P 3: Plasma Wall Interactions I / Astrophysical Plasmas

Time: Monday 14:00–16:00 Location: A 0.112

P 3.1 Mon 14:00 A 0.112

Impact of steady state deuterium plasmas on WCrY Smart Alloys — •Janina Schmitz[1,2], Andrey Litnovsky[1], Felix Klein[1], Tobias Wegener[1], Xiao Yue Tan[1], and Christian Linsmeier[1] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung, 52425 Jülich, Germany — [2]Department of Applied Physics, Ghent University, 9000 Ghent, Belgium

Tungsten (W) is envisaged as first wall material for future fusion devices such as DEMO. W-based smart alloys aim at improving one of the drawbacks of W, its fast oxidation in case of accidental reactor scenarios such as a Loss-of-Coolant-Accident (LOCA) with air ingress. By adding chromium (Cr) and yttrium (Y) as alloying elements a protective oxide scale is formed on the smart alloy's surface when coming into contact with oxygen. During normal plasma operation alloying elements should be depleted, leaving the plasma facing a pure W surface. For assessing the plasma compatibility of smart alloys, WCrY and pure W samples were exposed to steady state pure D plasmas in the linear plasma-device PSI-2. By means of target biasing the ion impact energy was varied. For the two experiments conducted a fluence of $1 * 10^{26}$ ions/m^2 was reached, further plasma conditions are based on calculated DEMO first wall loads. As a consequence of preferential sputtering, ion energies of 220 eV resulted in a nearly doubled volumetric loss of WCrY in comparison to W. In contrast to this, at lower ion energies of 120 eV, Cr and Y were significantly depleted towards the surface while W was enriched. Analysis by Focussed Ion Beam (FIB) Technique revealed similar erosion yields for W and WCrY.

P 3.2 Mon 14:15 A 0.112

Characterization of a SnO2:Ta magnetron discharge by a multifunctional plasma and deposition sensor — Michael Weise[1], Stefan Seeger[1], Rainald Mientus[1], Karsten Harbauer[2], and •Klaus Ellmer[1] — [1]Optotransmitter-Umweltschutz-Technologie e.V., 12555 Berlin (Germany) — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, 14109 Berlin (Germany)

A multifunctional sensor (Welzel et al., Appl. Phys. Lett. 102 (2013) 211605), based on a conventional quartz crystal monitor (microbalance) for mass increase/decrease measurements, was used to measure quasi-simultaneously the deposition/etching flux, the energy flux and the charged particle flux in a magnetron discharge with a SnO2:Ta target. By moving the magnetron radially relative to the sensor, the lateral (radial) flux profiles of the 75 mm * magnetron were measured with a lateral resolution of about 8 mm, the diameter of the aperture in front of the quartz crystal. By combining the different measured quantities the ion-to-neutral ratio jion/jneutral and the mean energy per deposited atom were calculated, parameters that are essential for the characterization of plasma deposition and etch processes. These radial distributions were related to the optical and electrical properties of the transparent and conductive SnO2:Ta films, indicating a strong influence of the jion/jneutral ratio on the film resistivity.

P 3.3 Mon 14:30 A 0.112

Separated effects of particle species on plasma deposited coatings — •Beatrix Biskup, Christian Maszl, Wolfgang Breilmann, Julian Held, Marc Böke, Jan Benedikt, and Achim von Keudell — Experimental Physics II - Reactive Plasmas, Ruhr-University Bochum, 44780 Bochum, Germany

This work investigates the influence of different plasma particle species, namely neutrals, ions, metastables and (V)UV-photons, on the properties of plasma deposited coatings. To separate the different species and their influence on plasma treatment and film growth, we build an ion-repelling grid system (IReGS), which repels ions from the substrate.

In a first approach the deposition rate in a high power impulse magnetron sputtering (HiPIMS) process of chromium was measured with the composition of the IReGS and a quartz crystal microbalance (QCM). With this setup it is possible to measure the ionized metal flux fraction (IMFF). In comparison with measured ion fluxes by mass spectrometry and spoke image data we see the direct influence of the anomalous transport through spokes on the IMFF.

P 3.4 Mon 14:45 A 0.112

The impact of carbon and oxygen impurities on the effective charge state distribution in Wendelstein 7-X — •Jörg Cosfeld[1], Michael Rack[1], Detlev Reiter[1], Yühe Feng[2], and Wendelstein 7-X Team[2] — [1]Forschungszentrum Jülich GmbH, Institut für Energie und Klimaforschung Plasmaphysik, Partner of the Trilateral Euregio Cluster (TEC), 52425 Jülich, Germany — [2]Max-Planck-Institut für Plasmaphysik, 17491 Greifswald / 85748 Garching, Germany

Carbon and Oxygen have been identified as the two major impurities in the first divertor operation phase of the stellarator Wendelstein 7-X (W7-X). We present a computational approach to evaluate basic differences between these impurities regarding the effective charge state profile in the boundary region. The three dimensional interpretation tool EMC3-EIRENE [1][2] is applied, to isolate computationally the plasma responses caused by the strong inflows of Carbon and Oxygen, respectively, from other unknown plasma properties.

Here, differences for a plasma containing Carbon impurities, a plasma containing Oxygen impurities and a combination of both are evaluated. Free parameters considered for this study are the spatial location of impurity sources, plasma material interaction coefficients (mainly sputtering coefficients) and further free simulation parameters. An overview of the influence on plasma parameters like 3D density and temperature distributions is given.

