

Atmospheric pressure plasma jets: high density, controllable sources of reactive species

A. R. Gibson^{1, 2*}, C. O'Neill³, D. O'Connell², T. Gans²

¹ LPP, Ecole Polytechnique-CNRS-Uni Paris-Sud-UPMC, 91128 Palaiseau, France

² York Plasma Institute, Department of Physics, University of York, Heslington, York, YO10 5DD, UK

³ Centre for Plasma Physics, Queen's University Belfast, University Road, Belfast, BT7 1NN, UK

* Corresponding author: andrew.gibson@york.ac.uk or andrew.gibson@lpp.polytechnique.fr

Non-thermal plasmas produced at atmospheric pressure offer unique environments for the conversion of stable molecular gases into reactive species at room temperature. As such, investigations are undergoing as to how they might be utilized in biomedical, industrial and environmental applications. A key requirement in such applications is the control and optimisation of the reactive species produced by the plasma source. The generation of reactive species at low gas temperature is possible in such plasma sources due to the lack of thermodynamic equilibrium between electrons and heavy particles. This means that electrons can be accelerated to energies on the order of several eV, sufficient to break chemical bonds and create excited species, while heavier particles remain near room temperature. This thermal non-equilibrium is typically attained using radio-frequency (rf) fields which preferentially accelerate electrons. The sensitivity of electrons to rf fields leads to the possibility to tailor the electron properties, and consequently the reactive species densities, by modifying the magnitude and shape of the voltage waveform. In this work a 1D fluid plasma model has been used to investigate the effect of changing the voltage waveform on reactive species densities in a He/O₂ atmospheric pressure plasma jet. It is found that by changing the magnitude of the voltage waveform at constant frequency (either 13.56 or 40.68 MHz), the densities of atomic oxygen and ozone produced by the plasma can be controlled independently. Furthermore, changing the shape of the voltage waveform by the superimposition of the two frequencies [1] allows for enhanced production of high energy threshold reactive species, in this case metastable helium in the 2³S₁ state, while the densities of species with low electron energy production requirements, such as atomic oxygen, remain comparatively constant. The physical mechanisms behind these changes and the potential implications from an application perspective will be discussed.

Acknowledgement: Funding is acknowledged through the LABEX Plas@Par project, ANR-11-IDEX-0004-02, UK EPSRC Manufacturing Grant (EP/K018388/1) and the York-Paris Collaborative Research Centre.

References

[1] C. O'Neill, J. Waskoenig and T. Gans, *Appl. Phys. Lett.*, **101**, 154107 (2012)