P 12: Plasma Surface Interaction II - Helmholtz Graduate School IV

Zeit: Dienstag 16:30–18:35 Raum: HS 20

Hauptvortrag P 12.1 Di 16:30 HS 20

Hydrogen permeation and retention in ITER steel — •Anne Houben, Jana Scheuer, Arkadi Kreter, Marcin Rasiński, Bernhard Unterberg, and Christian Linsmeier — Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, Partner of the Trilateral Euregio Cluster (TEC), 52425 Jülich, Germany

Fuel retention and hydrogen permeation in the first wall of future fusion devices is a crucial factor in order to estimate fuel losses and to guarantee an economical reactor operation. The main structure material of the ITER wall is 316L(N)-IG steel. Detailed permeation and thermal desorption spectroscopy (TDS) studies were performed on this steel.

The deuterium permeation through the bulk of the sample was measured on polished samples. In order to investigate the influence of technical surfaces, the sample surface was roughened or oxidized and measured. By comparing these results with the polished surface sample, the influence of technical surfaces can be estimated and evaluated.

Furthermore, the structure material will be exposed by high energetic deuterium particles in ITER. Therefore, the influence on the deuterium retention and permeation was studied by exposing 316L(N)-IG samples in the linear plasma device PSI-2 with deuterium plasma and performing permeation and TDS measurements afterwards. By comparing the results with unexposed samples, the change of the deuterium retention and permeation through the ITER wall during operation can be estimated.

P 12.2 Di 17:00 HS 20

Modelling of chemical vapor deposition (CVD) to improve tungsten fiber reinforced tungsten composites (W_f/W) — •L. Raumann[1,2], J.W. Coenen[1], J. Riesch[3], Y. Mao[1,2], D. Schwalenberg[1,2], H. Gietl[3], T. Höschen[3], Ch. Linsmeier[1], and O. Guillon[1,2] — [1]Institut für Energie und Klimaforschung, Forschungszentrum Jülich GmbH, 52425 Jülich — [2]Rheinisch-Westfälische Technische Hochschule Aachen, 52062 Aachen — [3]Max-Planck-Institut für Plasmaphysik, 85748 Garching b. München

Due to many excellent material properties, tungsten is currently the main candidate for the first wall material in future fusion devices. However, its intrinsic brittleness and its susceptibility to operational embrittlement are still a major concern. To overcome this drawback, W_f/W composites featuring pseudo-ductility are developed. Bulk material can be successfully produced by coating tungsten fabrics via CVD. However, a fully dense composite with a high fiber volume fraction (30-40%) is still a challenge. Therefore, a Comsol model is developed including the complex coupling of transport phenomena, chemical reaction kinetics and solid domain growth. The model was successfully validated experimentally for the deposition on single tungsten fibers in heated tubes varying the temperature, partial pressures and gas flow. Currently, the model is validated against the infiltration of tungsten fabrics with varying fiber distances. As next step the process parameters and the fabric geometry will be optimized within the model to acquire the recipe for a fully dense W_f/W composite with a sufficient high fiber volume fraction.

P 12.3 Di 17:15 HS 20

Impact of fusion-relevant plasmas on WCrY Smart Alloys — •Janina Schmitz[1,2], Andrey Litnovsky[1], Felix Klein[1], Karen De Lannoye[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

Only few materials are suitable to withstand the high heat and particle loads of the first wall of future fusion devices such as DEMO. While advantageous properties like, among others, low tritium retention and low sputter yields make tungsten (W) a suitable plasma-facing material, its disadvantageous property of fast oxidation in oxygen-containing environment may disqualify it. For this reason self-passivating chromium(Cr)-containg smart alloys (WCrY) are developed aiming at suppressing W oxidation in case of accidental scenarios in DEMO. Exposure to steady-state deuterium (D) plasma at low ion energies of around 120 eV up to a fluence of $1 * 10^{26}$ ions/m^2 has proven W-like erosion yields for the smart alloys [1]. In order to estimate the lifetime of plasma-facing materials like WCrY in more fusion-relevant conditions plasma exposure to different gas mixtures and moreover higher fluences is necessary. Results of a recent D exposure with increased fluence are presented in this contribution. Further, the results of oxidation in dry atmosphere at 1000 °C of plasma-exposed WCrY samples is discussed.

