P 6: Plasma Wall Interaction I

Time: Tuesday 11:00–12:30 Location: KH 01.020

Invited Talk P 6.1 Tue 11:00 KH 01.020

Controlled Exposure of High-Temperature Ceramics in the Scrape-Off Layer of WEST — •B. De Martino[1], J. P. Gunn[1], B. Guillermin[1], D. Mazon[1], A. Casner[2], L. Ciupiński[3], and G. Komorowska[3] — [1]CEA, IRFM, F-13108 St-Paul-Lez-Durance, France — [2]Université de Bordeaux, CNRS, CEA, CELIA (Centre Lasers Intenses et Applications), UMR 5107, F-33405 Talence, France — [3]Warsaw University of Technology, Faculty of Materials Science and Engineering, Woloska 141, 02-507 Warsaw, POLAND

The WEST tokamak Scrape-Off Layer (SOL) is equipped with mobile Langmuir probes that can be fitted with sample holders, enabling controlled exposure of materials to extreme heat ($10^6 - 10^8$ W/m^2) and ion fluxes ($10^{22} - 10^{24}$ m^{-1}s^{-1}). Two dedicated experiments were carried out to investigate the thermal response and ablation dynamics of High-Temperature Ceramics, using hydraulically and magnetically driven devices that target respectively the lower and upper ends of the accessible flux range. With the magnetically driven device, installed in the lower divertor, ablation of a SiC sample was achieved under strike-point fluxes. Strong Si emission lines are detected in VUV and visible spectroscopy immediately after exposure, indicating high sublimation rates. Divertor upper-view IR imaging shows saturation of the sample temperature, consistent with a phase change. The average parallel heat flux is estimated at 45 MW/m^2, with plasma conditions fully characterised by in-situ diagnostics. Post-mortem analyses enable the characterisation of the damage undergone by the exposed samples.

The full authors list will be presented in the talk.

P 6.2 Tue 11:30 KH 01.020

Experimental Investigations Of Hydrogen Isotope Interaction In Laboratory Boron Coatings — •Eduard Warkentin[1,2], Anne Houben[1], Marcin Rasinski[1], Sören Möller[3], Hans Rudolf Koslowski[1], Timo Dittmar[1], Marc Sackers[1], Arkadi Kreter[1], Tom Wauters[4], Bernhard Unterberg[1,2], and Christian Linsmeier[1,2] — [1]Forschungszentrum Jülich GmbH, Institut of Fusion Energy and Nuclear Waste Managment - Plasmaphysics (IFN-1), Jülich 52425, Germany — [2]Ruhr-Universität Bochum, Faculty of Physics and Astronomy, Bochum 44801, Germany — [3]Forschungszentrum Jülich GmbH, Institute of Energy Materials and Devices, Materials Synthesis and Processing (IMD-2), 52425 Jülich, Germany — [4]ITER Organization, Route de Vinon-sur-Verdon, CS 90 046 13067, St. Paul Lez Durance Cedex, France

Due to the change of the ITER first wall material from Be to W, oxygen and other impurities in the vessel are not sufficiently gettered by a W wall. A thin amorphous boron layer, which is applied via glow discharge boronization during the regular wall conditioning phase, can reintroduce impurity gettering and a more efficient plasma operation can be obtained. In order to investigate hydrogen retention and permeation of mixed boron coatings, B:D layers were fabricated by magnetron sputter deposition on W and steel substrates. After characterization, the gas driven deuterium permeation flux was measuered and the layer permeability was obtained. B:D coated samples were exposed to different deuterium plasma in order to investigate retention via nuclear reaction analysis and thermal desorption spectroscopy.

