O 63: Symposium: Frontiers of Surface Sensitive Electron Microscopy II (Invited Speakers: Jürgen Kirschner, Liviu Chelaru, Michael Bauer, Claus Schneider)

Time: Thursday 9:30–12:30 Location: MA 043

Invited Talk O 63.1 Thu 9:30 MA 043
Development of a "momentum microscope" for imaging of valence band electron states — •Juergen Kirschner[1], Burkhard Kroemker[2], and Matthias Escher[3] — [1]MPI fuer Mikrostrukturphysik, Weinberg 2, 06120 Halle — [2]Omicron Nanotechnology GmbH, Taunusstein — [3]Focus GmbH, Hünstetten-Hesselsbach

Our aim is to image the momentum distribution of photoexcited valence band electron states in an energy plane through the Brillouin Zone. Our design is based on a modified NanoESCA comprising a Photoelectron Emission Microscope (PEEM) with an imaging energy filter. The basic idea is not to use the real space image from the objective lens but to transfer the momentum image in the focal plane into a hemispherical analyzer by an additional transfer lens. The aberrations of the analyzer are compensated by a second hemisphere such that the inner electron trajectories in the first sphere become the outer trajectories in the second sphere. Thus, an aberration corrected image of the angular distribution of the electrons leaving the sample within a certain area (~ 70 μm diameter) appears at the exit of the second analyzer. The projected image displays the dispersion of the valence electrons within a plane of constant energy. The full valence band can be observed by a sequence of parallel cuts through the Brillouin zone. Because of the parallel detection of all electrons within a given energy window the process is very fast. We demonstrate with a Cu(111) surface and a standard discharge laboratory source (HeI) that complete dispersion planes can be obtained within a couple of minutes.

Invited Talk O 63.2 Thu 10:00 MA 043
Imaging Surface Plasmon Polaritons: Time-resolved Two-Photon Photoelectron Emission Microscopy — •Liviu I. Chelaru — Institut für Festkörperforschung, Elektronische Eigenschaften, Forschungszentrum Jülich, Germany

Routing and manipulation of light on nanoscale metallic circuits as surface plasmon polaritons (SPPs) is seen today as a way of integrating microscale photonics and nanoscale electronics on the same chip. A fundamental understanding of the interaction between light and metallic nanostructures is an essential prerequisite for the realisation of functional devices based on SPPs. In this presentation I will focus on the excitation and propagation of SPPs in single-crystalline Ag nanostructures of different shapes and sizes that are formed in-situ by self-assembly during deposition on Si surfaces. Imaging of the SPPs is accomplished by time-resolved two-photon photoelectron emission microscopy (TR-2PPEEM). Here the excited SPP wave is visualised as a result of the interference (beat pattern) between the laser pulses and the travelling SPP wave at the sample surface. I will present time-resolved high-resolution images of the propagating SPP waves recorded using a pump-probe setup. The problem of guiding the SPP waves, and the coupling of light into and out of the nanostructures is discussed by comparing nanostructures of different geometry.

O 63.3 Thu 10:30 MA 043
A PEEM Study of the Substrate Dependence of Pentacene Thin Film Growth on Silicon — •Simone Möllenbeck[1], Dagmar Thien[1], Peter Kury[1], Kelly R. Roos[1,2], Dirk Wall[1], Michael Horn-von Hoegen[1], and Frank-J. Meyer zu Heringdorf[1] — [1]Department of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE) Universität Duisburg-Essen, D-47057 Duisburg, Germany — [2]Department of Physics, Bradley University, Peoria, IL 61625, USA

We used Photoemission Electron Microscopy (PEEM) to compare the well known behavior of Pentacene on Si(001) with the growth of Pentacene on different silicon surfaces with orientations between Si(111) and Si(001). The growth mode and morphology of Pentacene films are neither changed by an increase of the surface step density nor by the transition from a threefold to a twofold symmetry of the surface. An explanation for the observed behavior is the covalently bonded, disordered wetting layer, that acts as an interfactant layer and isolates the film from substrate defects and the substrate's structure. Furthermore, we have studied the electronic properties of thin Pentacene films on Si(001) with time-resolved PEEM. As result we get spatially resolved pump-probe traces whereby a "lifetime map"can be generated. The observed lifetime $\tau = 200fs$ for electronic excitation in the Pentacene wetting layer is by a factor two smaller than the lifetime for the first layer. We attribute this to the difference in electronic coupling of the monolayers to the substrate, that is also apparent in the different work-function of these layers.

Invited Talk O 63.4 Thu 10:45 MA 043
Subwavelength control of nano-optical fields probed by non-linear PEEM — Martin Aeschlimann[1], •Michael Bauer[2], Daniela Bayer[1], Tobias Brixner[3], F. Javier Garcia de Abajo[4], Walter Pfeiffer[5], Martin Rohmer[1], Christian Spindler[6], and Felix Steeb[1] — [1]FB Physik, TU Kaiserslautern — [2]IEAP, Universität Kiel — [3]Inst. für Phys. Chemie, Universität Würzburg — [4]CSIC, Madrid — [5]Fakultät für Physik, Universität Bielefeld — [6]FZ Jülich

Theoretically it has been demonstrated that the interaction of polarization-shaped laser pulses with a nanostructure allows the control of the spatial and temporal evolution of an optical near-field [1]. Recently we succeeded in demonstrating this scheme experimentally [2]. Silver nano-particles are illuminated with polarization shaped femtosecond laser pulses. The near-field in the vicinity of these nanostructures is mapped by the two-photon photoemission pattern as recorded using a photoemission electron microscope. We show that the emission pattern depends on the time-dependent polarization state of the laser pulse. Furthermore, the adaptive polarization pulse shaping technique allows optimizing a particular emission pattern with sub-diffraction resolution. The experiments show that the local interference of the optical near-fields generated by the two orthogonal incident polarization components can be utilized to manipulate the local field distribution in space and time.

