Micro-second pulse and RF coupling in an APPJ

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Abstract: We report on the simulation and time-resolved electric and optical measurements of an Atmospheric Pressure Plasma Jet that couples a microsecond and a 27 MHz generator to two separate ring electrodes. Our findings demonstrate that both Ω and γ phases are present on the substrate in open air. Furthermore, we show that ion-surface interactions can be controlled by the micropulse voltage, while the RF power controls the discharge volume.

1. Introduction

The challenge of obtaining a diffused discharge in open air can be faced with several approaches from RF jets to nanopulses. We already showed that a possibility is offered by coupling two frequencies respectively in the kHz (LF) and MHz (RF) ranges [1]. This dual frequency configuration allows to expose a dielectric substrate to a RF plasma in the Ω regime and to ignite the γ phase only in selected fractions of the LF and RF period [2]. The advantage of the configuration is linked to the control of the ion-surface interaction and to the low sensitivity to substrate distance. However, the discharge is not stable.

Here, substituting the LF with a micropulse generator we show the stabilization of the discharge which gives further insight in the plasma-substrate interaction control and discharge characteristics.

2. Methods

The jet is a 6mm alumina tube with two outer ring electrodes. The upstream electrode is connected to an OLISCIE micropulse power supply, while the other to a 27.12 MHz RF generator. Ar gas is flown inside the tube and a silica slide substrate is placed at 5mm from the outlet. The optical emission is recorded by PMT together with the electrical signals. The plasma is imaged by an ICCD and characterized by optical emission spectroscopy. The discussion is supported by comparing the results with a 2D fluid model in the time domain.

3. Results and Discussion

The time resolved measurement showed that on the plasma is always on in between two consecutive micropulses (Fig. 1). A first strong ionization appears on the substrate at the beginning of the positive pulse sustained by the γ regime. After the pulse a return strike can be observed dominated by the Ω regime. The process replicates with the following oscillations but with lower intensity and the plasma in between is maintained by the Ω regime. A 2D model developed in COMSOL fully agree with this presentation highlighting the γ phase ignition as a function of the sheath voltage in front of the substrate.

The optical emission spectroscopy shows that the plasma density does not change as a function of the RF power, however it increases the number of filaments and slowly the gas temperature.

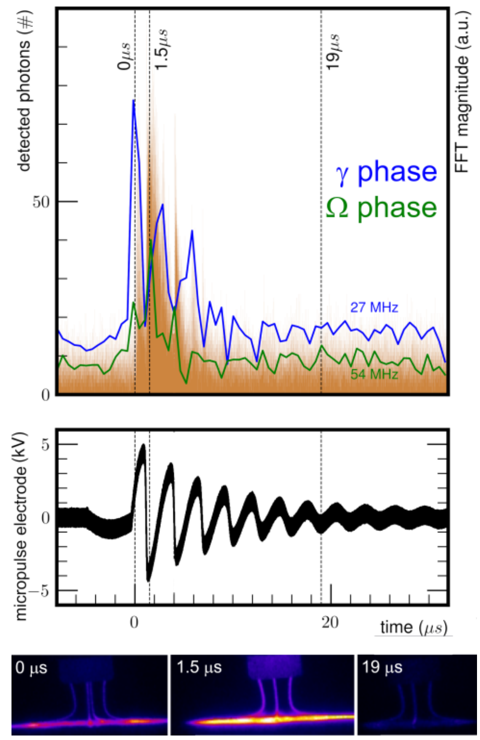

Fig. 1. (*top*) Number of photons detected with overlapped the FFT magnitude at RF (γ phase) and twice the RF (Ω phase) frequencies. (*bottom*) The voltage of the micropulse electrode and the ICCD images at three selected time-frames.

4. Conclusion

The substation of the LF with the microsecond power supply allows to stabilize the discharge, enabling its use for a dose control.

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References

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