Backward-Facing Step forced flow in a nanosecond pulsed cold atmospheric pressure argon plasma jet

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Plasma-Flow interaction in cold atmospheric pressure plasma jets (CAPPJ) is of great importance due to the direct influence on the reactive species production. So far, a majority of studies dealing with flow modifications have been devoted to helium CAPPJ. The role of the small perturbations on the highly unstable helium shear layer, due to the plasma generation, has been evidenced to explain the onset of turbulence at moderate Reynolds number [1,2]. It has also been shown that the effect of plasma heating and/or ionic wind in the plasma plume is too weak to explain the observed flow modification [3]. However, to our knowledge, the plasma-flow interaction with argon CAPPJ powered with DC pulses has never been investigated yet. This work studies the argon flow modification in a CAPPJ driven by nanosecond high voltage (HV) pulses [4], from single to multiple shots application. A Schlieren optical bench has been designed in order to visualize the argon flow downstream expansion in quiescent air, for moderate flow rates below 1 slm. A coupled approach is used between CCD Schlieren imaging and ICCD plasma plume imaging, both time-resolved. It is shown that the application of only one voltage pulse (i.e. single HV shot) is enough to disturb the flow, similarly to the model of Lietz *et al* [2]. The disturbed flow exhibits ripple propagation, on a timescale similar to the flow velocity. When operating in double HV shots, the second ionization wave can be used as a probe to instantly visualize the flow structure any time after the first voltage pulse application. For some flow rates, the ripple can increase in amplitude up to the point when it strongly deforms, or even stops, the plasma plume expansion, after which it is entrained by the flow and the plasma plume retrieves its full usual expansion. When a series of voltage pulses are applied, the maximal disturbance of the flow is achieved for a certain pulse repetition frequency, specific of each flow rate. It is associated with ripples alternation in the plasma plume, in a 3D helical-like arrangement. For greater pulse frequencies, the ripples progressively vanish, and the flow is clearly less disturbed. Once the ripples have vanished, increasing further the voltage pulse repetition frequency does not change the plasma plume and flow structures. We suggest that the repetitive plasma ignition mechanically forces the flow inside the capillary with consequences on the global flow structure, similarly to a forced backward-facing step flow with actuator [5],[6].

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