P 6: Poster I

Time: Monday 16:30–18:30 Location: ELP 6: Foyer

P 6.1 Mon 16:30 ELP 6: Foyer

Thermo-Field emission from cathodes made of selected materials — •Margarita Baeva[1], Dirk Uhrlandt[1], Dominik Bratek[2], Carsten Uber[2], Bogdan Barbu[3], and Frank Berger[3] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany — [3]Technische Universität Ilmenau, Germany

Electric discharges in a metal vapour released from the cathode during contact opening are observed in various application fields. In explosion protection, the ignition prediction in flammable gas mixtures is concerned with contact break discharges. The latter represent an ignition source for the gas mixture. In low-voltage switching devices, an electric arc in metal vapour occurs during the so called immobility phase, which is essential for the breaking performance of the device.

This contribution is concerned with the emission of electrons from cathodes made of selected materials (Cu, W, Cd, Zn, Ir) that occurs by collective effects (high temperature in the cathode, high electric field on the cathode surface). These effects characterize the arc regime of operation of electric discharges. In order to obtain the electron emission current for operation with cathodes of the aforementioned materials, the transferred matrix method is applied. This method is applicable to arbitrary shapes of the surface potential barrier. The selected materials considered in this work represent both refractory and non-refractory cathodes.

P 6.2 Mon 16:30 ELP 6: Foyer

Deducing line-integrated density, collision frequency and density profile of an atmospheric plasma torch from microwave diagnostics — •Christos Vagkidis, Eberhand Holzhauer, Walter Kasparek, Alf Köhn-Seemann, Stefan Merli, Mirko Ramisch, Andreas Schulz, and Günter Tovar — IGVP, University of Stuttgart, Germany

Microwaves are crucial in plasma applications, either as a heating mechanism or diagnostics tools. In this work we are utilizing high-frequency microwaves to deduce fundamental information of an atmospheric plasma torch. A network analyzer is used in order to measure the phase shift and the attenuation of a microwave that transverses the plasma torch. These measured quantities are directly related to the line-integrated density and the electron-neutral collision frequency of the torch through the plasma index of refraction. Additionally, the microwave is scattered due to the interaction with the plasma and this scattering depends on the plasma density profile. By moving the receiving antenna of the network analyzer, perpendicularly to the plasma torch, the beam scattering profile can be measured. Numerical full-wave simulations in a 3D domain have been carried out, which allow a variation of the density profile over a wide parameter range. Direct comparison of the experimental scattering profile against the simulations enables a precise estimation of a 2D density profile of the plasma torch.

P 6.3 Mon 16:30 ELP 6: Foyer

Kinetic Modeling of the Chemical and Physical Mechanisms in a Rf Plasma Combined with a Catalyst — •Fatma-Nur Seferoglu[1], Dirk Reiser[1], Achim Von Keudell[2], and Christian Linsmeier[1] — [1]Forschungszentrum Jülich Gmbh, Jülich, Germany — [2]Ruhr-Universität Bochum, Bochum, Germany

Plasma driven catalysis is a promising method for addressing environmental challenges, particularly in the removal of volatile organic compounds (VOC), the reduction of nitrogen oxides and the oxidation of hydrocarbons. The oxidation of n-butane is often used as a benchmark for the efficiency of a catalytic system to remove VOC. However, the description of the chemical and physical mechanisms of plasma catalytic processes can be very challenging due to the high number of possible reaction pathways. On the one hand, the plasma changes the surface coverage of the catalyst and on the other hand, the catalyst influences the variety of the plasma species, i.e. due to desorption of species from the catalytic surface.

This work presents an approach to model the species concentration in a radiofrequency atmospheric pressure plasma combined with a manganese dioxide catalyst and to identify the most effective reaction pathways. In the experiment, the plasma channel is filled with different admixtures of carbon dioxide diluted in helium to investigate the dissociation and recombination of molecules using fourier-transform infrared spectroscopy. For better understanding of the chemical and physical mechanisms in the plasma catalytic system, more gas phase and surface reactions will be tested.

P 6.4 Mon 16:30 ELP 6: Foyer

Silicon nitride membrane as entrance window for plasma-induced VUV radiation — •Görkem Bilgin[1], Luka Hansen[1,2], and Jan Benedikt[1,2] — [1]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]Kiel Nano, Surface and Interface Science KiNSIS, Kiel University, Kiel, Germany

The measurement of vacuum-ultraviolet (VUV) radiation generated by atmospheric pressure plasmas is restricted by the cutoff-wavelength of typical VUV window materials around 100 nanometers as the VUV radiation has to be transfered into the vacuum to avoid absorption [1]. Silicon nitride membranes originally designed for applications in transmission electron microscopes offer the possibility to be used as entrance windows in monochromators. First measurements show that these membranes are capable of withstanding the forces generated by the pressure gradient while being much thinner (20 nm to 200 nm membrane thickness) than typical VUV window materials.

