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DYNAMICS OF ATMOSPHERIC PRESSURE PLASMA JETS AND INTERACTION MECHANISMS BETWEEN MULTIPLE JET PLUMES

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In the last ten years, the variety of material processing and biomedical applications of atmospheric pressure plasmas jets highly increased the research in this field. There has been considerable interest in these types of jets due to their capability to launch the plasma in a relatively long distance in to ambient air[1].

The plasma jet design investigated here consists of a capillary dielectric tube with inner diameter of 4mm and outer diameter of 6mm. The tubular electrodes are assembled around the tube separated by a few centimeters. The powered electrode is driven with a pulse 20 kHz pulse reputation and high voltage (6 – 10 kV) supply. Helium is used as the discharge gas with 2 slm flow rate. A plume is observed to propagate out the open end of the tube and its length is found to depend on the operation parameters[1,2] (e.g.. applied voltage, gas flow rate, etc.).

In order to understand the mechanism of the discharge inside the capillary, in between the electrodes, and hence the plume formation outside the tube, time and space resolved images of the discharge were recorded with an intensified charge coupled detector (ICCD) triggered with a 20 nsec gate. It was observed that the discharge starts by a small "ball like" emitting zone close to the powered electrode and then moves like a streamer-type discharge toward the grounded electrode with two distinguished speeds. During the first phase the plasma velocity is comparable to the electron drift velocity[3]. When the discharge crosses the mid-distance between the electrodes, a steep increase in its speed in the order of more than double was observed.

The ICCD images show how the discharge "streamer" approaches the dielectric beneath the cathode then hits it and spreads out on the inner surface of the dielectric tube. The radial expansion of the streamer takes place in a symmetric manor on the surface of the dielectric tube and the discharge in this region look like a cone. The streamer starts its propagation on the dielectric surface beneath the cathode as a surface streamer that draws away outside the electrodes region. After the streamer impacts on the dielectric beneath the cathode a second discharge ignites in the vicinity of the driven electrode and moves toward the cathode. The penterating length of the second discharge region inside the tube depends on the value of the applied voltage.

Time resolved images of the jet outside the electrodes are also recorded. These measurements show that the plume (continuous to the naked eye) is in fact a plasma pulse. The geometrical structure of the plasma pulse is a donut shape[3, 4]. However, until now little is known of the nature of this donut structure. Here we present experimental insights into chemical and physical characteristics of the donut shape using ICCD images with interference filters of the main emission lines. The result shows that the plasma pulse emerges from the end of the tube with a ball like shape and then it proceeds to take the ring "donut" shape until it finally collapses back into a point ball-like structure. It was observed that the helium emission line (706.4 nm) dominates the first stage of the plasma bullet formation, and as the pulse propagates mixing with ambient air the nitrogen molecular ion line at (391.4 nm) appears at the edge of the plasma bullet and it is becomes very strong.

Two of these plasma pulses are allowed in interact with eachother in a controlled envirnoment and an interesting dynamics occurs. Time and space resolved images will be presented which hint at evidence for charge distribution within the plasma pulse.

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