Dynamics of Pulsed Atmospheric pressure Plasma Streams generated by a Plasma Gun

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A specific plasma jet device named Plasma Gun has been developed in GREMI for biomedical applications. Recent studies using this device concerned plasma antitumoral effect and potential endoscopic treatments. The plasma gun is based on dielectric barrier discharge (DBD) flushed with rare gases at low flow rates (10-1000 sccm), and powered by a pulsed generator. It allows Pulsed Atmospheric- pressure Plasma Streams (PAPS) generation at high velocities (10^8 cm.s^{-1}). PAPS can propagate over long distances in dielectric capillaries (from few tens of cm to m). At the capillary outlet, a plasma plume is generated in ambient air, leading to production of reactive species which participate to the plasma treatment. In order to optimize plasma target exposition, it is necessary to better understand the mechanisms of generation and propagation of the PAPS in the dielectric capillary and at its outlet.
In this work, generation and propagation mechanisms were investigated mainly by means of ICCD imaging. Fast ionization wave (FIW) velocity measurements are obtained using a bunch of optical fibers, connected to a PMT, placed along the PAPS propagation path. Two propagation modes have been highlighted: Wall hugging PAPS (Wh-PAPS) and Homogeneous PAPS (H-PAPS). PAPS propagation is dependent on the voltage pulse shape and, to a lesser extent, on the pulse repetition rate and the gas flow rate. It appears that the photo-ionization plays a minor role, but the PAPS propagation mechanisms are clearly dependent on the plasma tail characteristics (namely impedance) [1] that connects the higher intensity zone (corresponding to the FIW front) to the DBD reactor. Indeed, the PAPS propagation is sustained by the high electric field induced by the ionization front. Even at long distances, if the local electric field is high enough in the vicinity of the FIW, a secondary PAPS can be generated in another capillary close to the initial one through the dielectric wall.
A recent study based on a numerical model developed by Z. Xiong and M.J. Kushner at the University of Michigan, has investigated mechanisms of PAPS propagation, splitting and mixing. It has been shown that the PAPS splitting is symmetric, in terms of electron density n_e and electron temperature T_e [2] as can be *a priori* estimated from experiments performed in T-branched capillary. Even if there are still discrepancies between calculated and measured velocities, both simulation and experimental data emphasize the key role of the plasma tail between FIW and initial discharge volume on the final characteristics of the plasma created at the capillary outlet.
This work was supported by ANR ”PAMPA” and by Région Centre through the APR program “Plasmed”. V.S. was financially supported by Conseil Général du Loiret.

References

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