L-10

Ion Implantation into Diamond Like Carbon Films by Focused Ga^{+} Ion Beam

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Diamond-like carbon (DLC) is an amorphous carbon which shows intermediate structure between diamond of insulation and conductive graphite. The electrical resistivity of intrinsic DLC (i-DLC); ie, constructed sp^3 rich carbon in fourth group elements, has high electrical resistivity. We can control the electrical resistivity of i-DLC films by doping impurities, such as third group elements. Furthermore, the focused ion beam (FIB) [1] can implant the three group element with microscopic wire shape on the DLC film. In this study, we are measured the electrical resistivity of DLC films that is implanted gallium ion (Ga^{+}). The Current of deposited DLC films are measured by two probe method. As a result, the electrical resistivity of implanted DLC film is decreased from 0.18 [kΩ・cm] to 0.23 [Ω・cm] under -3.0 [kV] of negative bias voltage.

1.Introduction

Diamond-like carbon (DLC) have amorphous carbon structures which contain both sp^2 (graphite) and sp^3 (diamond) binding. DLC have various characteristics, such as high hardness, optical transparency, high electrical resistivity and chemical inertness. Taking advantages of these characteristics, the DLC have been used for many things. For instance, DLC have been used to coating film of magnetic hard disk and silicon solar cell. These characteristics arise from the sp3 component of their binding. In recent years, DLC have been focused as new material. By doping impurities in third or fourth group elements to DLC in fourth group elements, its electrical characteristic is changed. Previous report shows that we can control the electrical resistivity of amorphous carbon wire fabricated by focused ion beam (FIB) [3]. In this study, we deposit i-DLC films on the glass substrates by ion plating method [2], then the focused Ga$^+$ ion beam is irradiated to the surface of i-DLC films. We measure the current-voltage (I-V) characteristics and the electrical resistivity of deposited films by two probe method.

2. Method

The i-DLC films were deposited on the glass substrates (size: 2 [cm]×2 [cm]) by ion plating method (gas: C_6H_6 (10 [sccm]); negative bias voltage: -3.0 [kV]; filament current: 30 [A]; anode voltage: 60 [V]; reflector voltage: 20 [V]; pressure in chamber: 2.1×10^{-3} [Torr]; and fabrication time: 60 [min.]). To prevent charge up in irradiating beam, the electrodes of Au film were deposited on the i-DLC films by ion sputtering. The focused Ga$^+$ ion beam (ion source of beam: Ga; acceleration voltage: 30 [kV] and beam current: 5322 [pA]) was irradiated to the surface of i-DLC films. Furthermore, focused Ga$^+$ ion beam was irradiated to the surface of i-DLC films with increasing dose amounts from 1.0×10^{11} to 1.0×10^{17} [ions/cm^2]. Fig.1 shows processed model. Qualitative analyses of the deposited films were measured by Raman spectroscopic analysis. Current-voltage (I-V) characteristics of deposited films were measured by two probe method.

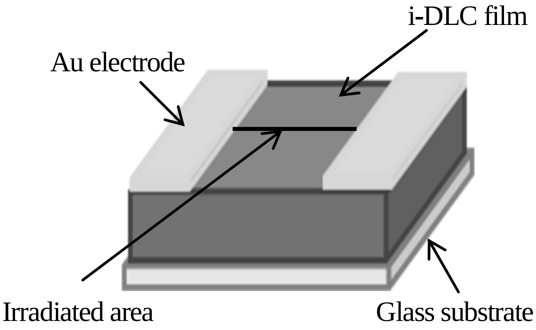

Figure 1. Processed model

3. Results

Figure 2 shows Raman spectra of deposited films by Raman spectroscopic analysis. The peaks of G-band are obtained at Raman shift of 1580 [cm^{-1}]. And the peaks of D-band are obtained at Raman shift of 1350 [cm^{-1}]. These spectra are peculiar broad spectra of DLC. It is confirmed that deposited films on the glass substrates are DLC films. Figure 3 and Figure 4 show I-V characteristic of deposited films by two probe method. Current of i-DLC film is not found to increase with increasing voltage. However, current of implanted DLC film is found to increase with increasing voltage. Compared i-DLC film with implanted DLC

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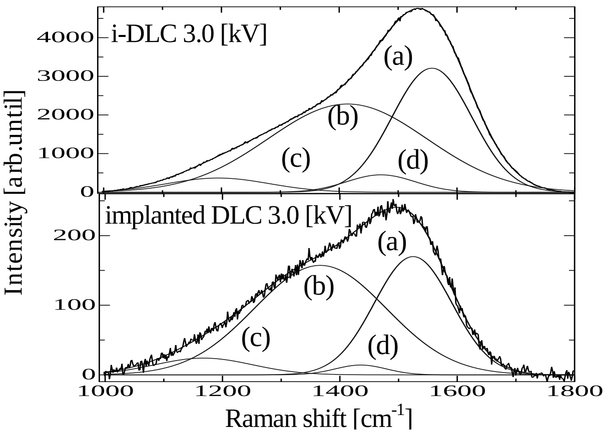

