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表面波プラズマCVD法によるカーボンナノ材料の低温合成に関する質量分析研究
Mass Spectrometric Study on the Low-temperature Synthesis of Carbon Nanomaterials by Surface-wave Plasma CVD

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Electronic devices currently hold an important place in human life. During the past two decades scientists all over the world make a lot of efforts to fabricate electronic devices based on the carbon nanotubes (CNTs). Significant progress have been made in this field: direct synthesis of CNTs from controlled locations on surfaces of the substrate, direct synthesis on different substrates including metal electrodes also has been achieved [1]. These accomplishments helped implement many applications like CNT-based field-effect transistors, sensors and others. However, despite this progress, high temperature of the CNTs synthesis limits the number of potential applications of CNTs. A lot of efforts have been made to reduce the temperature of growth in order to make the nanotube fabrication compatible with more substrates and applications. Different ways to reduce temperature have been proposed, but one of the most promising methods to realize low-temperature synthesis of carbon nanomaterials (CNMs) is the plasma-enhanced chemical vapor deposition.

Recently we demonstrated successful synthesis of CNTs onto polyimide substrate by microwave-exited surface-wave plasma CVD at relatively low-temperature of 250℃ using double-step treatment: NH_3 plasma pre- treatment and CNMs growth in NH_3/CH_4 plasma [2]. However few-layered graphene sheets have been observed together with multiwalled CNTs, what can be problem in case of real application of obtained material. To solve a problem of controllable growth of each type of CNMs it is necessary to understand mechanism of CNMs growth. To do it, in this study, we carried out the investigation of positive ions containing in the plasma used during the pretreatment as well as CNMs growth.

The results of NH_3 plasma investigation are presented in Fig. 1. It is seen that mass spectrum of the studied plasma consist of several peaks corresponding to different types of positive ions. Various ions have a different effect on the treated sample, i.e. hydrogen ions are responsible to the etching of amorphous carbon from the substrate while the nitrogen containing ions may lead to the surface modification of sample. Thus, it is very important to find correct ratio of the ions peaks to be able to get high quality CNMs. Inset of Fig. 1 demonstrates dependence of NH_3^+/H_3^+ and NH_3^+/H_3^+ ions intensities on the microwave input power. When this ratio is high, etching effect of ammonia plasma is not very strong, because relative concentration of hydrogen ions is rather low, and oppositely, low NH_3^+/H_x^+ ratio means existence of large amount of hydrogen ions in plasma and therefore we can expect that plasma at these conditions have strong etching effect. The details of this experimental work will be presented at the conference.

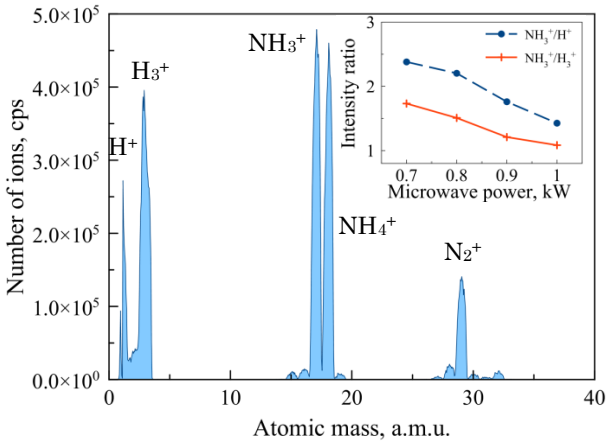

Fig. 1 Mass spectrum of positive ions in NH_3 plasma. Inset: efect of the input microwave power on ions peaks intensity ratio.

References

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