O 52: Poster Session - New Methods: Experiments

Time: Tuesday 18:15–20:00 Location: P2/1OG

O 52.1 Tue 18:15 P2/1OG

Design of an electron beam ion source for experiments with ultrafast timing resolution using SIMION simulations — •Johanna Fries[1], Anna Niggas[1], Gabriel L. Szabo[1], and Richard A. Wilhelm[1,2] — [1]TU Wien, Institute of Applied Physics, Vienna, Austria — [2]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Dresden, Germany

The interaction of ions with a solid surface is characterized by many different processes, such as sputtering, electron emission and nanostructuring. Time scales of these processes span from the sub-fs regime for charge exchange to the μs-regime for ion-induced defect diffusion. In order to investigate the dynamics of at least some of these processes in experiment, ion pulses with a pulse length and timing accuracy in the sub-ps range are necessary.

With the help of SIMION simulations we develop the design of an electron beam ion source (EBIS) capable of producing such ultrashort ion pulses. Our design uses a simple Ti:Sapphire oscillator as electron pulse trigger in contrast to high power or high harmonics laser systems for photo-ionization. Starting from the design of a commercial EBIS, several parts will be replaced with tailor-made components in SOLIDWORKS. The CAD drawing is then used for a particle trajectory simulation based on the code SIMION. To optimize the ion source performance with regard to pulse length, beam focus and output, parameters such as spatial dimensions and potentials are varied and systematically analyzed.

O 52.2 Tue 18:15 P2/1OG

Design of an ultrafast THz-STM — •Nils Bogdanoff, Sergey Trishin, Christian Lotze, Katharina J. Franke, and Tobias Kampfrath — Freie Universität Berlin, Department of Physics, Arnimallee 14, 14195 Berlin, Germany

Investigating the ultrafast dynamics of electronically excited systems is crucial for understanding its coupling to the environment. Most state-of-the-art ultrafast techniques are used to investigate isolated systems in gas-phase or applied to macroscopic surface areas of carefully tailored systems. However, many modern applications strive towards increasingly small, surface-coupled structures approaching the atomic scale. A standard technique for high electronic real-space resolution is scanning tunneling microscopy (STM). Its temporal resolution is limited by the bandwith of the amplifier, cabling and the junction capacity itself. In 2013 Cocker et al. demonstrated that applying a pulse of THz radiation to the junction of an STM can act as a transient bias voltage opening a tunneling channel only for an ultrashort period of time [1]. Using this in a pump-probe scheme and recording changes in the average tunneling current makes ultrashort timescales accessible by STM [1,2]. Here we present first steps on the way to constructing and characterizing a THz-STM using a tilted-pulse-front pumping scheme to generate THz-pulses in a lithium niobate (LN) crystal.

[1] Cocker, T. et al. An ultrafast terahertz scanning tunnelling microscope. Nature Photon 7, 620-625 (2013)

[2] Cocker, T. et al. Tracking the ultrafast motion of a single molecule by femtosecond orbital imaging. Nature 539, 263-267 (2016)

O 52.3 Tue 18:15 P2/1OG

Low Energy Positron Beam for Near-Surface Doppler-Broadening Spectroscopy — •Lucian Anton Joshua Mathes, Sebastian Vohburger, Vassily Vadimovitch Burwitz, and Christoph Pascal Hugenschmidt — Physics Department E21 and Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München

A new positron lab beam setup has been constructed for low energy Doppler-broadening experiments aimed at examining near-surface defect structures. Positrons are provided by a ^{22}Na source, then moderated in a thin tungsten foil from which they are guided to the sample chamber by a system of longitudinal and transverse magnetic fields. The positrons are accelerated electrostatically by a potential difference applied between moderator and sample to a kinetic energy from a few electronvolts up to 30 keV. Inside the UHV chamber the positron beam is focused onto the sample by an electrostatic single lens. This setup is intended to complement the positron instrument suite at NEPOMUC and expands capabilities in the field of defect studies close to the surface layer. First experimental results on oxides will be presented.

O 52.4 Tue 18:15 P2/1OG

Heat of Adsorption on Single Crystals: Microcalorimetry — •Ann-Katrin Baumann and Swetlana Schauermann — Max-Eyth-Str.2, 24118 Kiel

Rational design of new heterogeneous catalysts requires detailed understanding of the bonding interactions between the gaseous species and the catalytic surface. One of the crucial parameters in this interaction is the adsorption enthalpy of the involved surface species.

Adsorption enthalpies can be determined with high level of accuracy by a direct method of single crystal adsorption calorimetry (SCAC), which has a number of advantages over the commonly used indirect method of temperature programmed desorption. In contrast to indirect methods, SCAC provides heats of adsorption without relying on assumptions on the details of the desorption kinetics or reversibility of the desorption processes.

