Morphology of nanosecond discharge developing at the air-water interface

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Abstract: In this contribution, we report the characteristics of nanosecond discharge propagating along the air-water interface in a unique dielectric-barrier discharge-like configuration with electrodes fully submerged in water. The discharge was studied by ultrafast imaging, spatiotemporally resolved emission spectra and electrical characteristics.

1. Introduction

The ongoing intensive research in the field of electrical discharges in or with water is fuelled by the many unsolved problems concerning the mechanism of such complex discharges which can produced using various electrode arrangements (pin-to-pin, pin-to-plane, etc.) and power supplies (DC, AC, pulse, etc.). A nanosecond DBD-like discharge in a coplanar electrode configuration propagating along the air-water interface is a diagnostically attractive configuration as the physics of such discharges is complicated (due to the presence of irregular liquid–gas interfaces) and the detailed mechanisms of the discharge are often quite unclear and are still the subject of ongoing research.

In several studies [1-3], we have investigated the DBD-like discharge inside a flow-through reactor with geometries analogous to a surface coplanar DBD electrode system in which multiple filamentary discharges are generated by a bipolar pulse with nanosecond risetimes and expand along the surface of a thin water layer covering the electrodes.

2. Methods

Both temporally and spatially resolved UV-vis-NIR ICCD spectroscopy was combined with electrical characteristics and ICDD imaging to determine the basic properties of the DBD microfilaments, including vibrational distributions and rotational temperatures of nitrogen excited states, the presence of various radicals, time-resolved analysis of discharge phases and their morphologies.

3. Results and Discussion

Time-resolved images (see Fig 1) revealed a clear signature of diffuse streamer channels originating from the area directly above plastic blades where the electric field is the highest and propagating on the water surface perpendicularly away from the blades towards the electrodes. Some of the ionizing fronts later transform into brighter and larger discharge filaments (sparks). This transition is also marked by the dominance of molecular emission (mainly first and second positive system of nitrogen) in the initial “streamer phase” later overshadowed by the intensive atomic line emission in the “spark phase” (see Fig 2). The morphology and intensity of discharge (such as filament diameter or electron density) are linked to the water conductivity which rises throughout the operation by inevitable dissolution of plasma products in water.

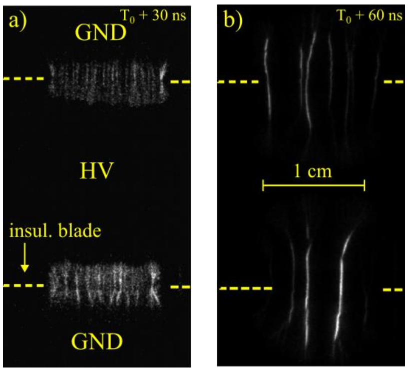

Fig. 1. Two distinct discharge morphologies: streamer phase (a) and spark phase (b).

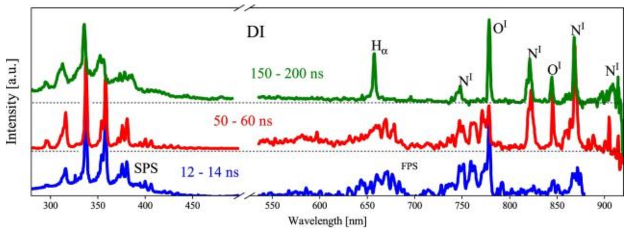

Fig. 2. Time evolution of optical emission in streamer-spark discharge. The molecular emission in the first ns is overshadowed by atomic lines in later discharge stages [3].

The polarity also played a role in discharge properties as the initial positively driven discharge tended to spread more slowly and also last longer, while the subsequent negatively driven discharge developed and was extinguished more rapidly.

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References

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