Neon Plasma Jet at Atmospheric Pressure. Spatiotemporal distribution of ambient air species

L. Chauvet, B. Caillier, L. Therese and Ph. Guillot

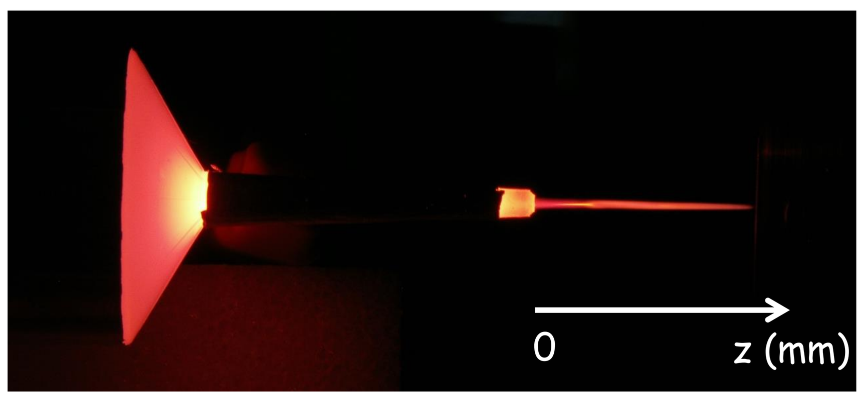
Laboratoire Diagnostics des Plasmas Hors Equilibre (DPHE),
Université de Toulouse, INU Champollion, ALBI, France.