In this work, an improved experimental setup of SCAC is presented. In ultra high vacuum, a pulsed molecular beam is employed to dose a known amount of molecules on a well-defined thin metal single crystal (1-2 μm) or nanostructured model surfaces containing supported metallic nanoparticles. The arising heat of adsorption is detected by a pyroelectric material (β-PVDF) pressed against the back of the thin metal crystal. Simultaneously the sticking coefficient of the molecules is recorded in order to determine the amount of molecules contributing to the signal and the total amount of molecules remaining permanently adsorbed on the surface. We present the adsorption energies of simple molecules employing an improved design of SCAC setup.

O 52.5 Tue 18:15 P2/1OG

Temperature measurement by a pyrometer: Determination of the emissivity coefficient and influencing factors — •Robert Decke, Mate Puljiz, and Mathias Getzlaff — Institute of Applied Physics, University of Duesseldorf

Pyrometers represent an elegant tool for the contactless measurement of temperatures. This technique is especially important under vacuum or aggresive conditions. Additionally, high temperatures can be determined. For a correct procedure the emissivity coefficient must be known which is a measure for the difference of the emitted light intensity at a specific wave length between a black body and the real object. The goal of this study was therefore to investigate the influencing factors of this coefficient.

Here we report on the investigation of a W(110) crystal at different temperatures with pyrometers working at two different wave lengths. The real surface temperature was monitored using a thermocouple. The influence of the setup, the focus condition of the pyrometer optics, the wave length and the angle between the surface normal and the detection direction will be shown.

O 52.6 Tue 18:15 P2/1OG

Towards a high-intensity ion source for preparative mass spectrometry — •Paul Fremdling[1], Laurent Bernier[2], Loukas Kyriakidis[2], Julius Reiss[2], and Stephan Rauschenbach[1] — [1]Department of Chemistry, University of Oxford, UK — [2]Institut für Strömungsmechanik und Technische Akustik, Technische Unversität Berlin, DE

Preparative Mass Spectrometry (pMS) is an ion beam deposition technique producing highly purified, mass-filtered homogeneous samples of non-volatile compounds such as metal ion clusters(1), sugars(2) or intact Proteins in vacuum(3). High-intensity ion sources are a prerequisite to apply pMS to produce technological coatings on a macroscopic surface as well as to selectively mass-filter and land low-abundance ionic species.(4) However, in current mass spectrometers the transmission efficiency from electrospray to high vacuum is less than a tenth and the maximum ion current achievable is limited to the low nA range(4). We want to overcome this barrier by developing a novel vacuum interface combining a high-capacity transfer capillary(5, 6) with an ion funnel system optimised under fluid dynamics aspects.

1. M. A. Röttgen et al., Rev. Sci. Instrum. 77, 013302 (2006). 2. S. Abb et al., Angew. Chem. Int. Ed. 58, 8336-8340 (2019). 3. J.-N. Longchamp et al., Proc. Natl. Acad. Sci. 114, 1474-1479 (2017). 4. S. Rauschenbach et al., Annu. Rev. Anal. Chem. 9, 473-498 (2016). 5. M. Pauly et al., The Analyst. 139, 1856 (2014). 6.

L. Bernier et al., J. Am. Soc. Mass Spectrom., 1-13 (2018).

O 52.7 Tue 18:15 P2/1OG

Femtosecond point-projection microscopy and holography – electron source coherence and spatial resolution — Faruk Krečinić and •Ralph Ernstorfer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin

Femtosecond point-projection microscopy (fs-PPM) is a technique for visualizing ultrafast charge motion in real space. A nanotip electron source is brought close to the sample such that the diverging electron beam projects a magnified image of the sample onto the detector. Due to the use of low-energy electrons, the PPM image is highly sensitive to local (nanoscale) electric fields. At high magnification, one observes an in-line holographic projection of the sample that is sensitive enough to visualize a single elementary charge [1]. By triggering the emission of electrons from the nanotip with an ultrafast laser it is possible to perform pump-probe PPM, visualizing the ultrafast dynamics of charge carriers with nanometer resolution [2,3]. However, the photoemission process can also lead to a decrease in the spatial resolution. Using a semi-classical model we show how spatial and temporal coherence, as well as electron-optical aberrations and the apex geometry, affect the spatial resolution of the PPM technique. The introduced semi-classical model is in principle more generally applicable to investigations of the wave-optical properties of (photo)electron sources for electron microscopy.

[1] T. Latychevskaia, et al., Nano Letters, 16(9), 5469-5474, (2016). [2] M. Müller, et al., Nat. Comm., 5, 5292 (2014). [3] F. Krečinić, et al., arXiv:1803.01766, (2018).

