux, A. Ruffing, D. Steil, M. Wiesenmayer, S. Mathias, O. L. A. Monti, M. Cinchetti and M. Aeschlimann, Nature Physics 9, 242 - 274 (2013)

TT 39.8 Tue 15:45 S051

Energy Dispersion and Spin Structure of Unoccupied States of BiTeI: A Matter of Surface Termination? — •Christian Langenkämper[1], Koji Miyamoto[1], Anke B. Schmidt[1], Peter Krüger[2], and Markus Donath[1] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Germany — [2]Institut für Festkörpertheorie, Westfälische Wilhelms-Universität Münster, Germany

We present a combined experimental and theoretical study on the unoccupied electronic structure of BiTeI along the $\overline{\Gamma}$-$\overline{\mathrm{K}}$ direction. We performed spin-resolved inverse-photoemission experiments on samples with different surface termination, Te and I.

For the two surface terminations we found distinct differences in the energy dispersion of the surface states around $\overline{\Gamma}$, which are caused by band bending. In contrast, this effect is not observed around the $\overline{\mathrm{K}}$ point. With the help of *ab initio* band-structure calculations we identify the observed states as bulk states, not influenced by band bending.

In addition, we studied the spin structure of the unoccupied bands. Around the $\overline{\Gamma}$ point, we found a Rashba-type in-plane spin polarization. Upon approaching $\overline{\mathrm{K}}$, the direction of the spin polarization rotates from fully in-plane to out-of-plane. This spin texture is in accordance with the crystal symmetry and independent of the surface termination.