P 17: Complex Plasmas and Dusty Plasmas/Codes and Modeling II

Time: Thursday 15:45–17:15 Location: CHE/0089

P 17.1 Thu 15:45 CHE/0089

Size evolution and plasma-particle interaction of single MF particles in the plasma sheath — •Sören Wohlfahrt, Cassedyn Wirtz, and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Germany

Complex (dusty) plasmas consist of micrometer sized particles in addition to the typical plasma species of ions, electrons and neutrals. It has been observed, that the particle size decreases for many materials during plasma exposure and that the particle surface is modified/roughened. This process is commonly referred to as 'etching', although in the context of dusty plasmas the detailed mechanism and surface reactions behind the decreasing size is not known yet and proposed explanations range from physical sputtering, over melting of the particle material to ion enhanced chemical reactions. We use an advanced light scattering diagnostic based on Lorentz-Mie theory to determine size and size evolution of single melamine formaldehyde (MF) particles in situ and with high temporal resolution. By adding small amounts of oxygen to the discharge, the etch process and plasma particle interaction become accessible [1]. In this talk, we will present precise measurements of the size evolution of single particles complemented with a reactive site model [2] that suggests an increase in surface reactions due to a roughening of the particle surface.

[1] S. Wohlfahrt, C. Wirtz, D. Block, Phys. Plasmas 29, 123702 (2022)

[2] R. Bray, R. Rhinehart, Plasma Chem. Plasma Process 21, 149-161 (2001)

P 17.2 Thu 16:00 CHE/0089

Ex situ measurement of dust size distribution of nanoparticle growth process and comparison with in situ measurements — •Andreas Petersen, Jakob Wötzel, and Franko Greiner — Institute of Experimental and Applied Physics, Kiel, Germany

We present the result of a size distribution analysis for plasma grown dust particles in their accretion phase. A multi-sample extraction process was used to prepare samples for analysis with SEM (ex situ measurement). This allowed for eight consecutive samples, without terminating the discharge. We find that a normal distribution is an adequate description of the particle distribution for the whole growth process. It is noteworthy, that the standard deviation of the distribution increases approximately linearly with average size. We also compare these results with those from a light scatter analysis, which was performed simultaneously and can determine average size and refractive index without opening the discharge chamber (in situ measurement).

P 17.3 Thu 16:15 CHE/0089

Characterization of a Pulsed Plasma and Macroparticles in an Industrial Scale ta-C Laser-Arc Coating System — •Mathis Klette[1], Martin Kopte[2], Wolfgang Fukarek[2], and Holger Kersten[1] — [1]Kiel University, Germany — [2]VTD Vakuumtechnik Dresden GmbH, Germany

Tetrahedral amorphous carbon (ta-C) coatings are commonly used in industry to improve tribological as well as corrosion and wear properties of treated objects. While ta-C can be deposited using various techniques, the Laser-Arc technology allows for a strong temporal and spatial control of the deposition process while providing high deposition rate and enabling up-scaling for industrial applications. A major limiting factor of this technology is the generation of macroparticles and the resulting defects in the coating. In this contribution we present measurements of plasma parameters, neutrals and macroparticles in dependance on arc parameters to get a better understanding of the impact on film growth and system upscaling. The carbon Laser-Arc system produces 100-300 us, 1-3 kA pulses, which are observed with a custom-tailored diagnostic setup. The Langmuir probes, retarding field analyzers, and the optical emission spectroscopy allow for spatially and time resolved measurements of electron and ion energy distribution functions, and estimates of neutral densities. Calorimetric probes monitor the energy influx to the substrate which is of special importance when forming tetrahedral bonds. The temporal and special macroparticle velocity distributions have been investigated with high-speed cameras.

P 17.4 Thu 16:30 CHE/0089

Viscosity of finite Yukawa liquids — •Yang Liu, Natascha Blosczyk, and Dietmar Block — IEAP, Christian-Albrechts-Universität, D-24098 Kiel, Germany

Viscosity is one of the basic characteristics to describe the dynamic behavior of a fluid. For dusty plasmas established methods exist to measure viscosity [1,2]. However, these methods are limited to large/infinite systems while in some experiments (e.g for binary mixtures) the system size is limited. Whether and how these methods can be adapted to measure the shear viscosity of a finite two-dimensional (2D) Yukawa liquid is presented in this contribution using non-equilibrium Langevin simulations. Two counter-propagating shear forces are used to push the particles, causing shear-induced melting of the cluster. Based on the Green-Kubo relation (which relies on the random thermal motion of individual particles of the liquids) we obtain a reliable shear viscosity by diminishing the effect of shear and boundary conditions. We find that the shear viscosity is in good agreement with the results in Refs. [1, 2] if an effective coupling parameter Γ^* is used. Surprisingly, the shear viscosity with this normalization follows a simple universal scaling. For $\Gamma^*>20$ and $0.5<\kappa<2$, the shear viscosity increases monotonously, and thermal motion positively affects the transport properties of dust particles.

References

[1] B. Liu and J. Goree, Physical review letters 94, 185002 (2005).

[2] Z. Donkó, J. Goree, P. Hartmann, and K. Kutasi, Phys. Rev. Lett. 96, 145003 (2006).

P 17.5 Thu 16:45 CHE/0089

Neural network based surrogate models for tokamak exhaust — •Stefan Dasbach and Sven Wiesen — Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich, Germany

For the design of future tokamak fusion reactors the heat transport in the scrape-off layer is a major challenge. A simulation can test only a single configuration at once and is computationally demanding, making it impossible to fully explore the high dimensional design parameter space with simulations alone. A promising approach to circumvent this is to use machine learning models trained on simulation data as surrogate models. After training such models can produce fast results for any configuration in the explored parameter space and could be used for rapid design studies of tokamak reactors or coupled with other models such as tokamak flight simulators or reactor control schemes. For the development of such models we created a dataset of 10.000 2D SOLPS-ITER simulations with reduced physical complexity. The simulations have eight varied parameters including a tokamak size scaling. Using this dataset neural networks are trained either to predict the electron temperatures in the whole 2D simulation domain or solely at the 1D divertor target. The accuracies of the network predictions in different physical regimes are evaluated and different network architectures are compared.

P 17.6 Thu 17:00 CHE/0089

Towards Machine-Learned Poisson Solvers for Low-Temperature Plasma Simulations — •Ihda Chaerony Siffa[1,2], Markus M. Becker[1], and Jan Trieschmann[2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Straße 2, 17489 Greifswald, Germany — [2]Kiel University, Kaiserstraße 2, 24143 Kiel, Germany

In multi-dimensional self-consistent low-temperature electrostatic plasma simulations, the computational effort for solving the Poisson equation can represent a large part of the overall evaluation runtime. Recently, it has been shown that by using machine learning (ML) techniques, in particular artificial neural networks (ANN), one can arrive to solutions of the Poisson equation faster (and with promising accuracy) than using the conventional numerical methods. However, the currently proposed ML-based Poisson solvers still fall short for being widely applicable in low-temperature plasma simulations, which may employ complex geometries, mixed boundary condition, etc. In this work, the requirements for making ML-based Poisson solvers applicable in low-temperature plasma simulations are discussed. Furthermore, a machine-learned Poisson solver that attempts to tackle these requirements is presented, with examples from dielectric barrier discharge (DBD) geometries. First results suggest that supervised training of an ANN with spatially dependent simulation properties and corresponding ground truth electric potential solutions allows for a machine-learned Poisson solver that generalizes well to various geometric and material configurations.