Two different non-thermal atmospheric pressure plasma sources, based on a capillary jet [2] and a DC microplasma [3], were used to generate He-excimer-radiation in the VUV range. Results of the vacuum resistance as well as the VUV absorption measurements of the silicon nitride membranes are presented for different membrane thicknesses.

[1] J. Golda *et al.*, 2020 *Plasma Process. Polym.* **17** 201900216
[2] T. Winzer *et al.*, 2022 *J. Appl. Phys.* **132** 183301
[3] L. Hansen *et al.*, 2022 *Plasma Sources Sci. Technol.* **31** 035013

P 6.5 Mon 16:30 ELP 6: Foyer

Overcoming He: Towards a more sustainable plasma-driven biocatalysis — •Steffen Schüttler[1], Tim Dirks[2], Sabrina Klopsch[2], Jannis Kaufmann[1], Niklas Eichstaedt[1], Julia E. Bandow[2], and Judith Golda[1] — [1]Plasma Interface Physics, Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum, Germany — [2]Applied Microbiology, Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum, Germany

In plasma-driven biocatalysis, an RF atmospheric pressure plasma jet operated with humid He is used to generate and deliver H2O2 into a liquid in which biological enzymes act as catalysts [1]. Promising total turnover numbers were found, showing that this approach is competitive with other approaches presented in literature. However, 99% of the operating costs of the process are due to the use of He as feed gas. Therefore, in order to achieve a more sustainable approach, Ar was used as a feed gas because it can be extracted from air and is less expensive than He. A less stable plasma operation and a lower H2O2 production were found, which counterbalances the lower cost of Ar compared to He. To obtain a more stable plasma with Ar, a kHz plasma jet was also tested, which could also be used well in biocatalysis. N2 or air as feed gas are the most cost-effective gases. Therefore, the operation of the kHz plasma jet in humid N2 has also been tested for plasma-assisted biocatalysis, enabling a wider range of applications.

This work is supported by the DFG within CRC1316 (Subproject B11, project number 327886311).

[1] A. Yayci et al., ChemCatChem 12, 5893-5897 (2020)

P 6.6 Mon 16:30 ELP 6: Foyer

Investigation of the morphology of a pulsed discharge in water using stereoscopic images — •Robert Werberger[1,2], Raphael Rataj[2], and Klaus-Dieter Weltmann[1,2] — [1]Universität Greifswald — [2]Leibniz-Institut für Plasmaforschung und Technologie e. V.

In the past, the morphology of streamer discharges in water was mainly analysed using 2D imaging systems, which resulted in measurement uncertainties due to the loss of depth information on the structure of the discharges. To take the spatial information into account, 3D images of the discharges are required. This study utilised a stereoscopic camera system to determine the disparity between two images resulting from different viewing angles. An automated analysis procedure was used to determine the corresponding points between the images, which was then used to create a 3D reconstruction of the discharges, thereby obtaining spatial information. The streamer discharges were generated at a needle-to-plate electrode with a positive, pulsed voltage signal with an amplitude ranging from 35 to 45 kV and a pulse duration of 100 ns. In the study, effects of voltage amplitude and liquid conductivity on the spatial positions of discharge channel branches and their splitting angles were investigated. Additionally, a comparison between two- and three-dimensional results will be presented.

P 6.7 Mon 16:30 ELP 6: Foyer

Experimental studies on H_2 addition to a CO_2 atmospheric microwave plasma torch — •Marc Bresser, Sophie Wahl, Katharina Wiegers, Andreas Schulz, Matthias Walker, and Günter Tovar — IGVP, University of Stuttgart, Germany

Man-made climate change, caused for example by an increased concentration of carbon dioxide (CO_2) in the atmosphere, is causing a switch from fossil fuels to renewable energy sources. The chemical industry is searching for new renewable ways to synthesize hydrocarbons. One way is to utilize the resulting CO_2 as a reactant and create a cycle process. CO_2 can be activated by a microwave plasma and split into carbon monoxide (CO) and oxygen (O_2). The big advantage is, that this technology enables the use of intermittent energy from wind and sun. The resulting CO can be further processed into hydrocarbons. One idea is to add other gases to the CO_2 plasma in order to utilize the energy and produce higher value products. In this work, the addition of "green" hydrogen (H_2) to a CO_2 plasma is investigated. The CO_2 gas is introduced tangentially in a reverse vortex flow of a microwave plasma torch. On top of the plasma torch a 13 mm restriction nozzle is mounted to quench the plasma and prevent the reverse reaction. The position of the H_2 addition is varied. After cooling to room temperature, the product gas is analyzed using a Fourier transform infrared (FTIR) absorption spectrometer. The influence of microwave power, gas flow and gas composition on the product gas is studied.

