RESEARCH OF MECHANISMS OF TARGET OVERHEATING AT INTENSE PULSED ION BEAM IRRADIATION

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The results of research of nonequilibrium overheating of metal targets at high-intensity pulsed ion beam irradiation (HIPIB) are presented. Studies were performed on TEMP-6 accelerator [1] (200-250 keV with 120 ns pulse duration), ion beam composition was carbon ions (80-90%) [2] and protons, the energy density was 1–12 J/cm^2, heating rate was above $3 \cdot 10^{10}$ K/s. The schematic of a diode system and waveforms are shown in Figure 1.

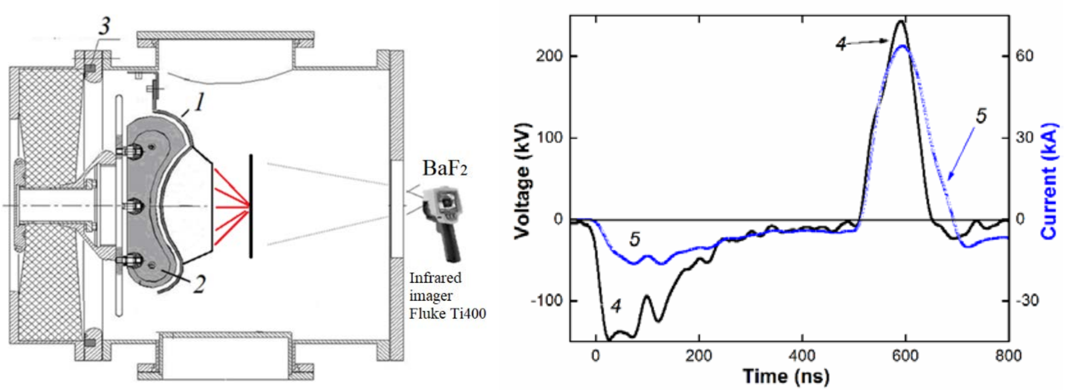

Figure 1 - Schematic of the diode joint (1 – Cathode; 2 – Anode; 3 – Rogowski coil) and waveforms of accelerating voltage (4) and diode current (5)

A strip focusing diode with a size of 22x4.5 cm with a focusing distance of 14 cm worked in self -magnetically insulation mode [3]. The anode-cathode gap spacing was chosen due to the condition of balance between the diode impedance and the wave resistance of double forming line (Blumlein). The anode is made of graphite, the cathode is made of stainless steel with slots of 2×0.5 cm, optical transparency is 70%.

Infrared imaging technique was used as a surface temperature-mapping tool to characterize the energy density distribution of high-intensity pulsed ion beam on a thin metal target. Figure 2 shows a thermal imprint of the target registered with an IR camera after ion beam irradiation and the distribution of the energy density in focal plane.

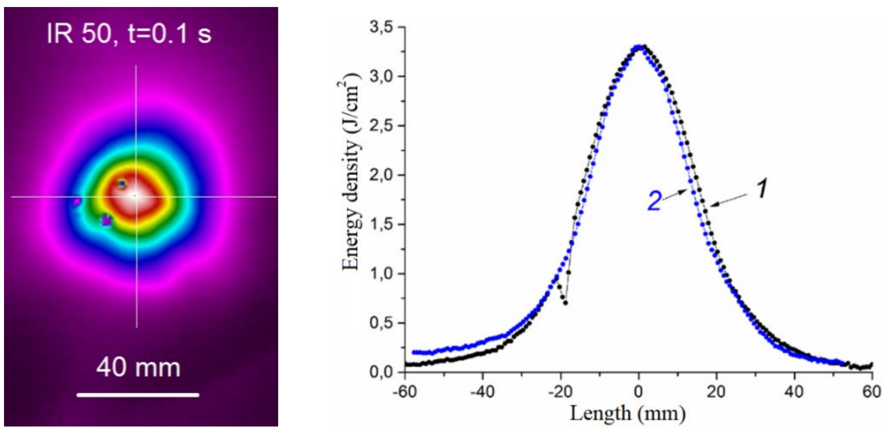

Figure 2 - IR diagram of HIPIB and distribution of energy density in the focal plane in horizontal (1) and vertical (2) directions

Experiments with targets from stainless steel, titanium, brass, copper and tungsten were performed. Our observation showed that the HIPIB maximum energy density, measured with the IR-diagnostics [4] considerably exceeds the ablation threshold of targets (Figure 3).

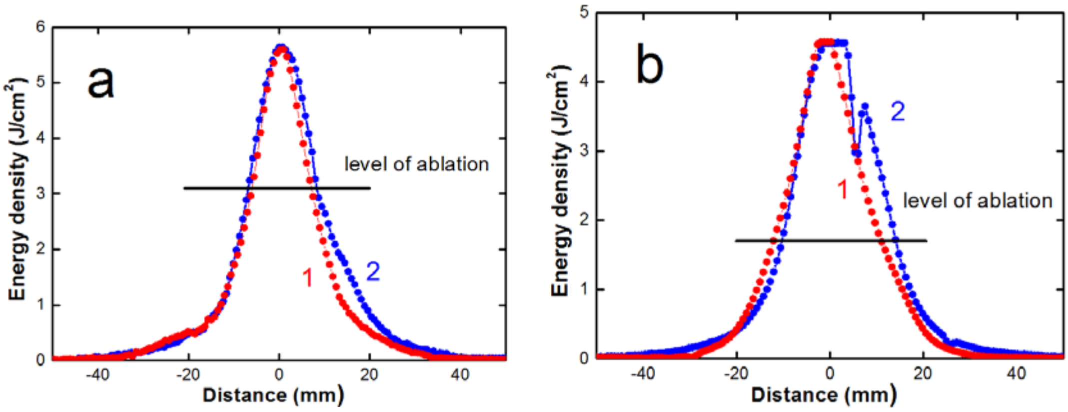

Figure 3 - HIPIB energy density distribution in the diode focus in horizontal (1) and vertical (2) directions. Large target from tungsten (a) and titanium (b)

The performed studies showed that overheating of targets during HIPIB irradiation is much higher than the values obtained by pulsed heating of metallic wires with an electric current or pulsed laser heating of a metal target (heating rate of 10^8 -10^{10} K/s). In addition, the overheating of the targets at HIPIB irradiation depends on target size and thickness. The effect of target overheating during ion beam irradiation is attributed to the formation, migration and subsequent annealing of radiation-induced defects in targets.

This work was supported by Russian Foundation for Basic Research, projects no. 16-48-700012 and 17-08-00067.

References

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