STUDY OF THE MECHANISMS OF INFLUENCE OF PREIONIZATION ON EFFICIENCY OF GAS-DISCHARGE X-RAY LASERS [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2021.48.1.081

S.I. Eliseev1, M.V. Timshina2,3, A.A. Samokhvalov4, Y.-P. Zhao5, V. Burtsev2,3

1Physics Department, Saint Petersburg State University, St. Petersburg, 198504
2Ioffe Physical Technical Institute, Russian Academy of Science, St. Petersburg, 194021
3”Burtsev Laboratory” limited company, St. Petersburg, 197022
4Photonics Department, ITMO University, St. Petersburg, 197101
5National Key Laboratory of Science and Technology on Tunable Laser, Harbin Institute
 of Technology, Harbin, 150080, China

The possibility of using nanosecond capillary discharges to create conditions suitable for enhancing spontaneous plasma emission in the soft X-ray range was first demonstrated in the late 1980s [1]. Interest to such discharges increased significantly after the achievement of the laser effect on transitions of neon-like argon ions in the plasma of a capillary discharge [2]. In the following decades, significant efforts were made to optimize discharge-based X-ray laser technology for various industrial and scientific applications.

A critical technological aspect of gas-discharge X-ray lasers is the preionization of gas inside the capillary, which increases the efficiency of the transfer of electrical energy to the plasma, ensures the stability of plasma compression at the main stage of the discharge, and also reduces the electrostatic load on the capillary. For these purposes, current pulses of significantly longer duration and lower amplitude, compared to the main pulse, are usually used. In a number of experimental studies, a significant sensitivity of the X-ray laser radiation intensity to the parameters of preionization schemes was observed [3-5]. Interpreting these results in terms of equilibrium plasma does not allow one to explain all the observed dependences.

In this work, a theoretical study of the mechanisms of the influence of plasma, formed at the preionization stage, on the main nanosecond capillary discharge was carried out. The formation of such plasma under conditions similar to those typically used in gas-discharge X-ray lasers was obtained as a result of self-consistent numerical calculations. The dynamics of the discharge was studied in detail, starting from the stage of gas breakdown, which occurs via the ionization wave mechanism, and ending with the formation of a self-sustaining column of cold nonequilibrium plasma. Possible mechanisms of the influence of the parameters of the initial plasma on the main stage of the discharge are analyzed.

The work was supported by Russian Science Foundation (grant №20-72-00039).

References

1. Matthews D. L. et al. Demonstration of a soft x-ray amplifier //Physical review letters. – 1985. – Т. 54. – №. 2. – С. 110.
2. Rocca J. J. et al. Demonstration of a discharge pumped table-top soft-x-ray laser //Physical Review Letters. – 1994. – Т. 73. – №. 16. – С. 2192.
3. Shuker M. et al. The effects of the prepulse on capillary discharge extreme ultraviolet laser //Physics of plasmas. – 2006. – Т. 13. – №. 1. – С. 013102.
4. Tan C. A., Kwek K. H. Influence of current prepulse on capillary-discharge extreme-ultraviolet laser //Physical Review A. – 2007. – Т. 75. – №. 4. – С. 043808.
5. Jiang S. et al. Observation of capillary discharge Ne-like Ar 46.9 nm laser with pre-pulse and main-pulse delay time in the domain of 2–130 μs //Applied Physics B. – 2012. – Т. 109. – №. 1. – С. 1-7.
1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVIII/It/ru/DF-Eliseev.docx) [↑](#footnote-ref-1)