Discharge Supported by a Pulse of Free Electron Laser as a Source of Extreme Ultraviolet Radiation [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2021.48.1.116

I.S. Abramov, E.D. Gospodchikov, A.G. Shalashov

Institute of Applied Physics RAS, Nizhny Novgorod, Russia

Sources of extreme ultraviolet radiation (EUV) with a wavelength of 9–14 nm are required for the development of modern projection lithography [1]. Interest in EUV radiation sources based on a discharge in a diverging jet of xenon, supported by terahertz (THz) radiation, is associated with a higher, in comparison with the traditionally used laser radiation, efficiency of absorption of THz radiation by plasma formation with characteristic dimensions and density optimal for generation of EUV-light [2,3].

In this regard, it is proposed to use the radiation of terahertz free electron lasers (FEL), in particular the Novosibirsk FEL (NovoFEL), to support the discharge [4]. FELs can generate radiation at frequencies of 10–15 THz [5,6], which makes it possible to effectively support a plasma formation with dimensions of several tens of micrometers and electron densities of the order of 1018 cm–3. Such a plasma is optically thin for the target EUV radiation in the 11.2 nm ±1% range, but optically dense for a large number of lines with a lower energy, which is beneficial for efficiency of the future source. The main drawback that complicates the use of terahertz FELs is the extremely short (1–100 ps) pulse of their radiation.

In this paper, we propose a theoretical model of a nonstationary strongly radiating discharge with high multiplicity ions in an expanding xenon flux, supported by a subnanosecond pulse of extremely focused terahertz radiation from a FEL. The model is used to search for promising experimental scenarios, which ensure the generation of EUV radiation in the 11.2 nm ±1% range.

The work was supported by the Russian Foundation for Basic Research (project 19-32-90019). I.S. Abramov thanks Theoretical Physics and Mathematics Advancement Foundation «BASIS» for personal support (grant 18-1-5-12-1).

References

1. V. Bakshi, *“EUV Lithography”*, SPIE Press, Bellingnam, 758 p. (2018)
2. I.S. Abramov, E.D. Gospodchikov, A.G. Shalashov, Phys. Rev. Applied **10**, 034065 (2018)
3. A.G. Shalashov, A.V. Vodopyanov, I.S. Abramov et al. Appl. Phys. Lett. **113**, 153502 (2018)
4. A.V. Vodopyanov, A.V. Sidorov, A.P. Veselov et al. Proc. of International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), 1–2 (2019)
5. “Table of Parameters for IRTHz FELs Worldwide ”, Helmholtz Zentrum Dresden Rossendorf Official Website (2020), <https://www.hzdr.de/FEL_table>
6. N.A. Vinokurov and O.A. Shevchenko, Physics-Uspekhi **61**(5), 435–448 (2018)

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVIII/Lt/ru/ES-Abramov.docx) [↑](#footnote-ref-1)