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The Optical Properties of Multilayers Thin Flims

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Abstract

This study aimed to fabricate multilayers thin films by Liquid Phase Deposition process "LPD" (Phenexazon, Rhodamine 6G and Coumarin 500) dyes solved by (ethanol) and deposited in glass substrate inside the Chamber, to determine their optical properties. The thickness of this thin films was deduced from the Michelson interference fringes the Sample was made of three layers. The thickness of each layer (Phenexazon, Rhodamine) equal to half the wavelength of He-Ne laser; while thickness of third layer (Coumarin) equal to the wavelength of (He-Ne laser) .From the obtained results, optical components in the region (532 to 915) nm, the maximum transmission at wavelength of 820 nm and also the maximum value of the refractive index was at 820 nm while the minimum value of absorption coefficient is at 820 nm, the increase in absorption coefficient lead to decreased the refractive index.

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Introduction

Thin films have become increasingly important in physics and engineering due to their uses in semiconductors, mirrors, lens coatings, and many other applications(Ali 2016 and 2018 and Krishna, 2002). In industry, there are applications in areas including optical electronics, communications, and a variety of coatings, energy generation, and energy conservation1. Thin Films are also heavily used in microelectronics and semiconductor devices. The thin film industry is growing as quickly as scientist and engineers can find applications for them. This field will become even more vibrant as we try to make appliances and systems smaller and thinner (Jeonghun et al., 2021**)**. One of the beauties of thin film physics is that it is a very multidisciplinary subject. Through thin films we can explore areas in solid state physics, surface 2 science, chemistry, vacuum science, crystal growth, and still more. The reason for this is that we are dealing with layers from millimeters of material to nanometers and beyond. With such small amounts of material, the structure and material properties become very important. Questions arise about discrepancies between effects in the thin films and effects in bulk properties of the same material. By investigating these abnormalities. After thin films were produced, the thickness is an important quality of thin films, it became necessary to find a way to measure the thickness of the films so that BYU—Idaho can begin developing thin films with specific applications in mind. Measuring the thickness will also be important to ensure that the deposition method which is used can produce films with consistent properties and quality.

A coating is a covering that is applied to the surface of an object, usually referred to as the substrate. The purpose of applying the coating may be decorative, functional, or both (Ho, 2021). The coating itself may be an all-over coating, completely covering the substrate, or it may only cover parts of the substrate. An example of all of these types of coating is a product label on many drinks' bottles- one side has an all-over functional coating (the adhesive) and the other side has one or more decorative coatings in an appropriate pattern (the printing) to form the words and images. Paints and lacquers are coatings that mostly have dual uses of protecting the substrate and being decorative, although some artist's paints are only for decoration, and the paint on large industrial pipes is presumably only for the function of preventing corrosion, (Felton and Porter, 2013). To make sure that coating, which were produced by a given process, satisfy the specified technological demands a wide field of characterization, measurement and testing methods are available. The physical properties of a thin film are highly dependent on their thickness. The determination of the film thickness and of the deposition rate, therefore, is a fundamental task in thin film technology. In many applications, it is necessary to have a good knowledge about the current film thickness even during the deposition process, as e.g. in the case of optical coatings. Therefore, one distinguishes between thickness measurement methods which are applied during deposition ("in situ") and methods by which the thickness can be determined after finishing a coating run ("ex situ"). (Davis *et al*., 2015).

Theoretical Background

The transmission of light defined as the amount of light that can be passes through material, it can be describe mathematically by relation

$$T=\frac{I}{Io} \qquad (1)$$

Where (Io) is incident laser intensity, and (I) is the transmitted laser intensity .According to transmission some optical constants (refractive index and absorption coefficient) can be calculated. The refractive index (μ) is ratio between speed of light in vacuum to tis speed on material, the refractive index of the fabricated multilayer thin film was calculated using the reflectivity (R) and the glass substrate refractive index (μ_s) according to below

$$\mu = \left(\frac{\mu_s(1+\sqrt{R})}{1-\sqrt{R}}\right)^{1/2} \qquad (2)$$

Where T_s represents the transmission of glass substrate.

