Investigation of synthesis of graphene materials using pyrolysis of hydrocarbons in thermal plasma

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Most of the available methods to obtain graphene related to mechanical or chemical cleavage of graphite or epitaxial growth of graphene films. These methods do not provide opportunities for large-area graphene and high quality. Significant progress was made recently by the method of chemical deposition from the gas phase graphene (CVD-method) on Ni-substrate, followed by transferring it to an arbitrary substrate.

Nevertheless, there is a problem of scaling of production of graphenes. From this point of view, very promising application of the thermal plasma when the plasma torches are used. The advantages of the proposed approach compared with the electric arc method [1] of the graphenes are: the possibility of a substantial increase in productivity by continuous operation; the opportunity to work with the starting materials in various states of aggregation; possibility of optimizing the process by independent control over a wide range of pressure, of energy input and plasma gas flow rate and a carbon containing substance; possibility of forming the stream using a variety of additional devices (nozzles), and by changing the geometrical parameters of the plasma torch. When using a plasma jet reactor based on the DC plasma torch in [2] pure layered graphenes were produced. Thus the number of graphene layers was controlled by an ethanol consumption. As the plasma gas argon was used at atmospheric pressure.

The synthesis of graphene plasma has been investigated used DC plasma torch up to 40 kW with an expanding channel of the output electrode and the vortex stabilization of the arc. As the plasma gas helium or argon at pressures of 200 to 730 Torr were used. Carbon source were the most affordable and provide high performance gases - methane and propane butane when the content in the gas phase from 2 to 20%. It was first investigated the effect of propane butane and methane on the characteristics of the plasma torch, set limit their expenses. By variation of gas flow rate and composition of a gas phase it was established that the highest yield (80%) of graphene is formed in the environment of helium at 350 Torr at a flow rate of 0.75 g/s. Several smaller the yield of graphenes (56%) was in argon at a flow rate of 3.75 g/s, but with the amorphous carbon and the graphitized particles. Synthesis of graphenes (ordinary sheets and crumpled sheets) was demonstrated by scanning electron microscopy. The large area graphenes with a typical size of up to 1500 nm have been found. Phase composition and thermal stability of the obtained materials were investigated by thermal analysis methods. Specific surface area of sheeted graphene measured by the standard method was 300 m2/g. In general the experimental data allowing scaling step by step the synthesis of graphene of desirable morphology are obtained.

References

1. Wu Y. et al. // Nano Res. 2010. V.3(9) P.661
2. Kim J. et. al. // Nanotechnology. 2010. V21. P.1