P 12: Atmospheric Pressure Plasmas I

Time: Wednesday 13:45–15:45 Location: KH 01.020

Invited Talk P 12.1 Wed 13:45 KH 01.020

Modelling and analysis of DBDs for thin-film deposition at atmospheric pressure — •Marjan Stankov[1], Lars Bröcker[2], Claus-Peter Klages[2], Markus M. Becker[1], and Detlef Loffhagen[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Institute for Surface Technology, Technische Universität Braunschweig, Braunschweig, Germany

Dielectric barrier discharges (DBDs) at atmospheric pressure are widely used as plasma sources for thin film deposition. The quest for non-invasive diagnostic methods able to reveal the underlying physics in such applications of DBDs has led to modelling studies emerging as a powerful solution. This contribution provides an overview on how time-dependent, spatially one-dimensional (1D-t) and two-dimensional (2D-t) fluid-Poisson models enable the investigation of the influence of Si-containing precursors like HMDS, HMDSO and TMS on the behaviour of argon DBDs in different configurations. The presentation focuses on 1D-t modelling findings on the importance of Penning ionisation of precursor molecules by excited Ar states for electron production. It highlights the outcomes of the analysis of particle surface fluxes, identifying ions as the primary contributors to deposition in discharges with a short gas residence time. It also shows how the 2D-t modelling can explain a unique discharge mode experimentally observed in the presence of small amounts of precursors. The work is funded by the Deutsche Forschungsgemeinschaft – project no. 504701852.

P 12.2 Wed 14:15 KH 01.020

The Influence of Floating Materials on Streamer Propagation in sDBD Systems — •Dominik Filla, Nils Schoeneweihs, Gerrit Hübner, Ihor Korolov, Thomas Mussenbrock, and Mate Vass — Department of Electrical Engineering and Information Science, Ruhr University Bochum, D-44780, Bochum, Germany

The efficient conversion of greenhouse gases and volatile organic compounds (VOCs) remains a significant challenge for environmental sustainability and advanced chemical processes. Surface dielectric barrier discharges (sDBDs) driven by nanosecond pulses offer a promising approach to address these challenges by exploiting the complex interplay between streamer discharges and nearby floating metal materials. This study investigates how floating surfaces affect the behavior of positive and negative streamers in He/N_2 sDBD systems. Using 2D plasma-fluid simulations, we analyze the impact of floating metal surfaces on streamer propagation, velocity, and the resulting electric field configuration. Numerical results reveal that streamers deposit charge on the floating material, thereby modifying the local electric field and subsequently affecting the propagation behavior of both positive and negative streamers. The simulations show good agreement with experimental observations via phase resolved optical emission spectroscopy. Supported by the DFG via SFB 1316.

P 12.3 Wed 14:30 KH 01.020

Spatio-temporal development of pulsed-driven dielectric barrier discharges in a single-filament arrangement in Ar — •Hans Höft[1], Alica Takáčová[2], Tomáš Hoder[1,2], and Markus M. Becker[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Department of Plasma Physics and Technology, Masaryk University, Brno, Czech Republic

Dielectric barrier discharges (DBDs) in argon were investigated using a double-sided, symmetric single-filament configuration with 0.5 mm alumina barriers and a 1 mm gas gap, which was housed in a Plexiglas cell and was flushed with a 100 sccm Ar flow at atmospheric pressure. The DBDs were driven by unipolar positive high-voltage pulses (50 ns rise/fall time, 10 kHz repetition frequency, 1 μs pulse width) with a varying amplitude (2.1–3.0 kV). Imaging by synchronised iCCD and streak camera measurements combined with fast electrical probes revealed a reproducible, thin constricted channel and surface discharges on both dielectrics. The discharge inception at the rising slope features as a cathode-directed streamer followed by a transient glow phase with complex characteristics; the streamer velocity was an order of magnitude lower than in air-like gas mixtures. Increasing the amplitude to 3.0 kV significantly altered the discharge inception and development compared to 2.1 kV, thus providing valuable data for modelling DBDs in Ar.

This work is funded by the Deutsche Forschungsgemeinschaft (DFG) – project number 504701852, and project LM2023039 funded by the Ministry of Education, Youth and Sports of the Czech Republic.

P 12.4 Wed 14:45 KH 01.020

Pressure-dependent streamer dynamics of a nanosecond-pulsed surface dielectric barrier discharge in He/N_2 — •Nils Schoeneweihs, Dominik Filla, Gerrit Hübner, Thomas Mussenbrock, Mate Vass, and Ihor Korolov — Ruhr University Bochum, Bochum, Germany

Surface dielectric barrier discharges (sDBDs) have been extensively studied for applications ranging from plasma-assisted gas conversion to surface treatment. In this work, sDBDs driven by nanosecond voltage pulses are investigated in He/N_2 gas mixtures and at various pressures. 2D plasma*fluid simulations (nonPDPSIM) and experiments are conducted to investigate streamer formation, propagation length and velocity and their implications for plasma-assisted conversion. Insights into the discharge dynamics are obtained by measuring emission from the He-I $(3s)^3S_1$ state (with an excitation energy of 22.7 eV) and by calculating the corresponding spatio-temporal excitation rate using phase-resolved optical emission spectroscopy (PROES). Good qualitative agreement is found between PROES measurements and simulations. The results suggest strong coupling between the positive streamer at the powered electrode and the negative streamer at the grounded electrode in a twin-sDBD configuration. Varying the pressure strongly influences the velocity and propagation length of the streamer. Supported by the DFG via SFB 1316 (Projects A5 and A7).