P 6.8 Mon 16:30 ELP 6: Foyer

Impact of CO_2 on the metastable atom density in the COST Reference Microplasma Jet — •Alexander Schicke, Sebastian Burhenn, and Judith Golda — Plasma Interface Physics, Ruhr-Universität Bochum, 44801 Bochum, Germany

In the plasma community, the dissociation of CO_2 has become a growing topic over the last years. Many applications include decarbonising the atmosphere and producing carbon for chemicals and fuels. Typical degrees of dissociation of about 45% can be achieved by adding CO_2 to e.g. a helium rf-plasma. The degree of dissociation can be increased by adding argon to the helium discharge gas stream. In previous works, it was assumed that two of the main reaction pathways responsible for the dissociation of CO_2 are electron impact dissociation and dissociation via Penning collisions with metastable atoms.
Therefore, to quantify how big of a role the metastable atoms play in the COST Reference Microplasma Jet, we changed the He/Ar ratio in the feed gas while simultaneously measuring the Ar and He metastable atom densities via tunable diode laser absorption spectroscopy (TDLAS). Additionally, the density profiles were measured as 2D maps, which gives us information about the spatial distribution of the metastable atoms in the discharge channel.

P 6.9 Mon 16:30 ELP 6: Foyer

Construction and test of a (micro-)hollow cathode assembly regarding hydrogen production via methane — •Marcel Margraf — Goethe Universität Frankfurt, IAP

A (Micro-)Hollow cathode assembly was designed with purpose of finding an efficient method to separate Methane into Hydrogen and Carbon. Compared to other discharges a hollow cathode discharge (HCD) allows for higher current densities at same conditions. Due to this higher dissociation degrees can be expected and thus possibly better efficiencies. A cylindrical cathode with a diameter of 0,8mm was used, separated from the anode by a 0,5mm thick MICA isolator. The assembly was powered by a DC high voltage generator and measurements were conducted from 0,2 to 0,9 mA under pressures of 300 to 800 mbar. Discharge voltage and current were measured with an oscilloscope and the conversion rate was measured with a gas analyzer. No correlation between pressure and efficiency was found in this test, however the efficiency went up with higher input currents. The best efficiency of 6,26% +/- 2,62% was achieved with 0,9mA at the highest pressure. This is a promising result for the idea to use such assemblies at atmospheric pressure and a basis for further tests.

P 6.10 Mon 16:30 ELP 6: Foyer

Imaging Spectrography at the Plasma Liquid Interface — •Kai Bröking[1,2], Daniel Tasche[1,2], and Christoph Gerhard[1,3] — [1]HAWK Hochschule für angewandte Wissenschaft und Kunst, Fakultät Ingenieurwissenschaften und Gesundheit, Göttingen — [2]Technische Universität Clausthal, Fakultät für Natur- und Materialwissenschaften, Clausthal-Zellerfeld — [3]Politecnico di Milano, School of Industrial and Information Engineering, Milano, Italy

Imaging spectrographs preserve spatial details imaged onto a spectrograph slit throughout the whole of their optical system. This grants access to spatially resolved spectral information, in our case about both plasma induced processes and, concurrently, to properties of the plasma. We have implemented a fast direct vision spectrograph for imaging in near real time, which allows access to process parameters in near real time as well. This is of marked interest for studying processes near the plasma liquid interface in the plasma induced formation of silver nanoparticles (AgNP). Taking spatially resolved absorption spectra of the AgNP simultaneously with the emission spectra of the plasma permits local process parameters to be observed in real time and investigated with a view to adjusting conditions of the reaction accordingly.

P 6.11 Mon 16:30 ELP 6: Foyer

Investigation of a plasma window arc discharge for particle beam transmission to high pressure targets — •Fateme Ghaznavi — Goethe University, Frankfurt am Main, Germany

A Plasma window [1] is a device which can be used to separate two different pressure levels, allowing for an unperturbed transmission of ion beams from the accelerator vacuum to high pressure targets. This sealing effect is provided by an arc discharge, burning along the ion beam transmission axis. At Goethe University Frankfurt, we constructed a plasma window, featuring an aperture of 5mm, using an 98%Ar-2%H_2 working gas compound and currents between 60-120 A with a flow rate between 1-4 slm. The aim of this study is to investigate the plasma physical characteristics of this arc discharge. A spectroscopic system is adjusted along the discharge axis to allow for a simultaneous estimation of the electron temperature and density at 4 different positions. They were found to range between 1-1.5 eV for the electron temperature and $0.6\text{-}3.8 \cdot 10^{16}$ cm^3 for the electron density, reaching 30% higher pressures compared to previous measurements utilizing the same aperture with lower currents [2].

