Optical spectra of plasma-streams and plasma from targets in plasma-focus experiments

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The paper reports on the selected results of optical emission spectroscopy of free plasma streams generated within the modified PF-1000U machine, and plasmas produced during interactions of such streams with different solid-state targets. The PF-1000U experimental chamber was filled up with pure deuterium at the pressure p_o = 1.6 or 2.4 mbar. When the use was made of the gas-puffing valve, located at the symmetry axis, behind the central opening in the inner electrode, there was injected additionally about 1 cm^3 of deuterium at a pressure of 2 bars. This gas-puffing was initiated 1.5 or 2 ms before the main discharge ignition. The investigated plasma discharges were supplied from a condenser bank charged to U_o = 23 kV (W_o = 352 kJ), and the maximum discharge current amounted to about 1.8 MA. In order to investigate a free-propagating dense plasma stream, the use was made of an optical emission spectroscopy (OES) technique. An optical collimator was situated side-on the vacuum chamber and coupled through an optical-fiber cable with a Mechelle®900 spectrometer. The optical spectra in the visible radiation (VR) range were recorded at a distance of 9 cm from the electrode outlets. Temporal changes of those spectra were compared for shots without and with the gas-puffing [1], and electron density was estimated from an analysis of the D_α-line profile, taking into account a linear Stark-effect. For discharges without gas-puffing the maximum electron density was about 1×10^{18} cm^{-3}, and for discharges with the gas-puffing it amounted to 2×10^{18} cm^{-3}. A comparison of the recorded spectra enabled the optimal operation mode of the PF-1000U facility to be selected.
The OES technique was also applied for studies of plasma produced from tungsten (W) and silicon-carbide (SiC) targets irradiated by plasma streams at a chosen distance from the PF-1000U electrodes ends. Measurements performed during interactions of plasma streams with the W-samples showed many WI and WII spectral lines [2], but their quantitative analysis was impossible because of overlapping. OES measurements were performed also for a SiC target [3], and produced impurity lines were identified, e.g. Si- and C-lines. In those cases the electron density was estimated from the D_α-line only, because D_β-line showed strong re-absorption effect. An analysis of temporal changes in the recorded optical spectra enabled to estimate dynamics of the target erosion. Structural changes upon surfaces of the irradiated targets were also analyzed by means of a scanning electron microscope (SEM) and the energy dispersive X-ray spectrometer (EDS).

References

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[3] E. Skladnik-Sadowska et al., Research on interactions of intense deuterium plasma streams with SiC targets in plasma-focus experiments. PAST. Ser. „Plasma Phys" (2014), № 6, p. 72-75.