impact of ion energy on the plasma-assisted synthesis of Graphene

E.G. Shustin, N.V. Isaev, I.M. Kotelyansky, V.A. Luzanov, E.N. Mirgorodskaya, and M.P. Temiryazeva

Kotelnikov Institute of Radio Engineering and Electronics Russian Academy of Sciences, Fryazino, Russia

The report is devoted to the development of the technology of plasma-chemical synthesis of graphene suitable for use in nanoelectronics, and to investigation of factors affecting the structure of the synthesized films.

The main methods to obtain graphene are currently mechanical or chemical exfoliation of graphene flakes from the surface of high-oriented pyrolytic graphite (HOPG) and CVD deposition of graphite on metal substrate catalysts. The most pressing challenge is producing structurally perfect graphene for nanoelectronics. The main efforts of the researchers now focus on finding ways of deposition of single-crystal graphite on substrates that can play the role of epitaxial growth catalysts. The high temperature required for the synthesis of graphene by CVD method create major problems for obtaining structurally perfect graphene. Therefore, increasing attention is drawn to the possibility of the synthesis of graphene in plasma enhanced processes (PECVD). It was shown that the use of plasmas for the synthesis of graphene can significantly reduce the process temperature up to 500-600°С. However, in all the works on PECVD synthesis of graphene published so far only polycrystalline graphene with a high density of defects was produced.

In the synthesis of graphene by PECVD method explicitly or implicitly assumed that the role of the plasma is reduced only to the decomposition of hydrocarbons. The influence of plasma on the growing film of graphene is considered as a negative effect; therefore, these impacts are trying to minimize (remote plasma enhanced process). When this energy spectra of ions and their influence on the structure of synthesized films practically not been studied.

In this work we investigate the influence of low energy ions from the plasma acting on the deposited film on its structure. The synthesis was carried out in the reactor on the basis of the beam-plasma discharge [1]. As the substrate used plates atomic-smooth sapphire deposited Nickel films with a thickness of 200-500 nm. Was possible to maintain the substrate temperature in the range 900 is C. To control the plasma potential, and consequently, energy entirely her ions used a special electrode in contact with the plasma.

It is shown that the structure of the synthesized films is very sensitive to the energy of bombarding ions: polycrystalline graphene was formed in the range of energies *Eion*= 5-10 eV. At ion mean energy *Eion* <5 eV amorphous carbon film is created; at *Eion* >10 eV competition of the processes of deposition of diamond-like films (DLC) and ion etching is observed. Predominating process is determined by the temperature of the substrate and by the rate of sputtering the graphite target. Currently, in our experiments the obtained graphite films do not inferior to the published results on PECVD synthesis of graphene in the structural characteristics.

This work was supported in part by the Russian Foundation for Basic Research (project no. 14-08-00143)

References

1. N. V. Isaev, I. L. Klykov, V. V. Peskov, E. G. Shustin, I. V. Vizgalov, and V. A. Kurnaev Instruments and Experimental Techniques, 2014 V57 p.82