Emission properties of a point-like discharge in an inhomogeneous gas flow supported by sub-THz radiation

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The latest developments of the powerful and reliable gyrotrons of the sub-terahertz range opens up new opportunities in research. In particular, detailed studies of the gas discharge in a focused beam of terahertz frequency range electromagnetic waves in an inhomogeneous gas flow were carried out recently [1–3]. This paper presents the results of experimental studies of point-like plasma emission in three spectral ranges: 112 - 180 nm, 20-40 nm, and 12 - 17 nm. The discharge was induced in a nonuniform gas flow (Ar, Kr, Xe) under the action of a focused beam of sub-terahertz waves. Two gyrotron complexes were used as the radiation source. They were 40 kW at 670 GHz and 250 kW at 250 GHz. An absolutely calibrated photomultiplier and an absolutely calibrated solid state detector with a set of filters were used to measure light properties. Promising results were obtained - a point-like discharge with a size of not more than 1 mm and a plasma density of more than 3×10^{16} cm^{-3} with valuable emission in extreme ultraviolet band was demonstrated. For instance, the light emission power of the point-like discharge sustained by the THz waves with frequency of 250 GHz in the wavelength range of 20-40 nm reached 300 W. Such a plasma object can be a promising source of extreme ultraviolet light for high-resolution projection lithography. The report contains the results of measurements of the light power for the above spectral ranges with temporal resolution. Prospects to increase the conversion degree of plasma heating power to extreme ultraviolet light are discussed in the paper. The work was supported by the Russian Science Foundation, project No. 14-12-00609.

References

[1] M. Glyavin *et al.*, “A point-like source of extreme ultraviolet radiation based on a discharge in a non-uniform gas flow, sustained by powerful gyrotron radiation of terahertz frequency band,” *Appl. Phys. Lett.*, vol. 105, no. 17, 2014.

[2] A. V. Sidorov *et al.*, “Measurement of plasma density in the discharge maintained in a nonuniform gas flow by a high-power terahertz-wave gyrotron,” *Phys. Plasmas*, vol. 23, no. 4, p. 43511, 2016.

[3] A. V. Vodopyanov, “Sources of ultraviolet light based on microwave discharges,” *EPJ Web Conf.*, vol. 149, p. 2009, Aug. 2017.