Institut National Universitaire Champollion

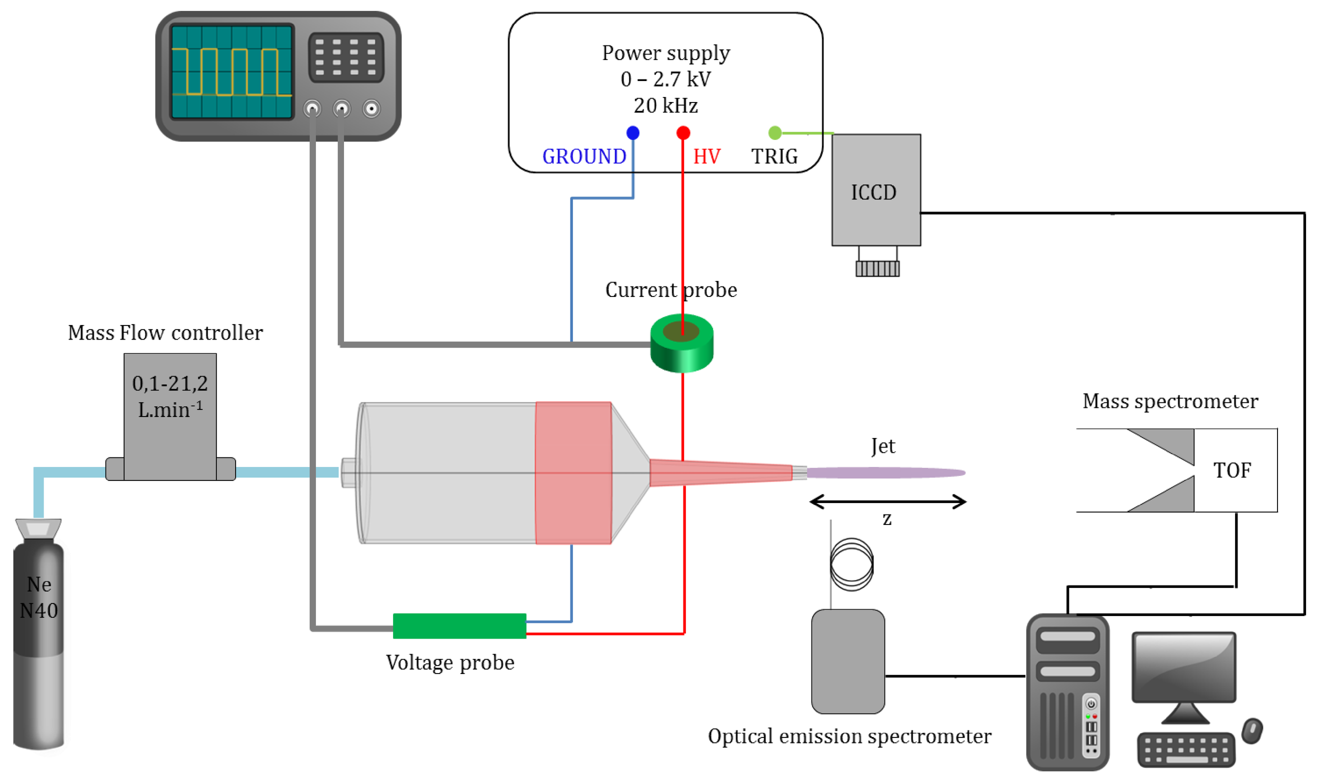
GD Day 15 - 16 September 2016

Introduction

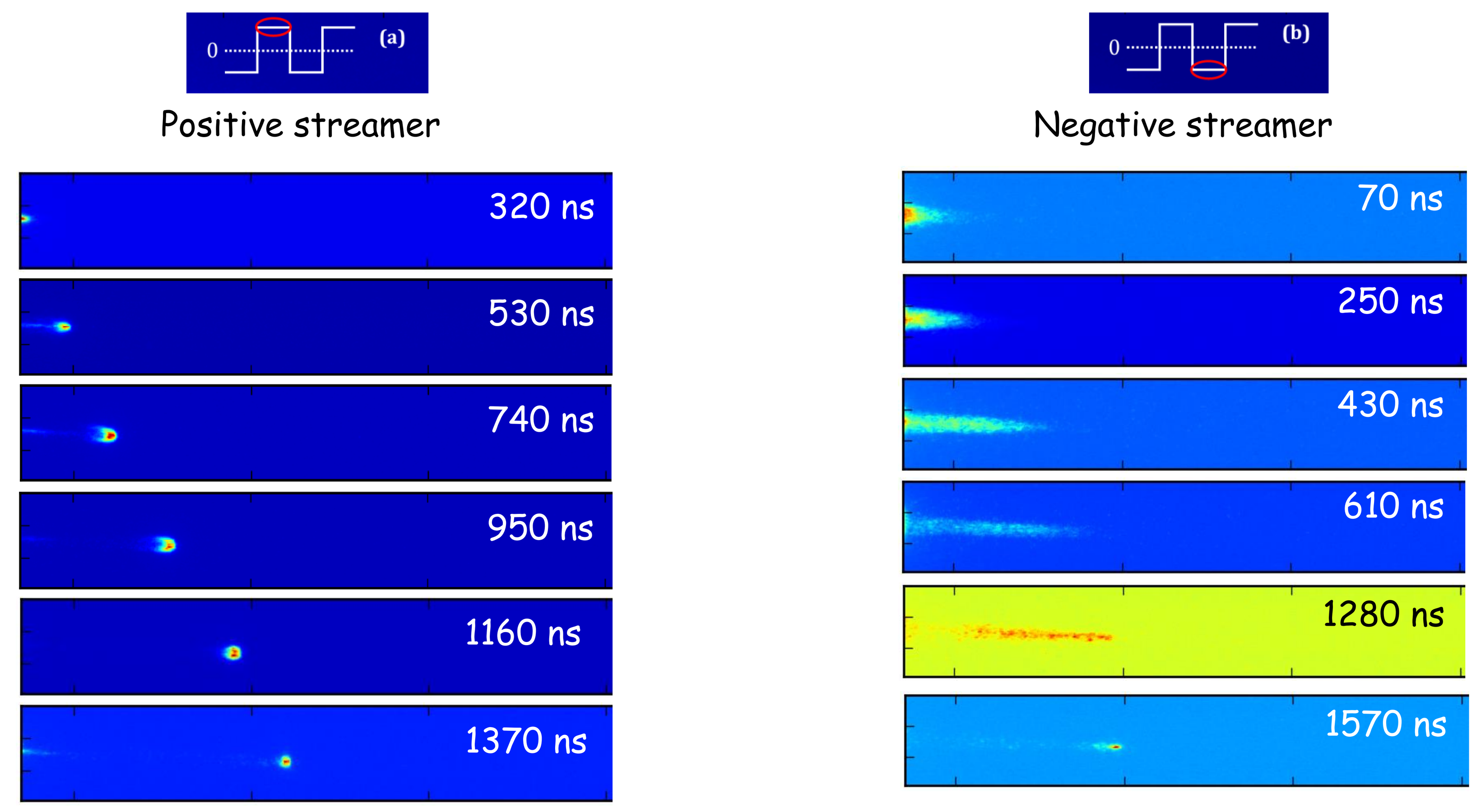
The source used in this work is based on Dielectric Barrier Discharge (DBD), it allows the formation of a cold atmospheric pressure plasma jet in open air [1-2]. In this configuration, they are not any conductive electrodes in contact with the discharge gas. Here, the source is fed with high purity neon. It is injected through a gas inlet at the back of the source. The source is operated with the neon flow rate at 2.3 L.min^{-1} and is powered by a 20 kHz square alternative voltage with an amplitude of 1400 V.
In this study, the optical measurements were performed with an optical emission spectrometer positioned in front of the plasma jet and then side-on to the jet (perpendicular) in order to record spectra each millimeter along it. And thus, we can visualize the spatial distribution of the species present within the jet. The measurements were also carried out through the use of an ICCD camera placed on the side of the jet. The propagation of the jet was recorded for both half periods of the voltage with and without filters in order to study the spatiotemporal distribution of the species emissions.



