Selective fabrication of graphene oxide by tribo-chemical reaction by using atomic force microscopy

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The modification of graphene surface has been widely studied to expands its potential for practical applications such as electronic devices and sensors. However, almost all modification methods are complicated and involves multiple steps. Here, we propose a novel method to locally modify the graphene surface utilizing tribo-chemical reaction induced by asperity contact of atomic force microscopy (AFM). We demonstrate the modification method by fabricating graphene oxide. The degree of oxidation was examined by X-ray photoelectron spectroscopy (XPS). The results show tribo-chemical reaction induced by AFM can modify graphene surface and the degree of reaction can be controlled by frictional condition.

Keywords: oxidation, graphene, friction, XPS, AFM

1. Introduction

In recent years, graphene has been widely studied due to its excellent properties. In addition, many researchers attempt to modify the inherent physical and chemical properties of graphene surface in order to expands its potential for practical applications such as electronic devices, catalysts and sensors [1]. As an example of existing research, the technology to develop integrated circuits (IC) by selectively modifying graphene on silicon wafers was studied [2]. However, the method developed is complicated and involves multiple steps. To simplify the process of surface modification of graphene, here we propose a novel method to locally modify the graphene surface utilizing tribo-chemical reaction induced by asperity contact of atomic force microscopy (AFM). In this study, we demonstrate the modification method by fabricating graphene oxide. The degree of oxidation was examined by X-ray photoelectron spectroscopy (XPS).

2. Experiments details

2.1. Manufacture method for graphene oxide

In our experiment, nanosheet graphene with single or double layers, made by chemical vapor deposition on a copper foil, was used. To generate a graphene oxide, we utilized a contact mode AFM (Nano Navi, Hitachi High-Tech, JP). The AFM test was conducted with the load of 5 to 160 nN to investigate the load dependency on the fabrication of graphene oxide. The AFM range is 100 μm × 100 μm. 10 cycles of scans were performed for each load condition. The test was done at room temperature and relative humidity 62%.

2.2. XPS Surface Analysis

XPS measurement was conducted to investigate the degree of oxidation. The binding energy was calibrated by C(1s) peak energy (284.8 eV) as an energy standard.

3. Results and Discussion

Figure 1 shows the spectrum of C 1s of graphene sample rubbed under 5 and 160nN. The intensity of C-O band of 160 nN is higher than that of 5 nN. Figure 2 shows load dependence of intensity ratio of C-O /C-C. The ratio increases as increase in the applied load. These results indicate that friction induced the chemical reaction between graphene and adsorbed water, led to formation of graphene oxide. Moreover, increase in applied load promoted the reaction. This suggests that tribo-chemical reaction induced by AFM enables to modify graphene surface and the degree of reaction can be controlled by frictional condition.

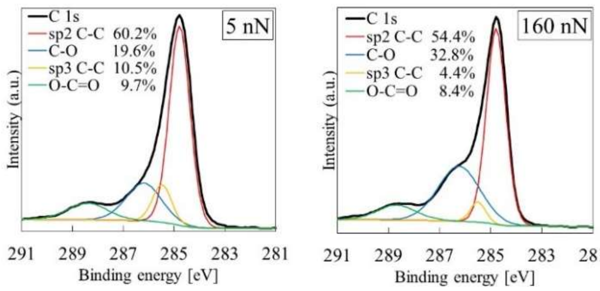

Figure 1: The spectrum of C 1s loaded 5 nN and loaded 160 nN.

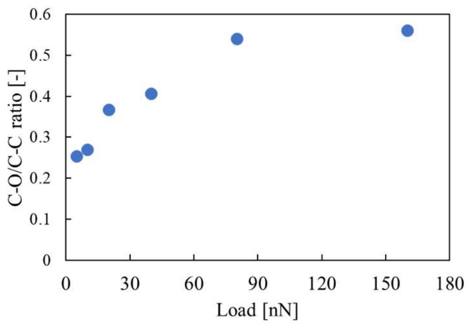

Figure 2: C-O/C-C ratio for each load.

4. References

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