P 9: Atmospheric Pressure Plasmas II

Time: Tuesday 14:00–16:00 Location: A 0.112

Invited Talk P 9.1 Tue 14:00 A 0.112
Next generation gases in gas discharge applications. — •Christian Franck — Swiss Federal Institute of Technology (ETH Zürich), Zürich, Switzerland

Insulation gases and dielectric discharges are used in a number of industrial and research applications. In many of these, fluorinated gases are used today that have a significant global warming potential and are now regulated by international policies or even phased-out. A strong international research and development for next generation gases and gas mixtures is thus ongoing. Besides the identification and synthesis of new molecules itself, also their behaviour in gaseous discharges needs to be investigated and understood to achieve a comparable performance in the final application.

In this presentation, the search, the requirements, and latest trends in using next generation gases in gas discharge applications are given in the context of two examples: high-voltage gas-insulated switchgear (GIS) and resistive plate chamber (RPC) detectors. Both are operated under very different condition, but the same properties need to be investigated. GIS is operated below the critical electric field strength and at high pressures and down to low ambient temperatures. RPCs are operated above the critical electric field strength, but at ambient pressure and temperature. Basic parameters of interest are ionization, attachment, detachment and ion conversion rates, synergistic behaviour with mixing gases, and basic thermodynamic properties.

P 9.2 Tue 14:30 A 0.112
Decomposition of Gaseous Dielectrics in Gas Insulated Switchgears (GIS) and Lines (GIL) — •Thomas Hammer, Martin Ise, Robert Fleck, Florian Kessler, Thomas Rettenmaier, and Wiebke Sarfert-Gast — Siemens AG, Corporate Technology, Erlangen

Currently substantial efforts are taken to develop climate friendly gaseous dielectrics having the potential for substituting SF_6 in gas insulated medium voltage and high voltage equipment. Recently 3M™ Novec™ 5110 Insulating Gas (heptafluoro-3-(trifluoromethyl)-2-butanone: C5-FK) and 3M™ Novec™ 4710 Insulating Gas (tetrafluoro-2-(trifluoromethyl)propane-nitrile: C4-FN) buffered with air like compounds such as N_2 and CO_2 were suggested for GIS application. Both partial discharges (PD) and switching arcs may irreversibly decompose these compounds. Thus laboratory experiments simulating the lifetime exposure of C5-FK and C4-FN mixtures with N_2 and CO_2 to PD and arcs were performed. Major decomposition products analyzed by means of GC/MS were CF_4, C_2F_6, C_3F_8, C_3F_6, and C_3HF_7. Less than 1% of the initial amounts of the dielectric fluids were decomposed. Specific energies of arc decomposition were around 250 kJ/mol for C4-FN/N_2, 193 kJ/mol for C4-FN/CO_2, and around 100 kJ/mol for C5-FK/N_2. Specific energies of PD decomposition were six times larger.

The authors gratefully acknowledge support of this work by the German Federal Ministry for Economic Affairs and Energy (Funding Code 03ET7551).

P 9.3 Tue 14:45 A 0.112
Experimental investigation of microdischarges in a needle-to-hemisphere dielectric barrier discharge in air at atmospheric pressure — •Sina Jahanbakhsh[1], Volker Brüser[1], and Ronny Brandenburg[1,2] — [1]INP Greifswald, Felix-Hausdorff-Str. 2, 17489 Greifswald — [2]Institut für Physik, Universität Rostock, Albert-Einstein-Str. 23-24, 18051 Rostock

Metal pin-to-dielectric coated electrode arrangement, known as barrier corona (BC), offers synergies between corona discharge (low breakdown voltage) and Dielectric barrier discharge (DBD) (charge limitation). In this study a sharp metal pin (0.2 mm tip radius) and a hemispherical (2 mm radius) alumina covered electrode are employed. A sinusoidal voltage at the frequency of 7.5 KHz is applied at 11.5 kVp-p. Using an ICCD camera and a Rogowski coil current probe, pictures and current pulses of individual MDs are recorded simultaneously. Time correlated single photon counting (TC-SPC) is used to record the spatio-temporal development of the MDs. The discharge inception and the MD properties in the two polarities of the sinusoidal voltage differ significantly. This contribution will focus on the results of the negative polarity (dielectric cathode). In this polarity two groups of MDs are observed in the same half-period. The first MD leaves a positive surface charge on the dielectric. This residual charge has considerable effects on the propagation and properties of the second MD, such as longer fall and rise time of the current pulse, and longer propagation on the surface of the dielectric.

