Optical Properties of Amorphous Carbon Films by Ion Beam Sputtering Technique

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Abstract. Optical absorption and electrical resistivity measurements have been carried out on amorphous carbon films deposited by ion beam sputtering technique under the operating pressure of 5×10^{-4} Torr. Results show that both optical absorption in the IR-UV spectral region and electrical resistivity are higher than those deposited under lower operating pressure of $\sim10^{-5}$ Torr.

Introduction

The ion beam sputtering deposition technique is one of many techniques of making so-called amorphous "diamondlike" carbon films, because these films show extreme hardness, chemical inertness, high dielectric strength, optical transparency, large band gap, high electrical resistivity and high thermal conductivity. These characteristics seems to be affected by the deposition conditions such as the operating pressure and the net ion energy.

In this report, we investigated the influence of the operating pressure of 5×10^{-4}Torr. on the optical absorption and the electrical resistivity. This operating pressure is about ten times as high as that of other papers[1,2]

Experimental

An ion beam sputtering technique was used to deposit thin films of amorphous carbon on room temperature substrates (KBr single crystals and glass) under the following conditions; initial pressure in the deposition chamber, 2×10^{-6}Torr.; operating pressure, 5×10^{-4}Torr., net ion energy, 1 keV, Ar ion current density, 0.8mA/cm^2. The target material was a high-purity graphite plate. The average deposition rate was abut 4A per min..

The optical absorption in the IR-UV spectral region was measured at room temperature as a function of the photon energy.

The temperature dependence of the electrical resistivity of resulting films was measured from 77 to 300K.

Some of the deposited films on KBr single crystals were removed from the substrates and examined by electron diffraction. Electron diffraction measurements of these films were carried out to compare with the other amorphous carbon films.

Results and Discussion

The optical density of various film thickness as a function of photon energy is shown in Fig.1. Transmission spectroscopy

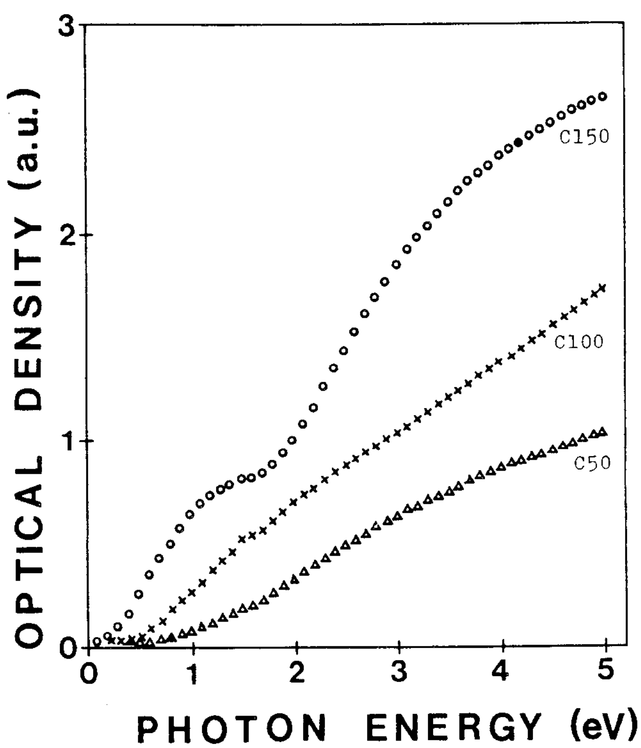

Fig.1 Optical density of various film thickness as a function of photon energy.

showed no well-defined absorption edge corresponding to the optical gap, however, at about 0.25eV there is already some small absorption and the absorption rises fairly remarkablly through into the visible. As for the thickest film in our measurement, the absorption coefficient vs photon energy is plotted in fig.2. A solid line in this figure is that of Ref.1 for comparison, in which amorphous carbon specimens were made in the operating pressure of about $\sim 10^{-5}$ Torr. Furthermore, an additional broken curve of Ref.2 are shown in the same figure, which is corresponding to the sample deposited under the same pressure as that of Ref.1 and with the larger ion energy of 6keV. The absorption of our specimens is the highest of the three curves in the whole range of wave length studied. It should be noted that the absorption coefficient increases with increasing ion energy at longer wavelength, however, the effect of the ion energy to the absorption coefficient is not so larger than that of operating pressure.

The temperature dependence of the electrical resistivity shown in Fig.3 was well fitted between 77 and 300K by the relation:

$$\rho = \rho_0 \exp (T_0/T)^{\frac{1}{3}}$$

, which is known as the two-dimentional hopping conduction of amorphous thin films. The electrical resistivity at room temperature of our films is larger than those of Ref.1 and Ref.2.

Electron diffraction showed only very broad diffuse rings peculiar to amorphous solids.

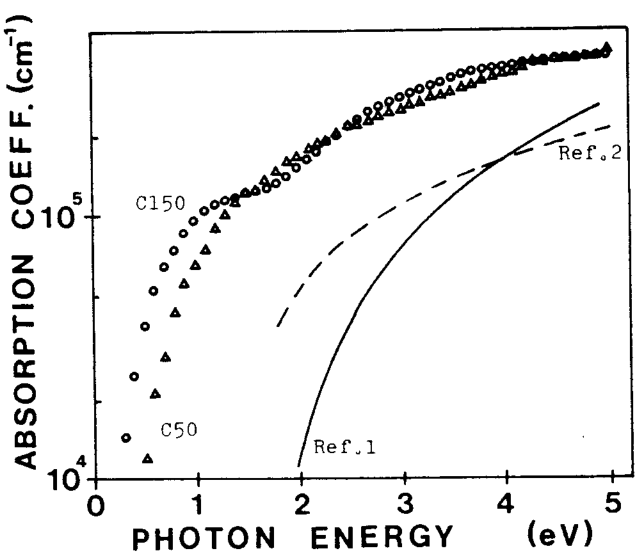

Fig.2 Absorption coefficient as a function of photon energy.

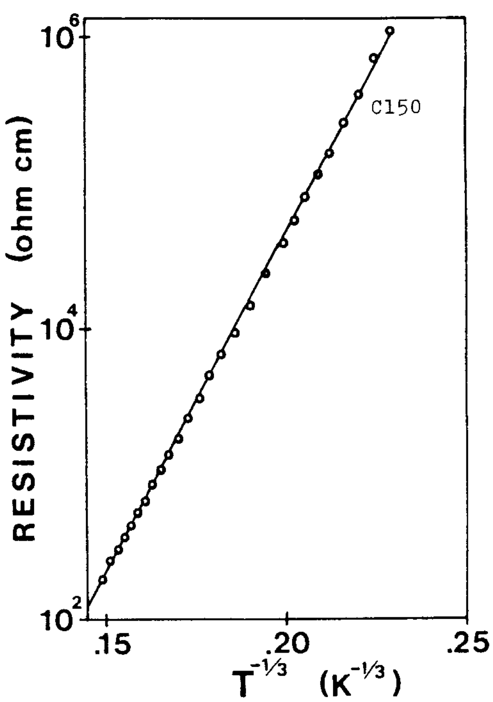

Fig.3 Electrical resistivity as a function of temperature.

References

1. A. A. Khan, D. Mathine, J. A. Woollam and Y. Chung, "Optical properties of "diamondlike" carbon films: An ellipsometric study", Phys. Rev.B 28 7229 (1983).

2. S. Fujimori, T. Kasai and T. Inamura, "Carbon film formation by laser evaporation and ion beam sputtering", Thin Solid Films 92, 71 (1982).