Discovery of anode-directed recombination emission wave in coplanar dielectric barrier discharge

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1. Introduction

The process of dielectric barrier discharge (DBD) formation and its spatial stability is governed by the residual surface charge built up during the discharge evolution/extinction – so called 'memory effect' [1].

So far two distinct discharge phases of DBD formation were described in literature [2]: Ph I - The main phase of discharge evolution comprising of the propagation of cathode directed ionizing wave (CDIW) accompanied with anode directed ionizing wave (ADIW); Ph II - the Townsend pre-phase at the anode edge that precedes the formation of the CDIW.

In presented work the observation of third DBD phase (Ph III) preceding the Townsend pre-phase is reported – attributed to radiative surface charge recombination wave. The observation was made by phase-locked fast 2D optical emission imaging of coplanar DBD in Helium stabilized in diffuse operation regime. Our results are in agreement with the measurement of the residual surface charge and its role on the spatial stabilization of filamentary volume DBD studied [1] using the Pockels effect experiment.

2. Experimental & Results

In presented work the discharge setup of homogeneous coplanar discharge (HCD) was used, see [3]. The HCD jitter was about 100-200 ns FHWM, that is 1-2 orders less than characteristic discharge dynamics times. This enables the adoption of highly accumulated hi-res 2D optical imaging of the phase evolution of the light emission from the HCD using ICCD camera PI-MAX3-1024i-SR-46-CM (Princeton Instruments) equipped with true-macro objective telelens (SIGMA 105/2.8 MACRO).

The radiative surface charge recombination wave is given in Fig. 1. The recombination wave occurs at the discharge phase close to the electrode polarity reversal. The wave is directed to the instantaneous anode, i.e. it follows the flow of electrons.

The time and intensity scales of observed discharge phases are as follows: Ph I - CDIW crosses the electrode gap at approx. 1 µs with certain emission intensity; Ph II - the localized anode edge emission (space-charge build up) lasts for approx. 10 µs with peak emission intensity 1-2×10^3 times smaller than Ph I; Ph III - the recombination wave lasts for approx. 20 µs with emission intensity 5×10^4 times smaller than Ph I.

Preliminary results of time-resolved optical emission spectroscopy indicates, that dominant source of emission in Ph III are impurities as OH, and/or N_2^+, but further research has to be carried to confirm these results.

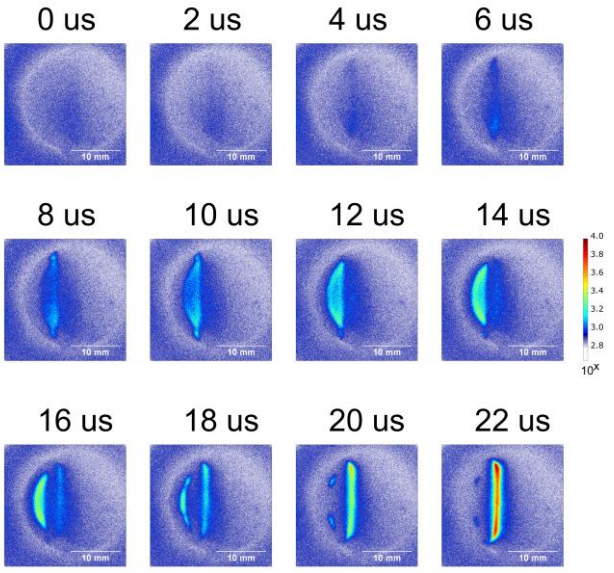

Fig. 1: *The evolution of emission patterns in Helium attributed to the process of radiative recombination, integration time 1 µs. Townsend phase starts at 16 µs.*

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References

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