P 14: Atmospheric Pressure Plasmas and their Applications II

Time: Thursday 14:00–16:00 Location: H5

Invited Talk P 14.1 Thu 14:00 H5

Streamer inception and imaging in various atmospheres —
•Sander Nijdam, Siebe Dijcks, and Shahriar Mirpour — Eindhoven University of Technology, The Netherlands

Streamers are the first stage of many discharges involving high voltages. They consist of a propagating ionization front leaving behind a trail of conductive, quasi-neutral plasma. In this contribution we will show experiments on streamers revealing some of their most important properties: their inception and their propagation and branching behaviour.

We study streamer inception by applying repetitive high voltage pulses and studying the statistics of inception delay. By means of small bias pulses between the high voltage pulses, we are able to manipulate these statistics, which reveals a lot on the processes governing the inception.

Secondly, we study the propagation and branching of streamers by a combination of stereoscopic and stroboscopic measurements of 'low complexity' streamer discharges. We have developed automated routines which can determine propagation velocities, branching angles and much more from these.

Finally, we study single streamers in great detail, using optical imagining, optical emission spectroscopy, Raman scattering and E-FISH together to get a complete picture of the properties of these discharges and compare this to numerical simulations.

P 14.2 Thu 14:30 H5

From single- to multi-filament arrangements for pulsed dielectric barrier discharges —
•Hans Höft, Manfred Kettlitz, and Ronny Brandenburg — Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Straße 2, 17489 Greifswald, Germany

It has been demonstrated that the discharge characteristics in pulsed-operated single-filament dielectric barrier discharges (DBDs) can be controlled by varying the pulse width of the applied high voltage (HV). The transfer of this knowledge to multi-filament DBDs is crucial for the further understanding and design of plasma reactors. Therefore, a direct comparison between a single-filament and a multi-filament arrangement driven by the same HV pulses with variable pulse width was performed in a gas mixture of 0.1 vol% O_2 in N_2 at 1 bar. Both arrangements feature a 1 mm gap with alumina-covered electrodes, with two hemispherical electrodes for the single-filament and two parallel tube electrodes for the multi-filament arrangement. The DBDs were characterised by electrical measurements (for energy, power, transferred charge, peak current) accompanied by synchronised iCCD imaging determining the filament number and the discharge development in the gas gap and on the surfaces. Generally, most physical quantities scale with the filament number. The impact of pre-ionisation on the DBD characteristics is very similar, although the filament number depends on the pre-ionisation.

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P 14.3 Thu 14:45 H5

Spatiotemporal emission of an atmospheric plasmoid —
•Roland Friedl[1], Saskia Steibel[1], Victor Slavov[2,3], and Ursel Fantz[1,3] — [1]AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg — [2]Faculty of Physics, University of Sofia, 1164 Sofia, Bulgaria — [3]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

An atmospheric pressure plasmoid is generated via a high voltage discharge (4.8 kV) above a water surface. After around 150 ms the connection to the power supply is interrupted and the plasmoid enters an autonomous phase which lasts up to 400 ms. The plasmoid has a diameter of around 30 cm and ascends in air with a velocity of about 1–2 m/s. High speed video analysis (600 fps) and optical emission spectroscopy is applied to gain insight into the plasma dynamics.

Survey spectrometers ($\Delta\lambda \sim 1.4$ nm) are applied to determine the dominant radiating plasma constituents for the three main evolution phases of the plasmoid: ignition, formation, and autonomous phase. Photo diodes with interference filters ($\Delta\lambda \sim 10$ nm) are used for monitoring the emission of specific plasma constituents (H, OH, Na) with high temporal resolution (0.5 ms). High resolution spectroscopy ($\Delta\lambda \sim 0.16$ nm) with a high speed trigger system is applied to measure the OH-A-X emission system during the temporal evolution of the plasmoid. In order to gain access to the plasma chemistry, rotational and vibrational temperatures of the hydroxyl molecule are evaluated using Lifbase, while its absolute emissivity is analyzed by collisional-radiative modeling.

P 14.4 Thu 15:00 H5

Atomic oxygen density distributions in an atmospheric pressure plasma jet and its effluent —
•David Steuer, Ihor Korolov, Sascha Chur, Julian Schulze, Volker Schulz-von der Gathen, Judith Golda, and Marc Böke — Ruhr-University Bochum, D-44801 Bochum, Germany

Micro atmospheric pressure plasma jets (μAPPJs) are attracting high attention due to their potential to treat temperature sensitive surfaces. For these applications, reactive species are produced in the plasma. In this work two-dimensional spatially resolved absolute atomic oxygen densities are measured within a μAPPJ (COST-Jet) and in its effluent. The plasma is operated in helium with an admixture of 0.5% of oxygen at 13.56 MHz and with a power of 1 W. Absolute atomic oxygen densities are obtained using two photon absorption laser induced fluorescence spectroscopy (TALIF). The results are reproduced by a combination of phase resolved optical emission spectroscopy (PROES) measurements and simple model calculations. Within the discharge, the atomic oxygen density builds up with a rise time of 600 μs along the gas flow and reaches a plateau of 8×10^{15} cm^{-3}. In the effluent, the density decays exponentially with a decay time of 180 μs (corresponding to a decay length of 3 mm at a gas flow of 1.0 slm). It is found that both, the species formation behavior and the maximum distance between the jet nozzle and substrates for possible oxygen treatments of surfaces can be controlled by adjusting the gas flow.

