P 24: Plasma Wall Interaction

Zeit: Donnerstag 8:30–10:15 Raum: HS 1010

Hauptvortrag P 24.1 Do 8:30 HS 1010

Quasi-steady state plasma operation in the Be/W material mix: from the JET tokamak to ITER — •Sebastijan Brezinsek — Forschungszentrum Jülich GmbH

ITER will operate with metallic wall an employ PFCs made of Beryllium at the first wall and Tungsten in the divertor. The positive aspects of the envisaged material mix for ITER have been confirmed (low fuel retention, low erosion and material migration, dust production), but plasma-surface interaction at these metallic components has shown vital impact on the operational space as we all as on the plasma performance. A two weeks period of identical plasma discharges in H-mode conditions accumulating more than 900s of plasma time and more than 30 000 ELMs has been executed to mimic ITER-like plasma discharge conditions which can be expected at half magnetic field operation as foreseen in the start sequence of ITER. Detailed analysis of the discharges as well as associated edge modelling will be presented to allow extrapolation to ITER.

P 24.2 Do 9:00 HS 1010

PWI in n=1 RMP scrape-off layer on EAST — •Marion Dostal[1], Yongliang Li[2], and Yungfeng Liang[1] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, Partner of the Trilateral Euregio Cluster (TEC), 52425 Jülich, Germany — [2]Institut of plasma physics, Chinese academy of science, China

Steady state operation of ITER and future power plants will require a detailed understanding of plasma-wall interaction. These plasma-wall interactions, in special particle and heat transport, depends on the magnetic topology. Lots of experiments have demonstrated the essential role of this interplay.

Therefeore experiments with n=1 RMP scrape-off layer on EAST were made by using a combined multi-channel retarding field analyzer. The results of fast particle confinement, heat transport and heat flux distribution for n=1 RMP plasmas w/ and w/o good phase for ELM controll will be shown.

P 24.3 Do 9:15 HS 1010

Spectral Emission of Fast Non-Maxwellian Atoms at Metallic Surfaces in Low Density Plasmas — •Sven Dickheuer[1], Oleksandr Marchuk[1], Christian Brandt[2], and Albrecht Pospieszczyk[1] — [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, Germany

We have observed Doppler-shifted emission of Balmer lines in hydrogen-argon mixed plasmas in a linear plasma ($n_e \approx 10^{11}$ cm^{-3}, $T_i \approx 2$ eV). In pure hydrogen plasmas no Doppler-shifted emission above the signal-to-noise ratio could be measured [C.Brandt et al. O3.J107, EPS conference (2015)]. But in H-Ar mixed plasmas with a composition of 1:1 the intensity of Doppler-shifted emission reaches its maximum and the blue- and red-shifted components of the Balmer lines could be clearly detected. Different target materials (e.g. Ag, Pd, C) have been used to measure the dependence of the Doppler-shifted emission on the target material. The dependence of the emission on the target potential has been investigated by varying the target potential between −30 V and −220 V. Two possible processes could explain the observations of Doppler-shifted emission. The first one is the excitation by argon ground state Ar + H → (ArH)* → Ar + H*, the other one is the excitation transfer from the argon metastable state Ar* + H → (ArH)* → Ar + H*. Both possibilities are discussed in the talk and compared to the theoretical cross sections and measurements with other hydrogen-noble gas mixed plasmas.

P 24.4 Do 9:30 HS 1010

Oxidation resistance of plasma-facing tungsten alloys — •Felix Klein[1], Andrey Litnovsky[1], Tobias Wegener[1], Marcin Rasinski[1], Christian Linsmeier[1], Jesus Gonzalez[2], Martin Bram[2], Uwe Breuer[3], Hongchu Du[4], and Joachim Mayer[4] — [1]Forschungszentrum Jülich, Institut für Energie- und Klimaforschung (IEK) - Plasmaphysik — [2]Forschungszentrum Jülich, IEK - Werkstoffsynthese und Herstellungsverfahren — [3]Forschungszentrum Jülich, Zentralinstitut für Engineering, Elektronik und Analytik, Analytik — [4]Ernst Ruska-Centrum, 52425 Jülich

Tungsten (W) is the prime candidate as plasma-facing material for the first wall of future fusion power plants like DEMO. Advantages of W include the high melting temperature and the low sputtering rate. A problem is oxidation and sublimation of radioactive oxide in case of an accident featuring a loss of active cooling and air ingress. Therefore, new alloys are developed. On the one hand the alloys exhibit the advantages of W and on the other hand they passively develop corrosion resistance in case of an accident. Using W-Cr-Y thin films, prepared by magnetron sputtering, the suppression of tungsten oxide formation was shown for up to 9 h at 1273 K. Cr continuously formed a protective oxide layer. In contrast, the problem of WO_3 formation/sublimation occurred during studies of first powder-metallurgically prepared bulk samples. A key difference was the distribution of Y: Homogeneous within the thin films versus nano-particles at the grain boundaries of the bulk samples. Microstructure and oxidation behaviour are analysed and approaches for further development are presented.

P 24.5 Do 9:45 HS 1010

Plasma exposure of W-based smart alloys for the fusion power plant — •Janina Schmitz[1,2], Felix Klein[1], Tobias Wegener[1], Xiaoyue Tan[1], Andrey Litnovsky[1], and Christian Linsmeier[1] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich — [2]Department of Applied Physics, Ghent University, Ghent

Although the final design of the fusion power plant DEMO has not been specified yet, there is no doubt that the plasma-facing wall will be subject to extreme conditions. Tungsten (W), featuring among others low tritium retention and sputter yield, is preferred as first wall material. In case of a LOCA (Loss-of-Coolant-Accident) the wall temperature rises above 1200 K for up to 3 months due to nuclear decay heat. With additional air ingress, radioactive volatile WO will be formed and its mobilisation into the environment poses a severe threat.
Smart alloys aim at suppressing the WO_3-sublimation while, thanks to preferential sputtering, behaving like pure W during plasma operation. Experiments in the linear plasma device PSI-2 help understanding the plasma influence onto the developed alloys. First experiments with W-Cr-Ti alloys and pure W showed comparable sputter yields (W: 1 mg, smart alloy: 1.1 mg mass loss) and confirmed the expected depletion of the alloying elements at the plasma-facing surface. In addition, the results of studies of new W-Cr-Y-systems under plasma impact, including changes in microstructure and oxidation behaviour, will be presented and discussed.

P 24.6 Do 10:00 HS 1010

Emulation of fusion neutron damage studies by 30 MeV protons — •Rahul Rayaprolu, Sören Möller, and Christian Linsmeier — Institut für Energie- und Klimaforschung - Plasmaphysik, Forschungszentrum Jülich GmbH, 52425 Jülich

Fusion reactor first wall materials are anticipated to undergo detrimental changes in mechanical properties upon exposure to characteristic neutron flux. The increase in yield stress in conjugation with drop in strain with increasing dose, initiates brittle behaviour which leads to imminent failure of parts under thermal cycling. Thus mapping of thermo-mechanical properties under fusion irradiation conditions is a major concern needing to be addressed.

While the straightforward path is to subjugate test materials to fission reactor studies, they often are time consuming (1+ years) and low energy tail biased. We propose the use of high energy (15 - 30 MeV) protons, under depth/ thickness constraints (300 - 500 μm) to obtain fusion irradiation emulated macroscopic mechanical properties. This is seen to reduce the cycle time from years to months and has shown better conformity to simulated fusion reactor estimates (1 dpa irradiation). Additionally, established codes FISPACT-II and SPECTRA-PKA are applied to completely describe proton irradiation behavior on materials.