Measurement of Plasma Power Consumption in Dielectric Barrier Discharges

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1. Introduction

The measurement of plasma power consumption is essential for all dielectric barrier discharge (DBD) applications and to assess the results of plasma treatment as a function of the specific input energy (SIE) consumed.

A common method for measuring the power consumption in a DBD is by calculating the area of a Lissajous figure obtained from the applied voltage and integrated charge [1]. However, by using a digital oscilloscope with a fast acquisition sampling rate, it is now easy to set alternative methods for measuring the power consumption.

Even so, the power consumption measured through these methods only gives the total power used on the discharge system. What is really meaningful is the power (and SIE) consumed in the plasma. This problem has recently been analyzed for homogeneous DBD [2] and through an electric model [3].

In this work we compare different methods for power measurement, computing the uncertainty on the results of each of them. We also discuss a model to compute the plasma power consumption for filamentary discharges, thus extending the work of Liu and Neiger [2].

2. Experimental set-up

The results were obtained with a cylindrical geometry chamber built from a 10 mm I.D. glass tube and a 5 mm Ø electrode, supported by MACOR fittings. The power supply used allowed a maximum rms voltage of 10 kV with a frequency range of 4-6 kHz. The signals were obtained with a Tektronix TDF 3052B osciloscope and a Pearson Rogowski coil on a $CH_4/CO_2/He$ mixture. Figure 1 shows typical waveforms for the applied voltage, charge current and current.

3. Power measurement methods

The following four (4) methods were used to measure the discharge power:

(a) The conventional Lissajous figure method using the applied voltage, integrating the discharge current through a capacitor and computing the area of the figure;

(b) a moving average method which combines the applied voltage with the integrated current;

(c) using the Rogowski coil to record directly the discharge current and combine this with the applied voltage, and

(d) through the product of the applied voltage and current given directly by the oscilloscope.

The statistic dispersion on the results allow to infer the uncertainty for each method and verify that although the results are of the same order of magnitude, they are significantly different. The best results were obtained with method (b).

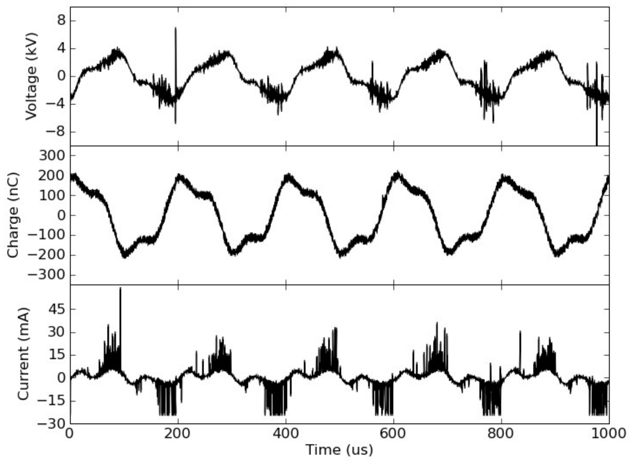

Fig 1: Applied voltage, integrated current (charge) and current as measured by the osciloscope.

4. Model for plasma power consumption

The model is based on two assumptions:

(a) The breakdown voltage is computed from the ignition criteria [4] relating the breakdown voltage to the Townsend ionisation coefficient of the gas and the secondary emission coefficient of the cathode, and

(b) the voltage across the discharge gap was estimated from a simplified statistic model for the micro-discharges.

Following a development similar to [2] the plasma power consumption can be related to the measured total power consumed in the discharge system.

References

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