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Investigation of DLC coating behavior in AL6061-T_6 made by DC Pulse-PACVD

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Abstract

Plasma-assisted chemical vapor deposition method was used to construct a diamond-like carbon coating on aluminum substrate 6061-T_6. Sedimentation was carried out using CH_4 as a process gas at different temperatures of 250-300 Celsius with constant flow rate and power. Raman spectroscopy was used to describe these samples. Raman analysis of DLC coatings at different temperatures has been done in detail for two different wavelengths of stimulation of 514 and 785 nm and the results are shown in this paper. Peak changes were observed in both D and G peaks of Raman spectrum with increasing sediment temperature, indicating the formation of compressive strain in DLC coatings at high temperatures. Scattering is observed at both D and G peaks for different wavelengths of excitation, indicating that the DC coating is hydrogenated. It seems that the degree of hydrogenation of DLC coating decreases due to sediment temperature. The study of nano-indentation with increasing sediment temperature shows a marginal increase in hardness.

***Keywords*:** DLC; PACVD; Aluminum; Raman; Nano

1. Introduction

Diamond-like carbon (DLC) is a mixture of SP^2 and SP^3 carbon hybridization which is dominant in SP^3 hybridization, so has diamond-like properties [1-3]. Good DLC coatings have good mechanical, optical, electrical, chemical and tribological properties and can be used in applications of anti-reflective coatings for solar cells, infrared optical materials, wear-resistant and low friction coatings, orthopedic implants, etc. DLC coatings are precipitated by physical and chemical processes such as spraying and microwave (MW) and radio frequency (radio) respectively [11-9]. Different process parameters such as reactive gases, bias voltage, etc. It can be used to precipitate DLC films in the chemical process [12-14].

Depending on the degree of hydrogenation, the properties of DLC coatings such as hardness, friction coefficient and anti-reflection can vary. Therefore, hydrogenation plays an important role in biomedical applications to reduce cytotoxicity and cytoxicity toxicity in DLC coatings [13-17]. In this paper, a hydrogenated quadrilateral amorphous carbon coating is created on an aluminum layer using plasma-assisted chemical vapor deposition using DC power. Raman analysis is a useful way to understand carbon materials such as DLC [18, 19]. In this paper, detailed Raman studies with laser stimulation of 514 and 785 nm were performed to understand the DC coating.

2. Experimental Methods

DC coatings with composite slope were placed on a T_6 aluminum substrate using a clean line coating system equipped with a voltage-controlled pulse generator. During casing, process parameters such as gas flow ratio, wall temperature, duration of pulse voltage on and off and total pressure were controlled. H_2, N_2 and CH_4 gases were used as process gases for coating sedimentation. The total pressure was maintained at 2 bars and the bed temperature was controlled at 250°C to 300°C to prevent the heated instrument steel temperature. Plasma nitride was used as a pretreatment to reduce the hardness slope between substrate and coating. The N_2/CH_4 gas flow ratio was defined as (N_2/N_2 + CH_4). Morphology of films was investigated using scanning electron microscopy and atomic force microscopy. The hardness and elastic modulus and friction coefficient of the layers was determined using nano-indentation test.

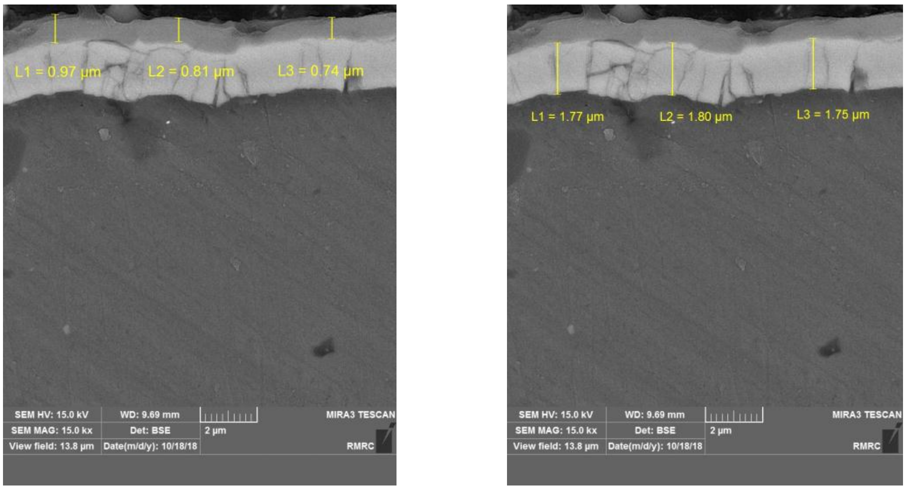
Hardness (H) and modulus of elasticity (E) are calculated from the charge-discharge curve using Oliver and oven analysis. In general, hardness, H, is defined as the peak load ratio, P_{max}, to the predicted mold area, Ac, ie $H = P_{max} / Ac$ and $Ac = f(hc^2) = 24.5hc^2$.

