Nitrization of graphite during its interaction with nitrogen plasma jet

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The results of spectral analysis of the nitrogen plasma jet and graphite surface interaction zone provide quantitative data on the effect of the surface and volumetric graphite nitrization on the component composition of plasma. The analysis was conducted with spatial and temporal resolution as the graphite sample was heated to the temperatures of 2500 – 3000 K. An experimental setup was designed and constructed that included a generator of high-enthalpy (H>20 kJ/g) argon, nitrogen and air plasma jets with a diameter of 8-20 mm and a partitioned calorimeter that is designed to measure the heat fluxes in the plasma-sample interaction zone. The measuring equipment used also included three high-speed video cameras, two fibre-optic spectrometers, one MS5204i spectrometer with a high-sensitivity matrix at its outlet.

1. Experimental set-up

As the plasma generator, a plasma torch with vortex stabilization and an expanding outlet channel is used, which provides a high flow performance, efficient heating of the working medium and low thermal losses into a water-cooled surface of the anode. Broad research and technological capabilities of such plasma torches are presented in [1]. The plasma torch with an expanding output electrode (anode) 6 or 10 mm diameter creates a downstream plasma jet with a temperature at the anode outlet of 10000 – 15000 K, which is defined by the plasma forming gas (argon, nitrogen, air) and the current arc that varies in 100-400 A range. The plasma jet outflows into the air atmosphere at a rate defined by the plasma forming gas flow rate and plasma density at the nozzle outlet. Heat-resistant sample (in this case graphite) is located on the plasma jet axis at a selected distance from the outlet section of the plasma torch. The graphite sample has a cylindrical shape with the bottom flat surface being mounted on an uncooled tungsten rods 2mm in diameter.

Spectral systems for longitudinal and transverse scanning of the plasma jet emission enable continuous monitoring of the emission spectra with a spatial resolution of 0.5 mm throughout the tests. Monitoring of spatial-temporal changes of plasma emission spectra is performed by scanning of the plasma jet's sharp image formed by lenses using spectrometers' fibre optic light guides. The detailed picture of changes in the near-surface region of the plasma is recorded with a scale of 1:1 on the high-speed camera and MS 5204i spectrometer with an Andor matrix camera at the spectrometer's outlet. The Andor camera records plasma's spectral intensity distribution along the vertical z axis near the sample's surface (0 – 5 mm above the sample's surface) and thermal radiation of the heated sample in the selected spectral range.

2. Experimental results

As shown by a comparison of the experimental spectrum with the model, vibrational and rotational temperature of cyanogen drop when approaching the surface of the sample and the relative concentration of cyanogen increases rapidly (Table. 1). The latter is probably due to the nitrization of the carbon that is released into a high-enthalpy nitrogen plasma stream during the destruction of carbon sample in the process C+N→CN, this process commences at high temperatures in both the gaseous environment around the sample and on the sample's surface [2, 3].

Table 1. Temperatures and relative plasma component concentration above the investigated graphite sample

Distance from the surface, mm	Vibrational temperature, K	Rotational temperature, K	Relative concentration of CN	Relative concentration of N2+
2	7800	5500	0,80	0,20
1	7500	5000	0,87	0,13
0	7000	5000	0,95	0,05

Another essential carbonaceous component that was observed in the surface region, is a strong spectral line C I 247,8 nm.

3. References

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