Topic number: 4

ANALYSIS OF FAST NEUTRAL OXYGEN ATOMS IN CAPACITIVELY COUPLED RF PLASMA

Kristian Dittmann(1,*), Timo Gans(2), Bert Krames(1), and Jürgen Meichsner(1)

(1) Institute of Physics, University of Greifswald, Felix-Hausdorff-Str. 6, D-17487 Greifswald, Germany

(2) Queen's University Belfast, Centre for Plasma Physics, Belfast, Northern Ireland

(*) **dittmann@physik.uni-greifswald.de**

The inhomogeneous and non-stationary sheath in front of the powered electrode of an asymmetric capacitively coupled rf plasma is of special interest concerning the sheath electron heating, ion acceleration towards the electrode, and secondary particle emission. In particular, the collision dominated rf sheath provides many expectations in generation of fast neutrals by charge transfer collisions or by backscattered neutralized ions from the electrode surface, and electronically excited species.

The study of axially and temporally (rf phase) resolved plasma induced optical emission of the atomic oxygen, e.g. at 777.4 nm (figure 1), in pure oxygen rf plasma combined with PIC-MCC simulation have been shown characteristic excitation patterns in front of the powered electrode [1, 2, 3]. These different patterns have their origin in electron impact excitation due to electron heating during the sheath expansion phase (I), secondary electrons including electrons from detached negative ions (II), energetic electrons in the sheath collapse phase due to electric field reversal (III), and the electronic excitation due to heavy particle collisions near the electrode surface (IV). In particular, the relative excitation rate of atomic oxygen by heavy particle collision is correlated with the flux of energetic oxygen ions to the powered electrode. Furthermore, fast neutrals may be involved, generated in charge transfer collisions or due to ion-surface interaction.

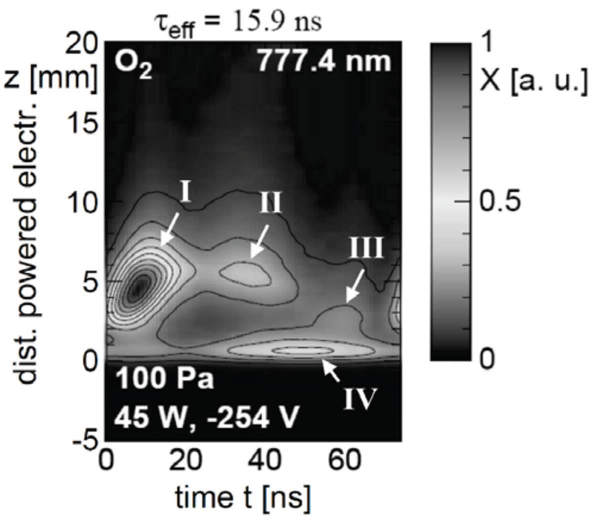

Fig. 1: Spatio-temporally resolved excitation rates within one RF cycle of 74 ns of the 777.4 nm transition of atomic oxygen in pure oxygen plasma (100 Pa, 45 W, -254 V self bias).

In hydrogen rf plasmas the generation of hyper thermal hydrogen atoms was investigated by Gans *et al* [4, 5]. They have shown that these species have their origin from ion neutralisation and reflection on surfaces. The fast neutral hydrogen atoms could have energies comparable to the energy of the impinging ions and therefore they can strongly influence the discharge behaviour.

We measured the Doppler-shifted (top view, in axial direction) and -broadened (side view) radiation of excited fast neutral oxygen atoms at 777.4 nm in the sheath region of capacitively coupled oxygen rf plasmas by optical emission spectroscopy with a spectral resolution of about 0.2 Å (figure 2). The Doppler-shift is a direct measure of the particle velocity and provides information about the energy of the fast excited neutrals and their direction of propagation. An increasing Doppler-broadening of the line profiles can be observed with increasing rf power (more energetic neutral oxygen atoms, higher kinetic energy) at axial position closer to the rf electrode surface (rf sheath, region of fast neutral oxygen production). Additionally the investigation of the Doppler-shifted radiation shows that the fast excited neutral oxygen atoms are moving towards the rf electrode, that means in opposite direction to the measured fast hydrogen atoms in hydrogen plasmas. These fast excited oxygen atoms may be produced in the rf sheath due to charge transfer collisions between energetic O_2^+ ions with the background gas O_2.

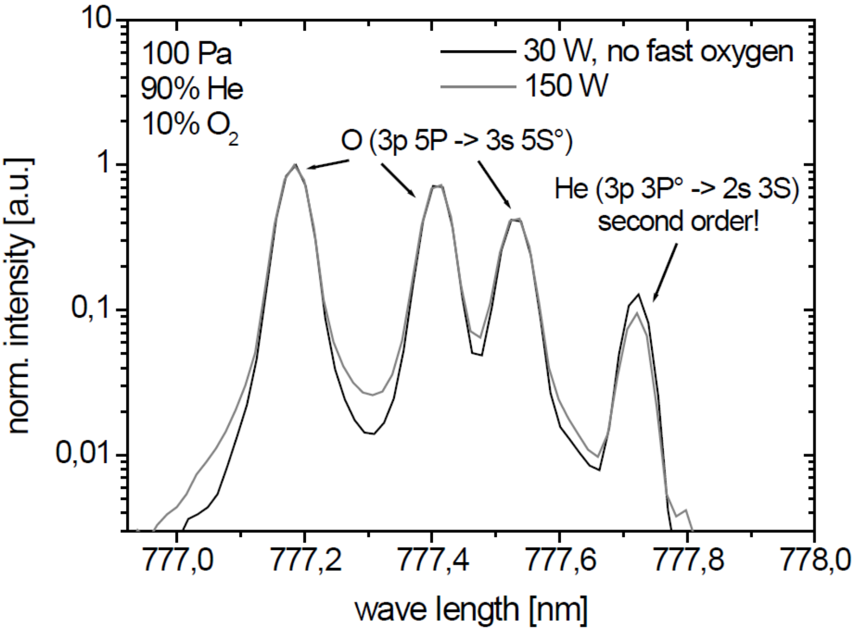

Fig. 2: Doppler-shifted optical emission from excited fast oxygen atoms (top view).

Reference

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