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Measurement of contractual stats between several metals and Ga ion implanted DLC

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Abstract: Metal materials which have ohmic contact property is necessary to control electric device. We investigated a contact state between metal and Ga ion implanted diamond-like carbon (DLC) thin films empirically. Materials of metal electrode were Aluminum (Al), Platinum (Pt) and Aurum (Au). Fabrications of metal electrodes were used photolithography and each method (Al: vacuum based deposition; Pt: FIB-CVD [1]; Au: ion spattering). We implanted Gallium (Ga) ion into DLC film between metal electrodes by scanning focused ion beam (FIB). [2] I-V (current-voltage) characteristics of these samples were measured by two probe method. Results of I-V characteristics which electrode used Au and Pt showed schottky properties. In the case of Al electrodes, this result showed property of warm carrier devises. [3] This property was effected by ohmic contact. [3] For this reason, contact between Al electrode -ion implanted DLC film were ohmic contact.

1. Introduction

Electronics devices were requiring improvement of downsizing and mechanical strength by development of electronics technology. We focused on diamond-like carbon (DLC) that acheive these electrical and mechanical requests. Because DLC have been utilized in several applications such as optoelectronic materials and micro-/nano-electromechanical devices. DLC formed amorphous carbon with sp^2 and sp^3 bonding. DLC possesses various attractive properties such as high hardness and wear resistance, low friction coefficient and high resistance, optical transparency and gas impermeability.[4] For leveraging DLC in electronic devices, we performed ion implantation into DLC film by focused ion beam (FIB) fabrication. The FIB could fabricate the following advantages for sample fabrication. First, Ga^+ FIB could implant gallium ions as acceptors impurity in carbon. Second, implantation dose amount could be easily controlled by FIB condition. Third, FIB could perform etching and deposition of arbitrary configurations. The contact state of metal-semiconductor is important factor for fabrication of electronic devices, because contact of metal-semiconductor has schottky properties or ohmic properties. In this study, we investigated electrical characteristics of the contact state between several metal electrodes (Pt, Au and Al) and ion implanted DLC film.

2. Method

We deposited intrinsic DLC (i-DLC) thin film on glass substrate (size: 2 cm × 2 cm) by ion beam plating method, and shows diagrammatic illustration of ionized deposition method in Figure 1.[5] Condition of deposition was negative bias voltage: -0.5 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. Figure 2 shows process of sample fabrication. Metal electrodes were fabricated on i-DLC by photolithography. These were fabricated by three types method (Al: vacuum based deposition; Pt: FIB-CVD; Au: ion spattering). [3] We performed Ga ions implantation in the DLC film. Furthermore, Ga^+ focused ion beam was irradiated to the surface of i-DLC films width dose amounts: 1.0×10^{17} ions / cm^2. Sizes of ion implanted part were height: 10 μm; width 350 μm. I-V (current-voltage) characteristics of these samples were measured by two probe method.

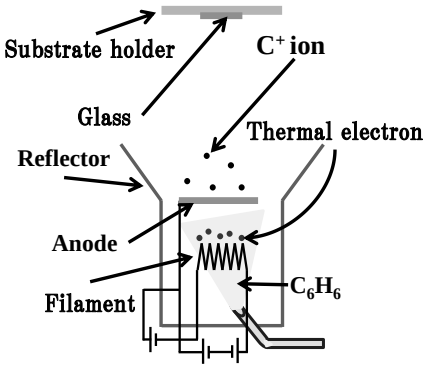
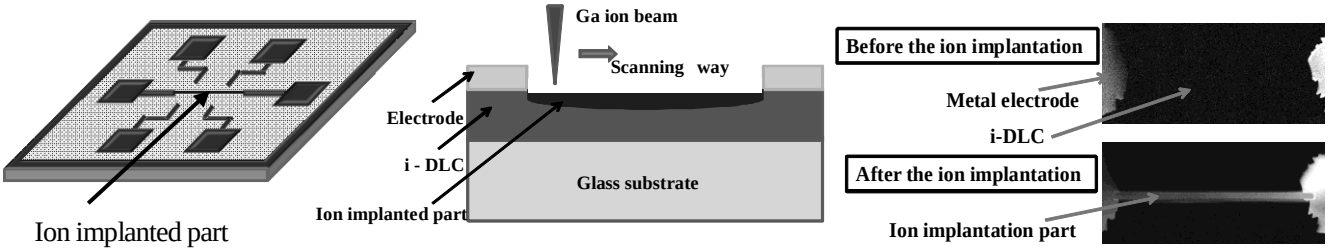