P 12.5 Wed 15:00 KH 01.020

Determination of the argon $3p^54s$ population distribution in a single-filament dielectric barrier discharge at atmospheric pressure — •Levin Krös[1,2], Hans Höft[1], Marjan Stankov[1], Detlef Loffhagen[1], Jean-Pierre H. van Helden[3], and Ronny Brandenburg[1,2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Institute of Physics, University of Rostock, Rostock, Germany — [3]Faculty of Physics and Astronomy, Ruhr University Bochum, Bochum, Germany

Atoms and molecules in excited states impact the discharge and chemical reaction kinetics by their contribution to the production of charge carriers, via, e.g., step-wise ionisation or chemi-ionisation processes. In argon discharges, these processes are mainly driven by the energetically lowest excited states in the $3p^54s$ group, namely in Paschen notation, the two resonance states $1s_2$ and $1s_4$ and the two metastable states $1s_3$ and $1s_5$. Measurements of number densities of all four $3p^54s$ states allow to determine the population distribution, which is valuable for benchmarking the kinetics of numerical models. We report spatio-temporally resolved number densities of those states measured in a single-filament dielectric barrier discharge operated with a sinusoidal high-voltage waveform at atmospheric pressure using tunable diode laser absorption spectroscopy. The population distribution will be compared with results of a time-dependent, spatially one-dimensional fluid model.

This work is funded by the DFG (project number: 504701852).

P 12.6 Wed 15:15 KH 01.020

Peculiarities of the current transfer on a copper cathode microarcs in air in presence of metal vapour — •Margarita Baeva[1], Jonas K. C. Ballentin[2], and Dirk Uhrlandt[1,2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Institute of Electrical Power Engineering, University of Rostock, Rostock, Germany

Analysis of the current transfer on the copper cathode is performed for a switching arc arrangement operated at DC of 2 A at atmospheric pressure in a mixture air/Cu. The analysis is based on a unified non-equilibrium model that provides in a self-consistent manner the spatial distribution of the plasma properties needed for this analysis accounts for the increase of the gap length during the contact opening.

The presence of metal vapour in the plasma even in the considered mole fraction of 0.002 leads to the dominance of the singly charged copper ion. Ionization process occurs both in the space-charge region of the cathode and beyond the edge to the quasineutral plasma bulk.

The computed spatial distribution of the electric potential indicates a maximum in the vicinity of the cathode, which causes an ion flux toward the plasma bulk. The predicted ratio of the ion to total current density amounts to 0.41-0.76 as a result of the interplay of increasing cathode voltage drop and in turn increasing ion mobility and drift velocity that overrules the decrease of the ion number density.

The work is funded by the German Research Foundation (DFG) Project number 524731006.

P 12.7 Wed 15:30 KH 01.020

Silicon Nitride Membrane for Vacuum Ultraviolet (VUV) Spectroscopy of Commonly Used Plasma Jets — •Görkem Bilgin[1], Jan Benedikt[1,2], and Luka Hansen[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 diagnostic of VUV photons generated by non-thermal atmospheric pressure plasmas is complicated by the strong absorption in air and common window materials (e.g., LiF, MgF_2) as these materials have cutoff wavelengths of around 110 nm [1, 2]. Various windowless techniques have been developed in the past to transfer the VUV photons into a vacuum, but each method has its drawbacks [2].

For this contribution, an evacuated monochromator, equipped with an ultra-thin (20 nm) silicon nitride (Si_3N_4) membrane as an entrance window for the VUV radiation, was upgraded compared to [2] using narrower entrance/exit slits and a new detector, in order to improve the spectral resolution and achieve higher intensities.

VUV spectra of the COST Jet [3], Capillary Jet [4], and kINPen [5] will be presented, and the VUV emission correlated with UV/VIS spectra and electrical measurements.

[1] J. Golda *et al.* 2020 *Plasma Process. Polym.* **17** 1900216
[2] L. Hansen *et al.* 2025 *Plasma Sources Sci. Technol.* **34** 12LT01
[3] J. Golda *et al.* 2016 *J. Phys. D: Appl. Phys.* **49** 084003
[4] T. Winzer *et al.* 2022 *J. Appl. Phys.* **18** 183301
[5] S. Reuter *et al.* 2018 *J. Phys. D: Appl. Phys.* **51** 233001