Emission of a low-power laser-induced vacuum discharge plasma in the EUV and SXR spectral ranges

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Vacuum spark discharge sources of intense X-rays and multiple charged ions have wide practical applications. However, their operation is unstable. It is shown [1] that the stability can be improved by using the laser initiation of a discharge providing the supply of a fixed portion of the working material into the discharge gap to achieve plasma pinching. It was also found that laser radiation parameters considerably affect the dynamics of such discharge plasma.

We present the results of experimental studies of X-ray spectral characteristics of the spark discharge with the storage energy up to 28 J, the voltage 16 kV, the current 28 kA and the current rise rate up to $5 \cdot 10^{11}$ A/s which was initiated by 6-ns pulse from a Nd glass laser in a wide range of laser power densities from 10^{10} to 10^{12} W/cm^2 on the cathode surface. The emission spectra of plasmas with cathodes made of various materials (Al, Fe, Cu) were recorded in the 30–300 Å spectral region with a grazing incidence spectrograph with a 600 l/mm concave grating with period 1.67 μm, radius of curvature 1 m, and grazing angle 4^0.

It is shown that the SXRand EUV emission efficiency from a laser-induced vacuum discharge depends on the relation between the laser pulse energy determining the mass of the evaporated plasma-forming cathode material and the discharge current determining the plasma pinching rate. If the material mass is small, the amount of the produced plasma, its compression and heating degrees in a micropinch are insufficient for generating an intense radiation flow. On the contrary, in the case of mass excess, the current value is insufficient for the efficient plasma jet compression and heating. The intense UTA (unresolved transition arrays) bands in the 230 - 270 Å and 160 - 200 Å ranges for Al and Fe, respectively, are inherent in the emission spectra of the discharge plasma besides of short-wavelength radiation in the range 30-100 Å. They suggest the formation during pinching, along with the hot plasma core with temperature T_e> 150 eV, also a relatively cold shell. By optimizing the laser pulse and discharge current parameters, the regime can be achieved in which a considerable fraction of the emission energy is concentrated in the long-wavelength band of the quasi-continuum (230 - 270 Å and 160 - 200 Å ranges for Al and Fe, respectively) which makes this discharge an intense source of narrowband EUV radiation.

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References

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