P 20: Plasma Wall Interaction II - Poster

Time: Wednesday 16:15–18:15 Location: Zelt West

P 20.1 Wed 16:15 Zelt West

3D global impurity transport modeling with WallDYN and EMC3-Eirene — •Lennart Bock[1,2] and Klaus Schmid[2] — [1]Physik-Department E28, Technische Universität München, 85747 Garching, Germany — [2]Max-Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

The wall of a fusion experiment is subject to bombardment by energetic ions from the plasma, which leads to sputtering of wall material and retention of incoming ions. Sputtered wall material is transported through the plasma and eventually redeposited on the wall. This process is called impurity migration and controls net erosion of the wall, impurity content in the plasma and retention of ions in the wall.

The global impurity migration code WallDYN calculates the surface composition and impurity fluxes self consistently by combining models for implantation, erosion and reflection of impurities with a model for impurity transport through the plasma. In WallDYN the impurity transport is described by the 2D code DIVIMP and thus limited to toroidally symmetric geometries. While for tokamaks the plasma is essentially toroidally symmetric, the first wall is not. Including the effect of toroidally asymmetric wall features like poloidal limiters or modeling other devices like stellarators therefore requires switching to a full 3D impurity transport model. For WallDYN this means switching from the 2D code DIVIMP to the 3D code EMC3-Eirene.

In this contribution the implementation of EMC3-Eirene to WallDYN is described and impurity transport models of DIVIMP and EMC3-Eirene are compared with focus on their validity range.

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Development of a Methode to Determine the Crystal Surface Orientation Dependenc of Tungsten oxidation — •Karsten Schlüter[1,2], Martin Balden[1], and Tiago Fiorini da Silva[3] — [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

The crystal orientation influences the properties of tungsten (W), thus affecting their performances in applications like fusion plasma devices. In this regard, it will be necessary to study the dependency of W properties (e.g. oxidation resistance or sputtering) on its crystal orientation to probably optimize the texture of the material. To evaluate a crystal orientation analyses for all, the low and high index surfaces, a measuring method was developed.

The grain orientations on a polycrystalline W sample were analyzed using electron backscatter diffraction. Subsequently, the samples were oxidized in a thermobalance, measuring the time dependent weight increase. The grain dependent oxidation rates were determined by measuring the thickness of the oxide layer of single grains by scanning electron microscope and confocal laser scanning microscope. W grains with {100} orientation have the highest and a two times higher oxidation rate in a range of 720 K to 870 K than to the lowest oxidation rates, e.g. like the oxidation rate of the {111} orientation. The high index surfaces are visualized in an inverse pole figure (IPFz).

P 20.3 Wed 16:15 Zelt West

Ultra-precise Machining of Surfaces Using Microwave-driven Cl-based Plasma Etching — •Faezeh Kazemi and Thomas Arnold — IOM Leibniz-Institute of Surface Engineering, Leipzig, Germany

Reactive plasma jet machining (PJM) is a technology for ultra-precise surface shape generation which can provide high etch rates due to its chemical characteristic. The basis of reactive plasma etching is the reaction between gas-phase radicals generated in a plasma discharge and the solid surface in order to form a volatile etch product. Etching processes for silicon-based materials have been mostly investigated using fluorine-based reactive plasmas since most of fluoride-silicon compounds are volatile. However, Al and some other elements do not form volatile etch products in fluorine-based plasmas. Therefore, extending the choice of reactive etch gases is required for the applicability to a new range of materials.

The aim of this study is to develop and use a plasma jet that contains reactive chlorine compounds and some other non-halogenated etch gases which are admixed to inert plasma gases like argon and helium. For this purpose, we investigate a fine-focused microwave powered plasma jet. Reactive species like atomic chloride or hydrogen are generated in the plasma jet by dissociation of suitable process gases. The etching behavior and reaction kinetics in a chlorine-based plasma jet process are examined for different substrate materials aiming to clarify the chemical kinetics of surface reactions.

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Aufbau eines Gegenfeldanalysators zur Untersuchung der Plasma-Wand-Wechselwirkung in HF-Plasmen — •Felix Georg, Thomas Trottenberg und Holger Kersten — Institut für experimentelle und angewandte Physik (IEAP), Uni Kiel, Deutschland

Für die Untersuchung der Plasma-Wand-Wechselwirkung in kapazitiv gekoppelten HF-Plasmen wurde ein Gegenfeldanalysator (RFA) entwickelt, welcher, neben der Möglichkeit verschiedene Materialien als Kollektor-Material zu verwenden, auch in Verbindung mit einer passiven Thermosonde (PTP) verwendet werden kann. Der Aufbau des RFA ist so gewählt, dass der Kollektor unabhängig von den anderen Gittern (Screen Grid, Scan Grid und Sekundär-Elektron-Repeller) ausgetauscht werden kann. Dadurch kann der direkte Einfluss (z.B. Sekundär-Elektronen-Emission) verschiedener Materialien auf die Randschicht im Plasma untersucht werden, indem das Kollektor-Material an das als Elektrode im Plasma verwendete Material angepasst wird. Schließt man zusätzlich ein Thermoelement an den Kollektor an, kann neben der Ionenenergieverteilung auch der Energieeintrag der einfallenden Ionen auf das Material bestimmt werden. Der verwendete Aufbau lässt zusätzlich eine Untersuchung der Plasmaparameter mittels Langmuirsonden-Diagnostik zu und bietet die Möglichkeit sowohl den RFA, als auch eine einzelne PTP in die Gegenelektrode einzubauen.

