PROPERTIES OF CARBONACEOUS FILMS PREPARED BY PLASMA CVD METHOD

H.Kakiuchi and T.Terai
Department of Quantum Engineering & Systems Science, University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan

Introduction

Diamond-like carbon (DLC) films have some interesting properties, including extreme hardness, high electrical resistivity, low friction coefficient and good adhesion properties to several materials such as iron and plastics. Although DLC is often used for coating application, DLC study is still in progress in comparison with that of synthetic diamond. We have been investigating the prepa-ration and the properties of DLC synthesized by several methods.

In this paper, we describe the results on the preparation of DLC thin films by plasma assisted CVD method, and their electronic properties and microstructure investigated by electronic property measurement, XPS, and ERDA. The influence of growing conditions on the electronic properties is discussed.

Experimental

DLC thin films were prepared by RF plasma assisted CVD method using CH_4 gas. A series of films were grown on Si substrates (99.999 %, high-resistivity grade: n-type) under the following deposition conditions; the radio frequency (13.56 MHz) power was 150 W, the total working gas pressure was 2, 20 and 500 Pa, and the deposition time was 4 hour. The substrate temperature was not controlled (about 40 ℃). The microstructure of these films was characterized by XPS (X-ray photo-electron spectroscopy) and ERDA (elastic recoil detection analysis). Electric resistance measurement was carried out as shown in Figure 1.

Result and Discussion

Figure 2 shows the XPS C1s spectra of a DLC thin film (500 Pa) and HOPG (highly oriented pyrolytic graphite). These spectra are corrected by the O1s peak on the specimen. The peak of the DLC thin film (285.0 eV) shifted from the position of the graphite peak (284.3 eV) to that of the diamond peak (287.5 eV: [1]), and the full-width at half-maximum of the spectrum of the DLC thin film was wide in comparison with that of HOPG (graphite). From these results, it is considered that the bonding of carbon atoms in DLC thin films obtained are mainly sp^2 and sp^3, which are mixed with each other.

Figure 3 shows the dependence of the hydrogen content of DLC thin films from ERDA on the working gas pressure. The hydrogen contents of the DLC thin films were about 27 to 38 at%, which was in the range shown in literature (about 17 to 60 at%) [2]. It increased with working gas pressure.

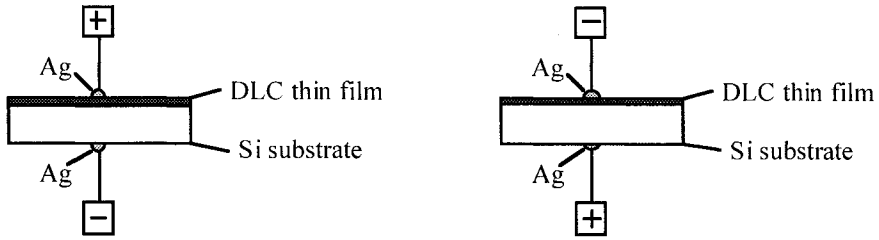
Figure 4 shows the result of electric resistance measurement. There was a big difference (2 orders of magnitude) in resistance between forward and reverse directions, which shows these samples have a diode-like rectification property. A similar result is shown in Figure 5, showing the I-V characteristic of the forward and reverse directions synthesized in 2 Pa. Electric current increases and tends to become saturated with applied voltage, which suggests that these samples show the Schottky barrier behavior.

Conclusions

DLC thin films were synthesized on Si substrate by RF plasma assisted CVD method, and their characteristics were investigated. The films on the Si substrates prepared showed a diode-like rectification property and the Schottky barrier behavior.

References

1. Handbook of X-ray Photoelectron Spectroscopy: JEOL.
2. J. C. Angus and F. Jansen, J. Vac. Sci. Technol. A6 (1988) 1778.



