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Effect of Catalyst on the Growth of Diamond-like Carbon by HFCVD

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ABSTRACT

Diamond like carbon (DLC) film was grown by hot filament chemical vapor deposition (HFCVD) technique. In the present work, we investigated the quality of the DLC films groew on the substrates that were coated with various metal nanocatalysts (Au and Ni). A combination of $CH_4/Ar/H_2$ renders the growth of carbon nanostructures technique (diamond like carbon). The utilized samples were characterized by the scanning electron microscopy (SEM) and Raman spectroscopy techniques.

Keywords: Diamond like carbon; DLC; HFCVD; Raman sepectroscopy

INTRODUCTION

Diamond-like carbon (DLC) is a metastable form of amorphous carbon containing a significant fraction of sp^3 bonds [1]. Since their first preparation by Aisenberg and Chabot in the early 70s, DLC films have attracted word-wide attention due to their excellent properties which make them reliable to use in various fields of science and technology. DLC films have widespread applications as protective coatings in areas such as optical windows, car parts, biomedical coatings and as micro-electromechanical device [2,3]. Some of the remarkable properties of DLC films are their high wear resistance, chemical inertness, low friction coefficient and particularly high hardness which make them one of the most suitable materials for coating surfaces. A wide variety of deposition techniques based on ion beam or plasma techniques have been developed for synthesizing DLC films. The most popular laboratory deposition method is rf PECVD. the reactor of two electrodes of different area. The rf power is usually capacitively coupled to the smaller electrode on which the substrate is mounted, and the other electrode (often including the reactor walls) is earthed [1]. In this work DLCs were grew on silicon substrate that coated with Ni and Au nanocatalyst by hot filament chemical vapor deposition (HFCVD) technique. A combination of CH_4/H_2 renders the growth of carbon nanostructures. Catalytic layers and DLCs were characterized by SEM and Raman spectroscopy.

EXPERIMENTAL

The substrates used in this experimental were mounted at dimensions of 2×2 cm. Pure metallic films of 5.56 and 6 nm of Ni and Au were deposited by plasma enhanced chemical vapor deposition (PECVD) and DC-sputtering system respectively. DLC coatings

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were prepared by hot filament chemical vapor deposition (HFCVD), Each sample was individually pre-treated under a constant flow of carrier gases, a mixture of Ar and H_2 with constant flow of 100 and 80 sccm, respectively for 10 min. After pre-treatment, the carbon source, CH_4 was released into the reactor at a constant flow of 20 sccm. During the synthesis, a tungsten filament placed at 1 cm above the substrate holder, was heated up to 600-700^{0}C. The morphology of the substrate was examined by scanning electron microscopy (SEM).

RESULTS AND DISCUSSION

Scanning Electron Microscopy (SEM) images in figure 1(a and b) shows the DLC deposited on Au and Ni nano catalyst. The Raman spectra of the DLC deposited films are shown in figure 2 and 3.