[1] Hershcovitch, A. High-pressure arcs as vacuum-atmosphere interface and plasma lens for nonvacuum electron beam welding machines, electron beam melting, and nonvacuum ion material modification J. Appl. Phys., AIP Publishing, 1995, 78, 5283

[2] B. F. Bohlender Characterization of a plasma window as a membrane free transition between vacuum and high pressure Physical review accelerators and beams 23, 2020

P 6.12 Mon 16:30 ELP 6: Foyer

Comparison of the finite element and spectral element methods in modelling of streamer discharges. — •I. L. Semenov, A. P. Jovanovic, and M. M. Becker — Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany

Numerical modelling of streamers at atmospheric pressures is a challenging problem due to the multiscale nature of this discharge type. The current need to simulate streamers in realistic geometries and model the streamer-surface interaction drives the development of novel computational approaches to this problem. One of the key challenges is the development and implementation of efficient methods for solving large-scale electrostatic problems. As it was shown in [I. L. Semenov, K. D. Weltmann, J. Comput. Phys. 465, 111378 (2022)], the use of the hierarchical Poincaré - Steklov (HPS) scheme can be a promising approach to improve the computation efficiency of solving elliptic problems in streamer simulations. The HPS scheme is a multidomain spectral collocation method that has a number of attractive features. In this contribution we compare the streamer simulation scheme based on the HPS method with that based on the conventional finite element method (implemented using FEDM within the FEniCS framework). A number of test problems is considered and the efficiency of both methods is assessed in terms of the required computational time and the number of discrete unknowns being involved.

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P 6.13 Mon 16:30 ELP 6: Foyer

Benefits and perspectives of semantic data acquisition in low-

temperature plasma physics — Ihda Chaerony Siffa[1], Hidir Aras[2], Harald Sack[2], Markus Stocker[3], and •Markus M. Becker[1] — [1]Leibniz Institute for Plasma Science and Technology (INP) — [2]FIZ Karlsruhe - Leibniz Institute for Information Infrastructure — [3]TIB - Leibniz Information Centre for Science and Technology

The scientific communities have recognized that structured storage and provision of data and technical information according to the FAIR data principles can represent a tremendous added value for research and development. This is reflected by the establishment of metadata schemas, ontologies, and knowledge graphs within the framework of the National Research Data Infrastructure (NFDI) in Germany and other projects in the field of research data management, where researchers from various fields work closely with computer scientists to develop sustainable infrastructures and tools. In this contribution, we present a basic ontology for low-temperature plasma (LTP) physics and show how a knowledge graph for LTP is created, which allows for easier reuse of data by providing a structured and interconnected representation of information. An application example demonstrates the development of an infrastructure for the simplified search of context-related information in patents, scientific literature and research data. Furthermore, we present how this can also support data-driven research and utilize the benefits of open-access publications.

The work was supported by the DFG (project 496963457) and by the BMBF (projects 16QK03A-B and 16KOA013A-B).

P 6.14 Mon 16:30 ELP 6: Foyer

Research data management with eLabFTW and Adamant — •Markus M. Becker[1], Ihda Chaerony Siffa[1], Robert Wagner[1], Nick Plathe[1], Kerstin Sgonina[2], and Marina Prenzel[3] — [1]Leibniz Institute for Plasma Science and Technology (INP) — [2]Institute of Experimental and Applied Physics, Kiel University (CAU) — [3]Research Department Plasmas with Complex Interactions, Ruhr-University Bochum (RUB)

The practical implementation of present requirements of the funding organizations with regard to the collection of standardized metadata and compliance with the FAIR data principles presents scientists and institutes with new challenges. Research data should be documented in a structured way and provided with identifiers to keep both data and metadata findable, accessible, interoperable and reusable. Electronic laboratory notebook (ELN) systems can support the implementation of these requirements. This contribution introduces the open-source ELN system eLabFTW (https://www.elabftw.net) and demonstrates its practical application in several groups in the field of low-temperature plasma physics. Furthermore, it is shown how the open-source tool Adamant (https://github.com/plasma-mds/adamant) can help to collect and store metadata in structured formats supporting the implementation of automated workflows for metadata acquisition, storage and publication on the basis of eLabFTW.

The work is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under the National Research Data Infrastructure – [NFDI46/1] – 501864659 and project 327886311.