DLC films were used on polished one-way layers. The sediment system consists of model and model: HBS 500. DLC films were coated on aluminum T6 layers. The beds were first cleaned with soap and eventually distilled with isopropyl alcohol in an ultrasonic bath. The substrates were cleaned before precipitation in argon plasma with a current rate of

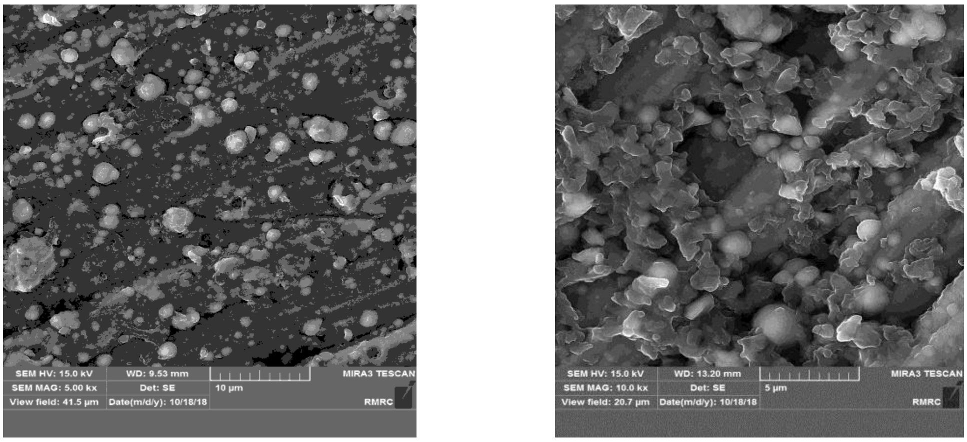
300 cm and a constant bias voltage of 400 volts for 20 minutes. Then, DLC precipitation with 100 cm Che4 as a fixed power process gas with D.C. power of 200 watts was carried out at a working pressure of 2 to 10-3 times. The sediment temperature was changed at 250 °C (sample name - L 250) and 300 °C (sample name - L300) to investigate the effect of sediment temperature on structural and mechanical properties of DLC coating.
Layer thickness and refractive index of DLC films were determined by scanning electron microscopy. Raman analysis of DLC films was performed using Seki Technotron STR 300 Raman spectroscopy with monochrome light of 514 and 785 nm. Young's hardness and modulus were evaluated by Agilent G200 nano-science.

3. Results and Discussion

Scanning electron microscopy showed that the thickness of DLC coatings decreased due to sediment temperature meaning that the DLC process was falling in the discharge area (Fig. 1 and Fig. 2).



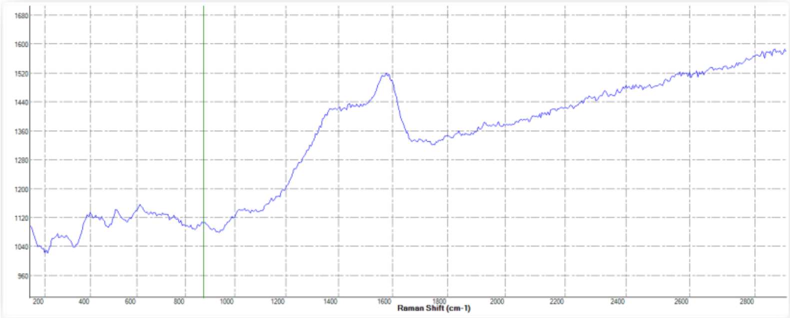
(a) (b)
Fig. 1. Thickness against deposition temperature changes of DLC coating process.
(a) 300 degrees Celsius, (b) 250 degrees Celsius.



