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PROPAGATION OF LASER DISCHARGE IN GAS FLOW DUE TO EXTREME ULTRAVIOLET RADIATION OF MULTIPLY CHARGED IONS *)

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The spectra of multiply charged ions of heavy gases are characterized by the presence of narrow peaks of extreme ultraviolet (EUV) radiation [1]. Peak localization makes it possible to use systems of multilayer Bragg mirrors to focus the generated radiation, which gives the possibility of practical application of this radiation for extreme ultraviolet lithography [2]. Thus, in particular, the Xe^{8+}–Xe^{17+} spectra have a distinguished maximum in the region of 11 nm, which corresponds to the peak reflectance of mirrors based on beryllium and strontium [3, 4].

One of the options for generation of plasma with multiply charged ions is a pulsed laser discharge in a gas jet [5–7]. Laser radiation is sharply focused in a dense gas, ensuring the development of breakdown in the focal region, significant heating of electrons by laser radiation and, as a consequence, efficient sequential multiple ionization by electron impact. This results in a point-like source of extreme ultraviolet radiation with a generation efficiency of over 1%.

This paper presents the results of simulation of a laser discharge in jets of heavy gases [8]. It has been shown that the discharge propagates beyond the focal region due to photoionization of the surrounding gas by EUV radiation of multiply charged ions and subsequent heating of the electrons of the photoionized plasma by the heat flow from the focal region due to electron thermal conductivity [9]. A model has been constructed that provides a consistent description of discharge propagation due to the specified mechanism with the key aspects of discharge dynamics, including gas breakdown, heating of electrons in elastic collisions with ions, elementary processes of ionization and excitation of multiply charged ions by electron impact, transfer of line radiation of ions in the discharge volume and neutral gas, surrounding the discharge. The agreement between the simulation results and the available experimental data has been demonstrated, confirming the theoretical concept of the crucial influence of the discharge propagation beyond the focal region on the spectral composition of the discharge radiation. Discharge modes that are optimal for generating EUV radiation have been found.

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