[1] J. Schmitz et al., Nuclear Materials and Energy 15 (2018) 220-225

P 12.4 Di 17:30 HS 20

Development of components for fiber reinforced tungsten (Wf/W) produced by chemical vapor deposition — •Daniel Schwalenberg[1,3], Jan Willem Coenen[1], Johann Riesch[2], Leonard Raumann[1], Yiran Mao[1], Alexis Terra[1], Till Höschen[2], Rudolf Neu[2,3], and Christian Linsmeier[1] — [1]Institut für Energie und Klimaforschung, Forschungszentrum Jülich GmbH, 52425 Jülich — [2]Max-Plank-Institut für Plasmaphysik, 85748 Garching b. München — [3]Technische Universität München, 85748 Garching b. München

The harsh conditions at the divertor in fusion reactors lead to very high demands for the first wall materials. Due excellent thermal properties, low sputter yield, hydrogen retention and low activation tungsten is the most promising candidate. The biggest issue for tungsten is the brittleness, which can lead to catastrophic failures of components. To compensate for the brittle behavior, a tungsten fiber reinforced composite material (Wf/W) is being developed. Because of the production process, the tungsten fibers are ductile. Together with a tungsten matrix they can be combined to form a pseudo-ductile material. To further characterize and improve the material, larger amounts of Wf/W have to be produced. Therefore the experimental setup was upgraded and the production speed increased. The next steps are first to establish a process to produce large amounts of Wf/W and second to determine the needed properties of the material for the application as divertor material. So that the material can be improved to meet the needed requirements for the implementation as a divertor component.

P 12.5 Di 17:45 HS 20

Ga^+ Sputtering of tungsten in regard to the Crystal Surface Orientation — •Karsten Schlüter[1,2], Martin Balden[1], Tiago Fiorini da Silva[3], and Kai Nordlund[4] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany — [2]Fakultät für Maschinenwesen, Technische Universität München, D-85748, Garching, Germany — [3]Physics Institute of University of São Paulo - Rua do Matão, trav. R 187, 05508-090 São Paulo, Brazil — [4]Department of Physics, P.O. Box 43, FIN-00014 University of Helsinki, Finland

Properties like sputtering or oxidation are influenced by the crystal orientation. To investigate this effect, a measuring method is developed to study the dependency of W properties on its crystal orientation to benchmark sputtering theories and to predict the properties of textured materials.

A polycrystalline polished W sample was sputtered with a 30 keV Ga ion beam. Sequentially the crystal orientations were analyzed using electron backscatter diffraction and the height measurement was measured with a convocal laser scanning microscope.

The height information is visualized in an inverse pole figure, representing the sputter yield in all crystal orientation. The sputter yield changes more than one order of magnitude with the crystal orientation. Molecular dynamic simulations confirm the experimental results.

P 12.6 Di 18:10 HS 20

Induction-heating based gas loading of tungsten samples for determination of protium and deuterium diffusion parameters in tungsten — •Georg Holzner[1,2], Thomas Schwarz-Selinger[1], and Udo von Toussaint[1] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching — [2]Technische Universität München, Boltzmannstraße 15, 85748 Garching

For future fusion power plants, it will be important to predict fuel retention and transport, i.e. deuterium and tritium, in the first wall, which will probably be made of tungsten. Retention and transport modelling depend on a proper description of diffusion. For the most basic hydrogen isotope protium, the generally accepted experimental diffusion parameters stem from Frauenfelder from the late 60s. Since then, measured values scatter by several orders of magnitude, for which presumably trapping effects are the reason. Recent DFT-results question the Frauenfelder value. Furthermore, for deuterium in tungsten the amount of available data is even more scarce.

For this reason, the diffusion of protium and deuterium in tungsten was measured as well as their solubilities. This has been performed at temperatures between 1800 and 2600 K, because at these temperatures trapping effects can be neglected and pure diffusion is the governing transport effect. An ultra high vacuum (UHV)/gas loading experiment was designed and built. The measured diffusion equation for protium deviates considerably from Frauenfelder's value, the diffusion prefactor for deuterium does not follow classical predictions.