Chapter 113
Diamond-Like Carbon Films Obtained by Ion-Plasma Magnetron Sputtering

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Abstract By ion-plasma magnetron sputtering obtained diamond-like carbon films. Determined phase composition, surface morphology, measured the thickness of the films.

Keywords Diamond-like carbon · Carbon films · Ion-plasma sputtering · Magnetron sputtering

113.1 Introduction

Carbon films are known for their ability to form a variety of electronic configurations, such as sp, sp2, sp3. The most common structural modification is a diamond with sp3-hybridization and the graphite has sp2-hybridization bonds [1]. In this regard, the task of producing artificial carbon films with different electron configurations attracted many scientists.

Thin carbon films have unique physical and chemical properties, such as inertia, durability, transparency in the visible wavelength range, hardness and thermal conductivity. In addition, changing condition of their proceeding can widely control the width of the band gap, the concentration of impurity atoms and the conductivity of the layer, which allows use diamond-like carbon films in the manufacture of electronic devices.

Currently, the most intensively developing areas in the study of diamond-like coatings are related to the manufacture of semiconductor devices and increase the

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stability of the field current (cold) electronic sources [2]. Getting carbon coatings for this purpose is mainly by chemical vapor deposition in a glow discharge [3], or using a hot filament [4] in an atmosphere of hydrogen and hydrocarbon gas (mostly methane).

113.2 Experimental Technique

Growing thin carbon films is realized on the basis of physical decomposition of carbon-containing gas (acetylene) and deposited on a silicon substrate monocrystal with orientation (111). Acetylene gas is obtained by chemical reaction of calcium carbide with distilled water. The gas is filtered with chemical fluid then passes to the vessel. Adjusting the gas flow is controlled by a piezoelectric element. The scheme of the reaction chamber is shown in Fig. 113.1.

The electrodes are made from high-purity graphite reactor. Single-crystal silicon substrate previously cleaned by washing in alcohol, hydrofluoric acid and distilled water, then placed in the reaction chamber. The reaction chamber connected to the piezoelectric valve for gas injection, and placed in a vacuum system. Vacuum in the chamber is obtained by backing and diffusion pumps and value is ~1,3* 10-1 Pa. The surface of the single crystal silicon substrate, oriented in the direction (111), polished in chamber by bombarding with ions of Ar^+. Polishing the surface of the substrate gained with stream of argon ions at ~1 kV.

For growing thin films of carbon, noble gas (Ar+) was replaced with acetylene (C_2H_2). In order to obtain films with different structural modifications the voltage were varied from 500 V to 1 kV, and the gas flow were varied to set the pressure

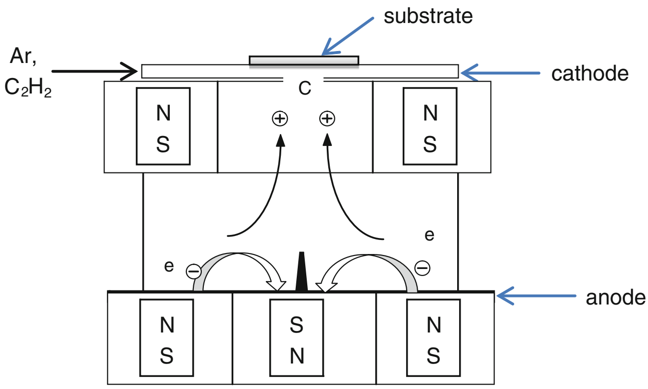

Fig. 113.1 Scheme of the reaction chamber

inside the chamber. Sharpened graphite rod is inserted to increase the strength of the electric field. Energized gas were ionized and the plasma is ignited inside the working volume. Molecules of acetylene (C_2H_2) which has covalent bonding separated into individual ions of carbon and hydrogen. The positively charged ions of carbon moves to the silicon substrate and deposited creating centers of crystallization. After a while centers of crystallization grows gradually creating a grainy surface, then forming a film. The thickness of the films ranges from nanometer to micron size.

