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# UV-VIS CHARACTERIZATION OF DIAMOND-LIKE CARBON THIN FILMS DEPOSITED USING (DC-PECVD)

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## ABSTRACT

Optical properties of Diamond-like Carbon Thin Films deposited by DC-PECVD are reported. The films were deposited on the corning glasses with the ratio of Hydrogen, $H_2$ (97%) and Methane, $CH_4$ (3%) and grew diamond like carbon (DLC) thin films with different temperatures up to 873K. The other important variables were fixed such as DC voltage (1.5 kV) and pressure (1 x $10^{-1}$ torr). From the light transmission using UV-Vis spectroscopy it was found that the type of optical transition is allowed indirect transition in the range of 3.8eV to 4.3eV. The thickness decreases with the increases of substrate deposition temperature. The photoluminescence analysis was order to obtain the peak of excitation and emission range of the sample films. It has been found that the transition energy in the range of 3.06 to 3.22 eV.

*Keywords*: Diamond-like carbon; optical properties;

## INTRODUCTION

The diamond structure is probably the most thoroughly investigated of all crystallographic structures of carbon. In the last few years, an important scientific and technological breakthrough occurred with the discovery that diamond thin films can be successfully grown by a large variety of chemical and physical vapor deposition techniques not requiring high temperatures and pressures [1]. Diamond-like carbon (DLC) is a carbon based materials that bridges the gap between $sp^3$ bond lengths less than the length of $sp^2$ bond.

The aim of this present work is the investigation of optical properties of DLC, which should be called amorphous-hydrogenated carbon (a-C:H) films grown by direct current-plasma enhanced chemical vapor deposition (DC-PECVD).

## EXPERIMENTAL DETAILS

The DLC (a-C:H) films were deposited by standard DC-PECVD on corning glasses. The substrates were cut in rectangular shape (2.5cm x 2.5 cm). Prior to the deposition process, substrates were ultrasonically cleaned using acetone, distilled water and dried, and kept in desiccators within a vacuum environment to avoid contamination. Further cleaning was obtained by Argon (Ar) gas ion sputtering in a high intensity plasma discharge for 10 minutes at 1.5 kV, maximum power 1.5 Watt and 1 x $10^{-1}$ torr of pressure. A gas flow of [$CH_4$] + [Ar] + [$H_2$] was fed into the reactor through mass flow controllers during deposition runs, while the substrate was placed on a holder distance 25 mm from the target. The holder also reacts as a cathode having diameter 68 mm and thickness of 5 mm and placed on the heater. It is then connected to the direct current and grounded together with the reactor chamber's wall.

In this work, five series of films were produced. Each series was deposited at 30 minutes with temperatures at 200 °C, 300 °C, 400 °C, 500 °C, and 550 °C. The other parameters were kept constant.

The thickness (*d*), refractive index (*n*) and extinction coefficient (*k*) of the films deposited was measured using Gaertner L117 Ellipsometry. Ellipsometry is based on the polarization of a light beam being altered on reflection from a bare or film coated surface. An elliptically polarized light beam is defined by the angular position of the ellipse (azimuth), its shape (ellipticity), and the sense of rotation of the light vector. Two parameters determine the state of polarization; these are the amplitude ratio, PSI and the phase difference DELTA. The ellipsometer is used to measure PSI and DELTA, and thus with the known values of PSI, and DELTA the *d, n* and *k* can be calculated respectively. Since the equation contains complex quantities, its solutions are done by computer.

The optical transmission, reflectance and absorption were measured using UV-visible spectrometer (UV-3101PC) at wavelengths 320 and 2500 nm with 0.3% accuracy. The transition energy was estimated using photoluminescence spectrometer based on the process of photo excitation that stated if the electron generally had excess energy which it lose before coming to rest at lowest energy in conduction band and converted back into a luminescent photon which was emitted from the films. Thus the energy of the emitted photon is a direct measure of the band gap energy, $E_g$.

## RESULTS AND DISCUSSION

The most important properties of DLC (a-C:H) films for optical applications are their infrared and visible light transparency. DLC films are typically transparent in the infrared region, weakly absorbing in the visible spectrum and are increasingly absorbing with decreasing wavelength in the UV [2].