P 6.15 Mon 16:30 ELP 6: Foyer

Characterization of millimeter-sized low-pressure plasmas in multi-scale aeromaterials — •Karin Hansen[1], Julian Held[2], Jonas Lumma[3], Lena Marie Saure[3], Fabian Schütt[3], Rainer Adelung[3], and Franko Greiner[1] — [1]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]Department of Mechanical Engineering, University of Minnesota, Minneapolis, USA — [3]Institute for Materials Science, Kiel University, Kiel, Germany

Environmental protection is pivotal in our daily lives, and catalysis, particularly plasma catalysis, stands as a promising avenue to address these challenges. The efficiency of chemical processes hinges on the interplay between the plasma and catalyst surface. Nanodusty plasmas, comprising nanometer-sized particles spaced at micrometer intervals in a low-pressure plasma, exhibit notable attributes - a high surface-to-volume ratio and exceptional plasma permeability with a filling factor $f \approx 10^{-5}$. Multi-scale aeromaterials, micron-sized tetrapodal frameworks with nano-sized walls, share a comparable filling factor. These highly porous and lightweight aeromaterials remain solid and deployable within a plasma environment.

Our investigation centers on probing the interaction between these aeromaterials and low-pressure, radio-frequency argon plasmas. The plasma is ignited in a system of millimeter-sized aeromaterial cylinders with cylindrical cavities, providing a large aeromaterial-surface to plasma-volume ratio. Optical emission spectroscopy and electrostatic double probes as key techniques have been tailored to this millimeter-sized system. Our preliminary studies focus on aeroglass (t-SiO2).

P 6.16 Mon 16:30 ELP 6: Foyer

Langmuir probe measurements in a dual-frequency capacitively coupled rf discharge — •Viktor Schneider[1], Jessica Schleitzer[1], Ihor Korolov[2], Gerrit Hübner[2], Peter Hartmann[3], Julian Schulze[2], and Holger Kersten[1] — [1]Institute of Experimental and Applied Physics (IEAP), Kiel University — [2]Chair of Applied Electrodynamics and Plasma Technology, Faculty of Electrical Engineering and Information Sciences, Ruhr University, Bochum, Germany — [3]Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Hungary

A dual-frequency capacitively coupled rf argon plasma has been investigated using a passively compensated Langmuir probe. The discharge is driven by two different excitation frequencies (13.56 MHz and 27.12 MHz) simultaneously with variable phase angle θ between them, utilizing the electrical asymmetry effect (EAE). With a passively compensated Langmuir probe the floating potential, plasma potential, electron temperature and electron density are measured for different phase angles in two different geometrically asymmetric discharges. Similar to the dc self-bias, the plasma parameters show a pronounced dependence on the phase. However, the measured profiles of the density and temperature as a function of phase in both experimental setups are not symmetric around $\theta = 90°$, unlike the dc self-bias. This observation is confirmed by PIC/MCC simulations, which reveal asymmetrical electron excitation/ionization dynamics at the corresponding phases. This implies that the observed trends are a property of the 2f discharge in combination with a geometric asymmetry of the discharge.

P 6.17 Mon 16:30 ELP 6: Foyer

Seagull - A compact helicon discharge — •Stefan Knauer, Nils Fahrenkamp, Sebastian Haag, and Peter Manz — Felix-Hausdorff-Str 6, 17489 Greifswald

The Seagull experiment is a radio-frequency powered plasma experiment with a planar double spiral antenna. The plasma forms in a cylindrical high-vacuum, within a volume of about 1dm^3. It was used to study capacitively (CCP) and inductively (ICP) coupled radio-frequency discharges, e.g. by means of a microwave interferometer, electron detachment and a set of Langmuir probes. Phase transitions and instabilities in electro-negative gases were investigated, as it aims to provide insight in industrial relevant coating processes. We plan to upgrade the experiment with copper coils to add a static magnetic field to the discharge area. A static magnetic field is required for helicon discharges, which are known for their height densities. Since Seagull exhibits unusual small vessel dimensions compared to other helicon experiments (sometimes multiple meters long), a comparatively short wavelength should be sufficient and thus a low magnetic field. This parameter and diagnostic set-up might enable well diagnosed helicon discharge measurements at the size of a table-top experiment.

