O 13: Focus Session: Ion Beam Interaction with Surfaces and 2D Materials II

Time: Monday 15:00–17:15 Location: GER 38

Topical Talk O 13.1 Mon 15:00 GER 38

Space weathering of planetary surfaces — •Peter Wurz — Physics Institute, University of Bern, Bern, Switzerland

The surfaces of planetary objects in interplanetary space are subjected to external agents modifying their chemical and mineralogical composition and causing removal of material from these surfaces into interplanetary space. These external agents are the flow of ions and electrons from the Sun (the solar wind), currents of magnetospheric systems, energetic particles from outer space, impacting micro-meteorites, and photons from the Sun. In particular, the ion precipitation on these surfaces is of high interest. The removal of surface material, e.g., the ion-induced sputtering, contributes atoms to the interplanetary particle population, which eventually end up as ions in the interplanetary plasma flow. The changes in composition of the surface are also of interest because they affect the spectroscopic appearance of these surfaces. Since most of the planetary objects are only studied via telescopic observations, relating the spectroscopic appearance of the space-weathered surface to the underlying material is of high importance.

O 13.2 Mon 15:30 GER 38

Quantifying the erosion of the lunar surface due to solar wind sputtering — •Johannes Brötzner[1], Herbert Biber[1], Noah Jäggi[2], Paul Stefan Szabo[3], Daniel Primetzhofer[4], André Galli[2], Peter Wurz[2], and Friedrich Aumayr[1] — [1]TU Wien, Institute of Applied Physics, Vienna, Austria — [2]University of Bern, Physics Institute, Bern, Switzerland — [3]University of California, Space Sciences Laboratory, Berkeley, USA — [4]Uppsala University, Department of Physics and Astronomy, Uppsala, Sweden

Without a protective atmosphere nor its own magnetic field, the lunar surface is subjected to bombardment by the solar wind, a stream of mostly H^+ and He^{2+} ions originating from the Sun. Combined with other effects, this leads to the ejection of material and subsequently the formation of a tenuous gas layer around the Moon, the exosphere. Understanding its formation and coupling to surface properties could potentially enhance our knowledge of not only the Moon, but also other rocky bodies in the solar system.

Previous attempts at modelling the creation of an exosphere used sputter yield values of limited validity for the sputtering contribution to this process – data for relevant minerals were simply not available. While in the past few years, investigations using adequate analogue materials have progressed, we present both experimental and numerical results for the irradiation of H^+ and He^+ ions on samples prepared from actual lunar material, gathered during the Apollo 16 mission in 1972.

O 13.3 Mon 15:45 GER 38

Sputtering from Sinusoidal Surfaces: Monte Carlo Simulations and Comparison to Analytical Results — •Gerhard Hobler[1] and R Mark Bradley[2] — [1]Institute of Solid-State Electronics, TU Wien, AUSTRIA — [2]Departments of Physics and Mathematics, Colorado State University, Fort Collins, CO 80523, USA

Sputtered surfaces are virtually never planar at the nanoscale, and so there has been longstanding interest in the spatially averaged sputter yield $\bar{Y}$ that results when a broad ion beam is incident on a surface with a nontrivial morphology. Considering the simple case of sinusoidal surfaces, the aim of the present study is (i) to investigate the contributions of redeposition and secondary sputtering to $\bar{Y}$, and (ii) to test a recently developed theory [1] that predicts $\bar{Y}$ for small amplitudes from the angular dependent sputter yield of a flat surface. For the simulations we use the Monte Carlo binary collision code IMSIL [2]. Apart from expected results on redeposition and sputtering by reflected ions, we also find that sputtering by recoils that are sputtered and then strike the surface may compensate for a sizable amount of redeposition. The simulations confirm the theory's prediction that $\bar{Y}$ may either increase or decrease with amplitude depending on the incidence angle. They also confirm the theory's prediction that redeposition scales with the square of the amplitude over the wavelength, and are generally in excellent quantitative agreement with theory.

[1] R.M. Bradley, G. Hobler, submitted for publication.
[2] G. Hobler, Nucl. Instrum. Meth. B 96 (1995) 155.

O 13.4 Mon 16:00 GER 38

MeV-SIMS: mass spectrometry with ultra-fast projectiles — •Lars Breuer[1], Tobias Heckhoff[1], David Theuner[1], Frieder Koch[2], and Andreas Wucher[1] — [1]Universität Duisburg-Essen — [2]GSI Helmholtzzentrum für Schwerionenforschung

While secondary ion mass spectrometry has become a standard tool in surface analysis, it still offers multiple challenges. While ionization probabilities are usually fairly low and may be altered by the chemical environment of the target surface, fragmentation of molecules introduces even more experimental challenges. Therefore, better understanding of the underlying processes and methodology improvement is an ongoing topic of research. Here, we present strategies developed to shed light on the fundamental processes in sputtering of different materials from metals and insulators to organic samples by tuning the contribution of nuclear and electronic sputtering. For that purpose, a time-of-flight spectrometer has been coupled to the M-Branch of the UNILAC at GSI in Darmstadt, using swift heavy ions as projectiles. By laser post-ionization not only secondary ions are accessible but their neutral counterparts as well to enable us to gain insight into sputtering and ionization under extreme conditions.

