Topic number 10

Investigation of streamer propagation and discharge development on dielectric surfaces

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Streamer propagation and discharge development on ceramic surfaces in nitrogen-oxygen gas mixtures at atmospheric pressure was investigated. It was possible to force the discharge to develop on the surface using pin electrodes attached directly to the dielectrics. The discharges were driven with unipolar square wave high voltages of 10 kV and 4.3 kHz. Ignition and discharge development on the surface were observed with ICCD and streak cameras. Images of single discharges showed a non-uniform and branched structure of discharge channels while accumulation over several events showed a propagation front rising from the electrode tip. The electrode polarity influenced the discharge dispersion and propagation velocity. Positive polarity of the metallic electrode (rising slope of the HV pulses) led to a cathode-directed streamer with higher propagation velocities than negative polarity (falling slope).

1. Introduction

Surface dielectric barrier discharges (SDBDs) create transient non-thermal plasmas [1-3] and are considerably used e.g. for gas flow control or surface modification [1]. Propagation of the discharge being in contact to a dielectric surface is not fully understood yet, but is of importance for the application of SDBDs. To get insight in this mechanism, a pin-to-pin arrangement was used to investigate single localized SDBDs on ceramics in a nitrogen-oxygen gas mixture.

2. Experimental set-up

The discharge arrangement consisted of a 1 mm thick alumina (AL_2O_3) plate with two metal pin electrodes on each side creating a 3 mm discharge gap (figure 1). One electrode was covered with silicone, thus plasma was generated only at one side. The electrode arrangement was inserted in a gas tight plexiglass cell and a gas flow of 100 sccm of 0.1 vol% oxygen in nitrogen was flushed through the cell. A unipolar square wave high voltage pulse of 10 kV at 4.3 kHz with a pulse width of 10 µs drove the uncovered electrode. The covered one was grounded. Fast current and voltage probes monitored ignition and discharge development on the surface. The uncovered pin electrode was observed optically with ICCD and streak cameras.

3. Results

During rising and falling slopes of the high voltage pulse, one discharge channel directly propagating along the gas-surface interface was formed. The discharges generated surface charges on the dielectrics, which led to a potential difference (i.e. polarity) to the pin electrode. The images of single discharges showed a non-uniform and branched structure of discharge channels while accumulation over several events showed the inception of the discharge at the electrode tip propagating off the tip.

Velocity measurements with the streak camera showed the slowing down of the discharge front within 1 mm from the tip and afterwards a moderate one on the dielectrics. The electrode polarity influenced the discharge dispersion and propagation velocity. Positive polarity of the uncovered electrode (rising slope of the HV pulses) led to a cathode-directed streamer with higher propagation velocities ($v_{max} \approx 5 \cdot 10^5$ m/s) than for negative polarity (falling slope). For negative polarity, the discharge was well localised at the electrode tip showing corona-like behaviour.

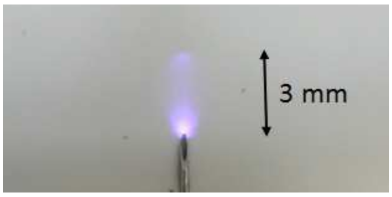

Figure 1: Photo of SDBDs on the ceramic surface.

4. References

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