PULSED ATMOSPHERIC PRESSURE PLASMA STREAMS: CHARACTERIZATION AND ROLE OF CRITICAL EXPERIMENTAL PARAMETERS*

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This work reports on the investigation of neon and helium atmospheric pressure plasma generation and propagation in high aspect ratio capillaries, either in straight or branched assemblies. ICCD imaging on ns and sub-ns time scales, together with measurement of the speed of the plasma ionization front reveal the specific features of such plasmas. The plasmas are ignited with DBD electrodes and launched into a tube flushed with a moderate flow (a few sccm) of rare gas and powered with high voltage pulses delivered in single shot or repetitive mode up to a few kHz. The plasma expands in a wall hugging mode in the vicinity of the DBD electrodes gradually switching to a much more homogenous plasma volume during its propagation before inducing a plasma plume in ambient air at the outlet of the capillary. This plasma pattern is associated with two ionization front velocity regimes during which the plasma experiences an order of magnitude deceleration from a few $10^8$ cm/s to a few $10^7$ cm/s in the wall hugging mode and then gradually slows over distances of up to a few tens of cm in the homogenous mode. The influence of pulse repetition rate, dielectric wall permittivity, voltage rising front (either µs or ns) and voltage polarity, will be discussed, while accounting for the roles of the impedance of plasma tail behind the ionization front region and the wall charging processes. For our conditions, photoionization appears to be of minor importance.

The plasma triggering, spatial and temporal dependence, and the rather extended plasma front ionization volume (having typical lengths of a few cm) at atmospheric pressure, appear quite different from those measured for conventional unconfined streamer discharges. This suggests that these confined plasma structures are qualitatively different than unconfined structures, and so are called Pulse Atmospheric-pressure Plasma Streams to account for the specific features of such rare gas plasma expanding in dielectric capillaries. Plasma modeling was recently performed and reveals good correlation with most of the experimental observations dealing with plasma propagation modes, splitting and merging.

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