Investigation on spatial asymmetry and fluctuations in electric field inside a helium atmospheric pressure plasma jet

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In modern times, atmospheric pressure micro-plasma is used as an innovative diagnostic tool in biomedical applications including bacterial deletion, sterilization, nail care, and treatment of wounds and cancer cells [1]. In biomedical applications, plasma dosages and optimization of plasma jets are two important key factors. The dosages include the amount of reactive oxygen and nitrogen species (RONS), and optimization deals with the positive selectivity of desirable damaged cells [2]. The electric field plays an important role in these applications. The electron energy distribution function (EEDF) can be changed with a change in electric field which further can change the rate coefficients of chemical reactions hence the concentration and compositions of RONS. Therefore, the concentration of RONS and the strength of the electric field are crucial factors from the application point of view. Minor fluctuation and non-uniformity of the electric field can harm the wound, treated cells or tissues, and the intended surface. Hence, it is important to study the spatial asymmetry, non-uniformity, and fluctuation in electric fields in plasma jets.

The plasma is ignited by applying a sine wave of maximum amplitude of 15 kV pp and frequency 10 kHz, inside a tapered glass capillary tube having an outlet inner diameter of 0.8 mm [3]. A ring-to-ring electrode configuration (~10 mm gap between the electrodes) has been used in this experiment. Helium is used as a working gas and the plasma flows out from the capillary tube with the pressure of the gas. The length and diameter of the plasma jet are ~10 mm and diameter ~ 0.8 mm respectively, as shown in Fig. 1. A two-pin probe is used to collect the floating potential at two nearby local points inside the jet, and a known distance between two pins (~0.267 mm) makes the axial and poloidal electric field

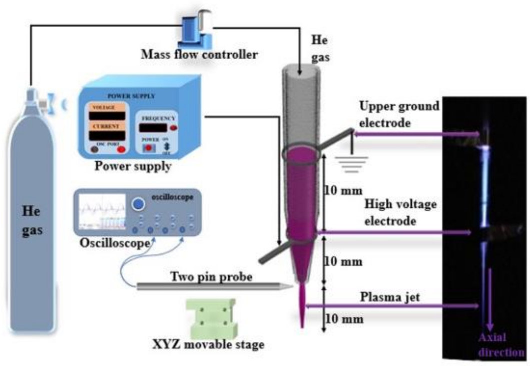

Fig.1. Schematic diagram of experimental setup of atmospheric pressure micro plasma jet with a two-pin probe system, along with its digital picture (applied voltage:10 kV, frequency:10 kHz, Gas flowrate:2 l/min)

measurement possible. The two-pin probe can be moved along the axial direction (orifice as a reference point) and rotated along the poloidal direction to find out the axial (E_z) and poloidal (E_φ) electric field asymmetry. The frequency characteristics of the electric field have been done by as fast Fourier transform (FFT).

In the recent work, a study on spatial variation of E_z (along the axial direction) and E_φ component (along the poloidal direction) of the electric field has been performed to confirm the non-uniformity in the electric field in the plasma effluent. The frequency characterization has been done to find out the fluctuation in the electric field at the different locations inside the jet. It is found that at a fixed applied voltage (11 kV), the electric field and its fluctuation enhance with an increase in the distance downward from the orifice of capillary for lower flow rates (1 and 3 l/min), and increase up to a distance (z)~5 mm, thereafter start to decrease for higher flowrate 5 l/min (turbulent regime). Fig. 2 shows the poloidal asymmetry present in E_φ component of the electric field at flowrate of 5 l/min. The electric field is weaker and more uniform

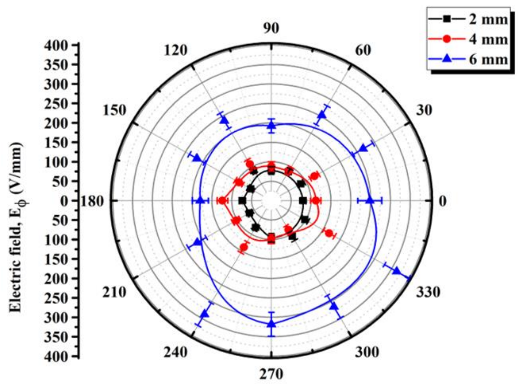

Fig.2. Variation of E_φ component of electric field along the poloidal direction of plasma jet [Applied voltage:11 kV, Gas flowrate: 5 l/min]

near the orifice and gets stronger and starts to fluctuate farther away from the orifice of capillary (z~6mm). A detailed experimental study on the spatial asymmetry of the electric field has been done, and would be helpful from the application aspects. To verify the experimental results, a theoretical model for electric field estimation is under development.

References

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