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# Gas flow modification by an atmospheric plasma jet

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## 1. Introduction

Cold atmospheric pressure plasma jets have demonstrated their ability in biomedical applications thanks to their low gas temperature and their capacity to produce radicals, reactive oxygen and nitrogen species (RONS), ions, electrons, UV radiation and electric field.

A key point for plasma treatment and analysis of biological action of plasma jets stands in the detailed study of plasma delivery over various targets. It has been shown that the ignition of a plasma jet changes the gas flow [1]. The mixing gas with surrounding air and its interaction with the target deeply influence the RONS production and transport to the target.

In this work, a Schlieren imaging setup is used to study the role of various parameters such as voltage polarity, frequency, feeding gas, gas flow and gas composition, on the Plasma Gun (PG) microsecond plasma jets features.

## 2. Experimental setup

The so called Plasma Gun, plasma jet used in this study, was a coaxial dielectric barrier discharge reactor with a 4 mm inner diameter quartz capillary tube [1]. The device was powered by  $\mu$ s-duration voltage pulses with a repetition frequency between 100 and 4000 Hz. A metallic grounded plate was set 2 cm away from the nozzle. The experiments were performed in pure helium, argon or neon and in helium with admixture of  $O_2$  or  $N_2$ .

The gas flow modification was studied by a classic Z Schlieren setup and the resulting images were recorded by a high-speed camera (FASTCAM SA5).

## 3. Results and discussions

In this study, we show that plasma gun fed with rare gas is able to channel gas even for heavy gas like argon.

Moreover the behavior according to the polarity seems universal and does not depend on the feeding gas (helium, argon or neon). Fig. 1 presents three Schlieren images when the plasma is powered by a positive pulse: plasma off and on with pure helium flowing through the device and plasma on with 2%  $O_2$  admixture. Positive polarity leads to a disturbed flow for pure rare gases (b), but the addition of  $O_2$  allows to create a well-defined channel even in positive polarity (c). Negative ions must play a role in that. On the contrary, the addition of  $N_2$  has no significant additional effect on the gas channeling.

Finally we have studied the effect of the frequency on the gas channeling. In low gas flow conditions (0.5 slm), when the frequency is too low ( $<500$  Hz), the gas flow

does not reach the target. On the contrary, if the frequency is too high ( $>1500$  Hz), pulse accumulation is less effective. Nevertheless at low frequencies the limitation can be overpassed with addition of  $O_2$ .

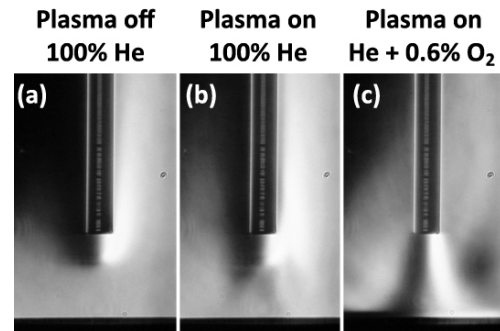


Fig. 1: Schlieren images of a Plasma Gun fed in helium and with  $O_2$  admixture. Positive polarity with a 500 Hz repetition frequency.

This work reveals a lot of analogies with the previous studies dealing with gas flow modification in the frame of plasma actuators for aeronautics applications. It was shown that negative ions play a key role in flow modification [2, 3]. They must likely be also responsible of the gas channeling in this work.

## 4. Conclusion

In this work, we present Schlieren images of a Plasma Gun discharge fed not only with helium but also with neon and argon gases. It was demonstrated that efficient gas flow channeling was observed with operation of the PG with any of the three gases. Such gas flow channeling is also proven to be dependent on voltage polarity and frequency. Analysis of the role of molecular admixtures ( $N_2$  or  $O_2$ ) confirms the non-thermal nature of the effect and the potential role of large negative ions.

## References

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