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CONTROL OF THERMAL IMPACT OF HYDROGEN PLASMA FLOWS ON TUNGSTEN USING A GAS SCREEN *)

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A previous study [1] demonstrated that nitrogen or neon injected in front of the tungsten target surface serves as a reliable method for protecting tungsten from direct impact of hydrogen plasma flow. The energy density absorbed by the tungsten target of ≈ 25 J/cm^2 is half of the energy absorbed by tungsten when exposed to a hydrogen plasma flow without the gas screen of ≈ 50 J/cm^2. This paper presents the results of an additional series of experiments in which the velocity of the hydrogen plasma flow was varied to regulate the thermal load on the target.

The experiments were carried out on the MKT facility (JSC SRC RF TRINITI). A hydrogen plasma flow with a velocity of (4÷6)×10^7 cm/s, a duration of 10÷15 μs, and an energy content of 30÷40 kJ was generated by a pulsed plasma accelerator. The maximum density in a gas screen reached 10^{17} cm^{-3}, with a thickness of ≈ 5 cm and a width of ≈ 15 cm. The tungsten target with dimensions of 12 cm × 14 cm and 8 mm thick was located at a distance of 4 cm from the axis of the gas screen.

The dynamics of the interaction of a hydrogen plasma flow, the gas screen, and the tungsten target were recorded using a four-frame MCP camera in the EUV-SXR range. A multichannel thermocouple calorimeter was used to measure the energy absorbed by the tungsten target and to determine its distribution across the surface. The target surface temperature was measured with an infrared pyrometer. EUV-SXR emission spectra from the plasma were recorded using a transmission grating spectrograph and a CCD camera. The total radiation energy from the near target plasma was measured using a radiation foil bolometer.

Analysis of the experimental data showed that during the interaction of the hydrogen plasma flow, the gas screen, and the tungsten target, the temperature of the front surface of the tungsten target increases during the period when the plasma of the gas screen has not yet in contact with the surface. Its heating is provided by EUV-SXR radiation generated by the plasma formed during the interaction of a hydrogen plasma flow with a gas screen. When using a nitrogen/neon gas screen, by varying the velocity of the hydrogen plasma flow, it is possible to regulate the thermal load on the tungsten target in the range of 10÷25 J/cm^2 (1÷2.5 MW/cm^2) and, consequently, the maximum achievable front surface temperature of tungsten within the range of 2000÷3700 K. Thus, the use of a gas screen in front of plasma-exposed materials makes it possible the regulate the thermal impact on the surface and expands the technological capabilities of processing structural materials through exposure to powerful radiation generated by the interaction of the plasma flow with neutral gas.

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References

[1]. Lidzhigoriaev S.D., Burmistrov D.A., Gavrilov V.V., Kostyushin V.A., Poznyak I.M., Pushina A.V., Toporkov D.A. // Plasma Physics Reports, 2024, v.50, n.11

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