[1] Y. Feng *et al. J. Nucl. Mater.* **266-269**, 812, (1999)
[2] D. Reiter *et al. Fusion Sci. Technol.* **47**, 172-186, (2005)

P 3.5 Mon 15:00 A 0.112

Experimental studies on tungsten produced by powder injection moulding as plasma-facing materials — •Robert Krug[1], Bernhard Unterberg[1], Steffen Antusch[2], Jan-Peter Bähner[1], Jan Willem Coenen[1], Christoph Kaufmann[1], Arkadi Kreter[1], Yulia Martinova[1], Sören Möller[1], Gerald Pintsuk[1], Marcin Rasinski[1], Michael Rieth[2], Marius Wirtz[1], and Christian Linsmeier[1] — [1]Institut für Energie-und Klimaforschung, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Karlsruhe Institute of Technology, Institute for Applied Materials, P.O. Box 3640, 76021 Karlsruhe

Tungsten is the plasma facing material for future fusion reactors. In this contribution, we report on plasma exposure of pure tungsten produced via Powder Injection Moulding in the linear plasma device PSI-2 using deuterium plasmas with a moderate plasma flux density.The sample temperature has been kept to 420-450° C. In addition, some samples have been exposed to transient heat loads ($0.38 GW m^{-2}$). Reference W samples(Plansee) were exposed under the same conditions for comparison. Net erosion, surface roughness and the resulting fuel inventory have been measured. The surface morphology has been analyzed prior and after the exposure. We observe in all cases an enhanced erosion of the PIM material. The response of the material to the transient heat loads is similar for both samples. Fuel retention in PIM-W shows strong variation with the resiudal carbon content. For PIM-W samples with lowest carbon content fuel retention is comparable to that in reference samples.

P 3.6 Mon 15:15 A 0.112

Optical spectroscopy of coronal iron in an electron beam ion trap — •Hendrik Bekker, Christian Hensel, Arnesh Daniel, Alexander Windberger, and José R. Crespo López-Urrutia — Max-Planck-Insitüt für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Solar eclipses, such as the recent (August 21st 2017) all-American total eclipse, are prime opportunities to study the weak optical coronal emission. This is because normally, emission from the photosphere overpowers it. Known since the 1870s, and first explained in the 1930s, the forbidden lines of highly charged iron ions are still a visible reminder of the not-yet well understood coronal heating mechanisms. This is in part due to a lack of reference data of the studied transitions. Therefore, we have investigated the optical spectra of highly charged Fe X-XIV ions using the Heidelberg electron beam ion trap (HD-EBIT). Using grating spectrometers, 12 lines were studied. Wavelengths of the often observed red and green coronal lines were determined with better-than-ppm precision, allowing in principle for absolute velocity determinations in coronal plasmas with uncertainties below 0.2 km s^{-1}. Furthermore, the Zeeman splitting of several of

the lines in the strong magnetic field of the HD-EBIT was measured, yielding data of interest for studying the influence of magnetic fields in the coronal heating problem.

P 3.7 Mon 15:30 A 0.112

Nuclear reactions in laser-generated plasmas and their applications in astrophysics — •Yuanbin Wu — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

Plasma screening is a general feature of nuclear reactions in astrophysical environments. We have recently theoretically demonstrated that it is possible to determine the plasma screening enhancement factor in the weak-screening regime for fusion reactions with an experimental setup envisaged at the upcoming ELI-NP facility where two laser beams generate two colliding plasmas [1].

In order to have a more similar condition to the astrophysical environments, we analyse here thermonuclear reactions in a single laser-generated plasma. Studies have shown that it is possible to isochorically heat targets at solid-state density to temperatures of a few hundred eV or even a few keV [2,3]. With this solid-state density plasma, we show that direct measurements of reaction rates in plasmas of astrophysical interest are possible under the conditions of strong-screening regime. Furthermore, neutrons produced from thermonuclear reactions in such plasmas have a very narrow energy spectrum which would have both astrophysical and industrial applications.

[1] Y. Wu and A. Pálffy, Astrophys.J. 838, 55 (2017).
[2] Y. Sentoku *et al.*, Phys. Plasmas 14, 122701 (2007).
[3] Y. Wu, J. Gunst, C.H. Keitel, and A. Pálffy, arXiv: 1708.04826.

P 3.8 Mon 15:45 A 0.112

Acceleration of Cosmic Rays in Supernova Shocks: mass to charge selectivity — •Adrian Hanusch[1], Tatyana Liseykina[1], and Mikhail Malkov[2] — [1]Universität Rostock - Institut für Physik — [2]University of California San Diego

The recent precise measurements of galactic cosmic rays (CR) by PAMELA [1] and AMS-02 [2] may shed light on the long standing problem of CR origin. While the CR particles are believed to be accelerated in supernova remnant (SNR) shocks via diffusive shock acceleration (DSA), it is still not understood how different CR elements are extracted from the supernova environments and injected into the DSA. The similarity of He/p, C/p, and O/p rigidity spectra demonstrated by AMS-02 has provided new evidence that injection is a mass-to-charge dependent process.

We perform hybrid simulations of collisionless shocks and study the joint injection of different ion species with A/Z up to 16. We analyze the A/Z-dependence of the injection efficiency, and by convolving it with the time evolution of the SNR reproduce the measured p/He ratio as a function of particle rigidity.

[1] O. Adriani *et al.*, *Science*, 332, 69, 2011.
[2] M. Aguilar *et al.*, *Phys. Rev. Lett.*, 115(21):211101, 2015.