Charge transfer and ultra-fast imaging of the surface barrier discharge at argon/water interface

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We report on time resolved study of the charge transfer and 2D imaging of the surface barrier discharge emerging from liquid electrode in atmospheric pressure argon. Using a precise analysis of the constructed Q-V plots (Lissajous figures) the different modes of the barrier discharge are identified. Electrical signatures found in Q-V plots are linked to the optical appearances recorded by ICCD camera and the mechanisms are discussed. Special nanosecond gated camera enabling multiple expositions in a row for a single discharge event reveal the spatiotemporal development of the discharge luminosity. A light emission of an excited gas prior to the breakdown is detected as well as the subsequent contraction to the streamer-driven filament. The streamer-to-leader transition is evidenced, too.

1. Introduction

Recently, the water containing plasmas attach an intensive attention [1], mostly due to the emerging applications in plasma medicine or polymer surface treatment [2]. A special case of the discharge generation in contact with water is the surface barrier discharge, where one electrode is created by water. Water interface wetting the dielectric surface in gas atmosphere creates so called triple junction or triple line, where the Laplacian electric field can reach highly elevated values if a voltage source is used. As a consequence, transient plasma is generated at this interface. This phenomenon is considered a complication in electro-wetting devices or it can be favourable for polymer surface treatment, as shown in [2] and patented.

2. Experimental results and discussion

The discharge is driven by 100 kHz sine applied voltage and thus the pre-ionization plays an important role here. The applied voltage is connected to the embedded electrode in fused silica cuvette while the deionized water outside the cuvette is grounded. Precise electrical measurements enable the construction of Q-V plots – a charge-voltage phase space attractors describing the dynamical system [3]. Two different modes of the barrier discharge operation are identified. A low-power one, where the discharge is generated just at the triple-line, see in Fig.1, and a high-power one, where the surface of the cuvette is covered by streamer and leader channels. Special nanosecond gated camera enabling multiple short expositions in a row for a single discharge event reveal the spatiotemporal development of the discharge luminosity. The charge accumulation during the pre-breakdown phase is visualised on timescale of units of microseconds. Also a subsequent contraction to the streamer-driven filament is observed. The streamer-to-leader transition is evidenced, spreading the surface charge over a surface area of units of centimetres.

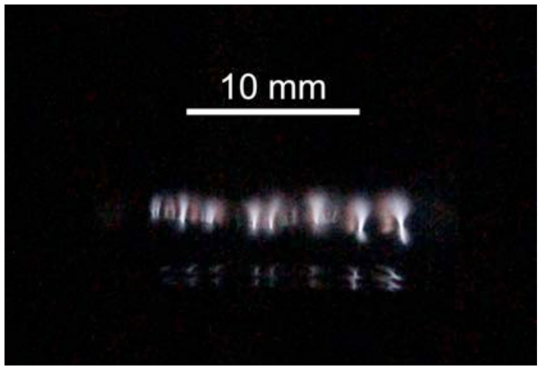

Fig.1: Discharge emerging in argon atmosphere at triple-junction consisting of argon/water/fused silica interface. The triple junction line is created by the elevated water interface wetting the fused silica cuvette. The micro-discharges are reflected at the water surface below.

3. Acknowledgements

This research was funded by the Czech Science Foundation project 16-09721Y and by the project LO1411 (NPU I) of Ministry of Education Youth and Sports of Czech Republic.

4. References

[1] P. Bruggeman et al. Plasma Sources Sci. Technol. **25** (2016) 053002
[2] D. Pavlinák et al. Appl. Phys. Lett. **105** (2014) 154102
[3] P. Synek, Yu. Akishev et al., J. Appl. Phys. to be submitted