[1] T. Brixner et al., Phys. Rev. Lett. 95, 093901 (2005). [2] M. Aeschlimann et al., Nature 446, 301 (2007).

O 63.5 Thu 11:15 MA 043
Energy and time resolved photoelectron emission microscopy (PEEM) measurements of nanostructured surfaces — •Christian Schneider[1], Martin Rohmer[1], Daniela Bayer[1], Michael Bauer[2], and Martin Aeschlimann[1] — [1]Department of Physics, TU Kaiserslautern, Erwin Schrödinger Str. 46, 67663 Kaiserslautern — [2]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24908 Kiel

The combination of two photon photoemission and photoelectron emission microscopy is a versatile tool to study electron dynamics at nanostructured surfaces with high spatial and temporal resolution. The fast parallel image acquisition allows to obtain "lifetime maps" with a temporal accuracy of a few femtoseconds, however, in general without any spectral selectivity. In the past year, our setup was upgraded with an interchangeable delayline-detector allowing simultaneously energy resolved measurements. The performance and the high energy resolution provided with this detector will be demonstrated at the example of the Shockley surface state of Cu (111). The simultaneous access to space, time and energy by the combination of PEEM, time-resolved 2PPE and delayline-detector provides thus the potential to study coupling effects between nanoparticles as well as plasmon decay in realtime. We will show first results of specially shaped silver nanoparticles measured with high spatial, temporal and spectral resolution, including lifetime-maps created for different electron energies.

Invited Talk O 63.6 Thu 11:30 MA 043
Probing thin film magnetism by photoemission microscopy — •Claus M. Schneider — Institut f. Festkörperforschung IFF-9, Forschungszentrum Jülich, D-52425 Jülich, Germany

X-ray photoemission microscopy (X-PEEM) has matured into a versatile tool for high-resolution studies of thin film and surface magnetism. Exploiting the intrinsic time structure of the synchrotron radiation even time-resolved investigations on the sub-nanosecond time scale have become possible. This contribution will address the opportunities and perspectives of photoemission microscopy in the field of magnetism. In this course we will give examples for the information that can be obtained from static XPEEM experiments on the magnetic domain structures and coupling phenomena in heteromagnetic film systems. Time-resolved experiments reveal a wealth of micromagnetic processes governing the dynamics of magnetic microstructures on the nanosecond and sub-nanosecond regime [1].

[1] G. Schönhense, H.-J. Elmers, S.A. Nepijko, and C. M. Schneider, in: Advances in Imaging and Electron Physics Vol. 142, ed. P. Hawkes. (Academic Press, London, 2006).

O 63.7 Thu 12:00 MA 043

Microscopic investigation of exchange bias in Ni/FeMn bilayers — •Florian Kronast, Joachim Schlichting, Ruslan Ovsyannikov, Florin Radu, Shrawan Mishra, Hermann Dürr, and Wolfgang Eberhardt — BESSY GmbH , Berlin, Germany

The exchange interaction at the interface between an antiferromagnet (AF) and a ferromagnet (FM) is responsible for exchange bias, i.e. an unidirectional anisotropy seen by a shift of the FM hysteresis loop. Element specific magnetic imaging by photoelectron emission microscopy (PEEM) is a powerful tool to investigate the arrangement of magnetic moments near the interface. Recent PEEM studies of Co/FeMn bilayers demonstrated the presence of uncompensated Fe and Mn spins at the AF interface [1]. But their influence on the exchange bias could not be revealed so far.

Here we report on the first attempt to investigate the magnetic interface coupling in Ni/FeMn bilayers by PEEM using applied magnetic fields during imaging. A magnetic yoke was especially designed to minimize the deflection of photoelectrons by the Lorentz force. We studied the domain structure in the FM layer and the arrangement of magnetic moments at the interface of the AF as a function of magnetic field. Our main objective was to obtain a nano-scale image of the exchange bias strength in Ni/FeMn bilayers and correlate this with the magnetic arrangement of uncompensated spins at the AF interface. Saturating the FM layer by the applied magnetic field we can separate pinned and unpinned spins at the interface of the AF which are expected to be essential for the exchange bias. [1] PRB 75, 224406 (2007)

O 63.8 Thu 12:15 MA 043

Imaging ferroelectric domains with reflected low energy electrons — •Salia Cherifi — CNRS-Institut Neel, BP166, F-38042 Grenoble, France

In the very-low electron energy regime, reflected electrons from a specimen mirror are highly sensitive to topography and to electric surface potential. The sensitivity of the so-called mirror electron microscopy have been exploited in this study for imaging periodic -up and down- ferroelectric nano-strips designed on thin ferroelectric films and multiferroics. The ferroelectric domains have been written with a conducting tip of an atomic force microscope (AFM) and imaged initially using piezoelectric force microscopy (PFM). The images obtained in mirror electron microscopy (MEM) show periodic bright and dark microstripes that can be clearly matched to the ferroelectric domains imaged with PFM. AFM measurements performed prior and after the mirror electron microscopy experiment exclude the contribution of topography in the MEM contrast and confirm the possibility of imaging ferroelectric domains using MEM. This direct imaging mode will open new possibilities -especially when combined with PEEM- for the study of dynamical processes in ferroelectric systems and multiferroics.