The absorption coefficient is a measure of the rate of decreased in the intensity of electromagnetic radiation as light pass through substance, it can be calculated by using following equation (3)

$$\alpha = \frac{1}{t}\frac{\mu(1-R)^2}{T} \qquad (3)$$

Where T is the transmission and t the thin film thickness.

The transmittance was calculated by the equation:

2. Materials and Methods

The material used in this work were Phenexezon, Rhodamine6G and Coumarin500 dyes dissolved in ethanol to made solution of each dye.

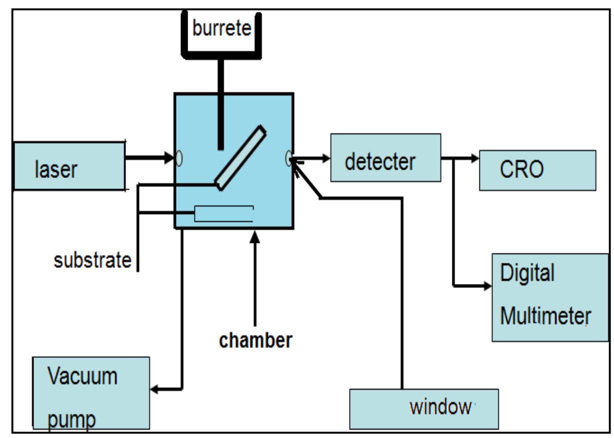

Figure (1): schematic diagram of the experimental setup

Figure (1): show the schematic diagram used to fabricate the multilayers thin films from the liquid dyes to study their optical properties, there are many parts in this diagram which are: laser source used during deposition process, chamber with two glass windows on parallel side one to entrance the laser beam and the other to output the laser beam to the detector, CRO and digital voltmeter to record the output., signal, vacuum pump to create a vacuum inside the chamber and vacuum gauge to measure the pressure inside the chamber, two Bibite contains the liquid dyes used for deposition the thin film on the glass substrate (Suliman, 2007).

Samples Preperation

To fabricate three multilayer thin films, the solution was prepared by dissolved the dyes (Phenexazon, Rhodamine 6G, Coumarin500) each one in the ethanol spirit for obtaining the lowest concentration. The sample holder was inserted in the vacuum chamber which holds the glass substrate at the angle of 45^0, and was closed after that carefully and then the vacuum pump was turned ON, the air was evacuated from the chamber till the pressure reach $0.3x10^{-2}$ mbar. He-Ne laser was turned ON, and then the incident laser intensity (I_0) was measured by the digital multimeter, and the signal was detected by CRO.

Phenexazon dye solution was deposited dropwise on the glass substrate, the laser signal was detected during the deposition until the interference fringes was appearance, then the interference fringe was photographed, the deposition process take 11 seconds to deposited this layer with thickness equal half wavelength of He-Ne laser, the above procedure was repeated for Rhodamine 6G and Coumarin500, the thickness of this layers showing in table (1). The transmission of multilayer thin film was recorded using UV-VIS spectrometer.

Table (1): the component and thickness of the sample's layers.

The thickness (nm) of the components of the sample (S)			The total Thickness(nm)
Phenexazon	Rohdamin6G	Coumarin	
316.4	316.4	632.8	1265.6

Results and discussion:

The transmission spectrum of this sample were recorded in the region between (532 to 915) nm by measuring (I_0) and (I) before and after deposition of the layers , the maximum intensity of thin film layers samples was formed as shown in table (2):

Table (2): The incident, transmitted intensity, the transmission and the reflectivity of sample (S)

λ (nm)	I_o (in volt)	I (in volt)	T	R
532.0	1.001	0.97	0.969	0.0309
632.8	1.002	0.973	0.97105	0.0289
671.0	1.004	0.98	0.976	0.0239
675.0	1.003	0.983	0.98	0.0199
820.0	1.0054	0.988	0.9826	0.0173
915.0	1.0023	0.975	0.9727	0.027

