DOI: 10.34854/ICPAF.51.2024.1.1.218

INVESTIGATION OF PLASMA PARAMETERS IN THE AREA OF ITS INTERACTION WITH THE SURFACE OF THE PROTOTYPE ELEMENT OF THE FIRST WALL OF A THERMONUCLEAR REACTOR AT THE PLM-M INSTALLATION *)

[1,2]Muravyeva E.A., [1,2]Kavyrshin D.I., [1]Budaev V.P., [1]Fedorovich S.D., [1,2]Chinnov V.F., [1]Tran Q.V., [1]Myazin A.S.

[1]*National Research University "MPEI", Moscow, Russia*
[2]*Joint Institute of High Temperature RAS, Moscow, Russia*

Plasma-facing elements of the lining of the thermonuclear reactor vessel will be exposed to neutron flux, electromagnetic radiation, as well as to high-density plasma flows, which will lead to degradation of the lining surface. The PLM (plasma linear multicasp) installation created at NRU MPEI is testing materials promising for use as the first wall in conditions close to the reactor conditions in a stationary mode in order to analyze the erosion of prototypes of the first wall.

Parameters of the helium plasma discharge used in the PLM installation: magnetic field - up to 0.03 Tl, in casps - up to 0.2 Tl, plasma discharge diameter - about 3.5 cm, electron temperature - 1÷10 eV, plasma density - 1012÷1013 cm-3, helium ion fluxes on test samples - up to 1022 m-2c-1.

The plasma installation of the PLM is equipped with optical and probe systems for plasma diagnostics. The MS7504(i) monochromator spectrograph allows recording plasma radiation in the range from 200 to 1100 nm with a spectral resolution of 0.013 nm and a spatial resolution of ~100 microns. The spectral range recorded at the same time is 16.5 nm. A CCD camera is installed at the output of the monochromator. The MS7504(i) monochromator spectrograph in combination with the AvaSpec fiber-optic four-channel spectrometer is used to register the optical spectra of plasma radiation near the surface of the structural materials samples introduced into it.

In order to increase the energy density (modeling the effects of ELMs and plasma breakdown on the wall), optical spectra were measured in the near-surface plasma zone with additional exposure to the target surface of Nd:YAG laser pulses with a duration of 10 ns with an energy of 0.5 J at a wavelength of 1064 nm. Laser exposure has practically no effect on the intensity of helium lines, while leading to ablation of the sample surface and the appearance of atomic tungsten lines in the spectrum, the intensity of which is inversely proportional to the recorded intensity of scattered laser radiation and increases with each pulse.

The wavelet transform of the probe signal registered in the helium plasma of the PLM installation contains information about turbulent structures. The dominant influence is exerted by structures associated with time scales of 120 microseconds. Under the action of a laser pulse on the material, the properties of the near-surface plasma change, the hierarchy of turbulent structures on scales from 10 to 500 microseconds is observed. This behavior is typically observed in the turbulence of the peripheral plasma of thermonuclear installations and is caused by long-range correlations of drift-dissipative (low-frequency electrostatic) plasma turbulence.

The study was carried out with the support of the RSF grant 21-79-10281.

References

[1]. V.P. Budaev et al., "The PLM Plasma Device for Tests of Tungsten with Powerful Stationary Heat Plasma Loads", Phys. Atom. Nuclei, 82, 1281–1291 (2019); https://doi.org/10.1134/S1063778819090023

*) abstracts of this report in Russian