INFLUENCE OF CHEMICAL REACTIONS ON THE TEMPERATURE BALANCE OF HEAVY PARTICLES IN THE CATHODE REGION OF A PLASMA PHOTOELECTRIC CONVERTER [[1]](#footnote-1)\*)

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The work continues the development of a model for direct photoelectric conversion of focused solar radiation in plasma [1]. The temperature balance of heavy particles in sodium vapor plasma in the pressure range 104 – 105 Pa is considered. The model takes into account the energy exchange between the heavy component and electrons, the nonmonotonic temperature dependence of the thermal conductivity of sodium vapor due to the transfer of dissociation energy of sodium molecules, and the release of energy in plasma-chemical reactions involving excited sodium atoms and molecular sodium ions.

It is shown that the transfer of radiation from the central regions of the plasma provides a high relative population of excited sodium atoms in the near-wall regions. Associative ionization with the participation of excited sodium atoms Na(3P) becomes the main mechanism for the formation of charged particles. In the resulting chemically nonequilibrium plasma, the concentrations of excited sodium atoms Na(3P) and electrons in the layer substantially exceed the equilibrium values for a given value of the electron temperature. As a result, the radiative energy flux is effectively converted into ionization energy.

It is shown that associative ionization, leading to the formation of molecular sodium ions at lower vibrational levels, with their subsequent dissociation due to collisions with neutral sodium atoms, leads to a significant cooling of heavy particles. These plasma-chemical reactions can lead to the formation of an internal boundary layer. Previously, such solutions were analyzed in relation to the system of diffusion equations, taking into account chemical reactions [2]. The important role of the cathode wall temperature in the formation of the inner layer is revealed. It is shown that the wall temperature should not exceed a certain critical value. In this case, the temperature gradient of heavy particles near the wall is small and reaches its maximum value at a certain distance in the depth of the plasma. The low gas temperature leads to the formation of an optically thick layer with a relatively high content of sodium molecules and molecular ions. The presence of the molecular component ensures efficient absorption of broadband radiation coming from the central regions of the plasma. The resulting layer plays the role of a heat-insulating shell, separating the high-temperature plasma from the cold cathode wall. This ensures that the heat flux carried away to the wall by the neutral component is small compared to the power spent on the generation of charged particles in the plasma. The conditions formed in the plasma are favorable for efficient direct photoelectric conversion of solar radiation.

References

1. Gorbunov N.A., Flamant G. Plasma Chem. Plasma Process. 2015, V. 35, p. 799-817.
2. Vasil'eva A.B., Butuzov V.F., Asymptotic Methods in the Theory of Singular Perturbations, Moscow: Higher school, 1990, 209 p (in Russia).
1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/L/Lt/ru/ER-Gorbunov.docx) [↑](#footnote-ref-1)