P 6.18 Mon 16:30 ELP 6: Foyer

Development and application of low energy plasma treatments for steel surfaces — •Gustav Gürtler[1,2], Wolfgang Burgstaller[1], Markus Valtiner[2], and Friedrich Aumayr[2] — [1]voestalpine Stahl Gmbh, voestalpine Straße 3, 4020 Linz, Austria — [2]Institute of Applied Physics, TU Wien, Wiedner Hauptstraße 8-10/E134, 1040 Wien, Austria

Plasma cleaning can be an efficient way of preparing metallic surfaces for subsequent coating procedures by removing oxides and other contaminants and consequently enhancing the adhesion of deposited coating layers [1]. This study investigates the efficiency of low-pressure plasma treatments of steel batch samples. Plasma monitoring via optical emission spectroscopy (OES) is performed on a pulsed-DC argon plasma discharge. A successful removal of sample material is confirmed by Fe atomic emission, while an estimation of electron density Ne and electron temperature Te is attempted by exploiting intensity ratios of neutral argon Ar (I) emission lines via a modified Boltzmann plot and a Te-dependent neutral Ar (I) emission line ratio [2]. A possible correlation of Te and Ne values and the amount of detached material is investigated.

[1] H. C. Barshilia et al, 2012, Vacuum, 86 1165-1173
[2] J. B. Boffard et al, 2012, J. Phys. D: Appl. Phys. 45 045201

P 6.19 Mon 16:30 ELP 6: Foyer

Helicon wave physics for the development of a helicon plasma cell for particle-driven wakefield accelerators — •Alf Köhn-Seemann[1], Luis Herrera[1], Oliver Lass[2], and Peter Manz[2] —

[1]IGVP, University of Stuttgart, Germany — [2]Institute of Physics, University of Greifswald, Germany

Plasma wakefield accelerators provide significantly higher gradients in the electric field to accelerate particles than linear particle accelerators, thereby significantly reducing their overall size. High electric fields require high electron plasma densities. Helicon plasma discharges are known to provide the highest electron densities. In this contribution we will give an overview of our newly started DFG-funded project to understand the helicon wave propagation and dissipation in the plasma based on a joint experimental and numerical approach between the University of Stuttgart and the University of Greifswald.

P 6.20 Mon 16:30 ELP 6: Foyer

Investigation of charge exchange collisions in an ion beam — •Philipp Georg Johannes Kropidlowski, Leo Zeidler, Thomas Trottenberg, and Holger Kersten — IEAP, Christian-Albrechts-Universität zu Kiel

Charge exchange collisions (CEX) play an important role in operation of ion beam sources for industrial applications and electric propulsion systems for space travel. CEX collisions convert part of the ions into a beam of fast neutral atoms.

Several diagnostic methods can be used to measure this phenomenon, like a combination of force probe [1] and Faraday cup [2]. In this contribution, we use a Faraday cup to measure the spatial electric current density of the beam ions. In addition, a force probe measures the momentum flux density of all energetic beam particles, including the neutrals generated by charge exchange collisions, which cannot be detected by a Faraday cup.

We present measurements in the beam of an inductively coupled plasma (ICP) gridded ion source.

[1] T. Trottenberg, A. Spethmann, and H. Kersten, EPJ Techn. Instrum. 5, 3 (2018)

[2]J. Benedikt, H. Kersten, and A. Piel, Plasma Sources Sci. Technol. 30, 033001 (2021)

P 6.21 Mon 16:30 ELP 6: Foyer

Transport Across an X-Point in HiPIMS plasmas — •Martha Finke[1], Achim von Keudell[1], Dennis Krüger[2], and Marc Böke[1] — [1]Fakultät für Physik und Astronomie, Bochum, Germany — [2]Fakultät für Elektrotechnik und Informationstechnik, Bochum, Germany

Magnetized low pressure plasmas have a wide range of applications such as sputter deposition of metals and oxides or plasma thrusters for small satellites. In case of High Power Impulse Magnetron Sputtering (HiPIMS) the plasma currents may affect the magnetic fields. By combining two magnetrons with their magnets facing each other one obtains a specific topology of the magnetic field with an X-point, where we seek to find signatures of magnetic recinnection events. We investigate in the time-resolved behaviour of the plasma during the HiPIMS pulse using an ICCD camera and observe that the plasma igniting in front of the driven targen is strongly influenced by the magnetic field of the opposite magnetron.

P 6.22 Mon 16:30 ELP 6: Foyer

Multidimensional effects in low-pressure discharges — •Jonas Thiel, Tsanko V. Tsankov, and Uwe Czarnetzki — Ruhr-University Bochum, Faculty of Physics and Astronomy

The transport in low-pressure discharges, such as the ones commonly used in many industrial applications, is governed by diffusion. Most of the insights on the behavior of these plasmas is obtained through the use of one-dimensional models. Such a treatment forces equality of the ion and electron fluxes and leads to the well-known ambipolar diffusion. However, in realistic systems with metal walls, flux balance has to be satisfied only globally but not locally. This leads to a peculiar behavior, with regions where the ion flux to the walls exceeds the electron flux and vice versa. In this contribution, the effect is investigated experimentally for a large area rectangular discharge chamber, which provides a simple geometry. The plasma is generated by inductive coupling provided by the recently developed INCA configuration. An array of wall-mounted planar probes allows the measurement of the spatial profiles across one of the major walls. The spatial distributions of the electron and ion fluxes, as well as of the plasma potentials, the densities and the electron temperature are measured and analyzed. The results demonstrate the expected deviation from local equality of the fluxes.