According to the experiment, the above agreement was proven in Figure 1(a). The curves of Figure 1(a) represent the transmittance of films on glass substrate. Based on the observation, different temperature will not affect the transmittance percentage. The films are found to have high percentage ~90% in the whole IR region.

The reflectance curves of a-C:H films were similar, suggesting an agreement of similar

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nature of the a-C:H films [3]. The spectra are almost featureless, decreasing respectively with wavelength and had a little R(%) only in UV region instead of visible and IR as shown in Figure 1(b).

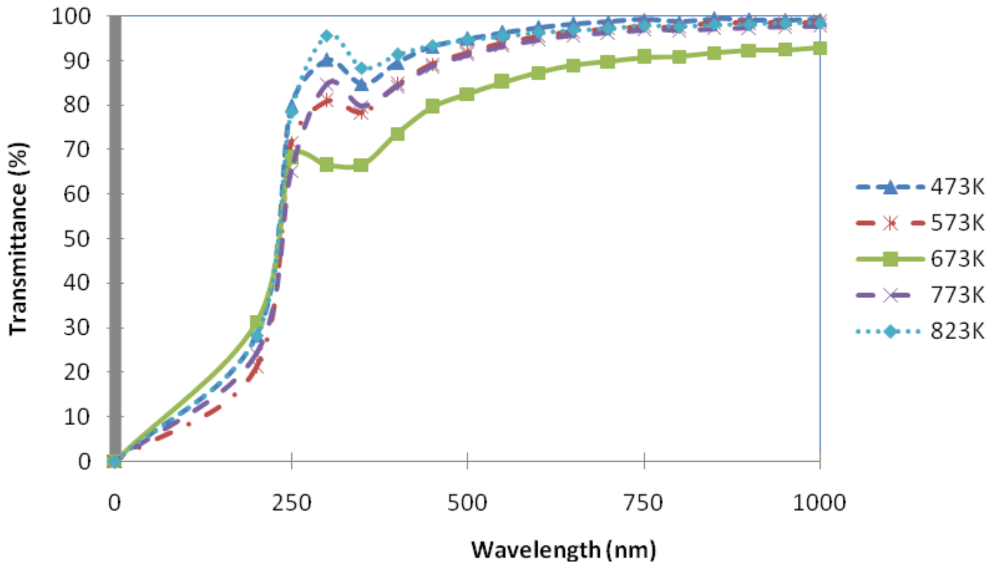


Figure 1(a): Transmission spectrum of the DLC (a-C:H) films deposited on corning glass substrate

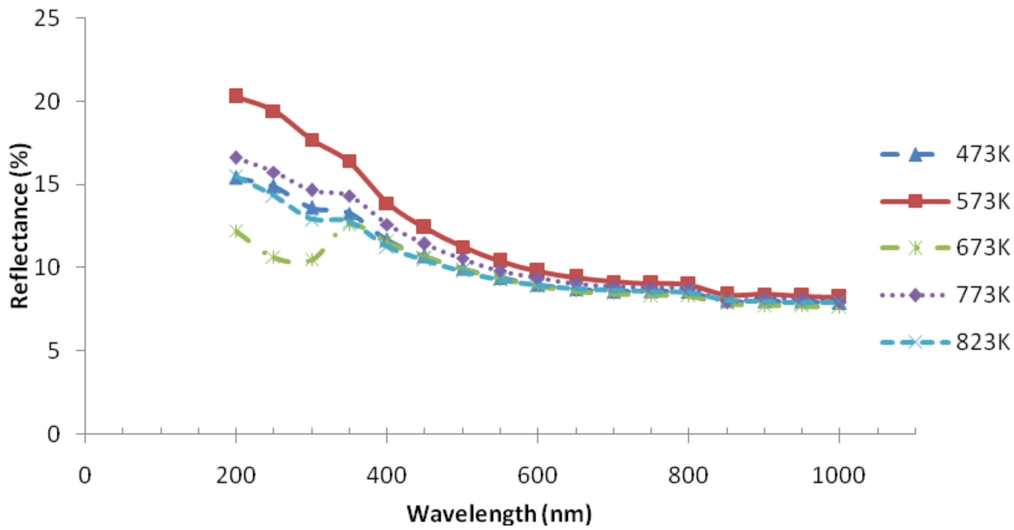


Figure 1(b): Reflectance spectrum of the DLC (a-C:H) films deposited on corning glass substrate

