P 3: Plasma Technology I

Time: Monday 14:00–16:00 Location: SPA HS201

Invited Talk P 3.1 Mon 14:00 SPA HS201

Spots on cathodes of DC glow and arc discharges: self-organization theory and its applications — •Mikhail Benilov — Departamento de Fisica, CCEEE, Universidade da Madeira, Largo do Municipio, 9000 Funchal, Portugal

A new class of stationary solutions in the theory of glow discharges and plasma-cathode interaction in arc discharges has been found during the past 15 years. These solutions exist simultaneously with the solution given in textbooks, which describes a discharge mode with a uniform or smooth distribution of current over the cathode surface, and describe modes with various configurations of cathode spots: normal spots on glow cathodes, patterns of multiple spots recently observed on cathodes of glow microdischarges, spots on arc cathodes. In particular, these solutions show that cathode spots represent a manifestation of self-organization caused by basic mechanisms of near-cathode space-charge sheath; another illustration of the richness of the gas discharge science. As far as arc cathodes are concerned, the new solutions have proved relevant for industrial applications. This talk is dedicated to analysis of properties of these solutions and their physical meaning. The analysis is performed in the context of general trends of self-organization in bi-stable nonlinear dissipative systems, which allows one to treat glow discharges and arc-cathode interaction within a single framework and offers a possibility of systematic computation of the multiple solutions. Relevant computational aspects and possible directions of future work are discussed.

Invited Talk P 3.2 Mon 14:30 SPA HS201

Simulation technischer Plasmen — •Thomas Mussenbrock — Ruhr-Universität Bochum, Lehrstuhl für Theoretische Elektrotechnik, 44780 Bochum

Technische Plasmen sind vielfältig und interdisziplinär. Auf Grund ihrer einzigartigen Eigenschaften haben die industriellen und kommerziellen Anwendungen stark auf das tägliche Leben Einfluss genommen. Als Beispiel sei hier nur die Fabrikation mikroelektronischer Bauelemente und Schaltungen und die Herstellung nanostrukturierter Funktionsschichten genannt. Die physikalischen Parameter sowie die Zeit- und Längenskalen, die maßgeblich das Verhalten der technischen Plasmen bestimmen, spannen dabei einen sehr großen Bereich auf, der sich über viele Größenordnungen erstreckt. Als Konsequenz werden technische Plasmen als hierarchisch, mehrskalig oder auch hybrid bezeichnet. In diesem Zusammenhang werden die wichtigen und oftmals multiphysikalischen Phänomene auf der Basis der räumlichen und zeitlichen Skalen kategorisiert und im Rahmen von Multiskalenmodellen beschrieben. Eine der größten wissenschaftlichen Herausforderungen ist dabei neben der korrekten Beschreibung der jeweils interessierenden physikalischen Effekte die Effizienz der entsprechenden Simulationsprogrammme. In diesem Beitrag wird die Fragestellung adressiert, welche Modelle geeignet sind, um 1) die Diversität technischer Plasmen zu erfassen und 2) den Anforderungen der wissenschaftlichen Exaktheit und Simulationseffizienz zu genügen.

P 3.3 Mon 15:00 SPA HS201

Plasma Simulations of a Sputter Source at Atmospheric Pressure — •Horia-Eugen Porteanu[1], Ulrich Hornauer[1,2], and Roland Gesche[1,2] — [1]Ferdinand-Braun-Institut, Leibniz Institut für Höchstfrequenztechnik, Berlin, Deutschland — [2]Beaplas GmbH, Berlin, Deutschland

Sputtering at atmospheric pressure is a new application of microplasma sources. Microwave energy is used to ionize helium atoms and to maintain a certain electron and gas temperature. Additionally to the microwave field, a dc field is applied in order to accelerate He atoms toward an Au target. In spite of the high density of the gas at atmospheric pressure, He atoms can acquire sufficiently high kinetic energy from the dc field because of their small collision cross section. High speed He atoms are then able to remove Au atoms from a target and to sputter them on different cold surfaces at a distance of few mm. In this contribution we present simulations within the plasma module of the COMSOL Multiphysics® software. Gasflow, microwave and dc fields, and plasma fluid model are combined in order to describe the physical processes. Electron density and plasma potential are compared with experimental data obtained in different conditions with Langmuir I-V measurements. Gas velocity and electron density distributions are calculated for different geometric arrangements in order to improve the deposition rate.

