Effect of Thickness on Optical Properties of (Cr_2O_3) Thin Films Prepared By Chemical Spray Pyrolysis Technique

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Abstract

Chrome oxide (Cr_2O_3) thin films at different thickness(1350-1600°A) were prepared by chemical spray pyrolysis technique at (400º C) on glass substrate .Absorbance and transmittancespectra have been recorded as a function of wave length in the range (190- 900nm).We found all optical properties such as (transmission,reflectance ,refractive index, extinction coefficient ,energy gap of allowed direct transition and dielectric constant in real and imagery parts all as a function of the wavelength decrease with increase thickness except the absorbance

Key words : Chrome oxide (Cr_2O_3), optical properties ,thin films thickness.

تأثير السمك على الخواص البصرية لأغشية (Cr_2O_3) الرقيقة المحضرة بطريقة التحلل الكيميائي الحراري

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الخلاصة

حضرت اغشية رقيقة من اوكسيد الكروم باستخدام تقنية التحلل الكيميائي الحراري على قاعدة زجاجيةعند درجة حرارة 400ºC ،وبسمك (1350 , 1600° A) قيس طيف الامتصاصية والنفاذية كدالة للطول الموجي ضمن المدى (-190 900nm). لقد وجد ان جميع الخواص البصرية (الامتصاصية، النفاذية، الانعكاسية ، معامل الانكسار،معامل الخمود، ثابت العزل بجزئيه الحقيق والخيالي وفجوة الطاقة للانتقال المباشر المسموح تأثرت بالسمك (قلت ماعدا الامتصاصية ازدادت بزيادة السمك).

الكلمات المفتاحية : اوكسيد الكروم (Cr_2O_3) ، الخواص البصرية ، سمك الاغشية الرقيقة

Introduction

Chromium oxide (Cr_2O_3) thin films are of great interest due to their wide variety of technological applications. This oxide exhibit high hardness and high wear with corrosion resistance which are an important properties for protective coating applications [1],it has already found several applications as protective coatings onread-write heads in digital magnetic recording units and in gas-bearing applications .It has been studied for opticaland electronic uses such as selectively absorbing films for solar energy conversion[2] films for windows,and electrode material for electro chromic windows [3].The most stable phase is the corundum structured(Cr_2O_3).This form of oxide has important industrial applications ,for instance and solar thermal energy collectors.Chromium oxide is an insulating antiferromagnetic material it is also suitable as a tunnel junction barrier[4].On other hand, despite its intrinsic insulator nature , (Cr_2O_3) films can either p-type or n-type properties in a single materials makes (Cr_2O_3) a key material for the development of a broad range of industrial applications[5].

We present in this work the effect ofthickness on some optical properties of(Cr_2O_3) thin filmsprepared by the chemical spray pyrolysis.

Experimental work

Thin films of Chromium oxide (Cr_2O_3) have been prepared by chemical spray pyrolysis technique. The spray pyrolysis was done with a laboratory designed glass atomizer ,which has an output nozzle about 1mm.The films were deposited on preheated glass substrates at temperature (400ºC) because we obtained the best homogeneous film at this temperature, the chemical solution with concentration 0.1 M prepared by using (0.8888 g) from ($CrCl_3.6H_2O$) in 100ml of water ,homogeneous mixture was achieved by using magnetic stirrer .The optimized conditions were arrived at the followingdeposition parameter

1-Substrate temperatures are (400ºC)

2-Spray rate (average deposition) 10 cm^3/min

3- Distance between Sprayer nozzle and substrate of 30 cm.

The glass substrates are placed on the hot plate fan about (30)min before spraying process,so the glass substrates are nearly at the same temperature as the hot plate .Each spraying period lasts for about (15 sec) followed by about (5) min waiting period to avoid excessive cooling of the hot substrates due to the spraying .The samples thickness were(1350 ,1600Ȧ) was measured using the gravimetric method.