P 6.3 Tue 11:45 KH 01.020

Characterization of the strike lines in the Wendelstein 7-X stellarator — •Sebastian Dräger[1,2], Thierry Kremeyer[1], Yu Gao[1], Felix Reimold[1], and Robert Wolf[1,2] — [1]Max Planck Inst. for Plasma Physics, 17491 Greifswald, Germany — [2]Technical University of Berlin, Strasse des 17. Juni 135, 10623 Berlin, Germany

Magnetic confinement fusion power plants need for sustaining operation an efficient plasma exhaust. After heating the plasma, removal of fusion products is necessary or a steady-state can't be maintained. Even for today's experiments, density control via particle removal is valuable. Inside a device like Wendelstein 7-X (W7-X), the ionized particles of the plasma are confined by the magnetic field. An exhaust can only be accomplished after their neutralization. Therefore, in a divertor system, diverted field lines carry plasma away from the confining toroid onto target plates. Such a diversion can be achieved through X-points, -lines, or -loops. At W7-X, X-loops are created through a resonance on rational rotational transform surfaces, resulting in magnetic islands. The field lines of these islands, especially their separatrix, are intersected by the divertor target plates. At the intersection the ionized particles neutralize. Strike lines, high-intensity regions, emerge on the target surface. Here the divertor needs to sustain the incoming plasma heat flux. Unexpected changes in the flux topology may lead to a reduction in the exhaust efficiency or a risk of the divertor's integrity. To better understand and predict the strike lines behavior a set of experiment programs were evaluated. A full characterization of the strike lines dimensions and magnitudes was accomplished.

P 6.4 Tue 12:00 KH 01.020

Vision transformer based model regression for plasma exposed surface structures — •Torben Schmitz[1,2], Dirk Reiser[1], Jose Ignacio Robledo[3], and Sebastijan Brezinsek[1,2] — [1]Forschungszentrum Jülich GmbH, Institute of Fusion Energy and Nuclear Waste Management Plasma Physics, Partner of the Trilateral Euregio Cluster (TEC), 52425 Jülich, Germany — [2]Faculty of Mathematics and Natural Sciences, Heinrich Heine University Düsseldorf, 40225 Düsseldorf, Germany — [3]Forschungszentrum Jülich GmbH, Jülich Supercomputing Centre, 52425 Jülich, Germany

Exposing a surface to an ion beam or plasma leads to erosion and the development of surface structures on the nanoscale. Such nanostructures have been observed on tungsten samples exposed to plasma in magnetic confinement devices. A convenient description of the evolution of these structures is possible using a Kuramoto-Sivashinsky (KS) type model whose parameters we aim to infer for given experimental data. There exist previous approaches to this problem, one training a regression model on the Fourier transform of the surfaces, another using pretrained convolutional neural networks, finetuned on the regression task. We propose a different approach using the vision-transformer architecture and including additional input features to the training process. We show that training the model on our KS dataset leads to good predictive performance. We present details of the method and results on our synthetic (simulated) dataset. The results show the capability of our architecture to understand and extract information from fusion relevant surface structures.

P 6.5 Tue 12:15 KH 01.020

Investigation on the Limitations of Liquid Metal Heat Pipes for Fusion Applications by Thermal Resistance Modeling — •Max Voncken[1,2], Menno Bakker[2], Seyedmohammad Vafaei[2], Yiran Mao[2], Alexis Terra[2], Jan Willem Coenen[2], and Christian Linsmeier[2] — [1]Eindhoven University of Technology, Power&Flow Group, Department of Mechanical Engineering, Groene Loper 3, 5612 AE Eindhoven, Netherlands. — [2]Forschungszentrum Jülich GmbH, Institute of Fusion Energy and Nuclear Waste Management - Plasma Physics (IFN-1), Jülich 52425, Germany

Liquid metal heat pipes (LMHPs) can manage extreme heat fluxes with exceptionally high thermal conductivity. This capability makes them a promising alternative to conventional monoblocks for cooling plasma-facing components (PFCs) in the divertor region of magnetic confinement fusion devices. In this study, the thermal limitations of sodium and lithium as candidate working fluids and viable design parameter ranges for the envelope, such as diameter, length, and wall thickness, are identified. This has been achieved by a relatively simplified model of thermal resistance, employed as a fast pre-design tool prior to detailed CFD simulations. The developed model is also used to evaluate the thermal performance of a commercially available LMHP, and it is validated against the experiments.