The optical constant such as thickness (*d*), extinction coefficient (*k*), and refraction index (*n*) are very important to estimate the optical applications. These parameters

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empirically proved that the deposition temperature affected the value of those parameters above. From Figure 2, the optical band gap was calculated and the range can be defined within 3.80 eV to 4.30 eV. The optical band gap values are reliable for DLC films that have range ~ 3.80 eV to 4.00 eV. As shown in Figure 3, the thickness decreases while the temperature increases. Figure 4 is a plot of the optical constants obtained for all sample from the multiple sample analysis along the optical constants obtained for these samples from the parametric model. The curves showed that refractive index for 5 different temperatures were mostly constant ~ 2.11.

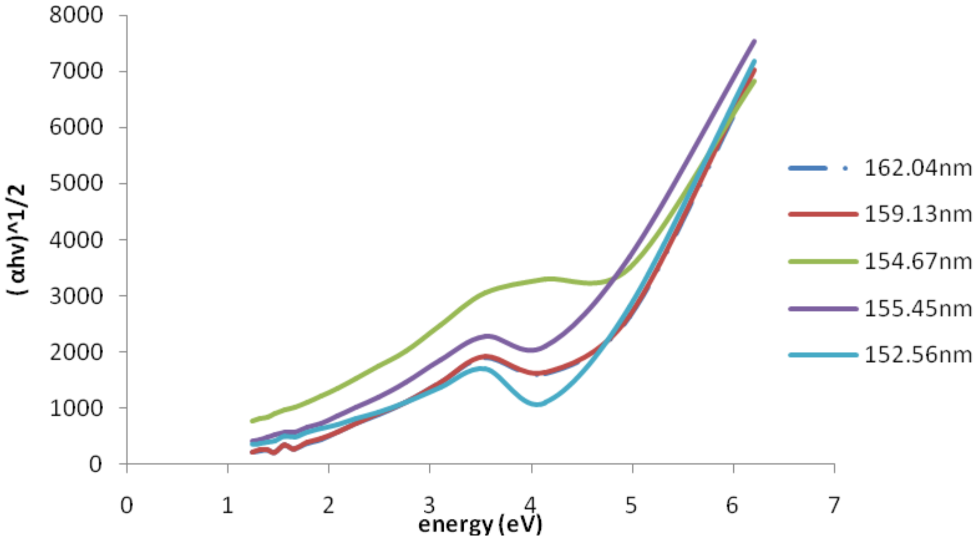


Figure 2: Graph of $(\alpha h v)^{1/2}$ versus *energy (eV)*

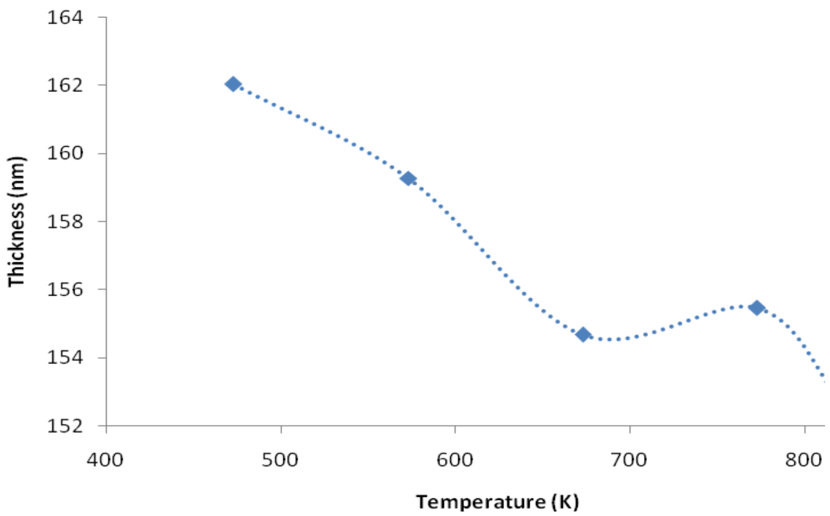


Figure 3: Thickness vs temperature of the DLC (a-C:H) films deposited on corning glass substrate

