Comparison of two electric field measurement methods for a kHz microsecond atmospheric pressure plasma jet

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Electric field associated with a kHz microsecond atmospheric pressure plasma jet has been measured using two different methods. The first one consists in an electro-optic probe allowing to measure the electric field outside the capillary in which propagates the plasma. The second one relies on Stark polarization spectroscopy on the 492.19nm line of helium. If the first one offers a nice time resolution, the second method has a better spatial accuracy but can be used only where light is emitted by the plasma. Thus these two methods complement one another and can even be compared depending on the conditions. If plasma is powered by a positive polarity voltage pulse both techniques are in good agreement. Nevertheless when negative polarity is used some discrepancies are observed.

1. Introduction

Atmospheric plasma jets are studied because of the wide range of applications they offers, especially in biomedical fields. They consist of an ionization wave propagating into a rare gas followed by a plasma channel [1]. If the role in biology of reactive oxygen and nitrogen species has been highlighted, other components of the plasma deserves more attention as transient electric fields (EF). This work focuses on the measure of these EF with two different methods based on Pockels effect [2] or Stark spectroscopy [3] for a Plasma Gun (PG) discharge. Depending on the situation both techniques can either be complementary or compared.

2. Experimental Setup

Plasma Gun consists in a vertically downward oriented capillary with an inner high-voltage electrode and an outer grounded one. Plasma is powered with µs-duration voltage pulses. First method to measure the EF uses an electro-optic probe (Kapteos), based on Pockels effect and made of a birefringent crystal in an alumina tube. The second technique, using Stark polarization spectroscopy of helium I 492.19nm line, has the advantage to be non-perturbative. A 1:1 image of the PG is created on the 70µm-wide spectrometer slit. The spectrometer contains two 1200 grooves.mm^{-1} gratings. In presence of strong EF, *i.e.* in this study only the one associated with the ionization wave, forbidden transitions become allowed, making appear a forbidden line in the spectrum. Moreover this line is shifted according to EF strength. Thus measuring the position of the forbidden line and the allowed one can allow to evaluate the EF strength.

3. Results

EFs in several situations have been investigated. In each one, EF measured by the spectroscopy in the plasma was compared with the one obtained thanks to the probe placed next to the capillary or the plume. If the plasma is powered with positive polarity voltage, both methods give results with a good agreement. For example, the transient EF was measured in the plume with a metallic grounded target 1cm away from the end of the capillary. The value given by the spectroscopy in the plasma was compared with the one obtained with the probe, placed 5mm away from the axis of the tube. Both methods gave a value around 10kV.cm^{-1}

Nevertheless, EF with a negative polarity voltage is not as easy to evaluate. Spectroscopy shows that the EF is weaker than with positive polarity voltage: 5kV.cm^{-1} instead of 9 for positive polarity in the same other conditions at the end of the capillary. Yet, electro-optic sensor finds comparable values of EF, around 10kV.cm^{-1} for both polarities near the end of the capillary.

4. Acknowledgments

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5. References

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