Actinometry of O atoms with Kr at elevated pressures (10 - 100 Torr) in pure O_2 discharge

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This work is crucial part of fundamental research focused on plasma-chemistry of medium-pressure pure oxygen plasmas, where atomic oxygen plays important role. Kinetics of ground state oxygen atoms $O(^3P)$ is studied in rf (81 MHz) CCP discharge in quarts tube at pressures 10-100 Torr by means of actinometry: 5% of Kr was added to the discharge for determination of both relative $[O(^3P)]/N$ (N is total gas density) and absolute concentrations of atomic oxygen in stationary as well as in modulated discharge regimes. Spatial profiles of $[O(^3P)]/N$ were measured to determine atom loss rate on the wall. N was determined using the gas temperature found from the measurements of spectra of $O_2(b^1\Sigma_g^+,v=0)\rightarrow O_2(X^3\Sigma_g^-,v=0)$ molecular band. Thus, combination of spatially-resolved actinometry in stationary conditions together with time-resolved actinometry in pulsed regimes allowed studying kinetics of $O(^3P)$ atoms and making direct estimations of O atom loss frequency ν_{loss}^{O} and production rate k_{diss}^{O2} in the different plasma conditions.

Actinometry technique is optical emission spectroscopy (OES) method that is used to determine concentrations of atoms and molecules in plasmas relatively to known concentration of an actinometer – chemically stable (e.g., noble) gas, which is added in small quantities to the studied plasma so that its properties remain almost unchanged. Comparison of the light intensity produced by excited states of studied species and that of actinometer allows to determine the amount of the studied species relatively to amount of the actinometer, i.e., in our case, $[O(^3P)]/[Kr]$ can be found from the measurements of the emission line ratio I_O/I_{Kr}. However, this requires the detailed account for the balance of excitation and de-excitation of both O and Kr atoms, which, in turn, requires the knowledge of the corresponding reaction rates and electron energy distribution function (EEDF). The first problem of actinometry application in O_2 plasmas at elevated pressures lies in the predominance of collisional quenching of excited atoms while the corresponding rate constants are often unknown. Secondly, an accurate experimental obtaining of EEDF in such conditions is impossible. Therefore, the actinometer should be chosen in such a way that the actinometry becomes as weakly dependent on EEDF variations as possible. These questions of the actinometry applicability are discussed.

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