P 6.23 Mon 16:30 ELP 6: Foyer

Formation of ammonia in a surfaguide discharge assisted by catalysis — •Vinzenz Wolf[1], Roland Friedl[1], and Ursel Fantz[1,2] — [1]AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg — [2]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

Ammonia (NH_3) is an important chemical widely used as fertiliser and in the chemical industry. Plasma-catalysis has attracted great interest in the last years as an alternative for the energy intensive thermal-catalytic synthesis of ammonia via the Haber-Bosch process. The plasma generates photons, radicals, excited and metastable states which lead to and additional activation of the precursor hydrogen and nitrogen molecules, thereby lowering the activation energy needed for the generation of NH_3.

In this contribution, the effect of changes in pressure in the range of 3 Pa to 1000 Pa, the hydrogen-nitrogen gas composition, and the presence and position of a commercial Ruthenium catalyst (2 wt% Ru on γ-Al_2O_3 pellets) on ammonia production are investigated in a microwave (2.45 GHz) plasma discharge by means of mass spectrometry. The calibration of the mass spectrometer and the influence of considering the background water are described. Additionally, optical emission spectroscopy is used to determine the vibrational and rotational temperatures of the molecules in the plasma.

P 6.24 Mon 16:30 ELP 6: Foyer

Effect of low-pressure plasma treatment on triboelectric properties of polypropylene (PP) and polylactic acid granules (PLA) — •Alina Bachmann — Hessen, Germany

This study evaluates the effect of low-pressure plasma treatment of approximately spherical polypropylene (PP) and cylindrical polylactic acid granules (PLA) on triboelectric properties. Using low-pressure plasma, various process gases and treatment durations, surfaces of the polymer materials were modified.

Within the experimental procedure these process parameters were varied to achieve saturation charge for PP and PLA. The charge-to-mass ratio and surface charge density serve as crucial parameters for characterising the treated surfaces.

The results of the study find application in the electro-sorting of plastics based on triboelectricity. Since this phenomenon is not scientifically understood to a full extent, the generated data contributes to a more optimised implementation in the technical field.

P 6.25 Mon 16:30 ELP 6: Foyer

Stokes-Einstein Relation for Binary Mixtures — •Yang Liu and Dietmar Block — IEAP, Christian-Albrechts-Universität, D-24098 Kiel, Germany

The Stokes-Einstein (SE) relation connects the diffusion coefficient (D) of Brownian particles in liquids to their temperature (T) and the shear viscosity (η) [1]. Extensive evidence has confirmed the validity of the SE relation in ordinary liquids and dusty plasmas, except for systems near the melting temperature and for the gaseous behavior [2]. However, for binary mixtures, i.e. dusty plasmas consisting of two particle species with different charges, an explicit validation of SE is lacking.

In this paper, a Langevin simulation code is used to generate 2D binary systems whose structural and dynamical properties match the experimental conditions [3]. The obtained η and D in monodisperse and binary systems are analyzed and compared. Finally, the applicability of the SE relation to 2D finite binary mixtures is tested. Our results show that, even in finite systems the SE relation holds. Further, the transport properties of monodisperse and binary systems can be combined in a generalized SE relation if properly defined coupling strengths and screening parameters are used.

References

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P 6.26 Mon 16:30 ELP 6: Foyer

Plasma processing of Ag nanoparticles for resistive switching applications — •Arthur Fabritz[1], Florian Ziegler[2], Blessing Adejube[2], Alexander Vahl[2,3], Franz Faupel[2,3], and Jan Benedikt[1,3] — [1]Institute of Experimental and Applied Physics, Kiel University — [2]Institute of Materials Science, Kiel University — [3]KiNSIS, Kiel University

Given their negative charge when inserted or formed in plasma, nanoparticles can be stored in the positive plasma potential and can be effectively modified inside a plasma, which allows for applications in various fields such as opto-electronics, sensors, or medicine. A large area of study are their electric characteristics, where especially their utilization in memristive devices is still largely unexplored. Memristic devices allow for the simulation of complex neuronal systems, and could therefore contribute to a vast improvement in the functionality of electrical components.

