Optical and structure Characteristics of diamond like-carbon thin films produced by PLD.

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ARTICLE INFO
Submission date: 18 / 9/ 2019
Acceptance date: 4/ 11/ 2019
Publication date: 31/ 12/ 2019

Abstract

The utilizing of Nd: YAG laser (wave length-1064 nm) in the pulsed laser-deposition-PLD for placing diamond-like carbon DLC-film on glass substratum at the normal temperature of room. The composition and morphology of the surface for the atomic force microscopy (AFM), synthesized film and Fourier transform infrared FTIR-spectra for DLC utilized to know the presence of bonding were characterized by scanning electron microscopy-SEM and energy dispersive x-ray -EDX. Deposited DLC-film has a compact structure of dense grains, and the film contained irregular shape particles (clusters) of DLC. FTIR-spectra confirmed that the DLC-film contains carbon atoms with sp3-hybridization.Were investigated in optical properties with the results concerning the transmittance, absorption coefficient-(α), optical energy-gap, reflectance-R, extinction coefficient-k and refractive index-n.

Keywords: PLD , Diamond-Like Carbon , FTIR Spectra , Thin Film.

1. Introduction

Start studying the diamond like-carbon DLC-thin movies was resulting from their technological significance. Diamond like-carbon DLC-films exhibit a mixture of characteristics for example optical transparency, great hardness, wear resistance, chemical inertia and biocompatibility [1-2]. The films of diamond like-carbon DLC-thin could therefore be utilized in several uses owing to various physical and chemical characteristics like high visible and IR transparency, high thermal conductivity, high mechanical hardness [1,3,4]. Due to the presence of hydrogen in the DLC-thin film structure, diamond-like carbon-DLC-films are having two kinds either un-hydrogenated carbon (a-C) or hydrogenated carbon (a-C: H) in two types. Un-hydrogenated diamond-like carbon-DLC-films structure could be regarded as an amorphous blend with the chemical bonding structure of sp3 and sp2-hybrid carbon atoms [5]. The characteristics and quality of un-hydrogenated DLC-films could be determined by clustering sp2-phase and the proportion of sp3/sp2 hybridized carbon atoms in film microstructure. The bigger bond of the sp3, the closer the diamond-like-carbon DLC-film feature is to those of diamond (like diamond) for example optical transparency and elevated mechanical hardness, while the greater the sp2-bonded carbon content provides more graphite-like characteristics [6-7]. Pulsed-laser deposition method is a nice method utilized for DLC film deposition [8, 9, and10]. Also pulsed laser-deposition-PLD has excellent DLC-film preparation because of the ease of preparation of a target and the changing in the deposition parameters

optimization for example wavelength, power of laser and repetition frequency [10,11]. The current investigation has been aimed to study in the structure and optical characteristics of the deposition of thin films of DLC and the results' remainder.

2. Experimental

The films of dimond -like carbon-DLC- were placed on substrates of glass by technique of PLD utilizing pure graphite pellet as a target, which was rotated during deposition. Before the deposition, an ultrasonic bath was utilized to clean the substrates with deionized water and twelve minutes in ethanol. The substrates of glass were placed on 2 cm away from the goal. By utilizing Nd: YAG-laser (π=1064 nm) with 2Hz rate of repeating and 300 mj energy for each pulse was utilized for graphite-target ablation. In the processing chamber, the base pressure was 1×10^{-3} Torr. The films of DLC were deposited at R.T substratum temperatures by 200 laser shots utilizing Green Laser (532 nm), the thickness was calculated using the equation [12]:

$$t = \frac{\lambda}{2}.\frac{\Delta x}{x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3-1)$$

Where: d thickness of the film (nm), λ Laser wave length (nm)
Δx the distance between two fringes, x light fringes width.