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Assessment of nitrogen enrichment in plasma discharges cooled by nitrogen gas puffing in ASDEX Upgrade — •Thomas Reichbauer[1,2], Volker Rohde[1], Aleksander Drenik[1], and the ASDEX Upgrade Team[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Physics Department E28, TUM, Garching, Germany

To avoid divertor damage by overheating, intrinsic divertor radiation which dissipates power is too low. In ASDEX Upgrade (AUG) nitrogen is seeded into the divertor to reduce its power load. But nitrogen seeding leads to ammonia formation which could become an issue for gas handling plants and cryo pumps of future fusion devices. A direct measurement of the interacting nitrogen with D on the surface is not possible. The produced ammonia is measured with residual gas analyzers. The detection of ammonia is still not a straight forward procedure because all molecules are created in a mixed D/H environment with unknown ratio. Therefore the ratios of H_2O, CH_4 and NH_3 overlap. A fit routine was constructed to gain partial pressures of the different gases. For working reliably, the calibration is a key aspect. After N_2 seeded discharges nitrogen is implemented in walls and stays in AUG for the following ones. The connection of nitrogen and ammonia is established in the following discharges. This could give a better insight of the amount of interacting nitrogen during N_2 puffing. First results on the NH_3/N_2 ratios during legacy discharges are presented and how they could be used to gain information about the formation mechanism of ammonia during N_2 seeded discharges.

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A piezoelectric particle injector for ASDEX Upgrade — •Alexander Bauer[1,2], Volker Rohde[1], Rudolf Neu[1,2], and the ASDEX Upgrade Team[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technical University Munich, Garching, Germany

In the Tokamak ASDEX Upgrade a significant amount of small (W) tungsten spheres with the size of over 1 μm is found during dust investigations, which are presumably produced by arcing. Macroscopic particles have a higher penetration probability into the core plasma compared to atoms, possibly causing a substantial W influx. To study their penetration a small injector, developed at KSTAR [1], will be put in operation at ASDEX Upgrade. In this contribution we report on laboratory investigation on characterization and commissioning. The mechanic is driven by a piezo motor that compresses a spring. When the spring expands a cylinder gets accelerated and injects particles supplied from a small reservoir. The device is of compact size and is capable to operate under vacuum conditions and strong magnetic fields. During the characterization different parameters were investigated. Tests were carried out at atmospheric pressure and under vacuum, mostly using high speed cameras to record the particle trajectories. Different methods are used to illuminate the launched particles. In the plasma the particles will be heated and get visible due to them glowing. For the injected amount of particles tests resulted in a W mass per shot of 24 ± 11 mg. The videos have shown initial velocities of 1.55 m/s in air and ranges of 8 cm. [1] H.Y.Lee et al., RSI, 85 (2014), 11D862

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Microscopic modeling of Ar atom scattering from a Pt(111) surface: a combined molecular dynamics and rate equation approach — •A. Filinov[1,2,3], D. Loffhagen[2], and M. Bonitz[1] — [1]ITAP, CAU Kiel, Leibnizstr. 15, 24098 Kiel — [2]INP Greifswald, Felix-Hausdorff-Str. 2, 17489 Greifswald — [3]Joint Institute for High Temperatures, Izhorskaya Str. 13, 125412 Moscow

A combination of molecular dynamics (MD) simulation with a rate equation model is presented and applied to the trapping and scattering of rare gas atoms from metal surfaces. The temporal evolution of the atom fractions being either adsorbed or scattered into the continuum is investigated. We consider trapped, quasi-trapped and scattering states for this description, which are distinguished by an energetic criterion. The rate equations contain the transition probabilities between the states that can be uniquely determined from an analysis of the particle trajectories generated by MD. Once the system reaches quasi-equilibrium, the rates converge to stationary values, and the subsequent thermal adsorption/desorption dynamics is completely described by the rate equations without the need to perform time-consuming MD simulations. As a proof of our model, we present studies for Ar atoms interacting with a Pt(111) surface and obtain good agreement with the experiment. The dependence of the rates, kinetic energy and the energy-loss distribution functions on the incidence conditions and the lattice temperature is analyzed. Our model is important for the plasma-surface modeling as it allows to extend accurate simulations to longer time scales.

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Two-dimensional particle-in-cell simulation of gas discharges — •Michael Marsand[1], Peter Hartmann[2], and Hanno Kählert[1] — [1]ITAP, Christian-Albrechts-Universität zu Kiel — [2]Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Budapest, Hungary

The simulation of gas discharges is a challenging task. At low pressure, particle-in-cell simulations with Monte Carlo collisions have become the method of choice as they allow for a fully kinetic description of the plasma species. However, they are computationally very demanding, in particular, if the specific geometry of the discharge must be taken into account. Here, we present our progress towards two-dimensional simulation models. We discuss their numerical implementation and compare with the results of one-dimensional codes. One of the central goals for the 2D codes is an accurate description of the interaction between plasmas and surfaces, where both the shape and the properties of the material are accurately accounted for.