A point-like discharge, sustained by powerful radiation of terahertz gyrotron

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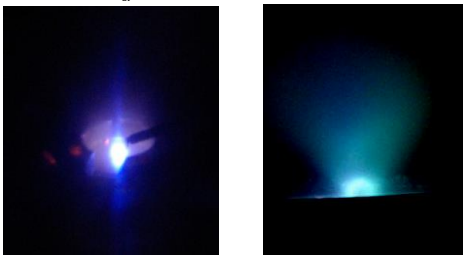
We propose to use the discharge plasma sustained by terahertz radiation as a source of extreme ultrabviolet light for high-resolution lithography. Experimental studies of the breakdown sustained by terahertz waves in the nonuniform gas jet was performed on two cases: in pulsed mode - the radiation frequency of 670 GHz, pulse duration of 30 μs, power of 50 kW; in CW mode - the radiation frequency of 263 GHz; power up to 1 kW. The plasma density was measured from the Stark broadening of the line H_α. The radiation in the vacuum ultraviolet region was investigated using a calibrated PMT and filters, the radiation in the extreme ultraviolet investigated absolutely calibrated detector with filter sets.

Today micro- and nano- electronics industry requires a source of extreme ultra-violet (EUV) radiation with a wavelength of 13.5 ± 1 % nm for high resolution projection lithography. The power of the source must be at a level of 1 kW at the size of the emitting region of less than 1 mm. One of the most promising sources of EUV light is considered to be a source that uses a pulsed CO_2 laser radiation focused on a specially formed stream of droplets of tin with dimensions of the order of 0.1 mm. However, along with tangible achievements in these light sources have a number of fundamental flaws that do not allow us to consider the problem of creating a EUV light source to be solved.

We propose to use discharge plasma sustained by terahertz radiation as a source of EUV light for high-resolution lithography. In this report we discuss the experimental investigation of two types of EUV sources based on discharge sustained by powerful gyrotron radiation. An increase in plasma density with increasing frequency of the heating wave to the value of 10^{15} cm^{-3} and above makes a plasma resonance heating mechanism effective with small plasma size. The main idea of creating of a point discharge with high emissivity in the required wavelength band is the realization of a breakdown in a nonuniform gas jet with the scale of the inhomogeneity of the order of 1 mm. In this case, breakdown conditions fulfilled only in a small region of space and discharge cannot go beyond it [1-3].

In this work the experimental studies of the breakdown sustained by terahertz waves in the nonuniform gas jet was performed on two cases: in pulsed mode - the radiation frequency of 670 GHz, pulse duration of 30 μs, power of 50 kW; in CW mode - the radiation frequency of 263 GHz; power up to 1 kW. Figure 1 shows the photograph of the point-like plasma in that two cases. The plasma density was measured from the Stark broadening of the line H_α.



a) b)

Fig. 1. Photograph of the point-like plasma sustained by CW 263 GHz (a) and by pulsed 670 GHz focused beams

The radiation in the vacuum ultraviolet region was investigated using a calibrated PMT and filters, the radiation in the extreme ultraviolet investigated absolutely calibrated detector with filter sets.

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References

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