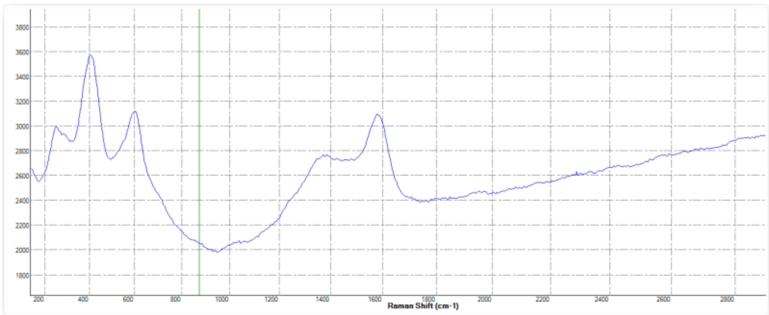
(a) (b)
Fig. .2. Morphology versus deposition temperature changes of the DLC coating
(a) 250 degrees Celsius, (b) 300 degrees Celsius.

The Raman spectrum for different sediment temperatures is shown in Figure 3. Both Raman D and G peaks are changed to water due to the sedimentation temperature of the DLC process. It is concluded that high sediment temperature leads to increased compressive stress. The amount of FWHM of both G peaks decreases, while peak D increases as sediment temperature increases. The Ad/Ag ratio (peak surface ratio of peaks D and G) is increasing due to the sedimentation temperature, which indicates that the concentration of the ring structure increases relative to the linear structure.

The dispersion of both G and D peaks at different wavelengths of excitation of 514 has been studied to study the changes in sediment temperature on the structural properties of DLC coatings (Fig.3). Dispersion occurs when peak shifts occur at different excitation wavelengths, which are usually associated with system disturbances [18, 19].
Further dispersion in G-peak confirms the formation of DLC coatings. However, it seems that peak D also changes with the wavelength of stimulation, indicating the hydrogenation of the DLC coating. It seems that dispersion for peaks D and G decreases to 300°C by increasing sediment temperature. This means that both hydrogenation and disruption of the DLC coating decreases as the sediment temperature increases. Similar results are obtained by analyzing the detection of non-Rutherford (non-RBS) and elastic regression (ERDA), in which the hydrogen-to-carbon ratio for DLC coating was calculated at 32:68, which decreased slightly during sedimentation. . Temperatures 300°C to 30:70.



(a)



(b)

Fig.3. Raman spectra of DLC coatings were collected at the excitation wavelength of 514 nm and precipitated at a) 250 degrees Celsius and b) 300 degrees Celsius.

The analysis of nano-indentation shows an increase in young and modulus hardness with increasing sediment temperature. The data are consistent with Raman results, which show that increasing sediment temperature leads to decreased irregularity, hydrogenation and increased content of ring structure and strain pressure which helps to increase the hardness and modulus of yang DLC. Cover. (Fig. 4)

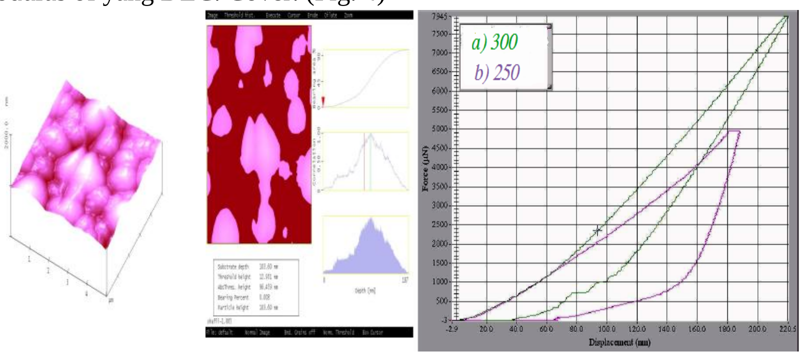


Fig. 4. AFM image of a 100 mN nano-cavity on the polished surface above the coating. A) 300 degrees Celsius, b) 250 degrees Celsius.

4. Conclusion

According to a detailed study of Raman analysis, the DLC coating made by the DC-PACVD process was irregular and partially hydrogenated. With increasing sediment temperature, it is observed that the disturbance and hydrogenation decrease slightly and compressive strain increases. The Ad/Ag ratio is also increased by sedimentation temperature, which indicates an increase in the content of the ring structure relative to the content of the linear structure. Overall structural properties help to increase the hardness of DLC coating.

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