O 13.5 Mon 16:15 GER 38

A new material science target station for swift and highly charged ions at CRYRING@ESR — •Kevin Vomschee[1], Michael Wagner[2], Nils Ulrich[2,3], Frieder Koch[2], Sadra Kour[1], André Maas[1], Christina Trautmann[2,3], Marika Schleberger[1], and Lars Breuer[1] — [1]Univ. Duisburg-Essen — [2]GSI Helmholtzzentrum für Schwerionenforschung — [3]Technische Univ. Darmstadt

This contribution describes the new target station MSS@CRYRING ("Material Science Station at CRYRING") operated at GSI. The new setup at the storage ring CRYRING allows the irradiation of samples with highly charged ions up to completely stripped uranium (U^{92+}) with full control over the kinetic energy of the projectile between keV and GeV. This allows the investigation of the specific effect of the kinetic and potential energy. The latter is dissipated in a very shallow volume upon impact while at high kinetic energies the entire bulk material is irradiated.
We report on results from the first beam times using the extracted beam at the new target station. For testing the setup, polymer films were irradiated with $^{107}Ag^{47+}$ at a kinetic energy of 5.9 MeV/u. Applying track etching techniques the number of ions per cm^2 was analyzed using scanning electron microscopy. Comparing these results with the number of ions extracted from the storage ring as deduced from a DC-transformer and a Schottky detector gives an ion transmission of 53.7 % and a maximum flux of $3 \cdot 10^7$ cm^{-2} per pulse.

O 13.6 Mon 16:30 GER 38

Compact Electron Beam Ion Source — •Daniel Thima[1], Matthias Werl[1], Gabriel Lukas Szabo[1], Paul-Friedmar Laux[2], Mike Schmidt[2], Günter Zschornack[2], and Richard Arthur Wilhelm[1] — [1]TU Wien, Institute of Applied Physics, Vienna, Austria — [2]D.I.S Germany GmbH, Dresden, Germany

In many modern fields of research, such as plasma and atomic physics, material science or astrophysics, highly charged ions play an important role. Research with highly charged ions relies strongly on stable ion sources, providing long-term operation with the low output currents in standard devices. Typically, these devices are heavy, stationary machines such as electron cyclotron resonance ion sources or electron beam ion sources (EBIS), sometimes even relying on cryogenic magnetic systems.

Gaining portability by downsizing an EBIS has been pursued recently by a commercial supplier. With only 30 cm in length and using in-vacuum mounted magnets, the resulting prototype EBIS fits onto almost any ultra high vacuum chamber, needing only a single CF40 port. An included Wien filter allows separation of produced ions based on their charge state and mass.

We are currently characterising this compact EBIS in our laboratory, focusing on ion output current. Here, we present our setup and the results of first measurements.

O 13.7 Mon 16:45 GER 38

On the path to ion based pump-probe experiment: generating picosecond keV Ne$^+$ ion pulses from a cooled supersonic gas beam — •Lukas Kalkhoff, Marika Schleberger, Klaus Sokolowski-Tinten, Andreas Wucher, Alexander Golombek, and Lars Breuer — University Duisburg-Essen, Duisburg, Germany

The dynamics triggered by the impact of an ion onto a solid surface has been explored mainly by theoretical modeling or computer simulation to date. Results indicate that the microscopic non-equilibrium relaxation processes triggered by the interaction of the ion with the solid occur on a (sub-)picosecond time scale. A suitable experimental approach to these dynamics therefore requires a pump-probe method with an appropriate time resolution. Our experiments have successfully used laser photoionization of a supersonic beam of cooled noble gas atoms at $T_{atoms} \simeq 4$ K in combination with a Wiley-MacLaren ion buncher. The measured distribution of the arrival time of individual Ne$^+$ ions impinging on the surface of a fast microchannel plate with a kinetic energy of 4 keV gives a full width at half maximum of the ion pulse of $t_{ion} = 130$ ps. A more detailed analysis shows that this pulse width is only an upper limit related to the detection limit of the electronics. The true pulse width results from extrapolation of our data and is $t_{ion} = 18 \pm 4$ ps. This opens the door to pump-probe experiments with keV ions with a time-resolution in the picosecond range.

O 13.8 Mon 17:00 GER 38

Generation of pulsed ions using ultrafast electrons — Marius Constantin Chirita Mihaila, Gabriel Lukas Szabo, Alexander Sagar Grossek, and •Richard Arthur Wilhelm — TU Wien, Institute of Applied Physics, 1040 Vienna, Austria

Ultrafast physics is a very active research field where high temporal and spatial resolution provides unprecedented structural information in material science.

Here, we describe the development of a new technique that allows the creation of pulsed ions using ultrafast electrons. The general technique of using picosecond ion pulses to study novel time-resolved processes in materials will be hugely impactful and aims at investigating ultrafast phenomena that are intractable with pump-probe measurements using pulsed electrons and lasers. However, the use of pulsed ions has been limited by the complexity of achieving short pulse lengths at the sample plane.

The experimental setup features a Ti: Sapphire laser that triggers femtosecond electron pulses from a low-workfunction cathode. The pulsed electrons then propagate through a miniaturized ion source and generate pulsed ions. Current challenges of preserving a short ion pulse length upon transport to the sample plane and prospects of pump-probe measurements with ultrafast ions are discussed.