INVESTIGATION OF ELECTRIC EXPLOSION OF THIN FLAT FOILS BY NANOSECOND CURRENT PULSE

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In this work, the explosion of thin flat foils [1–4] by a high-current electric pulse under different experimental conditions was studied. Generators with current from 8 to 1000 kA, voltage from 20 to 600 kV, and duration of pulse fronts from 350 to 100 ns were used. Aluminum, nickel, copper and titanium foils with thickness from 1 to 100 microns were studied using a complex of diagnostics in optical, UV and X-ray ranges. The experiments show that foil explosion is a complex process depending on many factors, including both foil material properties and current generator parameters. At the same time, a number of common features observed in a very wide range of initial conditions have also been found.

Experiments have shown that when flat foils with quasi-periodic structure are used, the energy injected into the foil depends on the mutual orientation of the foil structure and the direction of the current through it [1]. If the foil has its own one-dimensional structure, the application of an artificial profile in the form of grooves perpendicular to it and parallel to the current direction leads to a 15–35% slowdown in the development of instabilities. From this we can conclude that the application of transverse artificial structures on the foil should lead to a slowdown in the growth of instabilities in liners of any configuration [2].

Experimental work on the explosion of thin Al foils demonstrates the possibility of using radiation from the foil surface as a source of UV radiation [4]. The application of a periodic structure with a step of 400 μm on the foil made it possible to create a homogeneous source of UV radiation of a large size (4×20 mm) and maintaining the uniformity of radiation from the entire area during the time from 20 to 70 ns [5]. The radiation intensity of the exploded flat foil is sufficient for the use of time-resolved recording equipment, such as a camera with a microchannel plate, which gives a time resolution of 5 ns (Fig. 1). The application of a UV source based on exploded modified foil will be particularly relevant for imaging low-density plasma objects.

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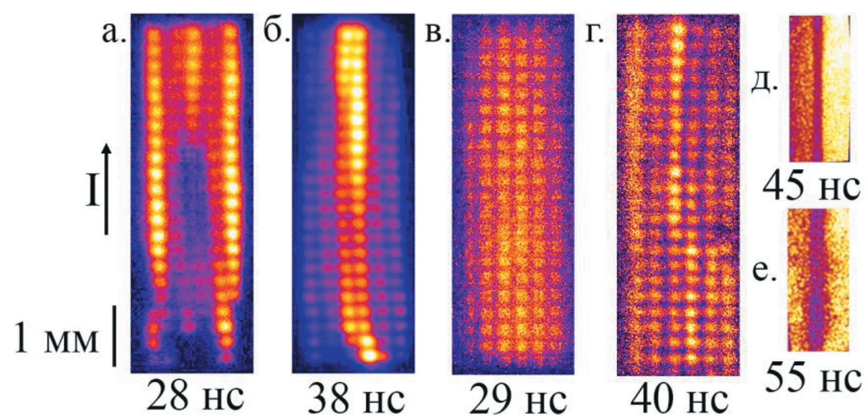

Fig. 1. UV image of a 500 μm mesh in radiation from foil (a, b) and from modified foil with artificial periodic in the form of 50 μm diameter holes applied to the foil with 400 μm period (c, d) and UV image of a exploded Cu wire with 70 μm diameter (e, f) recorded with a MCP camera illuminated by radiation from exploded modified Al foil with 4 μm thickness. The direction of the current through the foil is shown by the arrow. The frame start moments are indicated at the bottom of each image

References

1. **Shelkovenko, T. A.** Features of explosion of thin aluminum foils on an 8 kA, 350 ns pulse generator [Text] / T. A. Shelkovenko, I. N. Tilikin, A. R. Mingaleev, S. A. Pikuz // Phys. Plasmas. – 2020. – Vol. 27, No. 4. – P. 043508. https://doi.org/10.1063/1.5133126.

2. **Shelkovenko, T. A.** Explosion dynamics of thin flat foils at high current density [Text] / T. A. Shelkovenko, I. N. Tilikin, S. A. Pikuz et al. // Matter Radiat. Extremes. – 2022. – Vol. 7. – P. 055901. – DOI 10.1063/5.0098333.

3. **Shelkovenko, T. A.** Investigation of the Nanosecond Explosion of Thin Foils with Artificially Applied Surface Structure [Text] / T. A. Shelkovenko, I. N. Tilikin, A. V. Oginov et al. // Plasma Phys. Rep. – 2022. – Vol. 48. – P. 1226–1235. https://doi.org/10.1134/S1063780X22600815.
4. **Shelkovenko, T. A.** Methods of controlled formation of instabilities during the electrical explosion of thin foils [Text] / T. A. Shelkovenko, I. N. Tilikin, A. V. Oginov et al. // Matter Radiat. Extremes. – 2023. – Vol. 8, No. 5. – P. 055601. https://doi.org/10.1063/5.0146820.
5. **Tilikin, I. N.** Exploding foils with artificial structure as a source of ultraviolet radiation [Text] / I. N. Tilikin, T. A. Shelkovenko, S. A. Pikuz et al. // J. Appl. Phys. – 2023. – Vol. 134, No. 3. – P. 033302. https://doi.org/10.1063/5.0153853.