**The possibility of the plasma jet functionalization of carbon nanomaterials**

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The functionalization of carbon nanomaterials solves a number of urgent tasks in the fields of materials science, electrochemistry and catalysis by creating multifunctional nanostructures with desired electronic and catalytic properties. Most of the available techniques are related to the functionalization by chemical vapor deposition (CVD-method) [1]. The use of plasma for oxidative functionalization at atmospheric pressure [2] and the arc discharge [3] is well known. Nevertheless, it remains the problem of scaling the process of functionalization with maximum preservation of the morphology of nanomaterials. From this point of view the application of plasma torches are of interest.

For the functionalization of graphene and carbon nanotubes the dc plasma torch with an expanding channel output electrode and the vortex stabilization of the arc was used. The maximum power was 45 kW. The advantage of the plasma torch is in the simultaneous input of carbon source with the working gas and the possibility of regulation of the cooling rate of carbon vapor. Helium and nitrogen are used as working gases at pressures from 75 to 750 Torr. Ethanol served as the source of carbon. Preliminary spectral characteristics of the plasma jet were studied. It was found that the introduction of ethanol in the discharge gap insignificantly reduced the maximum electron temperature in an argon plasma from 14500 to 14000 K. The optimal conditions for the process flow of working gas (argon 3.0 g/s, helium 0.5 g/s) and ethanol (0.027 ml/s) have been found.

Scanning electron microscopy, elemental analysis and thermal analysis were used to study the surface features of the resulting products. Graphene and carbon nanotubes on their surfaces contained oxygen groups which provide thermal stability of the structures at oxidation in air up to 1000 K. Loss of mass was around 5%. In the micrographs was observed a characteristic features of morphology for graphene structures and threadlike nanotubes [2–3].

In general the experimental data was acquired that demonstrated the possibility of modifying the surface of carbon nanomaterials from different functional groups by using the plasma torches in a single step in scalable quantities.

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References

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