3. Results and Discussion

Fourierr Transform Infrared FTIR-spectroscopy could investigate the chemical structure of the thin films of DLC. The Fourier Transform Infrared FTIR-spectra for DLC-deposited on the substratum of glass at (300) mj/2Hz is demonstrated in figure (1). The spectra of DLC-films in the range (400-4000 cm^{-1}) are observed many bands. There is a common agreement with the predicted frequency, where that section is an indication of the presence of bonds (C-H) [14, 17]. From fig.1, the peaks at (2.854 $x10^3$) cm^{-1} corresponded for the sp3 (CH2) symmetric-stretching vibrations [1,13,16], and also the peak positioned at (2.923 $x10^3$) cm^{-1} is corresponded for sp3 (CH2) asymmetric-stretching vibrations [1,14,15], and the peak positioned at (2.960$x10^3$) cm^{-1} is correspond for the sp3 (CH3) asymmetrical stretching vibrations, and the peaks found at (1.520 $x10^3$) cm^{-1}attributed for the mixed stretch sp2-sp3 for bond's (C-C) [1,19], and the peak positioned at (1.643 $x10^3$) cm^{-1} is correspond for the Olefinic-sp2 [1], and the peak positioned at (1.060 $x10^3$) $cm^{-1}$is due for the (C=O), indicated that the films of DLC have a little oxygen [1, 20], and from the figure, we have the peak positioned at (2.372 $x10^3$)$cm^{-1}$is may be because ($C\equiv C$) stretch[29]. Also, from the figure, the peak observed at 3.452 $x10^3$ cm^{-1}, can be attributed to (O-H) stretching-vibrations [1, 18].

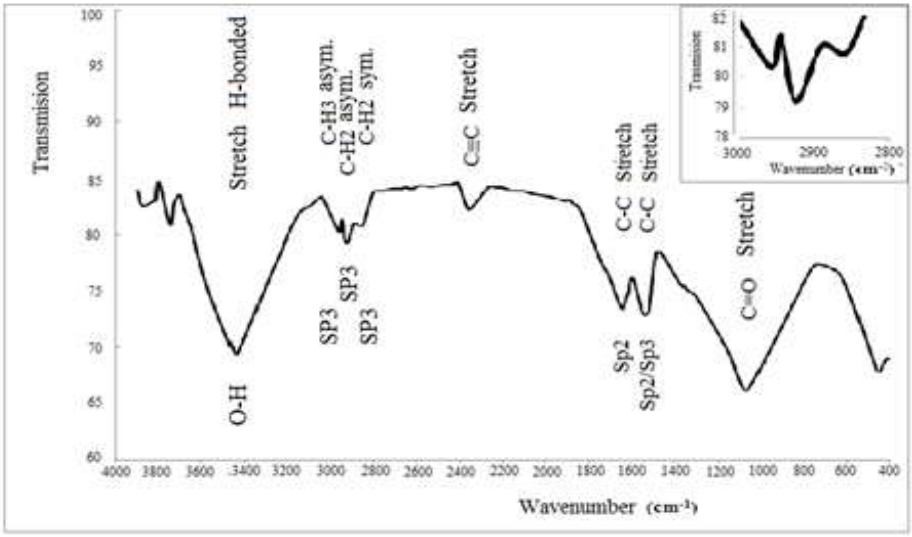

Fig.1- The images of FTIR spectra of DLC films at 300mj.

From fig.2, is showing the SEM-image, the deposited dimond like-carbon DLC-film has a built-in structure of intensive grains, and the film Consists irregular DLC(clusters) particles shape, with sizes about is ten of nanometer, and this resulting from agreement with those research by Honglertkong, et.al [21] and Ismail, et.al [22]

