SPECTRAL ESTIMATIONS OF TEMPERATURES IN MICROPLASMA DISCHARGES IGNITED ON CONSTRUCTION STEEL SAMPLES

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To develop the physical fundamentals of metal surface plasma processing and modification technology for construction materials [1] the optical emission spectra of micro plasma discharges (MPD) initiated in vacuum ~2 Pa by a short pulsed plasma flow and supported by a pulsed electric current source (100–600 Å, 0.5–20 мs) were studied experimentally. Samples of steel 45 were initially annealed at 400 °C at air to obtain a surface partially covered with a thin dielectric oxide film. Such an approach allows MPD to form a developed steady wear-resistant microrelief on the sample surface [1–3]. Discharge spectrum may contain atom and ion line spectra, the molecular component, and a slowly varying thermal component due to the emission of the melted area on the sample surface under the discharge.

The electron temperature was estimated by spectrum lines of Fe atoms (Te = 0.45 ± 0.15 eV) and singly charged ions (Te = 0.9 ± 0.2 eV) assuming local thermodynamic equilibrium [2].
A noticeable difference between these estimates may be caused by the fact that the second value relates to the area at a certain distance from the sample surface, and is due to the plasma heating induced by electrodynamic forces in the MPD.

The Planck temperature is estimated from the continuous component of the spectrum relating to the light emission of the surface local melted areas, this gives the value of ~0.4 eV, which agrees well with the morphology of the resulting surface, since it corresponds to a pressure of several hundred atmospheres [4]. The temperature and pressure values for the surface areas under the discharge are important for understanding both the processes in the surface layer of the material being processed [1, 3] and the dynamics of the discharge itself [2].

The gas temperature is of special interest. The rotational temperature of molecules is considered its best approximation. The processed material contains carbon atoms, and the molecular spectrum of C2 can be used to estimate the temperature under different conditions. However, the molecular spectrum of C2 was not observed in our experiments with different steel types. To introduce additional carbon into the surface of the prepared sample, a thin Teflon sheet was put in contact with it. In these discharges, the molecular bands of the Swan system of the С2 radical were registered, including those related to the = 0 band of the a3Pu–d3Pg electronic transition, with an edge of 516.5 nm. These spectra bands remained in several subsequent pulses after the Teflon was removed. Comparing the spectra of the radical С2 registered with a resolution of 0.3 nm with similar CVD discharge spectra [5] having TR ~ 4 kK and with spectra of a propane–butane gas burner having temperature TR ~ 2 kK gives an estimate for the rotational temperature in microplasma discharges ~ 4 kK.

References

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