# P 3: Atmospheric Pressure Plasmas and their Applications I

Time: Monday 16:30–18:15 Location: H6

**Invited Talk** P 3.1 Mon 16:30 H6

**An overview of the theoretical description and modelling of low-current arcs at small gap distances** — •Margarita Baeva — Leibniz Institute for Plasma Science and Technology, Greifswald, Germany

This contribution will present the achievements of a three-year research project that was concerned with the development of a unified non-equilibrium modelling of direct current electric arcs of short lengths at low currents. Such arcs are currently considered as promising tools in material processing. They are also encountered in switching devices among others.

A thorough analysis of the physical processes and arc plasma properties were carried out in order to provide knowledge about the spatial structure of the arc when the arc length was reduced to only a few millimeters and below one millimeter, and the electric current amounted a few Amperes. Results will be presented that demonstrate the arc-electrode interaction over different arc lengths, the spatial extension of the regions of space charge, and how these regions change when the arc length becomes minuscule. The challenges in modelling of short arcs between melting electrodes will be discussed.

The potentials and limitations of the modelling approach will be considered with respect to further developments.

The project on modelling of microarcs is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - project number 390828847.

P 3.2 Mon 17:00 H6

**Kalorimetrische Messungen an Plasmaspritzanlagen unter Atmosphärendruck mit passiven Thermosonden** — •Kristian Amand Reck[1], Maximilian Stummer[2], Thorben Kewitz[3], Rüdiger Foest[3] und Holger Kersten[1] — [1]Christian-Albrechts-Universität zu Kiel, Kiel, Deutschland — [2]INOCON Technologie GmbH, Attnang-Puchheim, Österreich — [3]Leibniz-Institut für Plasmaforschung und Technologie e. V.

Das Plasmaspritzen ist ein etabliertes Beschichtungsverfahren für metallische und keramische Schichten als auch für Polymere und Komposite auf verschiedenen Substraten. In der Industrie und Forschung besteht ein großes Interessen an der Kontrolle und der Optimierung des gesamten Prozesses. Aufgrund der höheren Energiedichte als bei anderen Plasmaquellen und der Zuführung von Beschichtungsmaterialien ist die Auswahl an Diagnostiken allerdings begrenzt.

Der Energiestrom bei Plasma-Oberflächen-Wechselwirkungen ist ein wichtiger Parameter für das Schichtwachstum. Zur Messung des Energiestroms wurden passive Thermosonden verwendet, die für die anspruchsvollen Bedingungen adaptiert wurden. Eine Anpassung und Erweiterung der Auswertung ist ebenfalls notwendig gewesen. Es wurden an zwei unterschiedlichen Plasmaquellen die räumliche Verteilung des Energiestroms und die Abhängigkeiten von der Leistung, Gasflüssen und Beschichtungsmaterialien untersucht. Die vorgestellten Messungen zeigen die vielseitigen Einsatzmöglichkeiten von passiven Thermosonden, auch um Plasmaspritzanlagen zu charakterisieren.

P 3.3 Mon 17:15 H6

**Influence of the fluid flow description on the characteristics of a plasma spray torch** — •Tao Zhu, Margarita Baeva, Thorben Kewitz, Holger Testrich, Detlef Loffhagen, and Rüdiger Foest — Leibniz Institute for Plasma Science and Technology, 17489 Greifswald, Germany

In direct current plasma spray torches operated at current values of several hundred Amperes, the velocity of the generated plasma jet can approach the speed of sound, i.e. Mach numbers (Ma) close to one are reached. Then, the description of the fluid flow can affect the models' predictions. We present a two-dimensional and stationary magneto-hydrodynamic model of a plasma in local thermodynamic equilibrium for the steady operating mode of a plasma spray torch. Approaches related to both low- and high-Ma (bounded by Ma=0.3) are considered on the computational platform COMSOL Multiphysics for a laminar and compressible flow with flow rates from 40 to 80 normal litre per minute (NLPM). The predicted pressure, plasma temperature, velocity, and electric potential differ depending on the approach employed. The thermal efficiency of the torch computed by the high-Ma model is between 50% and 60% and agrees well with experimental values. In contrast, a thermal efficiency of about 50% is predicted by the low-Ma model. It agrees with the measurements at a flow rate of 40 NLPM, but gradually decreases to about 40% for a flow rate of 80 NLPM.