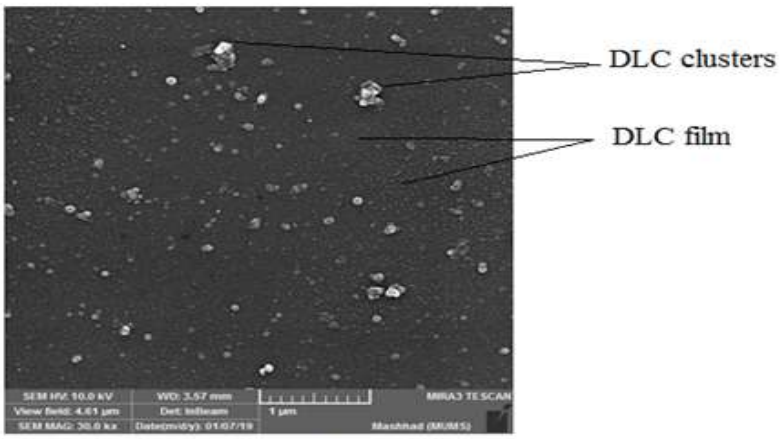

Fig. 2 SEM images of DLC film at 300 mj

From fig.3, of EDX-spectrum, the chemical composition of the dimond like-carbon DLC-film, it can be seen that mainly existence two bands belong to oxygen and carbon. The oxygen existence could may be due to keep the film in the air [23, 24].

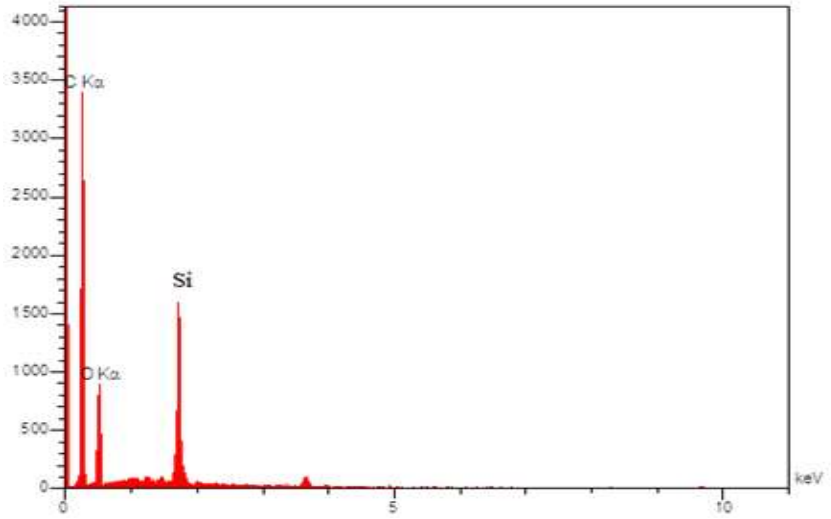

Fig. 3 EDX Spectrum of DLC film at 300mj

From fig. 4, the AFM-investigation which shows the 3D-image and also, particle size distribution of the deposited dimond like-carbon DLC-film, the DLC-film was uniform and take shape of non-spherical grains. The average grain-size was (59.35 nm) and roughness average was (2.54 nm) and the square root of mean roughness was (3.11nm), and the film has lateral and vertical growth, which affected usually in the surface roughness and deposited dimond like-carbon DLC-film shows Gaussian distribution.