(a) forward direction (b) reverse direction

Figure 1. Connection in electronic property measurement

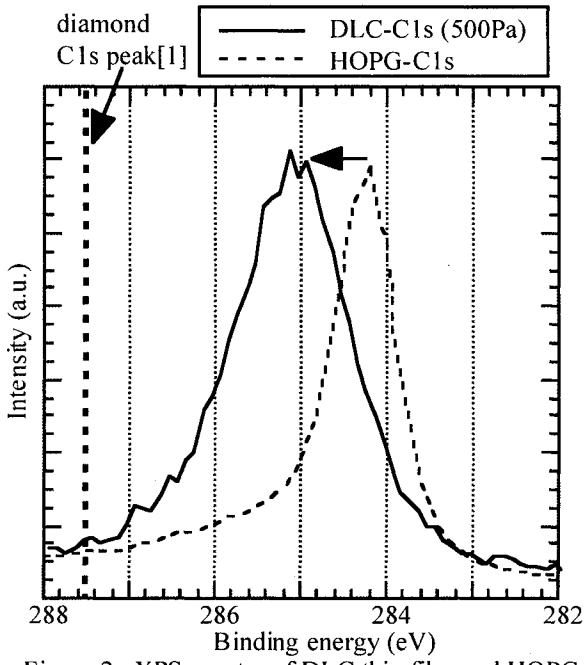


Figure 2. XPS spectra of DLC thin film and HOPG

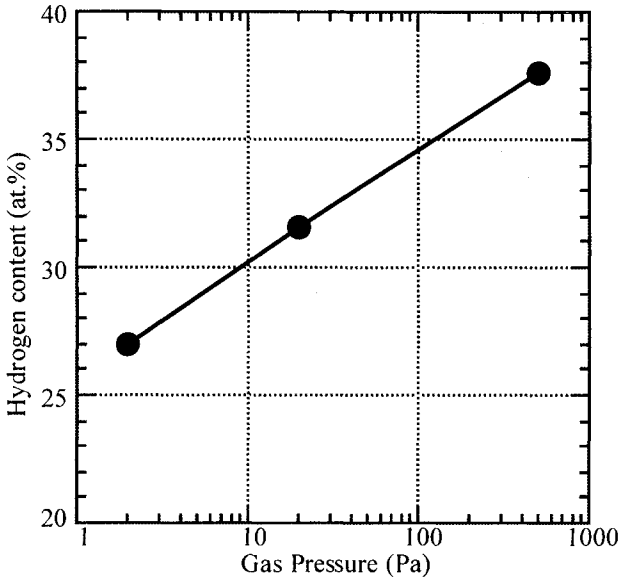


Figure 3. Dependence of hydrogen content of DLC thin film on gas pressure

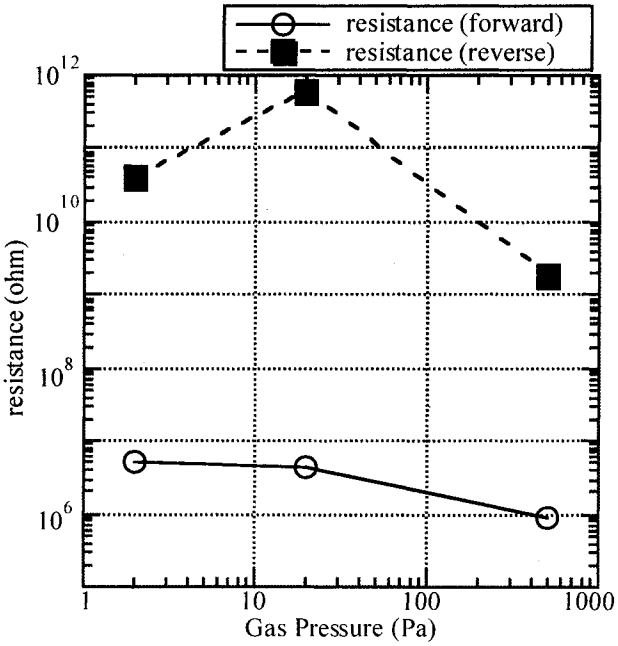


Figure 4. Electric resistance of forward and reverse directions

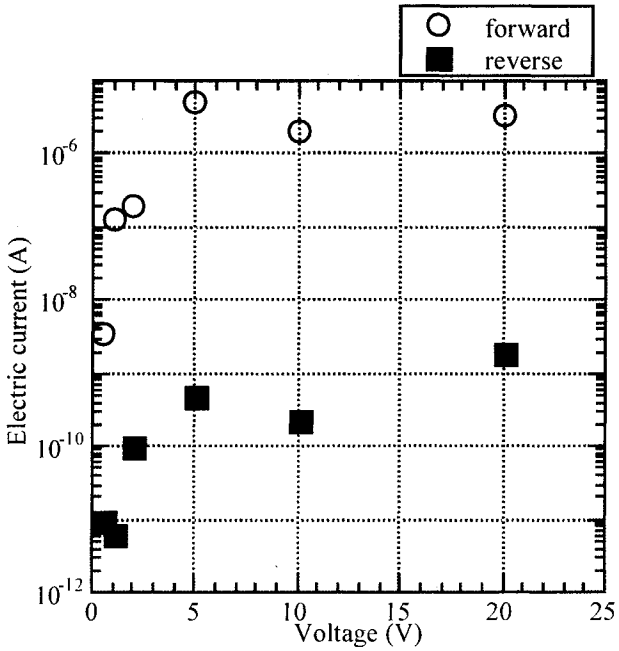


Figure 5. I-V characteristic of forward and reverse directions (gas pressure 2Pa)