SELF-CONSISTENT ANALYSIS of LOW-TEMPERATURE OXYGEN PLASMA and PROCESSES of its INTERACTION with SOME POLYMER MATERIALS

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Non-equilibrium plasma reacting with polymers is a system in which physical properties determining plasma chemical action depend upon the chemical reactions rates. For the understanding and quantitative description of connections between internal and external plasma parameters and plasma initiated chemical reactions it is necessary to analyze the following related questions: (i) what are main processes controlling the balance of charge particles, (ii) what active species cause the polymer etching and what are the kinetic regularities of this process; (iii) in what extent the etching products influence the yield of active species and the stationary plasma state. In present work the model of dc positive column in O_2 has been developed. The model is based on the solution of the following combined equations: full current equation, continuity equations for neutral and charged species, vibrational kinetics equations for O_2 ground state, Boltzmann equation for electron gas and heat conductivity equation. The equations take into account the most important species, i.e., $O(^3P, ^1D, ^1S)$, $O_2(X^3\Sigma, a^1\Delta, b^1\Sigma, A^3\Sigma)$, O_3, O_2^+, O^+, O^-. The plasma properties predicted by the model (reduced electric field, gas temperature, EEDF, $O(^3P)$ and $O_2(b^1\Sigma)$ concentrations, ionization rates and others) agree well with our experimental data and the data of other investigators.

Under the conditions of given species fluxes to the polymer samples surface and small plasma perturbation by the reaction products the etching kinetics of various type polyimide films, poly(ethylene terephthalate) film and fabric both in plasma and in its flowing afterglow has been investigated. The rates of mass loss, formation of gaseous etching products, consumption of oxygen as the functions of plasma parameters and sample temperature have been measured. Comparing the rates mentioned above with the formation rates of different species in plasma the most possible limiting stage of etching process and kind of etching particles have been determined. The effective activation energies, rate constants of atoms interaction with polymers and its heat effects were also determined. The gaseous etching products influence on the EEDF and on the appropriate rate constants has been also analyzed. The elaborated approach to the plasma modelling may be used for next self-consistent calculations of the plasma properties taking into account the influence of the heterogeneous reactions gaseous products on the plasma stationary state.