SYNTHESIS OF GRAPHENE AND ITS DOPING AT THE CONVERSION OF METHANE IN THE NITROGEN PLASMA

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Graphene - a material one atom thick is currently one of the most popular in the field of fundamental and applied research. This is due to its unique electronic properties: charge carriers in graphene behave like photons or massless quasiparticles with a constant "effective" light speed [1]. Another feature of graphene is the absence of an energy gap, which creates a set of problems for graphene implementation in nanometer-scale electronics. To control the electronic structure of graphene, it is doped with various atoms, including nitrogen [2]. There are many different ways to produce nitrogen-doped graphene (N-graphene), based on either the introduction of an impurity into the graphene lattice initially not containing nitrogen atoms, or using of nitrogen-containing reagents in the process of processing graphene [3].

The present work is devoted to an experimental study of the synthesis of nitrogen doped graphene by using a plasma jet and to the study of its gas phase components.

To generate a plasma jet, a plasma torch of direct current up to 35 kW with an expanding channel of anode and vortex stabilization of the arc has been used. Methane conversion was carried out in a nitrogen plasma at fore vacuum and atmospheric pressures. Varying the ratio of nitrogen and methane expenditure, arc current intensity and plasma torch power, optimal synthesis conditions for graphene and N-graphene were obtained.

To analyze the effect of the gas phase in the plasma jet on the synthesis processes, modeling of its gas composition was performed using the own software complex RADICAL. The change in temperature during the synthesis was taken into account. As a result of the kinetic analysis, reactions are revealed, from which components such as C2H2 and C6H6 appear which are the precursors of the formation of graphene sheets. The peculiarity of the process is that the plasma contains atomic nitrogen with a concentration of fractions of a percent, which is approximately constant throughout the synthesis, which is explained by the cyclic process involving N2, CH2, CH, HCN, CN, NH, H and H2.

Studies of synthesis products using electron microscopy, express gravimetry, X-ray photoelectron spectroscopy (XPS), and X-ray diffraction showed that free-standing flakes of graphene materials with a small number of layers are formed in volume during the conversion of methane in nitrogen plasma at atmospheric pressure. At a methane consumption of more than 0.4 g / s, products are formed in the structure of which nitrogen is present. According to the results of thermal analysis, a nitrogen impurity significantly increases the temperature stability limit compared to initial graphene. XPS methods show that pyridine nitrogen predominates in N-graphene, which is not an electron donor. In general, the obtained results demonstrate the possibility of a without catalytic synthesis of N-graphene in a plasma jet reactor.

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