This work is funded by the European Union and the Federal State of Germany Mecklenburg-Western Pomerania (Project number TBI-V-1-321-VBW-112).

P 3.4 Mon 17:30 H6

**Spectroscopical analysis of an atmospheric pressure argon methane microwave plasma for methane pyrolysis** — •Simon Kreuznacht, Marc Böke, and Achim von Keudell — Experimental Physics II, Ruhr University Bochum, Germany

Recently, the climate friendly and energy efficient production of hydrogen has gained a lot of interest. Today, hydrogen is used as an important precursor in the chemical industry, but hydrogen may also serve as energy carrier, for energy storage, or as climate friendly fuel in the future. Usually, hydrogen is produced by steam reforming of methane. However, this process produces a lot of $CO_2$ (9 t per ton of hydrogen). Methane pyrolysis in a microwave plasma, as an oxygen free technology, is a promising production method of hydrogen without the emission of greenhouse gases.

Here, we present a detailed spectroscopic analysis of an argon methane microwave plasma based on the evaluation of high resolution dicarbon emission spectra. The dicarbon rotational temperature deduced from these spectra can be used to estimate the space resolved gas temperature. The product gas stream was monitored using an online gas analyser at the same time. Since the gas temperature heavily influences the chemistry in the plasma, the space resolved determination of the gas temperature can be used to tune the microwave plasma methane pyrolysis for optimal conversion and energy efficiency.

P 3.5 Mon 17:45 H6

**Photo-chemistry of organosilicon and hydrocarbon precursors initiated by VUV/UV-radiation from an atmospheric pressure RF plasma jet in argon and helium** — •Tristan Winzer, Natascha Blosczyk, and Jan Benedikt — Institute for Experimental and Applied Physics, Kiel University, Kiel, Germany

Deposition of thin films using atmospheric pressure plasmas (APPs) has received increased interest in recent years. This is because APPs do not require expensive vacuum chambers and continuous material treatment is possible. However, hot electrons in the plasma lead to formation of negative ions and subsequently to particle formation, which can be incorporated as defects in the film.

APPs ignited in argon or helium emit intense VUV/UV-radiation from noble gas excimer species. In this study, this radiation is utilized to create ions and free radicals from a gas mixture of helium/argon and organosilicon or hydrocarbon precursors. A plasma source for separation of plasma generated species and photo-chemistry products will be presented. The electrons created by photo-ionization of the precursor gas remain cold and the production of negative ions via electron attachment is omitted. The photo-ionization products in dependence of plasma parameters and reactive gas admixture will be analysed using positive ion mass spectrometry. Deposited films are characterized using Fourier-transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM).

P 3.6 Mon 18:00 H6

**Electric field strengths within a micro cavity plasma array measured by Stark shift and splitting of helium** — •Sebastian Dzikowski[1], Syvain Iseni[2], Judith Golda[3], Marc Böke[1], and Volker Schulz-von der Gathen[1] — [1]Experimentalphysik II, Ruhr-Universität Bochum — [2]GREMI, Universität Orlêans — [3]Plasma Interface Physics, Ruhr-Universität Bochum

Over the last years micro-structured plasma devices have received increased attention for decomposition and reformation of volatile organic compounds (VOC) [1]. Here, we present a metal-based microcavity reactor which is a demountable alternative to silicon-based devices. This layer-structured reactor consists of a nickel foil operating as an electrode and an electrically grounded magnet. Both electrodes are separated from each other by a 40 microns thick dielectric foil. The nickel foil consists of four sub-arrays where hundreds to thousands of cavities in the 100 microns range are arranged equally. To obtain more control over charged particles, the electric field is of high importance. Here, the Stark effect of the allowed 492.19 nm Helium line and its forbidden 492.06 nm counterpart is exploited. By using a combination of a plane grating spectrometer and an attached ICCD camera the typical displacement of about 0.2 nm between both transitions can be resolved. With that technique spatial integrated and phase-resolved electric field strengths with a time resolution up to one microsecond can be measured for this reactor depending on operation and geometric parameters. Depending on the polarity of the applied voltage, the electric field increases with smaller cavity diameters up to 60 kV cm-1.