P 21: Atmospheric Pressure Plasmas II

Time: Friday 14:00–15:45 Location: P-H11

P 21.1 Fri 14:00 P-H11

Production of crystalline silicon nanoparticles in an atmospheric plasma jet — •Maren Dworschak[1], Filip Matějka[2], Niklas Kohlmann[3], Pavel Galář[2], and Jan Benedikt[1] — [1]Institute of Experimental and Applied Physics, Kiel University, Germany — [2]Institute of Physics, Czech Academy of Sciences, Czech Republic — [3]Faculty of Engineering, Kiel University, Germany

Due to their opto-electrical properties semiconductor nanoparticles can be used in a wide range of applications including photovoltaic cells. Cold atmospheric plasmas are highly reactive systems that can be used for the generation of such nanoparticles. Compared to low pressure systems the production of crystalline particles is more challenging, but also provides economical benefits. We report on an RF-driven capacitively coupled atmospheric plasma jet with a dielectric on the electrodes. The so-called HelixJet [1] can be operated at large powers and elevated gas temperature, where its operation is not compromised by depositions inside the jet. Its original setup has been modified with an additional electrode to work reliable even at high admixtures of reactive gases. Using silane, silicon nanoparticles with precise size control can be generated over a broad range of sizes. Different reactive gas admixtures are used to modify the surface passivation of the generated nanoparticles. Under the right conditions it is possible for the particles to become crystalline. Their crystallinity is observed through measurements of (time-resolved) photoluminescence, Raman spectroscopy and TEM measurements.

[1] J. Schäfer et al., Plasma Process. Polym. 17 (2020)

P 21.2 Fri 14:15 P-H11

Vibrational excitation in a CO_2/N_2 ns-discharge — Yanjun Du[1,2], •Tsanko V. Tsankov[1], Dirk Luggenhölscher[1], and Uwe Czarnetzki[1] — [1]Institute for Plasma and Atomic Physics, Ruhr University Bochum, D-44780 Bochum, Germany — [2]North China Electric Power University, Beijing, China

Repetitively pulsed ns-discharges exhibit large departure from equilibrium. This is especially well suited for studying the excitation of molecules due to the separation of the time scales for population and relaxation. Of particular interest in recent years is the study of discharges in CO_2 in relation to efficient molecule dissociation through ladder climbing excitation of the vibrational states [1]. A tunable quantum cascade laser system for absorption measurements has been set up to measure this excitation with ns resolution [1,2].

Here the system is employed to obtain the excitation dynamics of the CO_2 states in a ns pulsed discharge in a near-atmospheric pressure CO_2/N_2 mixture. The mechanisms for CO_2 molecular excitation during the discharge pulse and in the subsequent afterglow are discussed and compared to the ones in discharges in CO_2/He mixtures.

[1] Y. Du, Ts. V. Tsankov, D. Luggenhölscher, U. Czarnetzki, *J. Phys. D: Appl. Phys.* **54** (2021) 365201.

[2] Y. Du, Ts. V. Tsankov, D. Luggenhölscher, U. Czarnetzki, *J. Phys. D: Appl. Phys.* **54** (2021) 34LT02.

P 21.3 Fri 14:30 P-H11

Plasma catalytic synergies of a non-equilibrium atmospheric pressure plasma jet with MnO_2 surface catalyst — •Christoph Stewig, Theresa Urbanietz, Laura Chauvet, Marc Böke, and Achim von Keudell — Ruhr-Universität Bochum Institute of Experimental Physics II Faculty for Physics and Astronomy Universitätsstraße 150 Building NB 5/174 D-44780 Bochum

Plasma catalysis seeks to exploit potential synergies between surface catalytic reactions and plasma reactions. An excess of renewable energies could be used to produce value-added molecules and thus provide the chemical industry with important reactants or allow for alternative methods of energy storage.

Potential synergetic effects are: (i) a reduction or prevention of catalyst poisoning due to a cleaning of the catalyst surface, hence (ii) a lowering of the catalyst activation temperature, and (iii) an increase in the catalyst activity due to the creation of additional reactive sites by the plasma. (iv) finally, specific molecular excitations could promote specific surface reactions.

We investigate these mechanisms in a RF driven temperature-controlled capacity coupled plasma jet at atmospheric pressure. Fourier Transformed Infrared Spectroscopy (FTIR) measurements are conducted in the plasma and yield information on the excitation and density of noble gas diluted molecules like CO_2 or n-butane.

The effect of a MnO_2 surface catalyst for temperatures of 20°C and 200°C on the dissociation of n-butan are presented.

P 21.4 Fri 14:45 P-H11

VUV-photoionization chamber for the selective study of ion-substrate interactions — •Kerstin Sgonina, Alexander Quack, Christian Schulze, and Jan Benedikt — Institute of Experimental and Applied Physics, Kiel University, Germany

The high reactivity of cold atmospheric pressure plasmas, for example with biological substrates, is in addition to the reactive neutral oxygen and nitrogen species, also based on additive or synergistic effects of these reactive species with charged species, photons, and electric fields. In contrast to photons or electric fields, the study of the isolated effect of ions with biological substrates or ion-based deposition of thin films is more challenging as their isolated production under atmospheric pressure conditions is not trivial. To prove the expected enhanced effect of ions due to their charge and internal energy, knowledge about the ion composition and absolute ion fluxes to the substrate is needed.