In this work, silver nanoparticles generated in a gas aggregation source are injected into low pressure plasma and coated with thin films (hydrocarbons, SiOx) to form core-shell nanoparticles. Injection of additional silver nanoparticles and extraction of the trapped particles onto non-conducting substrate can prepare mixed nanoparticle films with the density of uncoated particles on the percolation limit, the condition needed for the successful construction of a device with memristive properties. The experimental setup, in-situ diagnostics with UV-Vis absorption spectroscopy, nanoparticle extraction and measurements of their electrical properties will be discussed.

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On the use of configurational temperature for an ion focus measurement — •Natascha Blosczyk and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany

Complex plasmas -especially those using micronsized dust grains- allow to study fundamental physical processes. Due to the particle size they attain a large negative charge and allow to study strongly coupled systems in a fluid and crystalline state. However, in the plasma sheath the negatively charged dust grains perturb the ion flow, resulting in a positive space charge region downstream of each particle which modifies the interparticle interaction force. This positive space charge region is called the ion focus and has a non-negligible effect on interaction strength as its charge is comparable to a significant portion of particle charge and its distance to the particle layer is of the order of interparticle distance. However, to determine the strength and position of the ion focus is a difficult task. In this contribution the configurational temperature method will be used to estimate the focus properties. If the particle charge and the screening length are known, the contribution of ion focus in terms of focus strength and position can be estimated from force equilibrium and a configurational temperature fit. The method is tested for results of MD-simulations as well as experimental data.

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The charging of nonspherical particles in a dusty plasma — •Isabel König, Armin Mengel, and Franko Greiner — Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany

For the most part, studies focus on the charging of spherical particles in a plasma, and only a few experiments were performed studying the charging of nonspherical particles. Nonspherical particles have a varying surface potential, which complicates the calculation of the equilibrium particle charge and also affects dust dynamics. One ansatz to determine the charge of nonspherical particles is the smallest enclosing sphere approximation [Asnaz, Phys.Plasmas 2018].

To analyze the charging of micrometer-sized nonspherical particles we use a combination of long-distance microscopy and the phase-resolved resonance method. We compare the nonspherical particles with spherical SiO_2 particles which levitate at the same position in the sheath. Measurements for different kinds of nonspherical particles are performed: clustered microparticles (doublets and triplets), cylinders, tetrapods, MgO and sapphire crystals, multiscale aeromaterials and MOFs.

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COMPACT – the future complex plasma facility for the ISS — •Daniel P. Mohr[1], Christina A. Knapek[1], Stefan Schütt[1], Daniel Maier[1], André Melzer[1], and COMPACT Collaboration[2] — [1]University of Greifswald, Institute of Physics, Greifswald, Germany — [2]International: CA, US, SE, DE

Complex, or dusty, plasmas consist of micrometer-sized grains that are injected into a low-temperature noble gas discharge. The grains become charged and interact with each other via a screened Coulomb potential. On ground, gravity compresses the system and prevents the formation of larger, three-dimensional particle clouds.

The future complex plasma facility COMPACT will allow the investigation of large three-dimensional complex plasmas under microgravity conditions aboard the International Space Station (ISS). Its technology is based on preliminary studies (Ekoplasma, PlasmaLab), including a novel plasma chamber with adaptive internal geometry, a four-electrode radio-frequency system for plasma generation, and a stereoscopic particle diagnostic that enables the 3D particle dynamics to be recorded in real time. COMPACT is a project with international scientific contributions, funded by space agencies (DLR, NASA). A phase 0/A study is currently underway in collaboration with the space industry and will be finished until 02/2024.

We will present the scientific objectives of COMPACT, scientific and technological progress and the project status.

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Oxygen dependent size evolution of PMMA particles in the plasma sheath — Franziska Reiser, •Sören Wohlfahrt, and Dietmar Block — Kiel University, Kiel, Germany

Microparticles are the essential component of complex (dusty) plasmas. The forces affecting the particles, as well as their accumulated charge, depend prominently on their size. However, dependent on the particle material, the size and surface morphology of the particle will change when exposed to the plasma. Polymethymethacrylat (PMMA) particles show a strong plasma-particle interaction, resulting in a significant size reduction, or etching of the particle. In addition, a heavily modified surface structure with crests and trenches that has a reduced mass density of up to 50 % was reported. Compared to melamine formaldehyde (MF) particles, which show only a moderate response to the surrounding plasma, PMMA particles are an excellent research object to investigate the material dependent plasma-particle interaction itself, as well as the possible influence of the surface morphology on charging processes. An enhanced light scattering diagnostic based on Lorentz-Mie-theory is used to determine and track size and optical properties of the particle and thus the evolution of the plasma-particle interaction. The time resolved evolution of size and the optical properties of single PMMA particles for a systematic variation of oxygen admixture to the argon plasma are presented in this contribution. The results are compared to MF particles and complimented with levitation height measurements, which act as an indicator for particle charge.