Controlling Atmospheric-Pressure Plasma Reactive Species Densities by means of Modulated Sinusoidal High Voltage

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Audio-frequency sinusoidal high voltage is here modulated by square-wave signals, by means of a microprocessor-based power supply. The modulated voltage drives a single-electrode microplasma reactor using helium at atmospheric pressure as feedstock gas. The emissive species induced downstream the reactor nozzle are identified with UV-visible optical emission spectroscopy, and the influence of two modulating parameters (i.e. period and duty cycle) on the relative density of excited probe molecules is studied independently. It is clearly demonstrated that, under the present experimental conditions, both parameters have a profound effect on reactive species densities, and may thus control and enhance the plasma chemistry with an engineerable manner.

1. Introduction

For atmospheric-pressure plasma applications, numerous reports consider the role of the reactor design, driving voltage features (a.c. or pulsed d.c.), gas composition, and gas flow rate, in optimizing the density of various species. Differently, sinusoidal high voltage is here modulated by square-wave signals in respect to excited species densities.

2. Plasma and Diagnostic Setups

The setups employed here are extensively presented elsewhere [1]. Here, the distance between the single-electrode tip and the capillary tube exit is 30 mm and a novel power supply (commercialized by our group) is used (see **Fig. 1** and its caption).

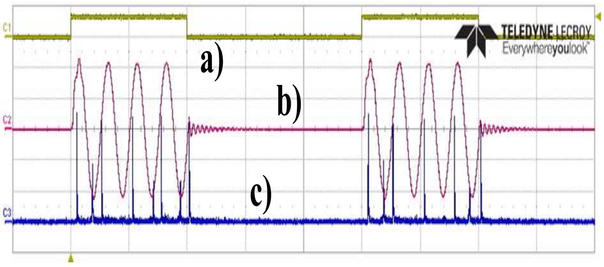

Figure 1: Representative oscillograms: a) square-wave modulating signal (TTL), b) modulated sinusoidal high voltage (9 kVpp; except the overshoot of each first cycle at 9.1 kVpp), and c) pattern of wavelength-integrated light impulses during "plasma bullet"-"guided streamer" propagation [1] (a.u.). The light is spatially-integrated over the first 5 mm in front of the reactor nozzle.

3. Results and Discussion

Fig. 2 shows how the relative density of an excited probe molecule – in terms of optical emission spectroscopy intensity (resolution 0.01 nm; integration time 2 s) – is affected by the modulating parameters. The linear increase vs. duty cycle is probably due to the increasing mean power (ionization/excitation) of the plasma. But, the sharp increase vs. frequency is still under investigation.

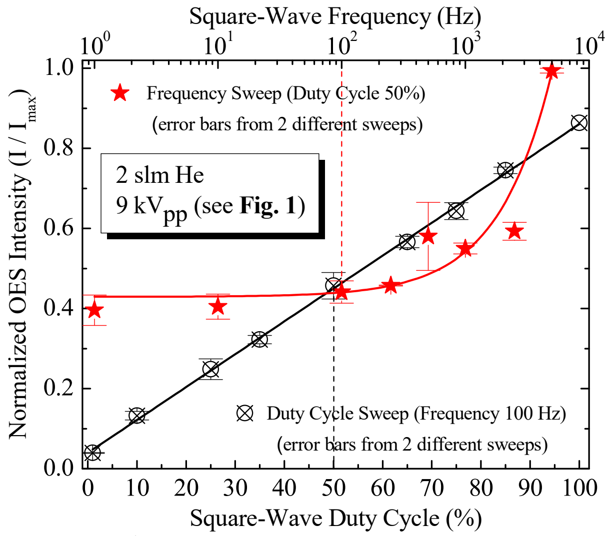

Figure 2: $N_2^*(C^3\Pi_u\text{-}B^3\Pi_g$; v'-v": 0-0) relative density.

4. Conclusions

Appropriately modulated sinusoidal high voltage is potentially a new way for controlling the chemistry of atmospheric-pressure plasmas.

5. References

[1] K. Gazeli et al., J. Appl. Phys. **114** (2013) 103304.

Acknowledgments

D.A. acknowledge I.K.Y. (State Scholarships Foundation; NSRF 2014-2020) for financial support.