P 3.4 Mon 15:15 SPA HS201

Speckle and Shadowgraphy Techniques for the Diagnostic of Switching Arcs — •Jan Carstensen, Emmanouil Panousis, Patrick Stoller, and Michael Schwinne — ABB Corporate Research, Baden-Dättwil, 5405, Switzerland

Gas circuit breakers (GCBs) are vital for the protection of electricity transmission networks. The interruption of high currents at high system voltages is done by the quenching of electric arcs. The diagnostics of these kind of arc discharges is challenging because of the short time and length scales involved but indispensable for a better understanding of the switching capability of GCBs. In this contribution shadowgraphy and speckle measurements of the high and low current phase of switching arcs are presented; they are sensitive to the first and second derivatives of the refractive index of the arcing medium, respectivley. The combination of a 20 ns pulse laser with a high resolution camera (16 MP) reveals the boundary layer between the arc and the superimposed gas flow in detail. For nearly axis-symmetric arcs, it is even possible to obtain quantitative information about the gas density and temperature in the arcing zone.

P 3.5 Mon 15:30 SPA HS201

Diagnostics of high-current vacuum arcs for simple electrode geometries — •Kristoffer Ole Menzel, Lukas Hofstetter, Romeo Bianchetti, and Thierry Delachaux — ABB Switzerland Ltd, Corporate Research Center, 5405 Baden-Dättwil, Switzerland

Vacuum interrupers (VI) represent the state-of-the-art technology for high-current interruption at medium AC-voltages of 1kV-36kV. While breaking the current a vacuum arc is ignited between the contacts of the VI. The arc is sustained by copper vapor from the hot electrodes. Due to the pinch effect the arc will appear in a constricted mode for currents above 10kA-15kA resulting in a high thermal load on the VI contacts. To successfully break these high currents, the electrodes are often designed such that an additional transverse magnetic field (TMF) is generated, which induces a motion of the arc. A detailed understanding of the underlying mechanisms of these constricted arcs is of great interest to increase the performance of the VIs. Therefore, in this contribution, measurements of the main characteristics of constricted arcs are presented. In order to allow for an easy diagnostical approach the experiments were conducted for simplified electrode geometries. Besides using high-speed camera videos and arc voltage measurements the high-density copper plasmas were investigated using optical emission spectroscopy. The resulting spectra allow to determine temperature and pressure evolutions when compared with results from FEM simulations. The appearence of Cu(III) lines hints at plasma temperatures above 3eV.

P 3.6 Mon 15:45 SPA HS201

Einfluss von Dichteänderung und Segregation auf die elektrische Isolationsfähigkeit von Gasgemischen — •Thomas Hammer — Siemens AG, CT RTC PET, Günther-Scharowsky-Str. 1, 91058 Erlangen

Gasgemische sind ein bewährtes Mittel für die elektrische Isolation in Anlagen der Energieverteilung und Übertragung im Mittel- und Hochspannungsbereich. Die dielektrische Festigkeit der Gasisolation hängt dabei maßgeblich von der Massendichte und der Zusammensetzung des Gasgemisches ab. Deshalb wurde der Einfluss physikalischer Prozesse, die zu Dichteänderung oder Segregation in Gasgemischen führen können und so die dielektrische Festigkeit beeinflussen, anhand einer Reihe von Modellen exemplarisch am Beispiel von SF6-N2-Mischungen untersucht. Die dielektrische Festigkeit wurde dabei anhand der durch numerische Simulation [1] ermittelten kritischen reduzierten elektrischen Feldstärke des Gasgemisches bewertet. Die untersuchten Phänomene umfassen Barodiffusion, Thermodiffusion, Kondensation, und Elektrophorese sowie die diesen Prozessen entgegenwirkende Konvektion. Modelle und Ergebnisse werden exemplarisch vorgestellt.

[1] T. Hammer: Model Calculation of Negative Wire-Cylinder Corona Discharge Properties in Humid Synthesis Gas. International Journal of Plasma Environmental Science & Technology, Vol. 6, No. 1, 20-24 (2012)