Thickness = (Δ W /ρ.S)

Where ρ the density (g/cm^3) ,s the film area(cm^2)

The absorbance and transmittance measurements were carried out using a Shimadzu UV/VIS -1650PC,double beam spectrophotometer in the wavelength range of (300-900 nm).

Results and Discussion

The Reflectance(R) calculated from the spectrum of absorption (A) and transmission (T) according to the law of energy conversation [6,7].

$R + T + A = 1$ (1)

The extinction coefficient (k) is the absorption energy in the thin film and it also represent the imaginary part of refraction index according to the relation [8].

$n = c/v = n_0 - k$ (2)

Where:

(v) is the velocity of light in the thin films ,(c) is the velocity of the light in the vacuum and (n_0) is the real part of refractions index .Also the extinction coefficient is related to absorption coefficient (α) by the relation [9].

$K = \alpha \lambda / 4\pi$ (3)

Absorption coefficient (α) represents the relation of decreasing in intensity of radiation through the material by following relation [10].

$\alpha = (1/t).(1n\ 1/T) = 2.303A/t$ (4)

Where (t) is the thickness of the thin film, and (T) is the transmittance.

Refractive index (n) associated with the reflectance of thin film by the relation[11].

$n = \{(1+R)/1-R)^2 - (k2+1)\}^{1/2} + (1+R/1-R)$ (5)

The reaction between the light and the charges of the medium occur by presses of the absorption of energy in material and that lead to polarized of the medium's charges, this polarization decrypted by the complex dielectric constant for the medium by the relation [12,13].

$\varepsilon = \varepsilon_r - \varepsilon_i$ (6)

Where ; (ε_r) is the real part of the dielectric constant,

(ε_i) is the imaginary part of the dielectric constant.

From the last relation the real and imaginary parts of the dielectric constant are calculated as following :

$\varepsilon_r - \varepsilon_i = (n - k)^2$ (7)

$\varepsilon_r = n^2 - k^2$ (8)

$\varepsilon_i = 2 nk$ (9)

As direct band gap semiconductors, the incident photon energy (hν),absorption coefficient(α),and optical energy gap (E_g) are related by the following relation[8]:

$h\nu\alpha = \bar{A} (h\nu - E_g)^n$ (10)

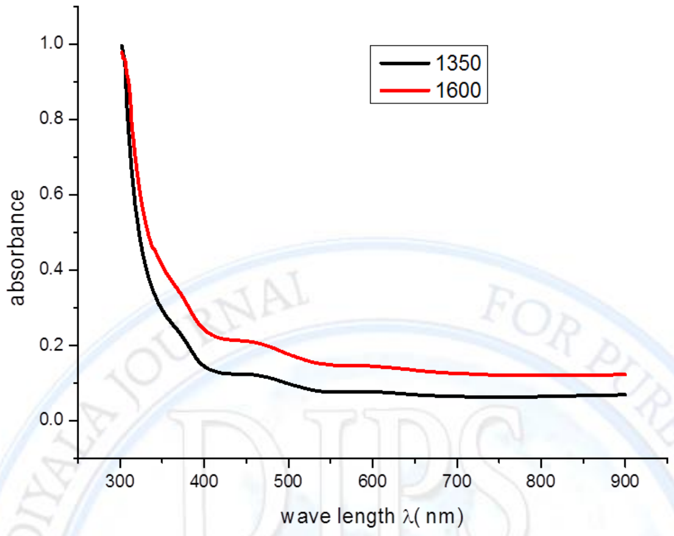
It was found that n = ½ is the best fit for our results(allowed direct transition)get:

$(\alpha h\nu)^2 = \bar{A} (h\nu - E_g)$ (11)