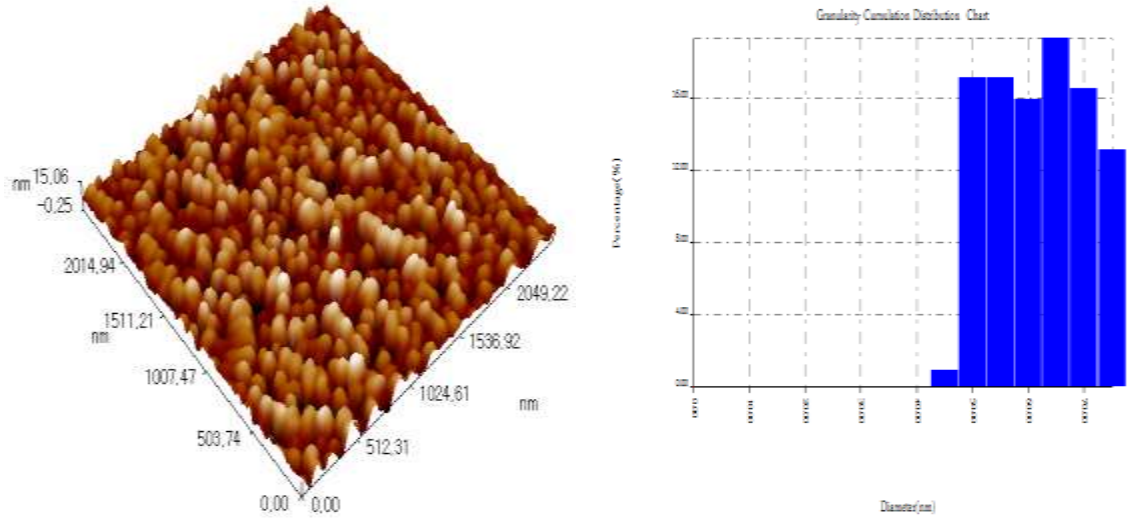

Fig.(4) 3D AFM image of the DLC (a) and grain size distribution (b)

The XRD-patterns of deposited DLC-films prepared with laser power confirmed that there were not diffraction peaks observed indicating the amorphousness of DLC-films. The results are very compatible with other Researches results [27, 28].

Fig. 5 shows the spectra transmittance of dimond like-carbon films of DLC in the range of (330-1100nm), deposited on glass substrate. Showed the films high transparency (up to 78%). High transmittance-spectra can be observed above due to increased sp3-bonding hybridization ratio to sp2-bonding hybridization as shown in

FTIR-spectra. Also, it was detected that optical transmittance increase in the near infrared and visible area with increasing the wavelength. The coefficient of absorption (α) for films of DLC in the range of (330-1100nm) where calculated from transmittance results in accordance with equation:

$$\propto = \frac{2.303A}{t}$$

Whereas, t & A are the thickness and absorbance respectively.
From figure, that the absorption coefficient of the thin film's DLC is defined by a strong absorption at the shorting wavelength region between (330-350nm).The coefficient of absorption (α) shows high magnitudes of α (α=2.2* 10^4) for wavelength 345 nm, which refers that there is a high possibility for the allowing of the direct transition. Also, the coefficient of absorption (α) decreasing with increment the wavelength for DLC-thin film.

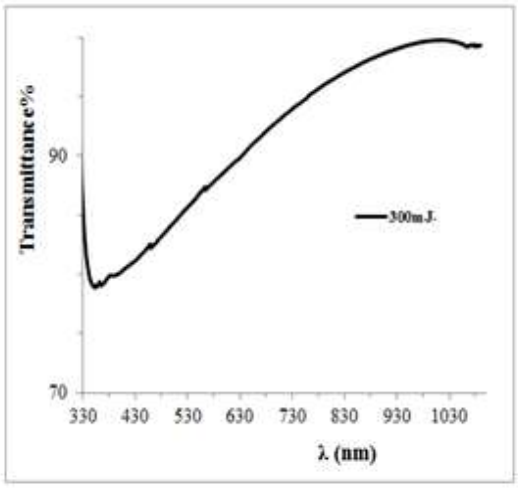

Fig. 5 Transmittance spectra for DLC film at 300mj

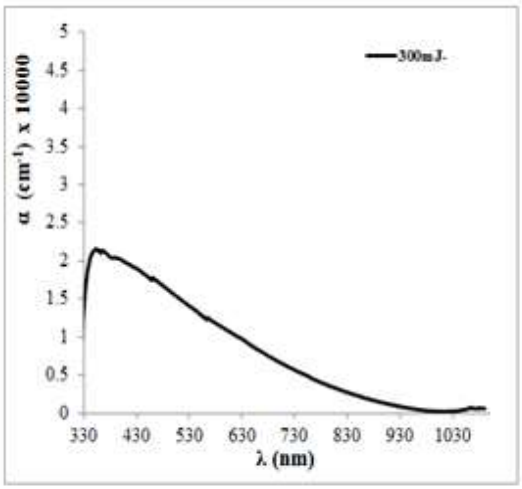

Fig .6 The absorbance spectra for DLC film at 300mj

The band gap-Eg, was calculated in an amorphous-DLC, the relationship between the coefficients of absorption (α) and incident energy of photon (hυ) could be placed as [25].

