Journal of the Korean Institute of Electrical and Electronic Material Engineers, Vol. 19, No. 5, p. 477, May 2006.

논 문 19-5-13

Properties of Carbon for Application of New Light Source Technology

Sang Heon Lee[1,a]

Abstract

Carbon films was grown on Si substrates using the method of electrolysis for methanol liquid. Deposition parameters for the growth of the carbon films were current density for the electrolysis, methanol liquid temperature and electrode spacing between anode and cathode. We examined electrical resistance and the surface morphology of carbon films formed under various conditions specified by deposition parameters. It was clarified that the high electrical resistance carbon films with smooth surface morphology are grown when a distance between the electrodes was relatively wider. We found that the electrical resistance in the films was independent of both current density and methanol liquid temperature for electrolysis. The temperature dependence of the electrical resistance in the low resistance carbon films was different from one obtained in graphite.

Key Words : Carbon, Methanol, Si, Film

1. INTRODUCTION

Carbon was known to be a typical high temperature semiconductor, very inert to chemical substrances, and a number of attemps have been made to fabricate both passive and active electronic devices using diamond[1]. The thin films of diamond like carbon have recently attracted much interest for their potential use as hard, wear resistant films, and optical coatings. The method s known for depositing carbon films, such as pulsed laser deposition[2], and ion beam deposition[3], were all vapor deposition techniques. Using these techniques, high quality films and rapid growth rate have been achieved.

There was experimental evidence that most materials which can be deposited from the vapor phase can also be deposited in liquid phase using electroplating techniques and vice versa[4]. Suzuki et al.[5]. Recently made an attempt to deposit carbon phase in the films by electrolysis of a water ethylene glycol solution. Graphitic carbon had been obtained according to their Raman spectra. Nevertheless, ethylene glycol was a viscous solution, which will cause some difficulty in cleaning substrates after deposition. Since carbon films synthesized in the liquid phase has significant scientific and technological implications, it is worth pursuing research with other electrolysis. In this work, a film deposition was attempted in methanol solution by the techniques of electrolysis. Methanol is selected because its polarizability and conductivity are stronger than those of ethanol, and the structure of methanol is even closer to that of carbon.

1. Department of Electronic Engineering, Sun Moon University
(Tangjeong-myeon, Asan-si, Chungnam 336-840, Korea)
a. Corresponding Author : shlee@sunmoon.ac.kr

접수일자 : 2005. 7. 27
1차 심사 : 2005. 10. 3
심사완료 : 2006. 4. 5

2. EXPERIMENTS

A schematic diagram of the deposition system was shown in Fig. 1. Analytically pure methanol (99.5 %) was used as electrolyte. A silicon (100) substrate with a size of 15 × 20 × 0.3 mm^3 was mounted on the negative electrode. Before deposition the substrate were in the mixture of dilute HNO_3-HF solution for a few minutes and then cleaned by ultrasonic treatment. The distance between the substrate and positive electrode was set to 10 mm. The potential applied to the substrate could be changed from 0 to 5000 V under a constant temperature. The deposited films were examined by scanning electron microscopy(SEM).

3. RESULTS AND DISCUSSION

Carbon film is used a high resistance film with about 10^8 ~ 10^{11} Ωcm. Figure 1 is a schematic diagram of the deposition system. Considering the fabrication procedure used in this study, the carbon quality should be influenced by process parameters such as applied voltage, current density, distance between electrodes and solution temperature.

Figure 2 is the D.C. voltage change at a constant current density of 30 mA/cm^2 with distance between Si and graphite electrode. As shown in Fig. 2, in which the resistance more than 20 MΩ(marked H in figure) were observed at 35 ℃ constant solution temperatureat each electrode distance such as 3, 5, 10, 15, and 20 mm respectively. Low resistance marked L in

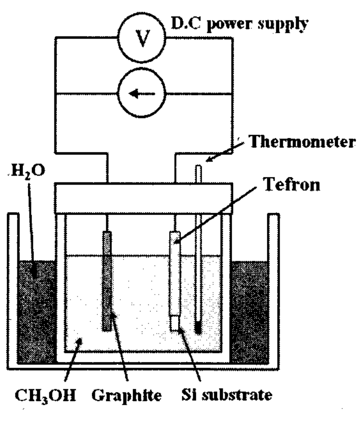

Fig. 1. Schematic diagram of the deposition system.

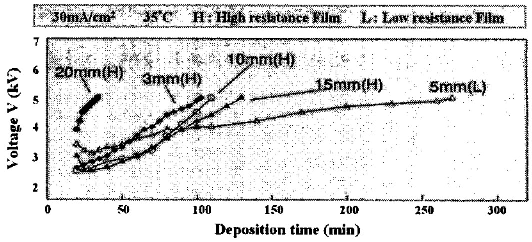

Fig. 2. Electrode distance and voltage change with deposition time.

