P 14: Atmospheric Plasmas and their Applications IV

Time: Wednesday 13:45–15:30 Location: ZHG006

Invited Talk P 14.1 Wed 13:45 ZHG006

Carbon Dioxide Splitting in Dielectric Barrier Discharges: Power Dissipation and Plasma Chemistry — •Ronny Brandenburg[1,2], Milko Schiorlin[1], and Volker Brüser[1] — [1]Leibniz-Institut für Plasmaforschung und Technologie e.V., Greifswald — [2]Universität Rostock, Institut für Physik

The conversion of carbon dioxide to carbon monoxide (CO), oxygen and ozone in planar volume dielectric barrier discharges (DBDs) is studied. The type of the electrodes, the barrier material, the barrier thickness, the discharge gap, the flow rate, the high voltage frequency and amplitude as well as the electrode area are varied systematically. Power dissipation is studied by voltage-charge plots based on an adapted equivalent circuit and the Manley-equation for discharge power is generalized for the occurrence of parasitic capacitances and so-called partial surface discharging. The energy yield of CO (EY) results in similar values of about 25 g/kWh in pure carbon dioxide within the specific input energy (SIE) range 20 - 2000 J/L, independent on the above mentioned parameters. SIE higher than 3000 J/L yield a slightly lower EY. A comparison with various other DBD-reactors is done and the role of SIE as a scaling parameter is discussed. Funded by German Federal Ministry of Education and Research (BMBF) and European Union NextGenerationEU under grant 033RC030D.

P 14.2 Wed 14:15 ZHG006

Multi-PMT System and 0-D Chemical Modeling for Analyzing Atomic Oxygen Production in Micro Cavity Plasma Arrays — •Henrik van Impel, David Steuer, Volker Schulz-von der Gathen, Marc Böke, and Judith Golda — PIP & EP2, Ruhr-University Bochum, D-44801 Bochum

Dielectric barrier discharges (DBDs) have numerous applications, including ozone generation and the treatment of volatile organic compounds, which can be further enhanced by integrating catalysts. Understanding the underlying processes requires fundamental knowledge about the generation of reactive species. In this study, we investigated atomic oxygen production within a micro cavity plasma array, a customized surface DBD confined to micrometer-sized cavities. Using optical emission spectroscopy, we analyzed the plasma chemical processes. The discharge was operated in helium with a 0.25% molecular oxygen admixture at atmospheric pressure, using a 15kHz 600V triangular excitation voltage. High dissociation degrees were observed with helium state enhanced actinometry (SEA). Utilizing a multi-photomultiplier system proved effective for monitoring the discharge, especially following the temporal evolution of the atomic oxygen density or dissociation degree, making it highly suitable for industrial applications. To further confirm the consistency of the measurements, we developed a simple 0-dimensional chemical model.

The project is funded within project A6 of the SFB 1316.

P 14.3 Wed 14:30 ZHG006

In situ XRD and XAS at Plasma Treatment of Ce(IV)-O-Clusters and Ce(IV)-MOFs — •Alexander Quack[1], Diletta Morelli Venturi[2], Hauke Rohr[2], Tim Graupner[2], Anastasia Molokova[3], Kirill Lomachenko[3], Kerstin Sgonina[1], Malte Behrens[2,4], Norbert Stock[2,4], and Jan Benedikt[1,4] — [1]Institute of Experimental and Applied Physics, Kiel University — [2]Institute of Inorganic Chemistry, Kiel University — [3]European Synchrotron Radiation Facility (ESRF), Grenoble — [4]Kiel Nano, Surface and Interface Science (KINSIS), Kiel University

The utilization of non-thermal atmospheric pressure plasmas, to supplement the existing chemical industry by using access renewable resources, allows for the potential usage of less heat resilient catalysts like metal-organic-frameworks (MOFs). While some MOFs are observed to be stable, while other MOFs are not, the exact processes of decomposition of the MOFs has not directly been investigated.

We have developed a dielectric barrier reactor with an open optical axis to allow for in situ x-ray analysis of material within the plasma. The plasma operates with H_2 gas combined with Ar or CO_2 at 20 kHz at 10-15 kV_{pp} and can be externally heated up to 200 °C. This design was employed during the beam-time of CH-7281 at BM-23 at the European Synchrotron Radiation Facility (ESRF) to treat clusters and MOFs containing cerium. The chemical stability of these compounds was analyzed using in situ x-ray diffraction (XRD) and x-ray absorption spectroscopy (XAS).

Invited Talk P 14.4 Wed 14:45 ZHG006

Insights into Mode Transitions and Reactive Species Densities in a Micro Cavity Plasma Array — •David Steuer[1], Henrik van Impel[1], Volker Schulz-von der Gathen[2], Marc Böke[2], and Judith Golda[1] — [1]Plasma Interface Physics, Ruhr-University Bochum, D-44801 Bochum, Germany — [2]Experimental Physics II: Physics of Reactive Plasmas, Ruhr-University Bochum, D-44801 Bochum, Germany

Micro-cavity plasma arrays are promising for plasma-catalytic research due to their ability to ignite plasma in direct contact with catalytic surfaces. A critical aspect of their application lies in the generation of reactive species within the cavities. He/O2 systems are ideal for studying these species, offering reduced complexity while oxygen plays a crucial role in oxidizing target gases or activating surfaces. Optical emission spectroscopy measures O-densities within the cavities, while laser-based methods analyze areas outside the discharge. A diffusion model connects these regions, revealing that atomic oxygen is generated exclusively inside the cavities, with dissociation degrees close to 100%. Transport out of the cavities is governed by diffusion and ozone formation. Varying oxygen admixtures reveals a shift from a homogeneous glow discharge (<1%) to a filamentary discharge at higher oxygen concentrations. This transition, evident in parameters as current, power, and electric field, significantly impacts conversion efficiency. Fine-tuning of the discharge mode provides a pathway to enhance plasma-catalytic performance. This work is supported by DFG within SFB1316 (A6).

P 14.5 Wed 15:15 ZHG006

The Impact of Electrohydrodynamic Forces on Vortex Formation and Flow Behavior in sDBD Systems — •Dominik Filla[1], Alexander Böddecker[1], Mate Vass[1], Ihor Korolov[1], Thomas Mussenbrock[1], and Sebastian Wilczek[2,3] — [1]Department of Electrical Engineering and Information Science, Ruhr-University Bochum, D-44780, Bochum, Germany — [2]TH Georg Agricola University, D-44787, Bochum, Germany — [3]enaDyne GmbH, D-04103, Leipzig, Germany

The efficient conversion of greenhouse gases and volatile organic compounds (VOCs) remains a significant challenge for environmental sustainability and innovative chemical processes. Surface dielectric barrier discharges (sDBDs) driven by nanosecond pulses offer a promising approach to address these challenges by leveraging the complex interplay between discharge and fluid dynamics. This study investigates the coupling between electrohydrodynamic (EHD) forces induced by positive and negative streamers and gas flow in He/N_2 sDBD systems. Using 2D plasma-fluid simulations, we evaluate the impact of EHD forces on vortex formation and flow behavior. Numerical results reveal that streamers produce localized EHD forces, subsequently driving flow dynamics and shaping overall gas flow patterns in the system. The simulations show high qualitative agreement with experimental data, including particle image velocimetry and schlieren measurements. This work highlights the potential of plasma-assisted flow control to advance the understanding and optimization of gas flow processes in dielectric barrier discharge systems. Supported by the DFG via SFB 1316.