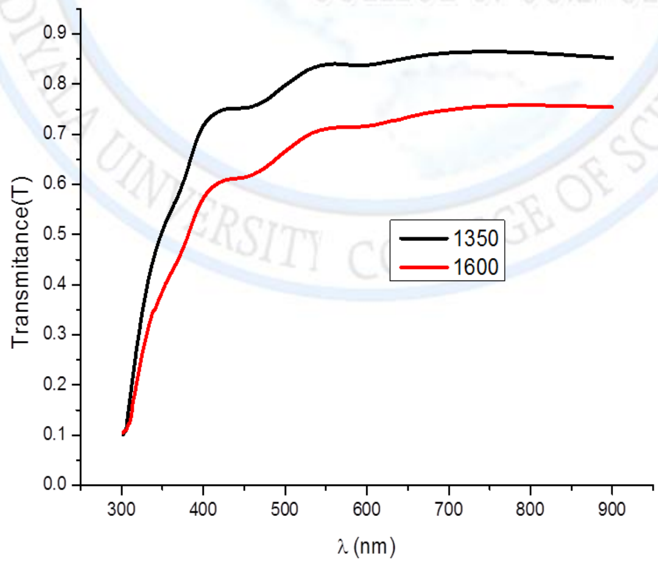
Where($\bar{A}$) is a constant

The optical properties(absorbance ,transmittance , reflectance, refractive index ,extinction coefficient ,real part and imaginary part of dielectric constant of the films as a function of wavelength in the range (300-900 nm) are shown in figures(1-7)respectively. We can observe from these the all optical properties decreases with increasing the wavelength and the thickness except absorbance.

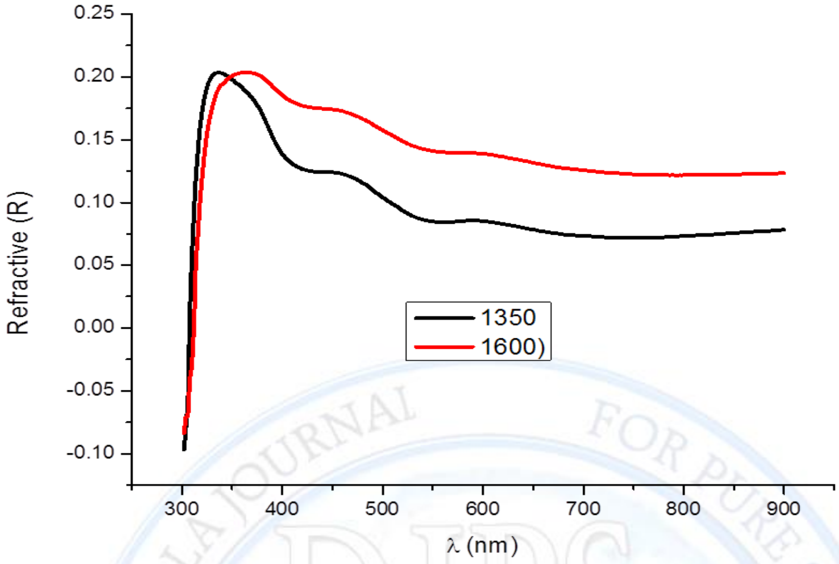
The variation of $(\alpha h\nu)^2$ versus photon energy for Cr_2O_3films at different thickness are plotted in fig (6). optical band gap(E_g)can be evaluated by extrapolation of the liner part to be(3.862,3.75 eV)for (1350 ,1600 Å) respectively .the variation of $(\alpha h\nu)^2$ versus photon energy for Cr_2O_3films at different thickness are plotted in fig (6). optical band gap(E_g)can be evaluated by extrapolation of the liner part to be(3.862,3.75 eV)for (1350 ,1600 Å) respectively .



Fig(1) Absorbance of Cr_2O_3 against wave length at different thickness films.



Fig(2) Transmission spectra of Cr_2O_3 against wave length at different thickness films.



Fig(3) Reflectance spectra of Cr_2O_3 against wave length at different thickness films.