113.3 Results and Conclusions

The experiment received diamond-like carbon film with a thickness of about 3 km (Fig. 113.2). At the initial stage of deposition, on a surface of silicon substrate appears crystallization centers, as a result of which forms a carbon film. Depending on the applied voltage different structures of carbon formed on the surface, it can be a diamond-like film, graphite, amorphous carbon. Carbon film thickness was measured with an electron microscope at a slice. The sample breaks down into two and set perpendicular to the electron beam.

The surface of the films mostly flat, has a different grain structure, the grain size range from 30 to 80-nm, mainly dominated by grains with a diameter of 50 nm, rarely occurs grains with larger diameters like 200 nm (Figs. 113.3, 113.4, 113.5, and 113.6).

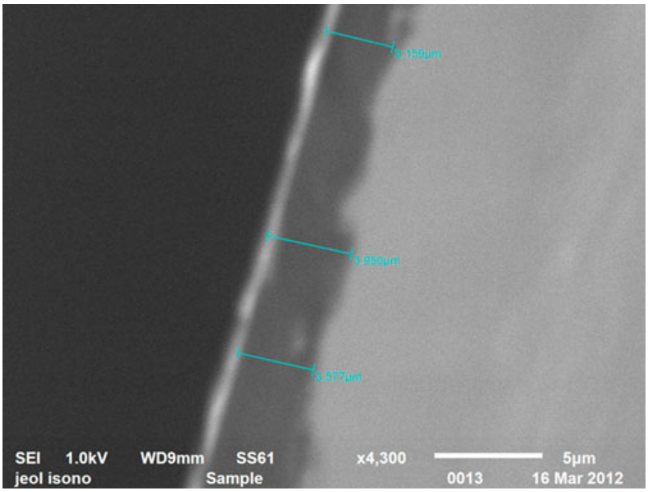

Fig. 113.2 The thickness of the carbon film. The picture was taken with an electron microscope

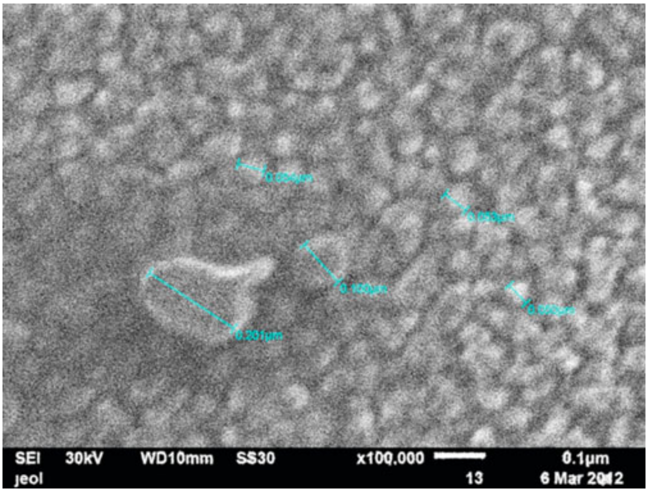

Fig. 113.3 Snapshot of the surface of the carbon film. The picture was taken with an electron microscope