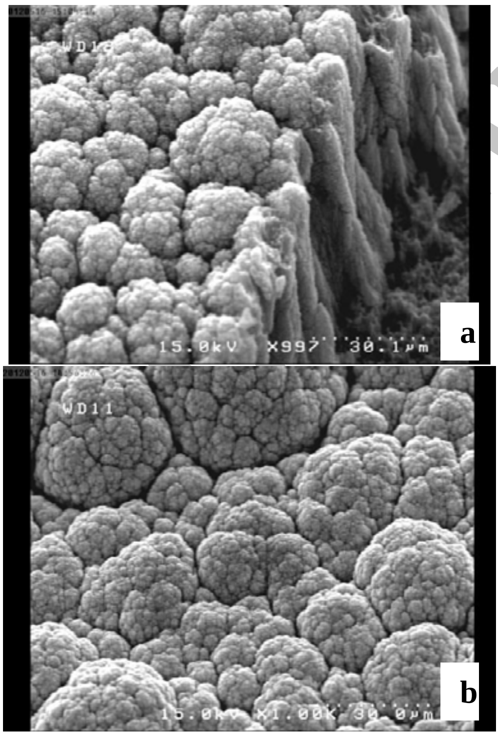

Fig. 1. The SEM images of the DLC deposited on (a) Au, (b) Ni nanoparticles

Indeed, the Raman spectroscopy is an effective technique for the characterization of DLC structure [4]. All carbon materials such as DLC coated indicate features in Raman spectra, named as D and G peaks. The G peak (labeled 'G' for graphite) corresponds to any pair of sp^2 sites in both rings and chains while the D peak (labeled 'D' for disorder) is assigned to the breathing modes of sp^2 atoms only in aromatic rings not in chain [5-9].

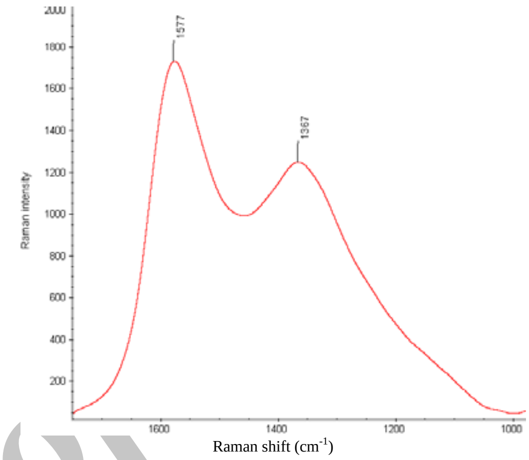

Fig. 2. The Raman spectra for DLC coating on Au nanoparticles.

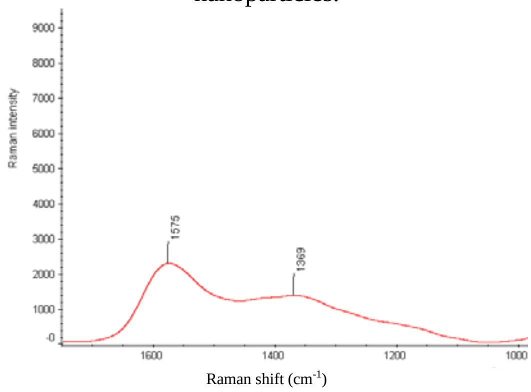

Fig. 3. The Raman spectra for DLC coating on Ni nanoparticles.

In amorphous carbons, the intensity ratio I_D/I_G is related to the size of the sp^2 phase organized in rings [10-13]. For visible excitation, Raman spectra for carbon show 'G' (1560cm^{-1}),' D' (1360cm^{-1}), The Raman spectra of the DLC films grew on nickel and gold coated silicon substrate display two major features for each sample separately, corresponding to the D and G bands, respectively. In this study, the above ratios for the two samples with various catalysts were compared (see Table 1).

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Table 1. The statistic data of DLC growth on the different substrates

Sample	D band (cm^{-1})	G band (cm^{-1})	I_D/I_G
a	1367	1577	**0.72**
b	1369	1575	**0.55**

The intensity ratio I_D/I_G for the DLC coating on Au and Ni substrates was o.72 and 0.55 respectively. If the ratio I_D/I_G becomes lower or zero, the sp^2 phase is organized rather in chains whereas a higher ratio I_D/I_G indicates an increase of the sp^2 phase in aromatic rings [14], but also a higher overall sp^3 content [15]. These results suggest that the quality of DLC structures can be improved in nickel catalyst compared with gold catalyst.

CONCLUSIONS

In this study, DLC films were deposited on to the Au and Ni catalysts coating the silicon substrates. The Ni and Au nanoparticles layers were successfully deposited onto the substrate surfaces with 5.56 and 6 nm thicknesses respectively. Raman analysis enabled evaluation of the intensity ratio I_D/I_G for the DLC coating on the a and b substrates. The results showed that, a lower intensity ratio I_D/I_G can obtain for DLC films that deposited onto the nickel catalyst compared with gold catalyst. These results suggest that the quality of DLC structures can be improved in nickel catalyst compared with gold catalyst.

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