P 13: Plasma Wall Interactions

Time: Wednesday 11:00–12:15 Location: b302

Invited Talk P 13.1 Wed 11:00 b302

Power exhaust by impurity seeding in fusion reactors — •Matthias Bernert[1], Felix Reimold[2], Arne Kallenbach[1], Bruce Lipschultz[3], Ralph Dux[1], Marco Wischmeier[1], the ASDEX Upgrade team[1], and the EUROfusion MST1 Team[4] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Forschungszentrum Jülich GmbH, IEK, Jülich, Germany — [3]University of York, York Plasma Institute, Heslington, York, United Kingdom — [4]See http://www.euro-fusionscipub.org/mst1

Power exhaust is one of the big challenges for future fusion reactors. The power load at the divertor targets, the primary plasma-wall interaction zone, would exceed material limits and, thus, must be reduced. Therefore, 90% of the exhaust power needs to be dissipated and the divertor is anticipated to be in the detached regime, where the interaction of the plasma with the wall is significantly reduced. Radiation is the dominant dissipation process and is increased by impurity seeding. The radiation distribution can be tailored by using different seed impurities (N for radiation outside, Ne and Ar for radiation at the edge of and Kr for radiation inside the confined region). The tailoring of the radiation profile is required in order to maximize the radiated power and at the same time minimize the impact on the energy confinement.

Recent experiments with intense impurity seeding at the ASDEX Upgrade tokamak demonstrate operation at highest heat fluxes and detached divertor targets at radiated power fractions of up to 90%. In these scenarios the radiation originates predominantly from the confined region and leads to an unexpectedly small confinement reduction.

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Yttrium Oxide Coatings as Tritium Permeation Barriers — •Jan Engels, Anne Houben, and Christian Linsmeier — Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich, Germany

In fusion power plants the hydrogen isotopes deuterium and tritium are used as fuel. To prevent the loss of fuel and the accumulation of radioactive tritium in the first wall, the cooling system, and other parts of the fuel vessel, a tritium permeation barrier is necessary. Oxide thin films, e.g. Er_2O_3 and Y_2O_3, are promising candidates as tritium permeation barrier layers. With regard to the application, this is especially true for Y_2O_3, because of the favorably activation behavior of the yttrium, compared to the other candidates.

By means of magnetron sputtering Y_2O_3 thin films are deposited on Eurofer97, a reduced activation steel developed for fusion applications. The thin films are annealed at 600°C to achieve a stable and homogeneous cubic phase of the Y_2O_3 system. The X-ray diffraction analysis proves that the final phase of the thin films is actually cubic. To be able to quantify the permeation reduction factor of the Y_2O_3 thin films a new gas-driven deuterium permeation measurement setup has been constructed. Comparing the permeation flux through a bare substrate and a coated Eurofer97 substrate, the permeation reduction factor can be determined. The first measurement result suggests that the permeation reduction factor is higher than ten.

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Studies on Yttrium-Containing Smart Alloys — •Felix Klein[1], Tobias Wegener[1], Andrey Litnovsky[1], Marcin Rasinski[1], Joachim Mayer[2], and Christian Linsmeier[1] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik — [2]Ernst Ruska-Centrum, 52425 Jülich

Tungsten is the main candidate as plasma-facing armour material for future fusion reactors, like DEMO. Advantages of tungsten include high melting point, high thermal conductivity, low tritium retention, and low erosion yield. A problem is oxide volatilisation under accidental conditions where the temperature of the first wall can reach 1200 K to 1450 K and air ingress occurs. Therefore smart tungsten alloys are developed. Smart alloys are supposed to preserve properties of tungsten during plasma operation coupled with suppressed tungsten oxide formation in case of an accident. Lab-scale tungsten-chromium-yttrium (W-Cr-Y) samples prepared by magnetron sputtering are used as model system. The mechanisms of oxidation and its dynamics are studied using a thermogravimetric system, focussed ion beam, and electron microscopy. A composition scan was conducted: The new material composition featuring W, $\sim$ 12 wt. % Cr, $\sim$ 0.3 wt. % Y showed strongest suppression of oxidation, no pores, and least internal oxidation. At 1273 K in argon-oxygen atmosphere an oxidation rate of $3 \cdot 10^{-6}\, mg^2 cm^{-4} s^{-1}$ was measured. At 1473 K ternary W-Cr-Y alloys suppressed evaporation up to 20 min while for W-Cr evaporation was already evident after 5 min. Comparison of passivation in dry and humid atmosphere, at temperatures of 1073 K to 1473 K is performed.

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Systems Code Erweiterung: Berechnung der Erosion einer Wolfram Wand im Hauptraum für DEMO — •Mitja Beckers, Wolfgang Biel und Ulrich Samm — Institut für Energie- und Klimaforschung - Plasmaphysik

Zur Auffindung möglicher Parameterräume für ein DEMO-Kraftwerk, werden in der Frühdesign-Phase Reaktor Systems Codes eingesetzt. Die Erosion der ersten Wand wurde bisher in solchen Codes nicht detailliert behandelt. Die Reaktorwand wird durch Ionen, darunter Plasma-Verunreinigungen, die in der Debye-Schicht beschleunigt werden, und durch umgeladene Neutralteilchen, zerstäubt. Für das Schädigungspotenzial von Letzteren ist die radiale Position der Umladung entscheidend, und damit die Plasmaparameter für Dichte und Temperatur im Rand-Pedestal, sowie in der scrape-off-layer. Prompte Redeposition erodierter Wolframatome ist einer der Selbstheilungsmechanismen, wohingegen Selbstzerstäubung durch Wolfram die Schädigung verstärkt. Diese Effekte werden mithilfe des vereinfachten Monte Carlo Codes CELLSOR simuliert. CELLSOR behandelt die Neutralteilchenprozesse in einer vereinfachten 1,5D Geometrie und wurde durch Vergleiche mit dem etablierten B2-EIRENE Code verifiziert. Auf der Basis vorgegebener Transportkoeffizienten wird das Dichteprofil in der scrape-off layer mittels der Kontinuitätsgleichung selbstkonsistent berechnet. Für die Berechnung der Erosion der Wand werden neben den Neutralteilchenstößen auch die durch die Schichtspannung an der Wand beschleunigten Plasmaionen berücksichtigt. Im Vortrag wird der neue Code sowie die Ergebnisse von Parametervariationen vorgestellt.