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# APPLIED VOLTAGE WAVEFORM SUITABLE TO CONTROL PARAMETERS OF DIELECTRIC BARRIER DISCHARGE PLASMA JET

M. E. PINCHUK[1], A. M. ASTAFIEV[1], R. A. AZNABAEV[1,2] and O. M. STEPANOVA[1]

[1] *Institute for Electrophysics and Electrical Power of the Russian Academy of Sciences, Dvortsovaya naberezhnaya 18, St. Petersburg 191186, Russia*

[2] *Saint Petersburg State University, Universitetskaya naberezhnaya, 7-9, St. Petersburg, 199034*
*E-mail pinchme@mail.ru*

**Abstract.** The paper demonstrates that it is possible to control a guided streamer traveling along a helium dielectric-barrier discharge plasma jet by means of varying the output transformer capacitance. It has realized with the additional output capacitance for the stepwise propagation of the streamer in the numeric simulation.

## 1. INTRODUCTION

Non-equilibrium atmospheric plasmas are currently used in a wide range of new technologies. Novel approaches to apply such plasmas and unexpected ways to develop them are constantly appearing (Adamovich et al. 2017; Nikiforov et al. 2019). Here, the challenge to use atmospheric plasmas, including plasma jets based on dielectric-barrier discharge (DBD) in biomedicine is one of the powerful driving tasks (Metelmann et al. 2018; Bekeschus et al. 2019; Brandenburg et al. 2017).

The type of the applied voltage determines the characteristics of plasma jets significantly: their parameters are different for ns- and μs- pulsed voltage and sinusoidal voltage (Walsh et al. 2006; Xiong et al. 2010; Zhang et al. 2014, Florez et al. 2019). The development of the power supplies for such a gas-discharge system can be considered as a separate research topic (Bonnin et al. 2013; Dragonas et al. 2015, Moshkunov et al. 2018). And to fit the applied voltage mode to the load, a set of issues should be figured out (Bonnin et al. 2013; Dragonas et al. 2015, D'iez et al. 2007).

Previously, we recorded a stepwise mode of the guided streamer propagation (Pinchuk et al. 2019, 2020; Stepanova et al. 2020) along a helium plasma jet fed by voltage of a special waveform consisting of a superposition of bipolar rectangular pulses and oscillating sinusoidal signals shifted relatively ground potential.

This paper considers the possibility of controlling guided streamer stepwise propagation by varying the output capacitance of the power supply transformer (Martin-Ramos et al. 2008; Rueda et al. 2019) owing to the addition of a filtering capacitance.

## 2. APPLIED VOLTAGE WAVEFORM AND GUIDED STREAMER PROPAGATION

The studied discharge system was the same as in (Pinchuk et al. 2019, 2020; Stepanova et al. 2020). It was designed to generate the atmospheric pressure plasma jet (APPJ) based on a DBD in a helium flow in an axisymmetric electrode system “inner electrode (central rod) – gas gap – dielectric barrier (quartz tub) – outer electrode (outer ring)”. A diameter of inner electrode is 1.5 mm; the inner diameter and thickness of the quartz tube are 4.6 and 1 mm, correspondingly. A ring grounded electrode 5 mm wide is located 5 mm from the edge of the discharge tube. The experimental setup is described in more detail in Stepanova et al. 2017.

To simulate the propagation of the plasma jet, we used an equivalent circuit of APPJ made up of RC-circuits cascades (see Figure 1) (Slutsker et al. 2017). The developed numerical model (Pinchuk et al. 2018a, 2018b) was implemented in XCOS/Scilab. It adequately describes the experimental data on slowing down a guided streamer at adding air admixture into the helium plasma jet and the stepwise propagation of the streamer (Pinchuk et al. 2015, 2019).

In XCOS, a cascade of ten RC-circuits simulating a space with a length of 1 cm is put in one block. Then, the series of blocks are equivalent to the space of a definite extension. A section of the equivalent circuit (see Figure 1) with Rg, Cg and Cd elements substitutes DBD inside the discharge cell, whereas the circuit section of RN-CN is of APPJ propagation space.

