P 14: Plasma Wall Interaction II / HEPP III

Time: Wednesday 16:00–17:10   Location: P-H12

P 14.1   Wed 16:00   P-H12
Surface Segregation of Cr in the WCrY SMART Alloy — •Pawel Bittner[1], Hans Rudolf Koslowski[1], Andrey Litnovsky[1,2], and Christian Linsmeier[1] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung, 52425 Jülich, Germany — [2]Institute of Laser and Plasma Technologies, National Research Nuclear University MEPhI, 115409 Moscow, Russia

Self-passivating Metal Alloys with Reduced Thermo-oxidation (SMART) are promising candidates for the first wall of the DEMOnstration power plant (DEMO). These materials aim at having an increased oxidation resistance during accidental conditions and acceptable plasma performance during regular operation of the power plant. In this work, the effects of surface segregation, diffusion and sputter erosion on the Cr concentration of a tungsten-chromium-yttrium SMART alloy (WCrY) with a composition of 68 at% of W, 31 at% of Cr and 1 at% of Y are studied with low energy ion scattering (LEIS) measurements and numerical calculations.

A three-parameter phenomenological model to describe the time and temperature dependent surface concentration of Cr is proposed. Further, temporally resolved ion scattering measurements during thermal annealing between 800 K and 1100 K were conducted. The parameters of the model were changed in consecutive numerical calculations to fit these measurements best. The calibrated model is applied to conditions in which the samples were sputtered during annealing and the similarities and differences between theoretical prediction and experimental results are discussed.

P 14.2   Wed 16:15   P-H12
Secondary electron emission from metals at low impact energies — •Franz Xaver Bronold and Holger Fehske — Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany

The interaction of electrons with the walls of discharges is an important surface process in low-temperature plasmas. It affects, for instance, the operation modii of barrier discharges, Hall thrusters, and divertor plasmas in fusion devices. Little is known quantitatively about the process because it typically occurs at energies below 50 eV which are hard to access experimentally. There are thus only a few attempts to measure secondary emission yields in this energy range. A few years ago, we presented therefore an approach, based on an embedding principle, for calculating the complement of the emission yield, the absorption probability, from a microscopic model and applied it to dielectric walls at impact energies below the band gap, where backscattering due to electron-electron collisions is absent. We now generalized the approach to account for it. In addition, we developed a scheme to solve numerically the full nonlinear embedding equation (not only its linearized version), and included–depending on the crystallinity of the surface– Bragg gaps due to coherent scattering on the crystal planes parallel to the interface or incoherent scattering on the ion cores of the bulk. Applying this approach to metal surfaces, we find for impact energies up to 20 eV good agreement with measured emission yields. Depending on the metal and surface quality, the yields are around 10-30 %. Hence, even metal surfaces turn out to be not perfect absorber for electrons.

P 14.3   Wed 16:30   P-H12
Surface charge diagnostics by infrared multiple internal reflection spectroscopy — Kristopher Rasek, •Franz Xaver Bronold, and Holger Fehske — Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany

We propose to measure the surface (wall) charge accumulating at a floating plasma-dielectric interface via infrared multiple internal reflection spectroscopy [1]. The negative charge deposited into the plasma-facing dielectric, forming the negative part of an electric double layer (the positive part being the plasma sheath), leads to a change of the reflection coefficient, when the interface is subjected to infrared radiation. Based on the Boltzmann equations for the charge kinetics of the double layer and nonlocal surface response functions to calculate the reflection coefficient in the presence of the charge inhomogeneity at the plasma-solid interface, we show theoretically and numerically that a local, Drude-like expression is in fact sufficient to describe the optical response. It contains only the integrated surface charge, enabling thus a straightforward analysis of measured data. To amplify the charge-induced change in the reflectivity, we suggest an experimental setup utilizing the plasma-solid interface as a multiple internal reflection element. Numerical results indicate that in such a setup the magnitude of the wall charge can directly be determined from the change it causes in the transmitivity of the optical element. [1] K. Rasek, F.X. Bronold, and H. Fehske, Phys. Rev. E 104, 015204 (2021)

P 14.4   Wed 16:45   P-H12
Effects of thin surface oxide films on deuterium uptake and release from ion-damaged tungsten — •Kristof Kremer, Maximilian Brucker, Thomas Schwarz-Selinger, and Wolfgang Jacob — MPI for Plasma Physics, Garching, Germany

In a fusion reactor, the uptake of deuterium (D) and tritium fuel into the plasma-facing tungsten (W) components is a critical issue with respect to fuel loss and radioactive inventory. However, the possible influence of natural surface oxides on the D uptake in W is not fully understood yet.

Therefore, we investigated the D uptake into W through 33 to 55 nm thick oxide films in dependence of D fluence, D ion energy and sample temperature. To trace the D, we created a 2 micron thick layer of self-ion-damaged W underneath the oxide. It acts as a getter layer and traps any D that permeates the oxide film. We measured the depth-resolved concentration of D and oxygen with ion beam analysis and the surface modifications of the oxide film with scanning electron microscopy. To study D release through the oxide we filled the self-damaged layer with D prior to oxidation and measured the D release with thermal desorption spectroscopy.

We observed a strong influence of surface oxide films on D uptake and release. Uptake: The oxide films block D uptake into metallic W. We explain this by the different heat of solution of D in W oxide and metallic W. At high ion energies, however, D partly reduces the oxide film and enters the metallic W. Release: The oxide film delays the D release until it is chemically reduced under formation of heavy water.