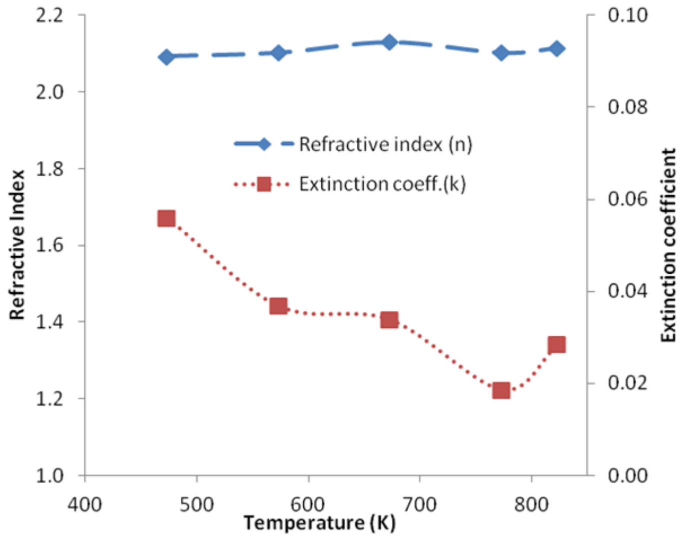


Figure 4: Dispersion of the refractive index and the extinction coefficient of the DLC (a-C:H) films deposited on corning glass substrate

The absorption coefficient measurements as shown in Figure 5 were identified with the relationship with thickness, transmission and reflectance values from the spectroscopy.

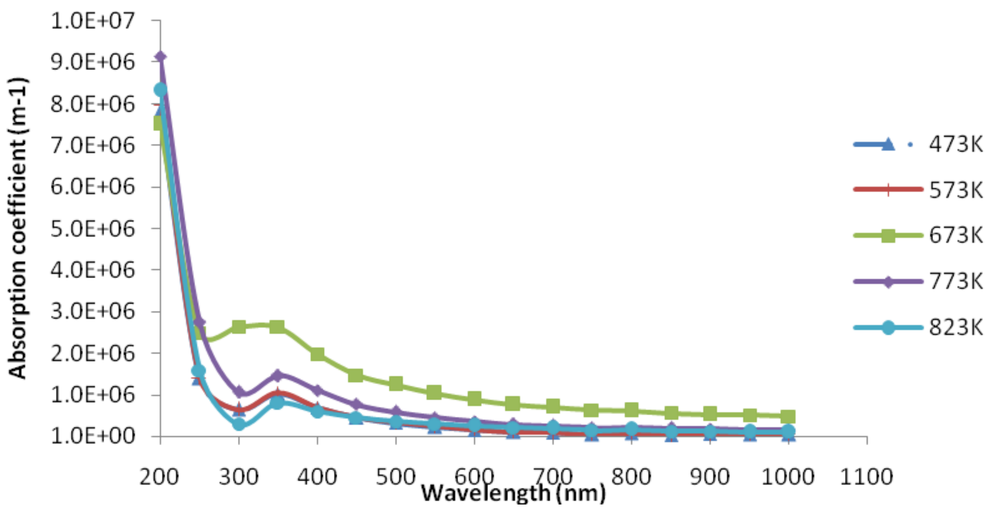


Figure 5: Absorbtion coefficient vs wavelength

Figure 6 shows the PL spectra measured at room temperature with excitation energy ~ 300 nm. It is found that every sample has its own excitation energy. This excitation energy is an energy which is needed to excite the atom, so that it have photoluminescence spectrum. After the sample had pre-scanned by Luminescence spectrometer LS55, the excitation wavelength of that sample can obtained. The peaks show that the transition energies are in the range between 3.06 eV to 3.22 eV. These peaks are generally due to radiative recombination through the defect states and structural defects such as stacking faults and dislocations [4].