The calculations were done with taking account the following assumptions: (i) the distance of 5 cm along the jet's axis was divided into 50 elements; (ii) each element of the jet length was substituted by the corresponding capacity and resistance (Pinchuk et al. 2019, 2018a).

The schematics of the power supply is presented in Figure 2. The power supply is built according to the half-bridge circuit with a step-up transformer. Adding the capacity $C_0$ decreases the frequency of the self-oscillations of an output circuit with the plasma jet. The experimentally measured applied voltage for the helium APPJ with the gas rate of 5 l/min is shown in Figure 3. At $C_0$ = 20 pF the changing of the frequency is about 35 kHz.

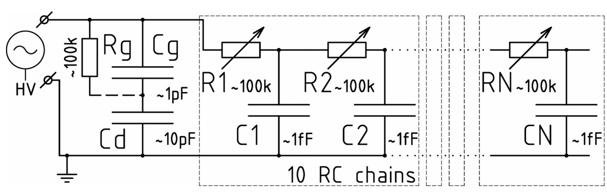


Figure 1: Equivalent circuit of APPJ.

The dynamics of the jet's propagation has been considered. To simplify the analysis, the oscillating part of the applied voltage was simulated without damping. We obtained (see Figure 4) that the additional capacity makes the streamer stop a little further with a little longer period of slowing down at the same jet's length.

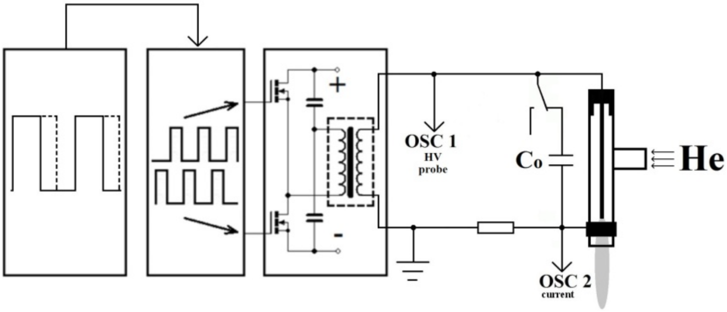


Figure 2: Power supply for APPJ generation.

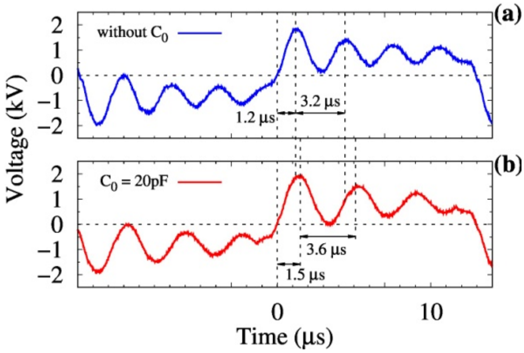


Figure 3: Applied voltage signal for helium APPJ without capacitance $C_0$ **(a)** and with additional capacitance $C_0$ **(b)**.

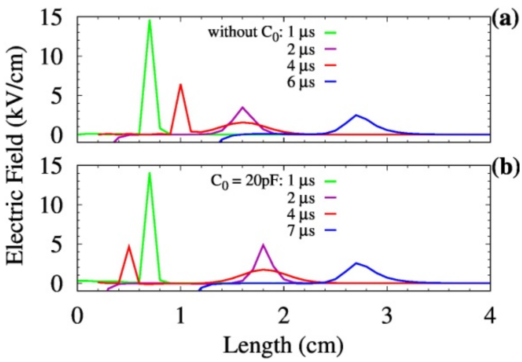


Figure 4: Calculated profiles of the electric field along the APPJ without capacitance $C_0$ **(a)** and with additional capacitance $C_0$ **(b)**.

## 3. CONCLUSION

The streamer propagation variation at tailoring applied voltage was calculated by means of numerical modeling. The way of flexible plasma jet control has been demonstrated. It is realized by changing the capacitance of the power supply transformer.

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