O 52.8 Tue 18:15 P2/1OG

New 100-kHz User Beamline Based on High-Harmonic Generation for Time-Resolved Photoemission — •Charlotte E. Sanders, Yu Zhang, Adam S. Wyatt, Gabriel Karras, Richard T. Chapman, Gregory M. Greetham, Michael Towrie, and Emma Springate — Central Laser Facility, STFC Rutherford Appleton Laboratory, Harwell OX11 0QX, UK

The UK's Central Laser Facility (CLF) Artemis Laboratory offers open access to pump-probe angle-resolved photoemission spectroscopy (ARPES), whereby ultrafast dynamics in solid-state systems can be probed using high-harmonic generation. Our beamline supports the study of dynamics ranging from the femtosecond to the picosecond regimes, with tuneable polarization in both the pump and probe. We have recently upgraded our capabilities to include a 100-kHz laser system. In our first user call, in 2020, we plan to offer temporal and spectral resolution of around 50 fs and 100 meV, respectively, and probe photon energies of 25–40 eV, combined with pump photon energies of 0.48 or 0.73 eV (1.7 or 2.6 μm). In the future, with further development, we will offer additional options such as tuneable pump energy and probe energies up to 100 eV. The high repetition rate will permit favourable statistics and space charge conditions relative to lower-repetition rate systems.

O 52.9 Tue 18:15 P2/1OG

Extracting Protein Collision Cross Sections (CCSs) from Pre-Fourier Transform Mass Spectrum Transients — •Dhiren De Silva, Paul Fremdling, Tim Esser, Joseph Gault, and Stephan Rauschenbach — Department of Chemistry, Oxford University, UK

The collision cross section (CCS) of a molecule gives a sense of its size and shape and is defined as the area of a circle with radius equal to the sum of the radii of two colliding molecules. Protein CCSs have conventionally been measured through Ion Mobility experiments with dedicated instruments. More recently, procedures involving analysis of mass spectrum transients have been used to determine protein CCSs. These new methods make use of the fact that the transient signal, which is an oscillating signal due to the motion of ions in the trap, displays beating due to the superposition of the individual signals and decays in amplitude over time mainly due to ion-neutral collisions. Transients of several model proteins such as ubiquitin, cytochrome C and myoglobin in various charge states were recorded with the QE UHMR Orbitrap Mass Spectrometer. An algorithm was developed to extract the decay lifetime and calculate the CCS using ubiquitin in charge state 9 as a calibrant. We explore monitoring the CCS during native protein deposition ES-IBD experiments in a modified QE Orbitrap Mass Spectrometer. This will allow online monitoring of shape during protein deposition for imaging applications.

O 52.10 Tue 18:15 P2/1OG

Selective Preparation of Electron Micrsocopy grids via Native Electrospray Ion-Beam Deposition — •Sam Britton, Tim Esser, Paul Fremdling, Stephan Rauschenbach, and Dhiren De Silva — University of Oxford

Due to the close relationship of structure and function, structural determination of proteins is an enormously important area of biochemistry. Cryo-electron microscopy (EM) can generate highly resolved structures by averaging many low contrast, single particle images of proteins embedded in vitreous ice; however, TEM is typically unable to reach high resolution for heterogeneous samples. Here we outline an alternative approach of preparing samples for single-particle EM, which is based upon native electrospray ion-beam deposition (ES-IBD). Samples are prepared using a modified commercial mass spectrometer (Q Exactive UHMR - Thermo Fisher) and subsequently imaged with atomic force microscopy and TEM. We explore the ability of this instrument to mass select single species followed by focused, soft deposition onto a TEM grid, thereby eliminating the issue of sample heterogeneity.

O 52.11 Tue 18:15 P2/1OG

Following the motion of a charged conducting sphere by electrostatic induction in a parallel plate capacitor — Mirco Kaponig, •Andre Mölleken, Doris Tarasevitch, Detlef Utzat, Hermann Nienhaus, and Rolf Möller — Fakultät für Physik/Cenide, Universität Duisburg-Essen, Germany

The charges induced in the plates of a parallel plate capacitor due to a conducting charged moving sphere have been measured up to the mechanical contact. For larger distances the induced charge scales linearly with the distance. However, when the sphere approaches the plate further the charges on the sphere are attracted by the induced charges in the plate and move on the surface of the sphere towards the plate. This leads to a further increase of the induced charge. The experimental results compare well to an approximate formula which will be discussed in detail.

O 52.12 Tue 18:15 P2/1OG

Statistical evaluation of the switching current in a STM Josephson junction — •Martina Trahms[1], Rika Simon[1], Nils Bogdanoff[1], Olof Peters[1], Gaël Reecht[1], Clemens B. Winkelmann[2], and Katharina J. Franke[1] — [1]Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Univ. Grenoble Alpes, Institut Neél, 25 Avenue des Martyrs, 38042 Grenoble, France

The intrinsic order of the superconducting ground state is given by the superconducting order parameter. In a Josephson junction this order parameter can be determined by measuring the junction's critical current. A Josephson junction is formed in a scanning tunneling microscope (STM) using a superconducting tip in close proximity to a superconducting surface. In the I-V characteristic of this junction the transition from the Cooper pair to the quasi particle tunneling regime is specified by the switching current. In a purely thermal activated system the switching current follows a Poisson distribution around the critical current. However, the distribution of the switching current might also be sensitive to other energy fluctuations, e.g. quantum noise and spin related excitations induced by magnetic adatoms. To investigate these activation processes we statistically analyse the switching current in a Josephson junction formed between a Pb tip and Pb(111) surface.