P 9.4 Tue 15:00 A 0.112
Numerical and experimental analysis of breakdown initiation in single-filament dielectric barrier discharges — •Markus M. Becker, Hans Höft, Manfred Kettlitz, and Detlef Loffhagen — INP Greifswald, Felix-Hausdorff-Str. 2, 17489 Greifswald

During the last decade the analysis of single discharge filaments in dielectric barrier discharges (DBD) has proven to be a useful tool for the design and optimization of DBD. In the present contribution, a combined experimental and numerical modelling study of a single-filament DBD at atmospheric pressure (0.1 vol% O_2 in N_2) is presented with special focus on the streamer propagation phase. The DBD has a gap width of 1 mm and is driven by a 10 kV voltage pulse with a rise time of about 45 ns. The experimental diagnostics consists of an iCCD and a streak camera system (50 ps temporal and 2 μm spatial resolution) combined with fast electrical probes. The numerical investigations are based on a spatially two-dimensional axisymmetric fluid model using the local mean energy approximation for the determination of the electron transport coefficients as well as the excitation/ionization rate coefficients. Besides Poisson's equation, balance equations for electrons, the most relevant heavy particle species and the surface charges accumulated on the dielectric surfaces are included. First numerical results are in fair agreement with electrical measurements and the experimental determination of the streamer propagation velocity by means of optical measurements. It is shown that the streamer properties, e.g. propagation velocity and electric field strength, of the DBD differ markedly from those of streamers in unbounded domains.

P 9.5 Tue 15:15 A 0.112
Differences in heating mechanisms for helium and argon discharges in the COST-Jet — •Judith Golda[1,2] and Volker Schulz-von der Gathen[2] — [1]Institute of Experimental and Applied Physics, Kiel University, Germany — [2]Experimental Physics II, Ruhr-Universität Bochum, Germany

Non-thermal atmospheric pressure plasma jet devices - such as the well-investigated micro-scaled atmospheric pressure plasma jet (μ-APPJ) - efficiently generate reactive species at low gas temperature. Hence, they are commonly used for surface modification and considered for use in bio-medicine. However, the μ-APPJ relies on helium as feed gas and attempts to operate the source in argon without any geometric modifications proved to be difficult due to yet unknown reasons.

Here, we present investigations of the COST-Jet, the successor of the μ-APPJ, that allows operation in helium and argon. The two plasma discharges will be compared by means of electrical, optical and phase-resolved optical measurements.

Electrical and optical measurements are correlated to explain the differences between the behavior of argon and helium discharge. Our results show that the main discharge processes in the argon discharge are similar to the helium discharge, but slight differences due to the intrinsic properties of the gases notably change the discharge behavior.

Funded by the DFG within PlaCiD SCHU-2353/3-1.

P 9.6 Tue 15:30 A 0.112
Particles densities and temperatures in atmospheric pressure microwave plasma torch — •Ante Hecimovic, Federico Antonio D'Isa, Emile Carbone, and Ursel Fantz — Max Planck Institue für Plasmaphysik

Microwave plasmas at atmospheric pressure are commonly used in the field of species detection, for surface treatment and decomposition of harmful gases. Lately, the microwave plasmas at atmospheric pressure have been investigated for use in that field of energy storage, by storing the energy in the form of chemical energy achieving high energy and conversion efficiencies. A plasma torch is used to generate the plasma, which is a custom made resonator consisting of a coaxial and cylindrical resonator, allowing the plasma to be ignited directly at atmospheric pressure (2.45 GHz, 300W-3kW) inside a tube with inner diameter of 25 mm. In this contribution we report on investigation of the microwave plasma in air and air/Ar/N2 mixtures using optical emission spectroscopy, and mass spectrometry. After initial test in air/Ar/N2 mixtures, the transition from an air/Ar/N2 plasma to CO2 plasma is planned. The focus on using the spatially resolved OES investigation is the vibrational and rotational bands of N2, with the energy load of vibrational levels being comparable to the energy levels of CO2. Mass spectrometry measurements of the plasma effluent are performed where the influence of the gas flow, air/Ar gas mixture, and the power level is investigated. The mass spectrometry measurements are done using a custom made spectrometer which configuration should overcome gas-demixing effects.

P 9.7 Tue 15:45 A 0.112

Plasma window as a pressure Valve for FAIR — •Bernhard Bohlender, Andre Michel, Marius Dehmer, Marcus Iberler und Joachim Jacoby — Institut für Angewandte Physik, Goethe Universität Frankfurt

This contribution shows the progress in the development of a plasma window at the institute for applied physics at Goethe University Frankfurt. A plasma window* is a membrane free transition between two regions of different pressure, enabling beam transmission from a rough vacuum area (˜1mbar) to a higher pressure (up to 1bar) region on short length scales. In comparison to differential pumping stages a length reduction by a factor of up to 100 is achievable, while the absence of a solid membrane yields prolonged operation time. The sealing effect is based on the high temperature arc discharge sustained in a cooled copper channel between the pressure regimes. Due to a bulk temperature around 10,000K** the viscosity of the gas is dramatically increased, leading to a slower gas flow, enabling a higher pressure gradient. This contribution will present first results regarding the pressure gradient in dependence of the discharge current and the aperture. Until now, a pressure factor around 100 has been established for well over 50min. This contribution goes along with the one from Mr. A. Michel, he focuses on the spectroscopic analysis of the arc plasma. * Hershcovitch, A. J. Appl. Phys., AIP Publishing, 1995, 78, 5283 ** Krasik, Y. E.; Gleizer, S.; Gurovich, V.; Kronhaus, I.; Hershcovitch, A.; Nozar, P. & Taliani, C. J. Appl. Phys., AIP Publishing, 2007, 101, 053305