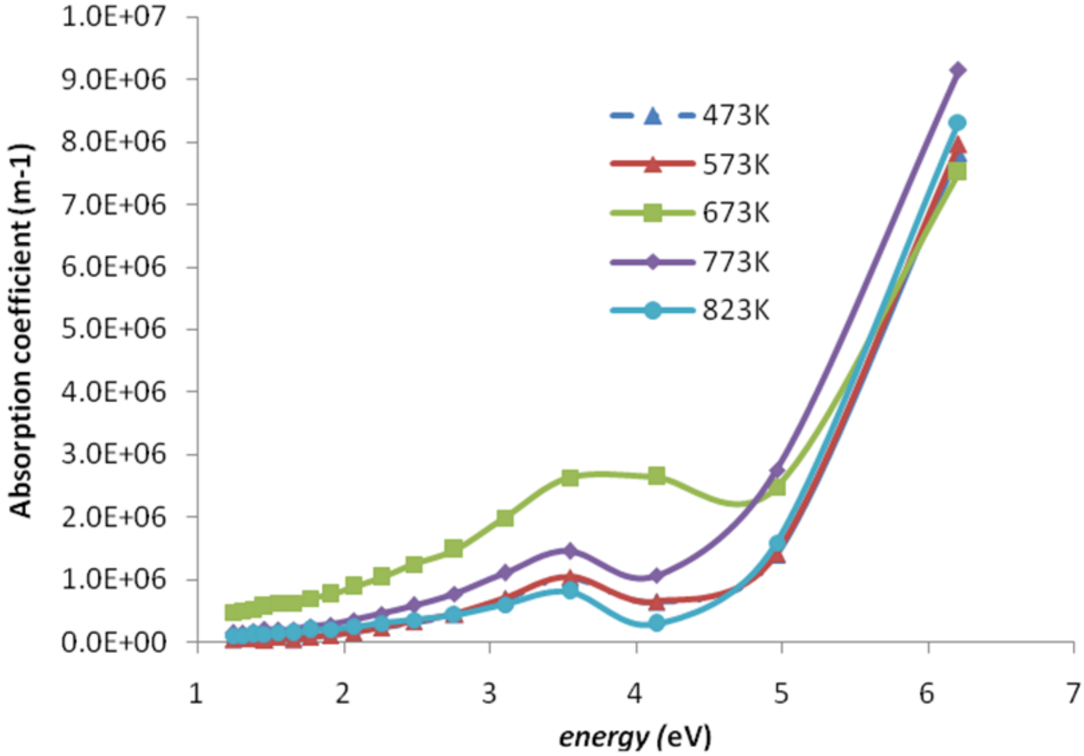


Figure 6: Absorbtion coefficient vs energy (eV)

## CONCLUSION

We have obtained the optimized parameters for use in industrial technologies. The material refractive index, thickness, extinction coefficient, absorption coefficient, transmittance and reflectance were measured. Applications of a:C-H films may be varied as protective optical coating, fabrication, antireflective system and also scratch resistant based on the parameters studied.

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## REFERENCES

[1] M.S Dresselhaus, G.Dresselhaus,P.C Eklund, Science of Fullerenes and Carbon Compund (Academic Press, San Diego, California, 1996)
[2] A.Grill, *Thin Solid Films,* **355-356** (1999) 189-193
[3] B.Mednikarov, *Journal of Optoelectronics and Advanced Materials*, **7** (3) (2005) 1407-1413
[4] Micheal D.Lumb, "Luminescence Spectroscopy", (Academic Press, London, 1987)
[5] S.G Tomlin, *Thin Solid Films*, **13** (1972) 265-268
[6] M.A.Fathallah, *Journal of Non-Crystalline Solids*, **352** (2006) 1388-1391
[7] William A.McGahan, *Thin Solid Films,* **234** (1993) 443-446
[8] S.S.Tinchev, *Optoelectronics and Advanced Materials,* **8** (2006) 308-311
[9] J.C.Damasceno, *Thin Solid Films* **433** (2003) 199-204
[10] E.S. Braga, *Microelectronics Journal,* **31** (2000) 251-254
[11] Nurul Nisa, "Study Of Optical Properties Hydrogenated Amorphous Carbon (a-C:H) Thin Film Prepared By DC-PECVD", (UTM, 2010)