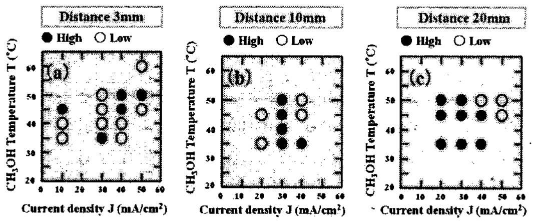

Fig. 3. Electrical resistance change with current density and solution temperature.

figure means about 10 kΩ ~ 100 kΩ varies. Since the current density was kept constantly during the measurement of resistance, the voltage increased with deposition time. One of interesting points in Fig. 2, the tendency of voltage increment depends on the resistance. For example, low resistance with 5 mm electrode distance shows moderate increment of the voltage, whereas, high resistance with different electrode distance like 3, 10, 15, and 20 mm shows stifflyincrement of the voltage. The moderate increment of the voltage means the deposition of carbon film with low resistance on silicon substrate. The high increment of the resistance results from the dopants of the carbon film with high resistance on the silicon substrate. From the Fig. 2, its voltage change during electrolysis deposition considered as one of the parameters to evaluate the final deposit.

Figure 3 is the resistance change with current density and solution temperature at a constant electrode distance. Solid and open circles in the Fig. 3 are carbon film with high resistance and that with low resistance, respectively. As shown

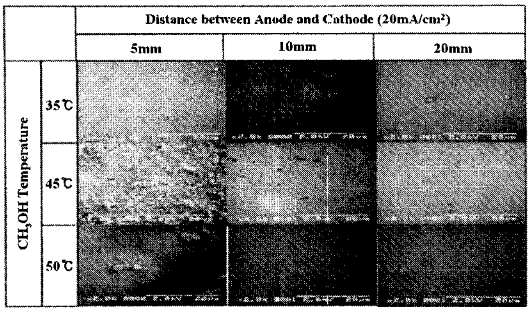

Fig. 4. Surface morphology change of carbon films with electrode distance formed at 20 mA/cm^2.

in Fig. 3, the carbon film with low resistance was well deposited than the carbon film with high resistance. As the electrode of distance was broad away from 10 to 20 mm, the carbon film with high resistance was well formed. Especially, the carbon film with high resistance was well formed at the vary of current density, 20 ~ 40 mA/cm^2 at 30 ~ 50 ℃. The surface of the carbon film is usually smoother than that of diamond film. The smoothness is one of important factor for the application of electronic device. The smoothness influence the effect of electric field emission, for the electronic field emitter, it is important to enhance the smoothness. In this study, methanol, CH_3OH, was electrolysis decomposed with electrode in distance. Figure 4 is surface morphology is observed by scanning electron microscopy. As shown in Fig. 4, rough carbon surface was observed at the current density of 20 mA/cm^2 and a constant electrode distance of 5 mm. The surface roughness was decreased while increasing electrode distance from 10 to 20 mm. This means that the surface roughness was increased with decreasing electrode distance, resultantly,the carbon film with low resistance was formed. However, the surface roughness was decreased with increasing electrode distance, resultantly, the carbon film with high resistance was formed.

In use of narrow electrode distance less than micro scale with high current density, electric spark was occurred, that increases the solution temperature. The high solution temperature by the electric spark changes the electrolysis deposition condition which results in decreasing surface smoothness and forming the carbon film with low resistance.

4. CONCLUSION

Carbon films were electrolysis on Si substrates in methanol solution. The carbon films with high electrical resistance and smooth surface were formed when the distance between the electrodes was relatively wider. Surface roughness was decreased with increasing electrode distance, which tended to form the carbon film with high resistance. The electrical resistance of the films was independent of both current density and methanol liquid temperature.

REFERENCES

[1] B. ate, "Electronic Properties and Applications", Kluwer Academic, Boston, Chap. 2, 1995.

[2] G. Celentano, C. Annio, V. Boffa, L. Cioneta, F. Fabbri, Gambradella, V. Galluzzi, and A. Mancini, "Superconducting and structural properties of YBCO thick films grown on biaxiaaly oriented architecture", Physica C, Vol. 341, p. 2501, 2000.

[3] Y. Dimitriev and E. Kashchieva, "Charge-density-wave transport properties", J. Mater. Sci., Vol. 10, No. 2, p. 1419, 1995.

[4] M. Murakami, M. Morita, K. Doi, and K. Miyamoto, "A new process with the promise of high Jc in oxide superconductors", Jpn. J. Appl. Phys., Vol. 28, No. 7, p. 1189, 1989.

[5] S. G. Lee and S. H. Lee, "Dielectric properties of creen-printed $(Ba,Sr,Ca)TiO_3$ thick films for microwave phase shifters", JKPS, Vol. 44, No. 2, p. 393, 2004.