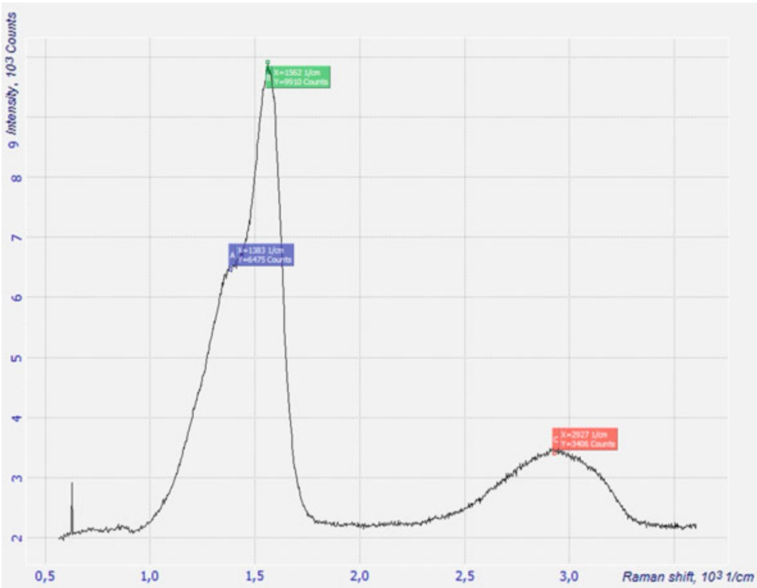

Fig. 113.4 The spectrum of the *diamond*-like carbon film produced by Raman scattering

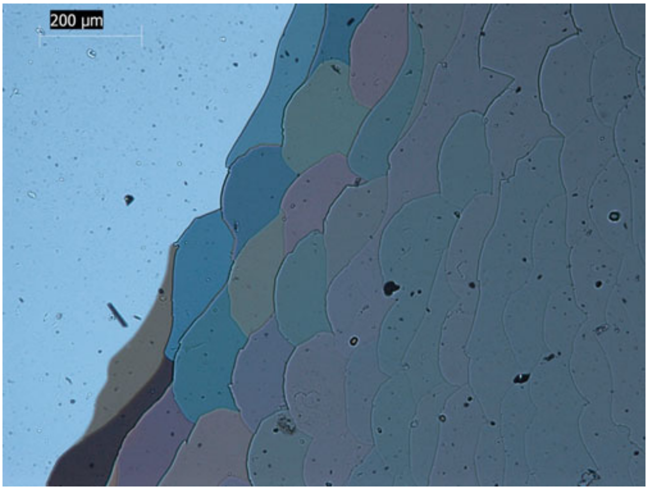

Fig. 113.5 The surface of the *diamond*-like carbon film obtained with an optical microscope

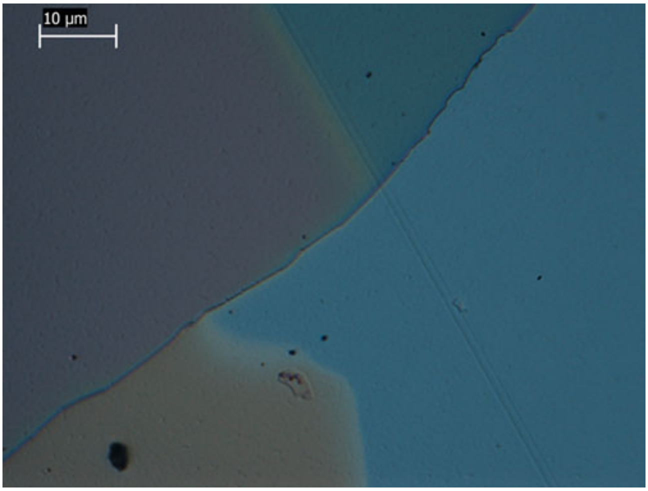

Fig. 113.6 The surface of the *diamond*-like carbon enlarged in 10^5

113.4 Conclusion

Describes a method of growing carbon films of different structural modifications in the vacuum system. Derived carbon films with high reflectance, abrasion resistance, mechanical strength and stability of the properties obtained in a simple and cost-effective method. A film thickness of 3-3,8 microns on silicon substrates. Investigated the phase composition, internal structure, surface morphology of the films.

References

1. Sarsembinov Sh, Prikhodko O, Maximova SJ (2005) Physical basis modification of the electronic properties of non-crystalline semiconductors. Almaty, pp 253–298
2. Semenov AP, Belyanin AF, Semenov IA, Pashenko V, Barankov YA (2004) Thin films of carbon. Structure and properties. J Appl Sci
3. Raiko VR (1996) Diam Relat Mater 10:1063
4. Wei J, Tzeng YJ (1993) Cryst Growth 128:413