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Plume morphologies and their formation mechanism of an atmospheric pressure argon plasma jet excited by a biased voltage
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Several morphologies of plasma plume are observed through using an argon plasma jet, including solid cone, hollow cone, regularly swells, corona surrounding filament, and corona surrounding feather. Results indicate that, with increasing the bias value of a low-frequency sinusoidal voltage, conical plume transits from solid to hollow. Through fast photography, a plump guided bullet (negative streamer) is found to propagate in the solid plume, while positive streamer is involved in the hollow plume. It behaves as a thin guided bullet starting out from the driven electrode end, which subsequently evolves into branched streamers propagating in the stream periphery. The hollow morphology is attributed to the mutual effects of Penning ionization and the residual charges, which are confirmed by adding different contents of oxygen or nitrogen into the working gas. With decreasing driving frequency, the conical plume transits to a regularly-swelling one. Investigation shows that intense discharges near the nozzle provide the following swell positions with active species, which can remarkably enhance the discharges there and induce the swells. This is verified through investigating distance of two adjacent swells as a function of gas flow rate and driving frequency. With a fairly high frequency, the corona surrounding filament plume is observed. Fast photography indicates that the central filament corresponds to guided positive streamer, while the surrounding corona come from guided negative streamer. Both of the two streamers can enhance each other. With changing the applied voltage to biased square wave, a corona surrounding feather plume is formed. It is found that there are two current pulses at the rising voltage edge and one at the falling edge. Result indicates that the feather corresponds to propagation of two positive streamers at the rising voltage edge, while the corona is formed during the propagation of negative streamers at the falling edge.

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