P 14.5 Thu 15:15 H5

Reaction kinetics of H2O2 in a cold atmospheric pressure plasma jet —
•Sarah-Johanna Klose[1], Levin Krös[2], Igor L Semenov[1], and Jean-Pierre van Helden[1] — [1]Leibniz-Institut für Plasmaforschung und Technologie e.V. (INP), Felix-Hausdorff-Str. 2, Greifswald — [2]Universität Greifswald, Greifswald

Since cold atmospheric pressure plasma jets have gained high interest particularly for biomedical applications, the tailoring of the reactive species composition produced by the plasma jet is an important issue. To be able to adapt the reactive species composition and to comprehend the impact of plasmas on cells, a good understanding of the production and consumption mechanisms in the plasma jet is pivotal. Hydrogen peroxide (H2O2) for example is a species with a high impact on cells that works as a signalling agent for intracellular communications when dissolved in a cell containing liquid.

In this work, we present the density distributions of H2O2, HO2, and H and O atoms in the gas phase of the plasma jet kINPen without contact to a liquid and deduce the most important reaction mechanisms by comparing the results to a reaction kinetics model. The distributions were obtained by continuous wave cavity ring-down spectroscopy and picosecond two-photon absorption laser-induced fluorescence spectroscopy. We will discuss the reactions in the plasma zone and the impact of the effluent's surrounding gas composition on the chemistry leading to the formation and consumption of H2O2 and its precursors.

P 14.6 Thu 15:30 H5

3-dimensional density distributions of NO in the effluent of the COST-Reference-Microplasmajet —
•Patrick Preissing[1], Ihor Korolov[2], Julian Schulze[2], Volker Schulz-von der Gathen[1], and Marc Böke[1] — [1]Ruhr-Universität Bochum, Experimentalphysik II — [2]Ruhr-Universität Bochum, Angewandte Elektrotechnik und Plasmatechnik

Plasma jets are known to generate a huge number of different reactive species. In that context Nitric Oxide is one of the key players, as it triggers many biological processes. In this study absolute densities of NO are measured in the effluent of an RF-driven micro atmospheric pressure plasma jet, that is operated in a He/N2/O2 mixture, by means of Laser Induced Fluorescence, with 3-dimensional spatial resolution. The densities are measured in two distinct atmospheres. In the first one, the jet is expanding into open air, whereas in the second configuration the jet is expanding into a controlled He/air mixture. From the time resolved LIF signals the quenching coefficients for He, air, N2 and O2 are determined, as well as the intrusion of the ambient air into the He gas flow expanding from the jet. It was found that the distribution as well as the absolute densities strongly depend on the surrounding atmosphere, due to quenching and collisions. Furthermore, the NO particles are strongly coupled to the He flow of the feed gas. Parameter studies, varying different parameters such as plasma power, gas flow and gas mixture have been performed and the influence on the absolute NO densities as well as its distributions are investigated.

P 14.7 Thu 15:45 H5

Loss processes of plasma-generated atomic oxygen in phenol solutions — •Kerstin Sgonina[1], Giuliana Bruno[2], Stefan Wyprich[1], Kristian Wende[2], and Jan Benedikt[1] — [1]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]Leibniz Institute for Plasma Science and Technology, Greifswald, Germany

Aqueous solutions treated by cold atmospheric pressure plasma jets contain high amounts of reactive species. It has already been shown that atomic oxygen produced by a cold atmospheric pressure plasma jet effectively reacts with organic molecules like phenol dissolved in water without any intermediate reaction steps [1]. However, it is unknown whether the reactions with atomic oxygen are liquid-surface or liquid-volume dominated.

To investigate the loss processes of atomic oxygen in liquid solutions, experimental results are combined with simulations of the reaction kinetics [2]. Phenol solutions were treated with the effluent of a He/O_2-plasma ignited in the COST-Jet which provides well-known densities of reactive oxygen species [3]. Variation of the phenol concentration allows an insight into the competing O-loss reactions in gas phase, liquid phase or at the liquid surface. The comparison to simulations of the reaction kinetics and transport from gas into liquid phase reveal the predominance of reactions of atomic oxygen at the liquid surface.

[1] J. Benedikt et al., Phys. Chem. Chem. Phys. 20 12037 (2018).
[2] K. Sgonina et al., J. Appl. Phys. accepted (2021).
[3] G. Willems et al., New J. Phys. 21 059501 (2019).