# Cold atmospheric pressure plasma jets - charge carried by plasma bullets

A. Sobota[1*] , E. Slikboer[1] , O. Guaitella[2]

[1] *EPG, Department of Applied Physics, Eindhoven University of Technology, The Netherlands*
[2] *LPP, Ecole Polytechnique, UPMC, Univeriste Paris Sud-11, CNRS, Palaiseau, France*
[*] *Contact e-mail:* a.sobota@tue.nl

Cold atmospheric pressure plasma jets are researched for applications in surface modification, synthesis, sterilization, medicine. Partially due to the relative ease of constructing a plasma jet, a great amount of work has been published on jets in a variety of gases, using excitation in a wide frequency range and in several typical geometries. Most commonly reported on are descriptions of discharge dynamics, densities of various reactive species, followed by gas temperature measurements, imaging of flow fields, and rarely electron densities and associated electric fields. The first reported measurement of the electric field associated with plasma bullets has been performed by using a spectroscopic technique and published in 2011 by Sretenović et al [1], followed by first results obtained by using the Pockels' technique in 2013 [2] and one more publication in 2014 [3].

The small number of publications on electric fields and charge associated with plasma bullets reflect the complexity involved with their measurement rather than the lack of interest in the subject. Detailed knowledge about the charge carried by plasma bullets is necessary for a better understanding of the processes in these discharges, the effects on the associated chemistry and finally the effect the plasma has on the treated surface in its final application. Any assessment of plasma parameters when transient low density plasmas are concerned requires the knowledge of the reduced electric field involved, as this is the parameter that governs charge production and the dynamics of the discharge.

The aim of this paper is twofold - to discuss the usage of the Pockels' technique in the measurements of electric field and charge carried by plasma bullets and to present results from measurements. For the latter a setup similar to the one reported on in [2] is used, featuring a Helium jet with flow rates up to 1 SLM, at 30 kHz frequency of sine excitation, in a low-power mode (up to 1 W dissipated in the discharge). The jet is run in the bullet mode where one plasma bullet is emitted per voltage period, without the presence of micro discharges around the grounded electrode. In addition to the measurements of electric field, the interaction of plasma and the dielectric target is observed by fast imaging techniques.

The usage of the Pockels' technique for this purpose will be discussed in terms of translating the obtained signal into usable data. The experimental results will focus on the relationship between the properties of the plasma bullet formed in the capillary and the applied voltage amplitude, gas flow, jet source geometry and the travelling length of the bullet. Certain features will be supported by the results of fast imaging. It will be shown that voltage amplitude and flow rate have limited influence on the charge carried by a plasma bullet.

## References

[1] G B Sretenović, I B Krstić, V V Kovačević, B M Obradović, M M Kuraica 2011 *Appl. Phys. Lett.* **99** pp 161502

[2] A Sobota, O Guaitella, E Garcia-Caurel 2013 *J.Phys.D:Appl.Phys.* **46** pp 372001

[3] R Wild, T Gerling, R Bussiahn, K-D Weltmann, L Stollenwerk 2014 *J.Phys.D:Appl.Phys.* **47** pp 042001