C1-O-024901

EXPERIMENTS ON THE INTERACTION OF A HIGH-ENERGY PLASMA FLOW WITH A GAS JET AND A SOLID-STATE TARGET*

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The interaction of a powerful plasma flow with a pulsed gas jet and a tungsten target was investigated. Study is carried out within the framework of a project to develop high-power line X-ray sources based on pulsed plasma accelerators. The results obtained may also be of interest for solving some applied problems, such as the development of a dissipative ITER divertor and technologies for purposeful modification of surface layers of solid-state materials.

The plasma flows with a velocity of $(4\div6) \times 10^7$ cm/s and energy content of ≈ 50 kJ was produced by the pulsed electrodynamics plasma gun at MK-200 (TRINITI) facility. Hydrogen, nitrogen and neon were used as the supply gas for the plasma gun. The plasma flow moved in a vacuum chamber with a magnetic field of ≤ 2 T induction. The supersonic gas jet of nitrogen/ neon was guided by a flat Laval nozzle along the surface of the tungsten target. The density in the gas stream reached 10^{17}cm^{-3} with a jet thickness of ≈ 5 cm and a width of ≈ 15 cm. The 120 mm $\times$ 140 mm tungsten target was located at 10/20/200 mm from the central plane of the gas jet, depending on the conditions of the experiment.

The EUV&SXR images of the plasma flow interaction with the jet and target were taken using a multi-framing MCP camera. The transmission grating spectrometer was used for recording emission spectra in the wavelength range 1-70 nm with a spatial and temporal resolution. Photodiodes measured absolute power of target plasma radiation. Set of thermocouples made it possible to record the energy absorbed by the tungsten target.

The result of the experiments is a large amount of data obtained with spectral, temporal and spatial resolution, the subsequent processing of which made it possible to draw important conclusions. It was found that jet-forming gases nitrogen and neon were ionized up to the He-like state and the Li-like state correspondingly. In particular, numerical modeling of the recorded spectra in the case of the hydrogen plasma flow and the nitrogen gas jet gives the value of plasma electron temperatures in the range of $40\div50$ eV, and in the case of a neon gas jet, it can reach $70\div100$ eV. Information was also obtained on the power of the radiation, its spectral and spatial distribution for targets various combinations (the tungsten target with no gas jet, and the tungsten target with nitrogen or neon jets) and plasma flow composition (hydrogen, nitrogen, neon).

An important feature of the hydrogen/nitrogen/neon plasma flow impact on the tungsten target with no gas jet is that the target plasma radiation contains mainly spectral lines of tungsten. In the case of the hydrogen plasma exposure, the tungsten vapor propagates to a distance of more 6 cm from the surface towards the plasma flow along the longitudinal magnetic field, as for non-hydrogen plasma, fewer 2 cm.

The results of the non-hydrogen (nitrogen/neon) plasma impact on the gas jet and the tungsten target are presented as well. In these experiments tungsten vapor also did not travel more than 2 cm from the tungsten target surface and the emission contained spectral lines of the gas jet, rather than the plasma flow.

*The work was supported by the Russian Foundation for Basic Research (Projects No. 18-29-21013 and No. 20-21-00153).