Experimental setup



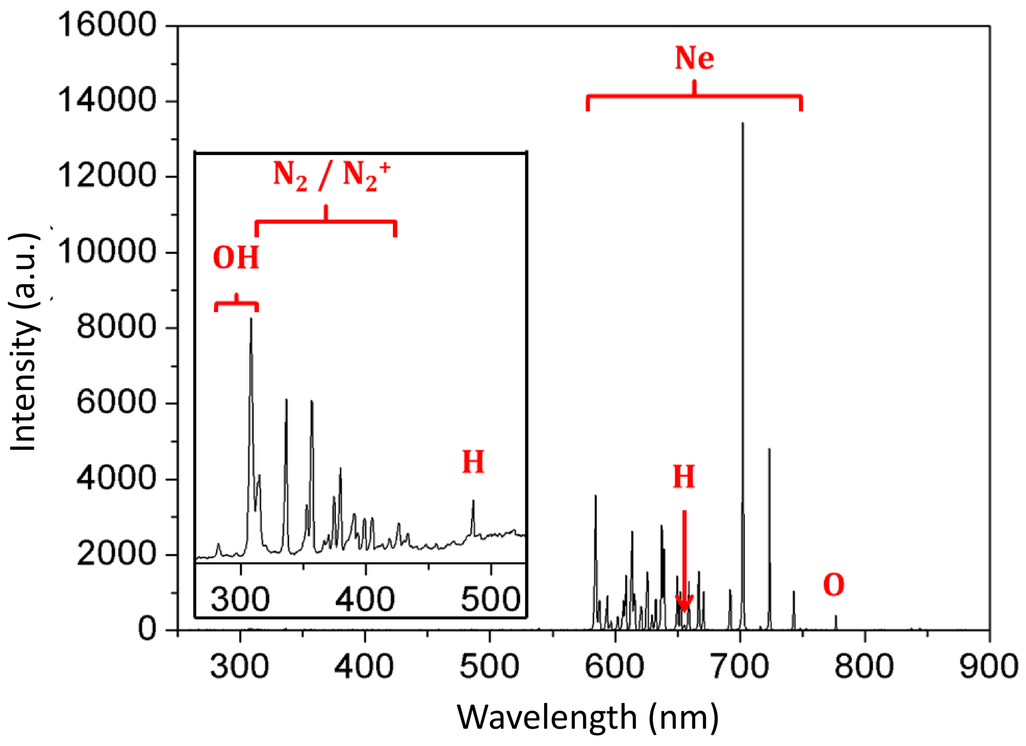
ICCD imaging – total emission



The discharge propagates outside the source as a positive streamer during the positive half period and as a negative streamer during the negative half period [3].

