nanosecond explosion of thin flat foils

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Traditionally, flat foils of different thickness are used as fast switches in high-power high-voltage pulsed current generators, for shock wave generation, and in designing detonators and other devices. At the same time, the process of foil explosion itself (in contrast to wire explosion) has not received systematic study. In spite of obvious differences (e.g., in the magnetic field configuration), it is believed that the processes of foil and wire explosions are generally similar. The goal of our experiments was to find factors that are general for foil loads of different design.

The experiments on foil explosion were carried out on the GVP (10 kA, 20 kV, 350 ns) and BIN (250 kA, 100 ns, 300 kV) pulsed high-current generators from Lebedev institute as well as on the XP (450 kA, 100 ns, 350 kV) and COBRA (1000 kA, 100 ns, 600 kV) generators from Cornell university. On the COBRA generator, the load (in particular, a flat foil) was installed in the main circuit of the generator and one or three X-pinches were installed in the return current circuit. On the BIN and XP generators, the foil was installed in the return current circuit, while a hybrid X-pinch (HXP) was used as the central load and used as a radiation source for point projection radiography. The COBRA generator was equipped with numerous diagnostics, especially in the UV and optical spectral ranges [1], in which the exploded foils radiate. Early stage of the foils explosion was studied on the GVP generator [2]. The GVP and BIN generators were synchronized. The BIN generator was used to power the pinches. Al, Cu, Ni and Ti foils with a thickness of 1–16 µm, a width of 1–3 mm and a length of 4–10 mm were used.

It was shown in the experiments that in the process of foil explosion the core and corona structures are formed, similar to the same structures, registered in the process of wire explosion [3]. The explosion of the foil begins with the formation of a "patterned" structure that does not have a selected direction. Then gaps are formed, elongated in a direction perpendicular to the current. The gaps remain in the liquid phase until the metal begins to boil. The boiling of the foil material begins in the center where the breakdown on the surface develops later, and, accordingly, more energy is deposited.

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References

1. T.A. Shelkovenko, D.A. Chalenski, K.M. Chandler, J.D. Douglass, J.B. Greenly, D.A. Hammer, B.R. Kusse, R.D. McBride, and S.A. Pikuz. Rev. Sci. Instrum. 2006, V. 77, P. 10F521.
2. S.I. Tkachenko, A.R. Mingaleev, V.M. Romanova, A.E. Ter-Oganesyan, T.A. Shelkovenko, S.A. Pikuz. Plasma Physics Reports 35(9), p. 734–753 (2009).
3. T.A. Shelkovenkoa, S.A. Pikuz, I.N. Tilikin, A.R. Mingaleev, L. Atoyan, and D.A. Hammer. Plasma Physics Reports 2018, V. 44, P. 236.