Topic number: no. or Wno.

CURRENT - VOLTAGE CHARACTERISTICS OF μ-APPJ OBTAINED BY USING DERIVATIVE PROBES

S. Lazović [1,*], D. Maletić [1], N. Puač[1], G. Malović[1],
A. Đorđević[2] and Z. Lj. Petrović[1]

[1] Institute of Physics, Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

[2] Faculty of Electrical Engineering, Bul. Kralja Aleksandra 73, 11000 Belgrade, Serbia

[*] **lazovic@ipb.ac.rs**

In this paper we present results of derivative probe measurements made on micro atmospheric pressure plasma jet previously developed by Schultz van der Gathen and coworkers [1]. This technically relatively simple capacitively coupled device is typically operated at an excitation frequency of 13.56 MHz. μ-APPJ plasma source is interesting both for applications as well as for the study of fundamental processes. Capability of applying μ-APPJ for different treatments is due to mild non thermal plasma generated at atmospheric pressure in a mixture of a noble gas and a small amount of molecular gas (in our case 99% of He and 1% of O2).

Determining adequate set of parameters in order to properly describe plasma is a very important task when it comes to reproducibility of desired plasma properties. Unpredictable changes in plasma properties can be caused by non-linearity of plasma impedance. For example, apparently neglectable change in matching network auto-set reflected power minima can cause significant variations in plasma properties due to this non-linearity [2]. This is manifested by drive frequency harmonics generation at external circuitry leads and by different amounts of power that are delivered to plasma. Therefore, power measured directly at power supply is not a representative parameter. On the other hand, derivative probes can provide us with the information about mean power delivered to the plasma and with harmonic composition of our signals. Until recently derivative probes have been applied for discharges of higher powers (i.e. currents and voltages) but we were able to develop probes with sufficient sensitivity to make their application in micro discharges possible.

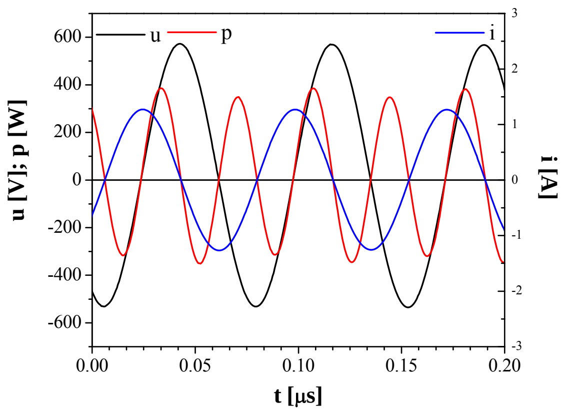

Fig. 1. Instantaneous current, voltage and power values for input power of 70 W and gas mixture flow rate of 1 slm.

We have used derivative probes [3, 4] to analyze volt-ampere characteristics of μ-APPJ for three different gas flow rates (1 slm, 2 slm and 3 slm). Current, voltage and power waveforms after the numerical procedure has been performed are shown in Figure 1. Numerical procedure consists of Fast Fourier Transform of current and voltage probe signals, followed by multiplication with adequate calibration curves in the frequency domain and finally of an Inverse Fast Fourier Transform. Power waveform is obtained by multiplying final current and voltage waveforms and mean power is calculated as an integral of this waveform (45 periods of 13.56 MHz).

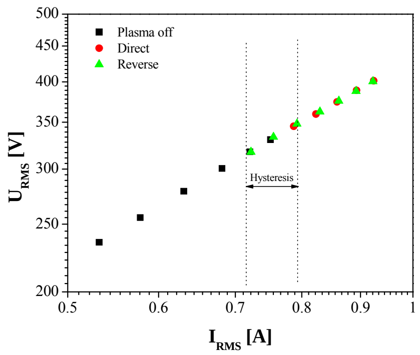

Fig. 2. U_{RMS}-I_{RMS} characteristics of the μ-APPJ when increasing (Direct) and decreasing (Reverse) power given by RF power supply. Gas flow was 2 slm.

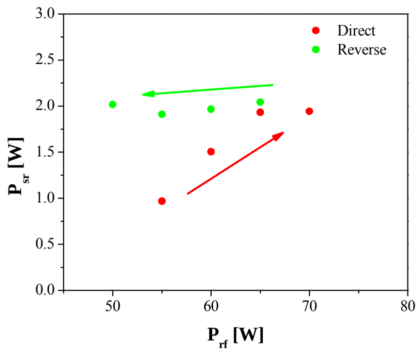

Fig. 3. Mean power values when increasing and decreasing input power. Gas mixture (1% O2 – 99% He) flow was 2 slm.

In Figure 2. U_{RMS}-I_{RMS} characteristics of the discharge are shown. We can see that the discharge operates in alpha mode. When decreasing the power we have observed that plasma remains ignited even for the input powers lower than the powers needed for its initial ignition. In case when hysteresis occurs we can see that more power is transmitted to the plasma (see Figure 3.)

Reference

[1] V. Schulz-von der Gathen, V. Buck, T. Gans, N. Knake, K. Niemi, St. Reuter, L. Schaper, and J.Winter, 2007 *Contributions to Plasma Physics*, **47** 7 510

[2] P.A. Miller, H. Anderson, M.P. Splichal, 1992 *J. App. Phys.* **71** 1171

[3] N. Puač, Z.Lj. Petrović, S. Živković, Z. Giba, D. Grubišić and A.R. Đorđević, Plasma Processes and Polymers, Eds. R. d'Agostino, P. Favia, C. Oehr and M.R. Wertheimer, (Whiley: (2005) p 193-203

[4] N. Puač, Z. Lj. Petrović, G. Malović, A. Đordević, S. Živković, Z. Giba and D. Grubišić, 2006 *J. Phys. D: Applied Physics* **39** 3514