Cavity ring-down spectroscopy study of the kinetics of oxygen atoms, ozone and negative ions in RF capacitively-coupled plasmas in O_2

Jean-Paul Booth*[1], Shu Zhan[1], and Garrett Curley[1]

[1]*Laboratoire de Physique des Plasmas (LPP), CNRS, Sorbonne Université, École Polytechnique, Institut Polytechnique de Paris, Palaiseau, 91120, France*

We have used monomode laser Cavity Ring Down Spectroscopy (CRDS) to measure oxygen atom densities and temperatures in discharges in pure O_2, via the the optically forbidden $O(^3P_2)\leftarrow O(^1D_2)$ absorption at 630nm [1]. As well as measurements in continuous discharges, time-resolved measurements in pulse-modulated plasmas were achieved by time-binning the (random) ringdown events, allowing observation of the decay of the atom density on the afterglow. Furthermore, the oxygen atom transition lies on a time-varying continuum that can be attributed to O^- negative ion photodetachment as well as to the Chappuis bands of ozone. The very different time-behaviour of these two components allows us to deduce the negative ion density in the active plasma as well as the density of ozone generated in the afterglow.

Measurements were made in a highly-symmetric radio frequency (RF) capacitively coupled plasma (CCP) plasma reactor with aluminium electrodes, at oxygen pressures of 0.5-6 Torr and 13.56 MHz RF power up to 900W.

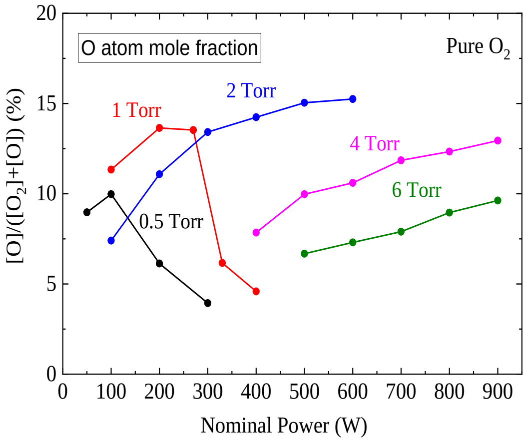

Figure 1 Oxygen mole-fraction as a function of O_2 pressure and RF power.

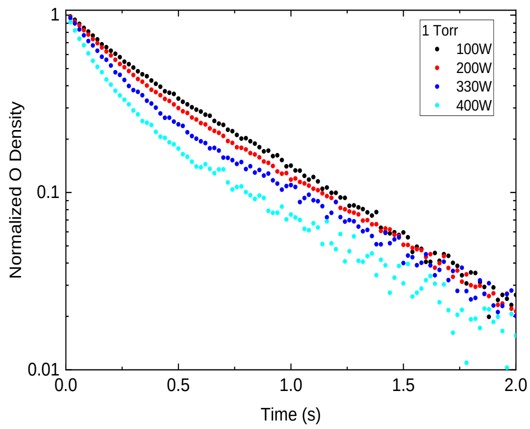

Figure 2. Oxygen atom decay in the afterglow at 1 Torr pressure

The oxygen atom mole-fraction increases with RF power at high pressure, and decreases with gas pressure. However, at 1 Torr and below it passes through a maximum with RF power. The afterglow decays under these conditions show that the decays are non-exponential, with an initial rate that increases with RF power. We attribute this to activation of surface recombination by energetic ion bombardment. This effect partially explains the maximum in mole-fraction, as will be discussed in detail in the talk.

We thank Applied Materials Corporation and Fédération de Recherche PLAS@PAR for financial support, and SZ thanks China Scholarship Council for a doctoral grant.

[1] J.-P. Booth, O. Guaitella, S. Zhang, D. Lopaev, S. Zyryanov, T. Rakhimova, D. Voloshin, A. Chukalovsky, A. Volynets, and Y. Mankelevich, Plasma Sources Sci. Technol. 32, 095016 (2023).

. *Presenting author: jean-paul.booth@lpp.polytechnique.fr