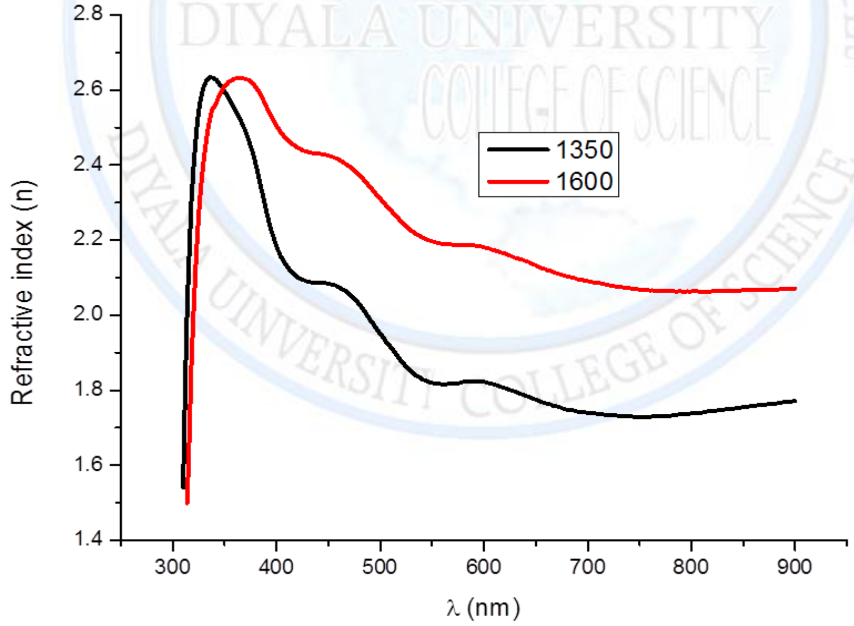
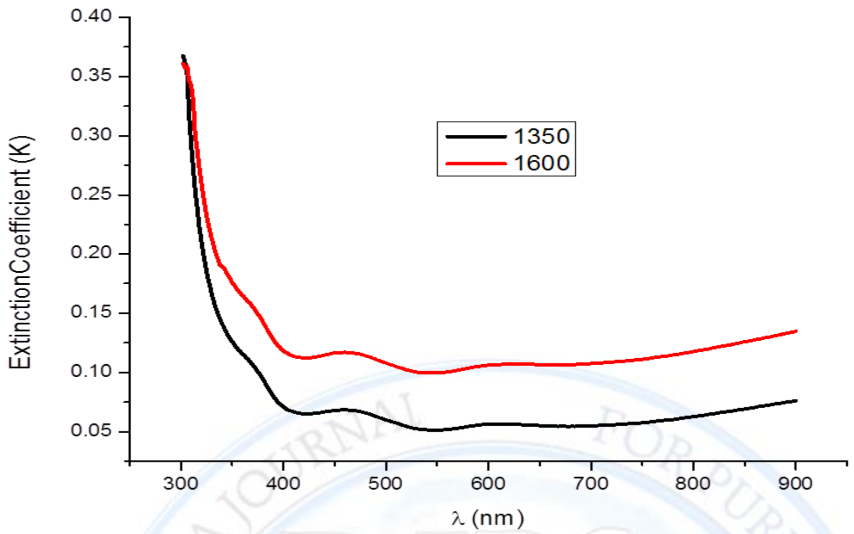


Fig (4) Refractive index of Cr_2O_3 against wave length at different thickness films.



Fig(5) Extinction coefficient for Cr_2O_3 against wave length at different thickness films.