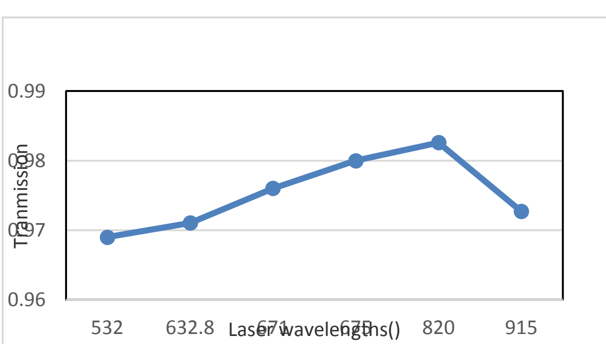

Fig (2): The transmission spectrum of the sample.

It can be noticed from figure (1) that the transmission for this sample is maximum at wavelength of 820 nm, which means that this sample can be used as a window for this wavelength. From the same figure one can see that this sample can be used as reflector or partial reflector in the region from 532 nm to 632 nm where the transmission was lower compared with other wavelengths.

Table (3): The refractive index and the absorption coefficient of the sample.

λ (nm)	N	$\alpha(cm^{-1})\times10^{-4}$
532.0	1.029	2.41
632.8	1.035	2.08
671.0	1.05	1.873
675.0	1.06	1.588
820.0	1.07	1.37
915.0	1.025	2.18

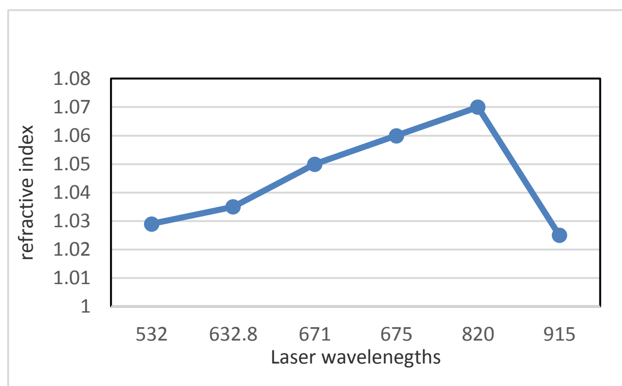

Fig (3): The refractive index of the sample versus wavelength

Figure (2) shows the refractive index of sample as a function of wavelengths. It was found that the highest value of the refractive index at 820 nm, and the lowest value was 915 nm. This Sample can be used for a reflector within the range 671 up to 820 nm. But at the range 532 to 632 nm and the wavelength 915 nm, the sample can be used as a partial reflector.

From figure (3) it can be observed that the least value for absorption coefficient is at (820 nm) compared to the other wavelengths. Indeed the sample at this wavelength can be used as reflector. Also the values of the absorption coefficient increased at other wavelengths compared to (820 nm), and reach the highest value at (532.8 nm).this feature means that this sample can be used as an absorption filter at (532 nm).

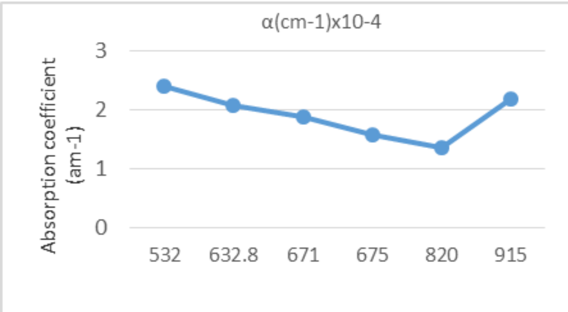

Fig (4): The absorption coefficient of the sample versus lasers wavelengths

Conclusions

Syntheses three multilayer thin films, the solution was prepared by dissolved the dyes (Phenexazon, Rhodamine 6G, Coumarin500). The maximum transmission is at wavelength of 820 nm and also the maximum refractive index value at 820 nm .The minimal absorption coefficient value at 820 nm. The refractive index decreased while absorption coefficient increased.

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