Light emission from diffuse coplanar barrier discharge in neon induced by charge relaxation

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1. Introduction

Diffuse barrier discharges operated in rare gases as helium and neon burn typically during a AC voltage period in two short time-windows, when the voltage reaches a breakdown level and the electric field is not yet diminished by charge deposited on the dielectric. This is manifested by regularly appearing narrow current peaks as well as by similar time development of light emission from atomic species. Outside those time-windows, light emission involving long-lived excited species is detected. For example, emission from OH can be detected within the whole period [1], when the molecules in excited OH(A) state are not quenched by water vapour [2]. Other possible radiation sources are e.g. discharge re-ignition outside charge-deposited regions, dissociative radiative recombination [3] or thermoluminescence from dielectric [4]. In this work, light emission from discharge in dark phases of discharge development is studied by method of single photon counting.

2. Experimental setup

The barrier discharge was generated in a coplanar electrode configuration with thin silver electrodes deposited on one side of a high permittivity dielectric (perovskit, $\varepsilon_r \approx 100$). The distance between the electrodes was 4-5 mm. Whilst this side was immersed in oil, the other, covered with a plastic chamber to control the discharge atmosphere, served for discharge generation. The discharge was sustained in neon, flowing through the reactor at a gas flow of 400 sccm. The discharge was driven by a high AC voltage of frequency 11 kHz. The chamber was equipped with a quartz window for discharge diagnostics. Temporally resolved optical emission spectroscopy was performed by a method of single photon counting. The light coming out of the discharge was collected by optical fibre, monochromatized with Jobin Yvon HR-640 (grating 1200 gr. mm^{-1}) and counted by a photon counter (Becker & Hickl SPC-150), with PMT (PMC-100-4) working in a photon counting mode. The photons were counted with a time resolution of 0.2 μs.

3. Results

A spectrally unresolved light emission from coplanar barrier discharge discharge in neon during one voltage half-period is displayed in Fig. 1. The emission pattern comprises a Townsend phase with a maximum intensity at the anode, a cathode-directed ionization wave slowing down above the electrode and secondary waves, which propagate to the cathode until they reach a dielectric already deposited with a charge. A similar, but inverted pattern is observed in the other half-period. A patch of very weak light is observed only in one half-period 10 μs prior to the Townsend phase above the anode (previous cathode). Whilst this light was observed on high-permittivity dielectric, it has not been seen with alumina barrier. Its existence can be attributed to charge relaxation processes developing shortly after the field reversal.

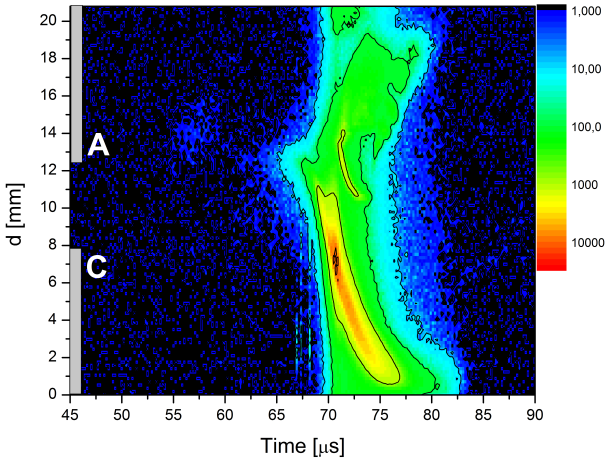

Fig. 1: *Time- and space-resolved light emission from coplanar barrier discharge in neon.*

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