$$\alpha h\nu = B\,(h\nu - E)^n$$

Whereas B & Eg are the constant and the optical gap band of the material, n is constant and take several magnitudes 1/2, 3/2, 2 and 3 based on the substantial and the optical transition type. Extra polating the linear portion of the $(\alpha h\nu)^2$ versus hυ draw to the hυ axis at a=0, the band gap-(Eg) can be determined from the intercept, as demonstrated in Figure (4), band gap-(Eg) magnitudes for pure dimond like-carbon DLC-films (2.38)ev.

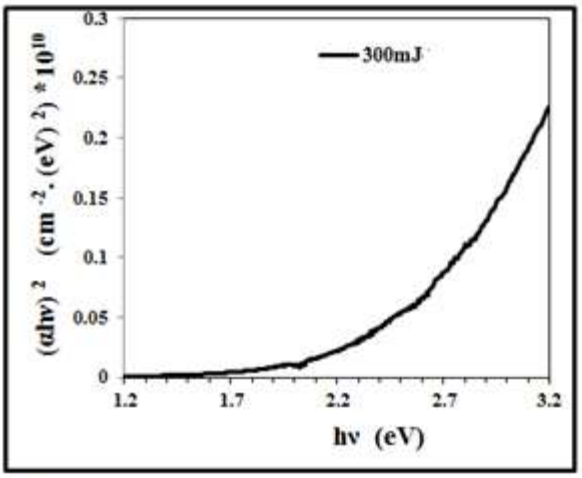

Fig.7 $(\alpha h\nu)^2$ versus hν plots for DLC films at 300 mj.

From Fig.8 , the extinction coefficient-(k)of DLC-film decrease from the UV to the IR-region and varies between 0.047 and 0.017 reaching values of 0.017 at 940 nm and pronounced maximum value at about 345 nm and a small decrease can be observed for k at the wavelength 600nm. The highest absorption for film; especially at short wavelength, can be due expected contain amount of sp2-bonded carbon. From fig.9, the index of refractive (n) of film's DLC differs between (1.18 and 1.5) and pronounced maximum magnitude at about 345 nm, but stay low comparison with dimond (2.41 at 633) nm [26].

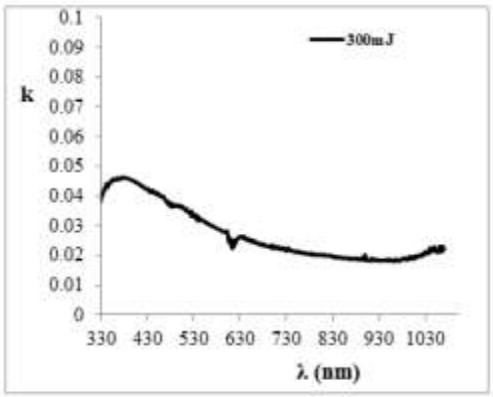

Fig. 8 Extinction Coefficient for DLC thin film at 300 mj.