Optical emission spectrometry (integrated / periods)

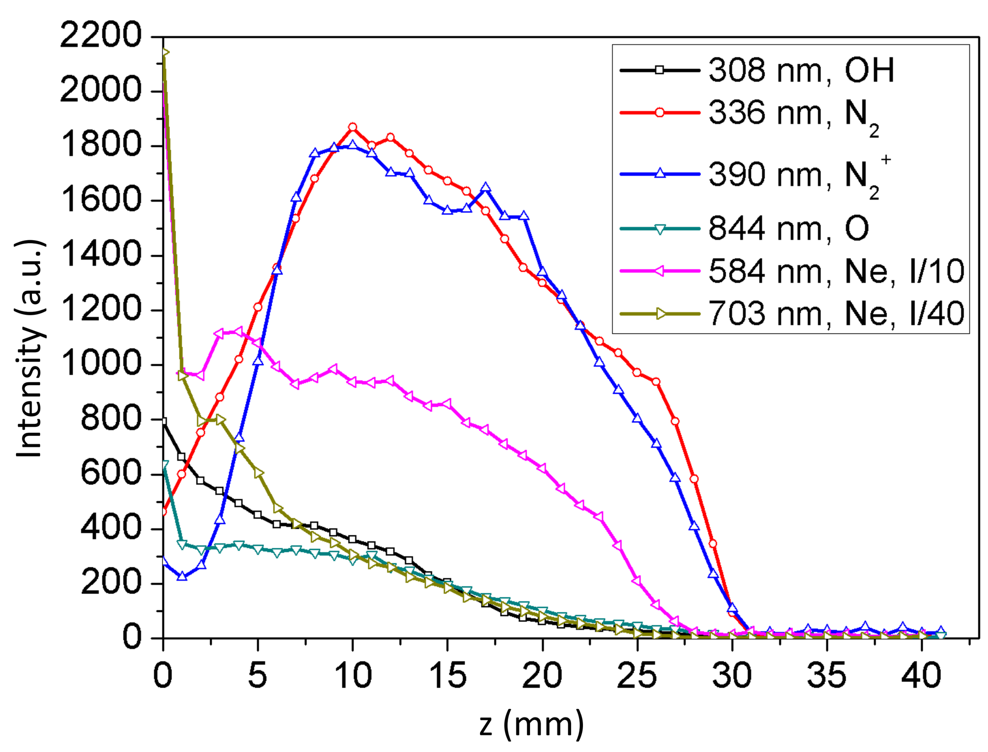
Plasma emission lines



Discharge gas:
Ne : 584 nm/614 nm/626 nm/ 637 nm/703 nm/724 nm

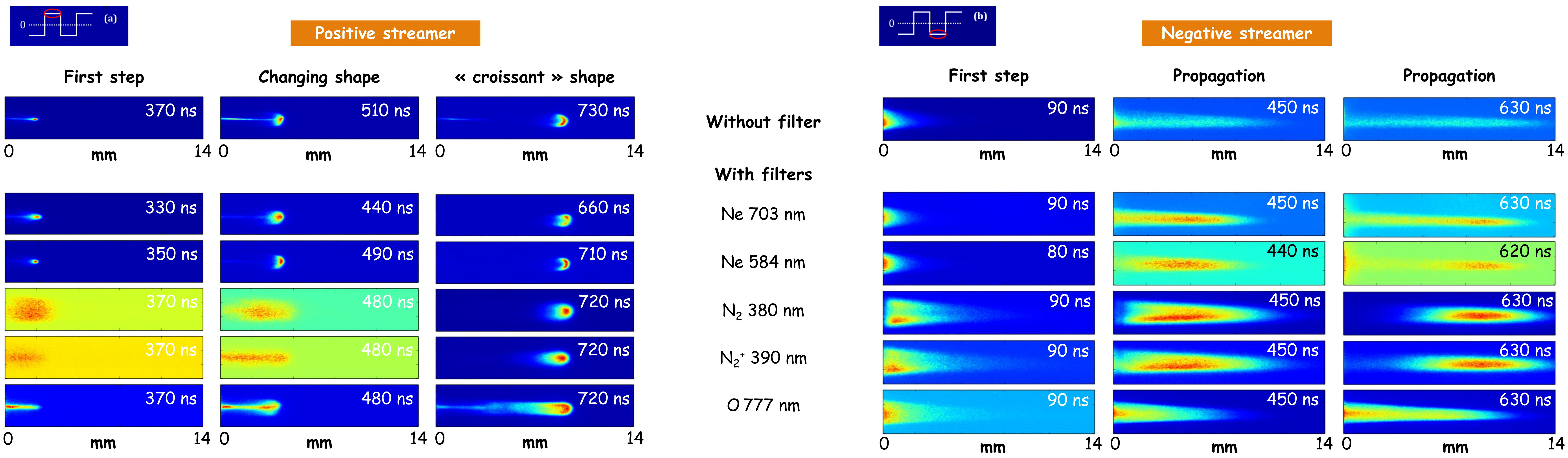
Ambient air species :
OH : 282 nm/308 nm
H : 486 nm/656 nm
O : 777 nm/844 nm
N_2^+ : 390 nm/427 nm/470 nm
N_2 : 315 nm/336 nm/353 nm/ 356 nm/370 nm/ 374 nm/ 379 nm/393 nm/ 399 nm/ 405 nm/419 nm/434 nm

Spatial distribution of emission lines



As a function of the species, the emissions are differently distributed. Two patterns exist.
For Ne, OH and O the emission maxima are close to the tube end of the source (z = 0 mm) and the intensities decrease along the jet. For N_2 and N_2^+, the intensities increase along the jet and reach a maximum value around z = 10 mm, they decrease further on. The evolution of the N_2 and N_2^+ spatial distributions is very similar.

Filtered spatiotemporal distributions from the exit



These pictures were recorded for both half periods, first without and then with filters for the lines of Ne (584 nm and 703 nm), N_2 (380 nm), N_2^+ (390 nm) and O (777 nm). They were recorded at the different steps of the propagation of the streamers (10 ns duration per image). The intensity is normalized for each image.

Conclusion

An atmospheric DBD plasma jet has been studied with neon flow. ICCD images show the propagation of a positive streamer during the positive half period of the applied voltage and a negative streamer during the negative half period.

The emission lines of the species present within the jet have been identified and their spatial distributions have been plotted showing two different behaviors.

Then, to get a better understanding of the plasma evolution, the spatially and temporally resolved distributions of the main species emissions have been investigated.

References

[1] L. Chauvet, L. Thérèse, B. Caillier, and P. Guillot. Characterization of an asymmetric DBD plasma jet source at atmospheric pressure. J Anal Spectrom, vol. 29, 2014, pp. 2050- 2057.

[2] S.B. Olenici-Craciunescu, S. Müller, A. Michels, V. Horvatic, C. Vadla, J. Franzke. Spatially resolved spectroscopic measurements of a dielectric barrier discharge plasma jet applicable for soft ionization. Spectrochimica Acta Part B: Atomic Spectroscopy, vol. 66 (2011), 268-273.

[3] Z. Xiong, X. Lu, Y. Xian, Z. Jiang, Y. Pan. On the velocity variation in atmospheric pressure plasma plumes driven by positive and negative pulses. Journal of applied physics, vol. 108 (2010), 103303.