(a) G-band (b) D-band

(c) C-C binding (d) C=C binding

Figure 2. Raman spectra of DLC films

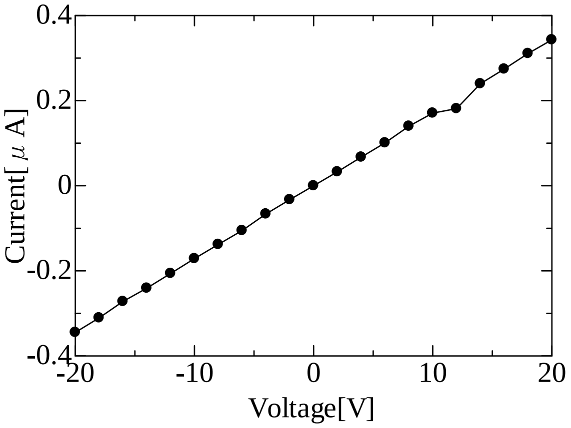

Figure 3. I-V characteristics of i-DLC film

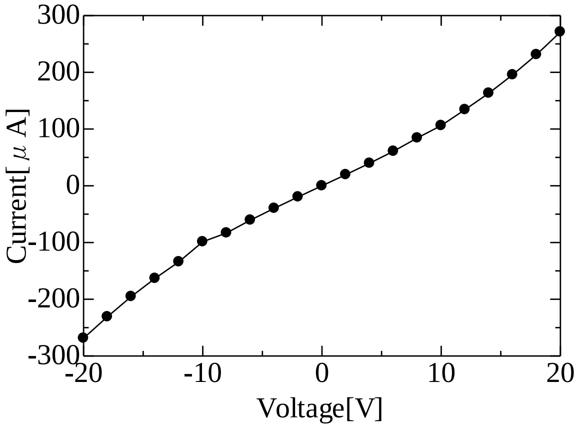

Figure 4. I-V characteristics of implanted DLC film

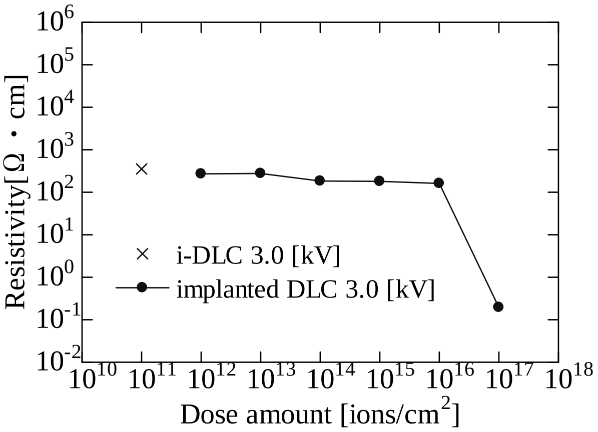

Figure 5. The electrical resistivity of DLC films

film, current of implanted DLC film was 1000 times higher than current of i-DLC film. Figure 5 shows the electrical resistivity of implanted DLC when dose amount of Ga$^+$ focused ion beam changing from 1.0×10^{11} to 1.0×10^{17} [ions/cm^2]. The electrical resistivity is shown exponentially decreased with exoinetially increasing dose amount of Ga$^+$ ion beam.

4. Conclusion

In this sutudy, We deposit i-DLC films on the glass substrates by ion plating method. The Raman spectra of deposited films show peculiar broad spectra of DLC film. It is confirmed that deposited films are DLC. The electrical resistivity of i-DLC film is decreased when Ga+ ion beam are irradiated. Thus, the electrical resistivity of i-DLC film is decreased with increasing dose amount of Ga$^+$ focused ion beam. We think that it arise from Ga$^+$ ion are combined with carbon of DLC film.That is to say, FIB may be able to inject Ga$^+$ ion to sample. If this is certain, we can control the electrical resistivity of DLC films.

5. Reference

[1] T. Adachi: “FIBsouchitosonoouyou”, Denshikenbikyou, Vol30, No3, pp112 (1996)

[2] Tnaka, Uemura, Ida, Nikai, Suzuki: “Synthesis of n-DLC:P/p-Si Photovoltaic Cell Using an Ion Beam Plating Method” ,Special Issue of Nihon University CST (2008) Annual Conference-Report of RISTNU-, pp.87-89

[3] J.Igaki, K.Kanda, Y.Haruyama, M.Ishida, Y.Ochiai, J.Fujita, T.Kaito, S.Matui: “Comparison of FIB-CVD and EB-CVD growth characteristics” Microelectronic Engineering, 83, pp1225-1228(2006)