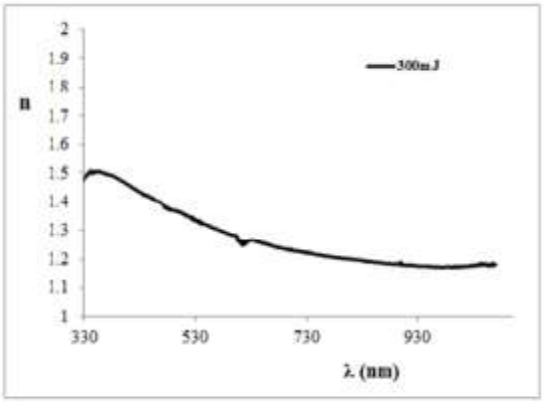

Fig. 9 Refractive index for DLC thin film at 300 mj

From fig.10, the reflectance-(R) curve of DLC-film, the spectrum are almost featureless, interference effect peak hinting at distinct absorption band coud be observer -R reaches 0.042 at 345 nm and a small decrease can be observed for -R at the wavelength 600nm.

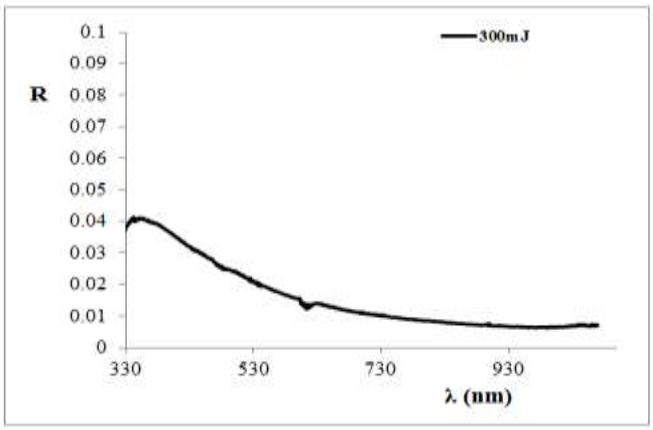

Fig. 10. Reflectance spectra-(R) of DLC-films at 300 mj.

4. Conclusions

DLC-films were synthesized by pulsed laser-deposition-PLD utilizing Nd: YAG-laser (wave length 1064 nm) was utilized to deposit diamond like-carbon DLC-film on glass substrate and temperature of room. DLC-film composes of a homogeneous, and compact grains, the surface contain irregular small clusters of DLC. The EDX-pattern of the DLC-film shows the mainly existence two bands belong to carbon, oxygen, and it was amorphous. A FTIR-spectrum shows that deposited DLC-film has a mixture of sp2 and sp3-bonded carbon and FTIR-spectrum ensures that DLC-film was hydrogenate and the energy gap were E_g = 2.38ev.

Conflict of Interests.

There are non-conflicts of interest

5. References

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الخلاصة

تم استخدام ليزر ND: YAGالطول الموجي ١٠٦٤ نانومتر في الترسيب بالليزر النبضي PLDلتكوين غشاء الماس شبيه الكاربون DLCعلى اساس زجاجي في درجة حرارة الغرفة. التركيب ومورفولوجيا السطح بالفحص بمجهر القوى الذرية AFMلدراسة الغشاء وتحويل فوريه لأطياف الأشعة تحت الحمراء FTIRللماس شبيه الكاربون DLCالمستخدمة لمعرفة وجود الروابط وكذلك خصائص المجهر الالكتروني الماسح SEMوتشتيت الطاقة بالأشعة السينية EDX. يحتوي غشاء الماس شبيه الكاربون DLC المرسب على بنية مدمجة من الحبيبات المتراصة ويحتوي الغشاء على جسيمات غير منتظمة الشكل (عناقيد) من DLCواكدت أطياف FTIRان غشاء DLCيحتوي على ذرات كاربون مع تهجين sp3وتم التحقيق في الخواص البصرية مع النتائج المتعلقة مثل النفاذية ومعامل الامتصاص وفجوة الطاقة البصرية والانعكاس Rومعامل الخمودKومعامل الانكسار n.

الكلمات الدالة الترسيب بالليزر النبضي ،الماس شبيه الكاربون ، طيف الاشعة تحت الحمراء، الغشاء الرقيق