PO2045

Characterization of rf discharges in narrow gaps of non-thermal atmospheric pressure plasma jets

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One possible method for generating non-thermal plasmas at atmospheric pressure is the so-called atmospheric pressure plasma jet (APPJ), which features a radio-frequency (rf) discharge between bare metallic electrodes. While this source is usually operated at gap spacings in the order of 1 mm, it has been recently shown that uniform discharges can be sustained down to gap spacings of 0.1 mm.
In the present study special attention is given to gap spacings between 0.1 and 0.5 mm, as this is the region were one would expect a sheath-only structure of the discharge within the gap. Careful experimental investigations revealed that uniform discharges can be sustained in helium within the entire region of interest. Surprisingly, it turned out that in very narrow gaps (≤ 0.2 mm) much more power can be dissipated in the jet when the gas flow rate is reduced. In a 0.1 mm gap at low gas flow rates uniform discharges can be sustained to at least to rf powers 5 times as high than usual, hence, no transition to a gamma discharge was observed anymore. A comparison of the impedances determined from electrical measurements with an equivalent circuit model revealed that the impedance characteristics can be modelled with a constant gap capacitance being in parallel with a resistance, which accounts for the dissipated power in the sheath. A detailed electrical characterization and interpretation will be presented.

Keywords
APPJ
helium
rf discharge
sheath-only structure