To study the isolated effect of ions on substrates and ion-based thin film deposition, an experimental setup has been developed in which photoionized ions are directed towards the substrate. The ions are generated in a helium atmosphere with a small admixture of O_2, C_2H_2 or other gaseous species by VUV-radiation of the helium excimer emission (60-100 nm) generated by a helium driven atmospheric pressure plasma. Mass spectra and relative ion fluxes along the substrate position are measured by ion mass spectrometry. Combined with spatial resolved current measurements, the absolute ion flux can be determined. The deposition of thin films with ions generated from C_2H_2 will be discussed.

P 21.5 Fri 15:00 P-H11

Vibrational excitation in a nanosecond discharge — •Jan Kuhfeld[1], Zoltan Donko[2], Nikita Lepikhin[1], Dirk Luggenhölscher[1], and Uwe Czarnetzki[1] — [1]Institute for Plasma and Atomic Physics, Ruhr University Bochum, D-44780 Bochum, Germany — [2]Wigner Research Centre for Physics, Budapest, Hungary

Vibrational distribution functions of nitrogen are measured in a nanosecond discharge (200-250 ns, conducting electrodes) by coherent anti-Stokes Raman scattering (CARS). It is found, that for vibrational states with $v < 8$ a two temperature distribution function is a very good approximation to the vibrational distribution. The excitation conditions for vibrational states are constant during most of the discharge pulse and agree very well with the excitation rates from the literature for the given electric field, which is measured by E-FISH (electric field induced second harmonic generation). The development of the vibrational states during the afterglow is compared to a state-to-state kinetic model, which is dominated by VV transfer and transport losses. Here too, good agreement was found for rates available in the literature. Additionally, Particle-in-Cell/Monte Carlo Collisions (PIC/MCC) simulations are performed for the same conditions as in the experiments. The results of these simulations are used to derive analytical models for the discharge. The models can explain the value of the reduced electric field in the plasma bulk (about 80% of the discharge volume), which favors vibrational excitation.

P 21.6 Fri 15:15 P-H11

CO2 dissociation by a nanosecond pulsed dielectric barrier discharge — •Sepideh Mousazadeh Borghei, Volker Brüser, and Juergen F. Kolb — Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany

Reduction of CO2 into value-added chemicals and fuels by means of plasma technology has gain significant interest in recent years. In this project, a coaxial dielectric barrier discharge generated with high voltage pulses of 15-20 kV and a pulse duration of 500 ns at ambient temperature and atmospheric pressure was used to investigate the process of CO2 splitting for CO2 and an admixture of Ar in the ratio of 1:2 (CO2:Ar). The influence of gas flow rate and more importantly the effects of positive and negative polarity on the process of dissociation were investigated. The gaseous product after plasma treatment was analyzed by Fourier transform infrared spectroscopy. The results

indicated that gas flow rate plays an important role in the process of dissociation, which the highest CO2 conversion of 5.6% detected for the lowest flow. In addition, positive polarity shows an up to 1.3 fold higher CO concentration compared to negative polarity. Indeed, the obtained results from the inception voltage approved that less voltage was required to start the plasma in positive polarity, and therefore, at the same condition, there are more filamentary channels in positive polarity than negative polarity.

P 21.7 Fri 15:30 P-H11

CO2 conversion in a barrier corona discharge at elevated pressures — •Hamed Mahdikia, Volker Brüser, and Ronny Brandenburg — Leibniz Institute for Plasma Science and Technology, 17489, Greifswald, Germany

A barrier corona discharge in CO2 with admixture of Argon is studied. The aim is to investigate the operation at elevated pressures up to 5 bar for industrial scale CO2 conversion. Therefore, the coaxial asymmetric dielectric barrier discharge contains an inner brush electrode to intensify the electric field strength and to minimize the amplitude of the applied high voltage driving the discharge. Charge-voltage plots are used to characterize the discharge. Depending on the conditions (sinusoidal voltage amplitude, gas composition and pressure), full or partial coverage of the electrodes is obtained. This so-called partial discharging is monitored by the variation of the effective dielectric capacitance. Optical emission spectroscopy was done at full coverage condition for each gas composition and pressure. The line intensity ratio of atomic oxygen at 777 nm to Argon excited species at 772 nm increase significantly by increasing the pressure. On the other hand, absolute CO2 conversion decreases by increasing the CO2 content in the gas mixture and pressure at constant specific energy input (SEI=1.5 kJ/L) while effective conversion increases as well as the energy efficiency, and CO production. A correlation of the mean reduced electric field strength (E/N) and the CO2 dissociation is found. The E/N decreased by increasing the pressure and sustaining voltage to ~ 40 Td for 5 bar which leads to a higher dissociation degree.