Topic number 10

On the axial and radial streamer dynamics in dielectric barrier discharges

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The temporal development of the discharge channel in axial and radial direction was investigated in pulsed dielectric barrier discharges (DBDs) in a 1 mm gap at atmospheric pressure using an iCCD and a streak camera system accompanied by a fast electrical characterisation. The analysis of the two-dimensional DBD structure together with the axial and radial propagation revealed an increasing DBD emission diameter with rising axial propagation velocity (cathode-directed streamer). The radial dynamics are slower compared to the axial propagation, i.e. the radial expansion velocity (~10^4 m/s) is approx. two orders of magnitude lower than the maximal axial propagation velocity (~10^6 m/s). In addition, the streamer diameter is smaller than the channel of the transient glow-like discharge, which is formed after the streamer has crossed the gap.

1. Introduction

Dielectric barrier discharges (DBDs) are a common tool to generate non-thermal plasmas at atmospheric pressure, which have a broad variety of applications [1]. Fundamental investigations on the DBD development, however, focus mainly on the axial dynamics, i.e. the propagation of the positive (cathode-directed) streamer and the subsequent transient glow phase. Therefore, this study is dedicated to both axial and radial breakdown dynamics. In addition, pulsed DBDs are proper test objects to study the radial dynamics of the streamer itself, because there are similar underlying breakdown mechanisms, and the streamer diameter is directly connected to the electric field strength [2].

2. Experimental set-up

A single-filament DBD arrangement (double-sided, half-sphere Al_2O_3 covered electrodes) with 1 mm gap was used [3]. The DBDs were driven by unipolar positive HV pulses with 10 kV amplitude and 10 kHz repetition rate at fixed pulse width of 10 µs in 0.1 vol% O_2 in N_2. Fast electrical, iCCD and streak camera measurements were performed to record the electrical characteristics as well as the spatio-temporal DBD development along and perpendicular to the discharge channel with sub-mm spatial and sub-ns temporal resolution.

3. Results

In figure 1, the two-dimensional emission structure and the corresponding spatio-temporal development in axial and radial direction are shown for a DBD at the falling slope of the HV pulse. The axial DBD characteristics feature the cathode-directed streamer propagation (v_{max} ~ 10^6 m/s) followed by the transient glow phase. The radial development is displayed at three positions in the gap; a different radial development is clearly visible, i.e. the slow expansion during the streamer propagation phase and the fast channel broadening after the streamer has crossed the gap (I,II). Directly in front of the cathode (III), no separation is visible, because the glow phase starts just when the streamer hit the cathode's surface.

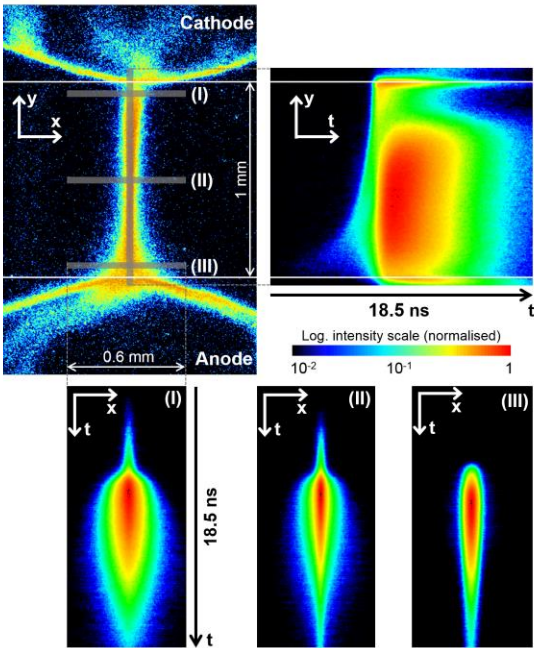

Figure 1: Two-dimensional emission structure (iCCD camera image, top left) and the corresponding spatio-temporal discharge development (streak camera images) along the axis and radially at positions (I) to (III) as indicated by grey bars in the iCCD shot.

4. References

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