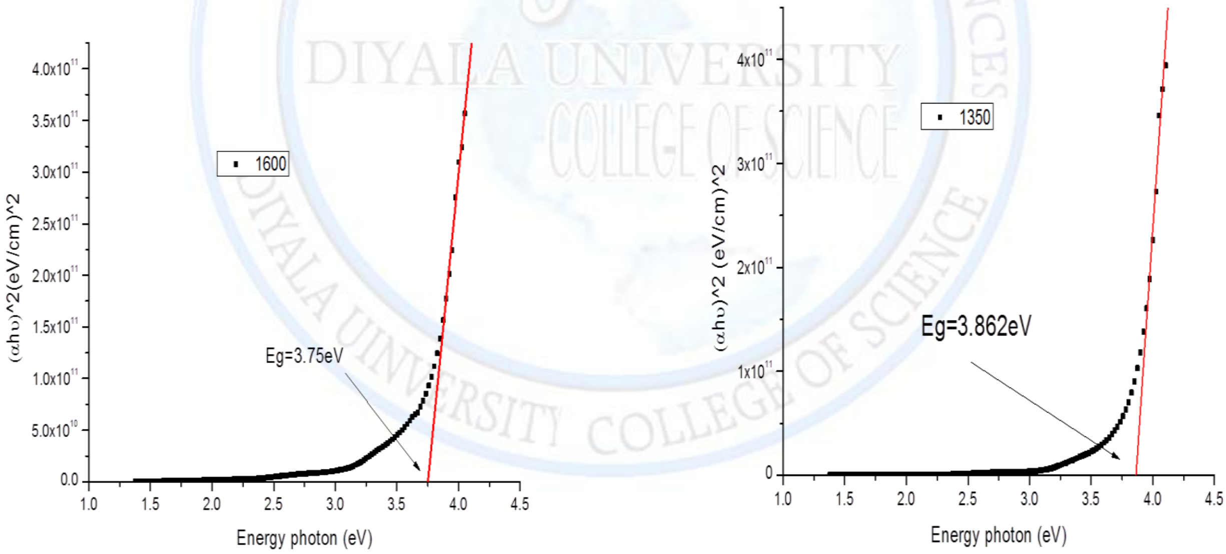
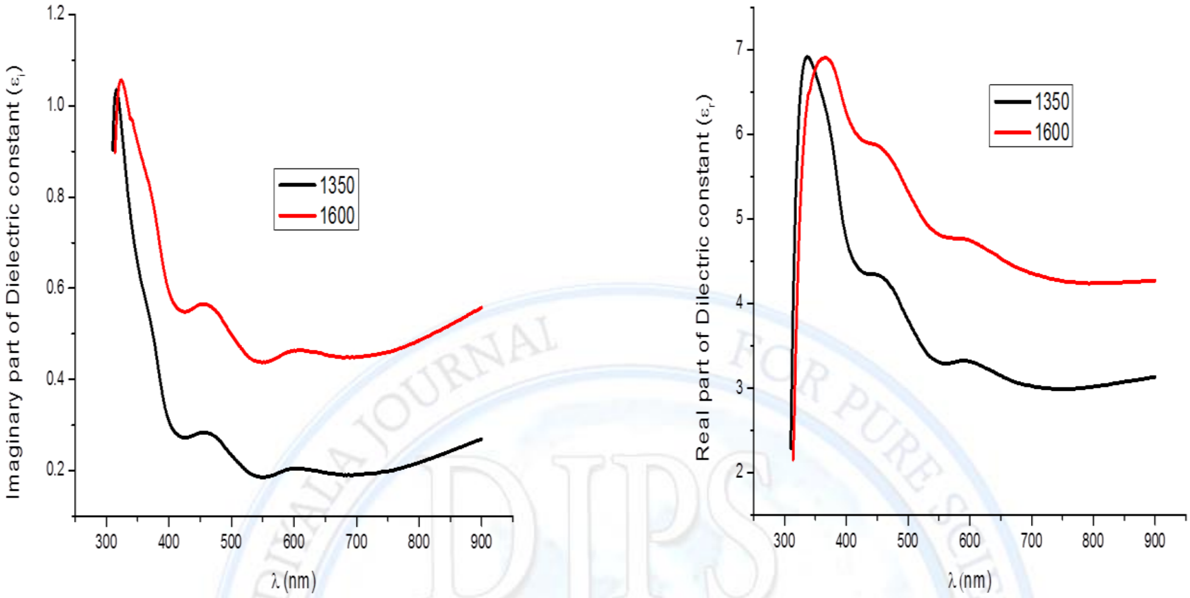


Fig (6): $(\alpha h\nu)^2$ for Cr_2O_3 against photon energy at different thickness films.



Fig(7) Real and imaginary part of dielectric constant for Cr_2O_3 against wave length at different thickness films.

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