Fig. 1 DLC deposition model



(a) Top view **(b) Cutaway view** **(c) SIM image**

Fig. 2 Sample pattern diagram

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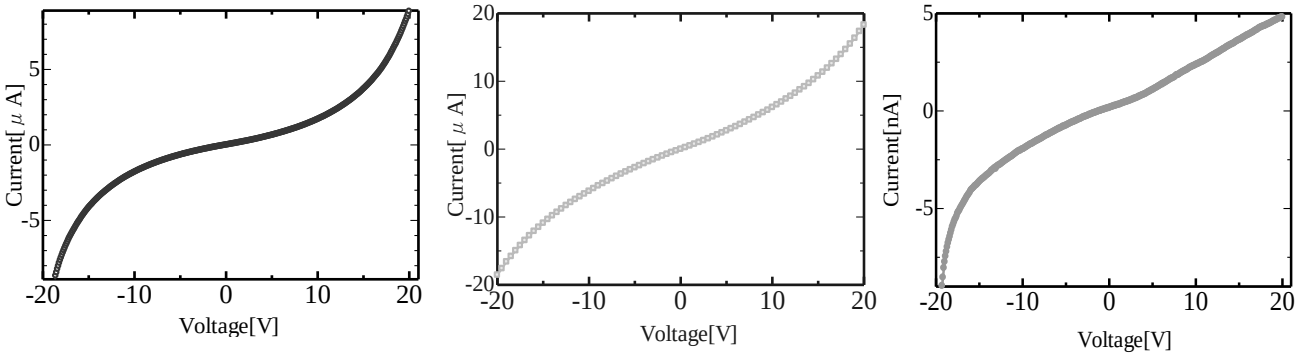
３．Results

Figure 3 shows I-V characteristics of each metal electrode by two probe method. Figure 3 (a) and Figure 3 (b) were nonlinear. These results showed schottky contact property. Figure 3 (c) was nonlinear. However, this result wasn't schottky property because linearity of I-V characteristics was showed in positive voltage range. This property was similar to properties of warm carrier devices. This property appear in case of ohmic contact, and was caused by difference of contactual forms which were both ends of semiconductor. I-V characteristics shows nonlinearity even if a contact is ohmic contact. Figure 2 (c) showed SIM images of non-implanted and ion-implanted films. The difference of electrodes form could be seen from figure 2 (c). Thus we calculated figure 3 (c) as warm carrier property. the contact state between Al and Ga ion implanted DLC was ohmic property. These results of I-V characteristics were caused by difference of work function. Pt, Au and Al each had resident work function (Pt: 5.3 eV; Au: 5.1 eV; Al: 4.5 eV). Metals which bear work fanction higher than 5.1 eV showed schottky contact and metals which bear work function lower than 4.5 eV showed ohmic contact.



(a) Pt electrode　(b) Au electrode　(c) Al electrode

Fig.3 I-V characteristics of each metal

４．Conclusion

I-V characteristics of figure 3 (a) and figure 3 (b) showed schottky property. Contact states between these metal electrodes (Pt and Au) and Ga ion implanted DLC was shottky contact. Hence, Pt and Au with implanted DLC can be applied to shottky diodes. I-V characteristics of contact state between Al electrodes and DLC was property of warm carrier devices. Thus, this contact proved to be ohmic contact. Warm carrier devices property are formed by difference of both electrode figuration. Ohmic property are formed by same electrode figuration. Al can be used to warm carrier devices and ohmic electrode for electronic devices with Ga ion implanted DLC.

５．Reference

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