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OPTICAL PROPERTIES OF V2O5:TIO2 THIN FILM PREPARED BY PLD TECHNIQUE

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Abstract:

In this work, pure and doped Vanadium Pentoxide (V2O5) with TiO2 of different ratios (0, 0.1 , 0.3, 0.5) wt were obtained using Pulse laser deposition technique on amorphous glass substrate with thickness of (250)nm at T=373k. The morphological, UV-Visible was studied. The Transmittance and Absorption of each Film, in the spectral range (300 to 1100) nm, were measured from which the optical constants (Refractive index, Absorption coefficient, Extinction coefficient and Energy gap) were determined .The energy band gap of the films was found to be change from (2.44 to 4.07) eV when the concentration of TiO2 increases from (2.66 to 4.07) eV The results showed a significant improvement in the transmittance and refractive index in TiO2 doped V2O5 thin films .All measured values were in consistent with other previous studies.

Keywords: Nanoparticles thin films; Optical properties; Pulsed laser deposition.

Introduction:

The optical properties of a semiconductor are related to intrinsic effect where the intrinsic location of the top of the valence band (V.B) and the bottom of the conduction band (C.B) in the band structure, the electron–hole pair generation occurs directly or indirectly [1] .The semiconductor V2O5:TiO2 is a direct and indirect band gap semiconductor. The fundamental absorption is the most important absorption process which involves the transition of electrons from the valence band to the conduction band. The process manifests itself by a rapid rise in absorption and this can be used to determine the energy gap of the semiconductor [2]. The semiconductors absorb photon from the incident beam, the absorption depends on the photon energy (hν); where h is Plank's constant, ν is the incident photon frequency. The absorption associated with the electronic transition between the V.B and the C.B in the material starting at the absorption edge which corresponds to minimum energy difference (Eog) between the lowest minimum of the C.B. and the highest maximum of the V.B [3]. If the photon energy (hν) is equal or more than energy gap (Eog), the photon can interact with a valence electron, then elevates the electron into the C.B and creates an electron–hole pair. The maximum wavelength (c) of the incident photon which creates the electron–hole pair defined as [4].

2. Experimental Parts

2.1 Material Preparation

Bulk samples of V_2O_5:TiO_2 prepartion by solid state reaction process. V_2O_5 and TiO_2 with a purity of 99.99% are manufactured are Grinded and mixed together at a different ratios of (X = O,O.1,O.3,O.5) wt. % of the formula $(V_2O_5)_{1-x}(TiO_2)_x$ in a compost machine for (10minute). Then it is compressed into pellets with (1.2) cm diameter and (0.2) cm thick, using hydraulic piston type (SPECAC), under the pressure of (2) tons/cm^2 for (5) minutes .The pellets are sintered in air to temperature (400 ^{0}C) at 1 hours then cooled to R.T. The temperature of the furnace is raised at a rate of (250) ^{o}C/hour. Nd-YAG laser (Huafei Tongda Technology—DIAMOND-288 pattern EPLS) was used for the deposition of (V_2O_5:TiO_2) upon glass substrate with laser wavelength (1064) nm، Pulse energy (600) mJ ,pulse duration 10 ns. Repetition frequency: (incident on the target surface makes an angle of (45°) with it). The distance among the target and the laser gun is exactly 15 cm . and the vacuum chamber under pressure of 10^{-3} mbar.

2.2 The measurements

Optical properties of films with different ratios of X in $[TiO_2]_x$ was measured and determined at a wavelength of range [400 to 1100] nm using [UV / VIS Central 5 spectrometer that previous GBC Scientific Equipment PTY LTD].

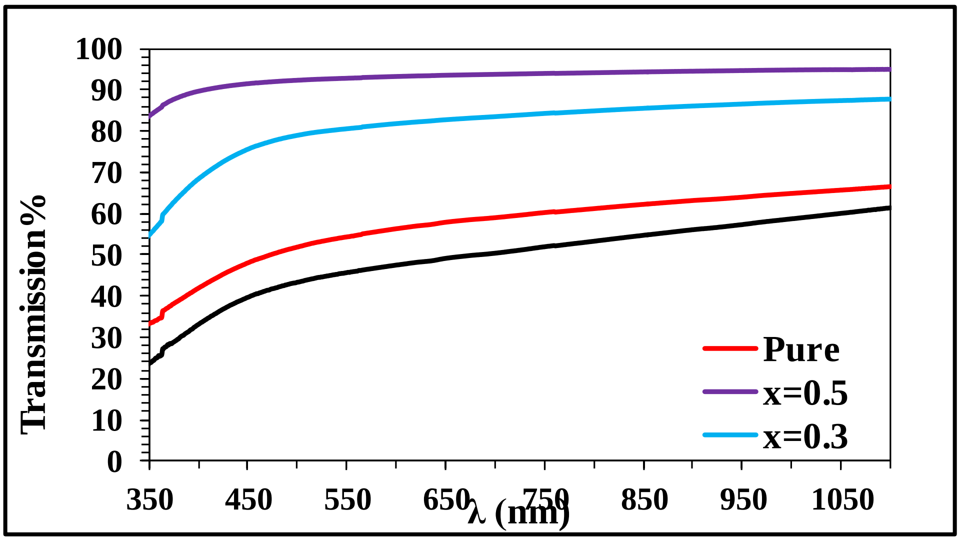
Result and discussion:

Optical Properties

The Transmittance

Figure (1). Shows the Transmittance Spectrum as a function of wavelength at the range of 45O-11OO nm of V_2O_5:TiO_2 Thin Films prepared at room temperature with different ratios TiO_2 (X= o,o.1,o.3 and o.5). It is obvious from this figure ; that the transmittance proportionate to concentration it increases with an increase of TiO_2 ratios. At x=0 (pure V_2O_5), films show transmittance up to 50% in the visible range of electromagnetic spectrum. Lack of oscillations suggests that the films so formed are very thin. At x=0.1 the transmittance is 70%.With the incorporation of TiO_2 there is gradual increase in transmittance as addition of TiO_2 leads to transparency of films which in turn leads to increase in transmittance. When x=0.5 films shows four to five fringes and there is a gradual increase of transmittance towards shorter wavelength. It is remarkable that a gradual increase in the blue-shift is observed with increase in TiO_2 doping.

Figure (1) Optical



transmittance for V2O5:TiO2 at T=373k.

The Absorption Coefficient

Figure (2) . presents the absorption coefficient of as-deposited vanadium oxide thin films as a function of wavelength and different concentration of TiO_2. It can be note from the figure that the values of Absorption C0efficient becomes higher [$\alpha > 10^4$] cm^{-1}; this supports to anticipate a direct electronic transition happens in these regions [5]. It is found that the value of the Absorption C0efficient losses with an increase of deposition time whose goes back into increases of the (Eg) , transmittance leads to decreases in the absorption of the photons which is attributed decreases the defects inside the gaps.

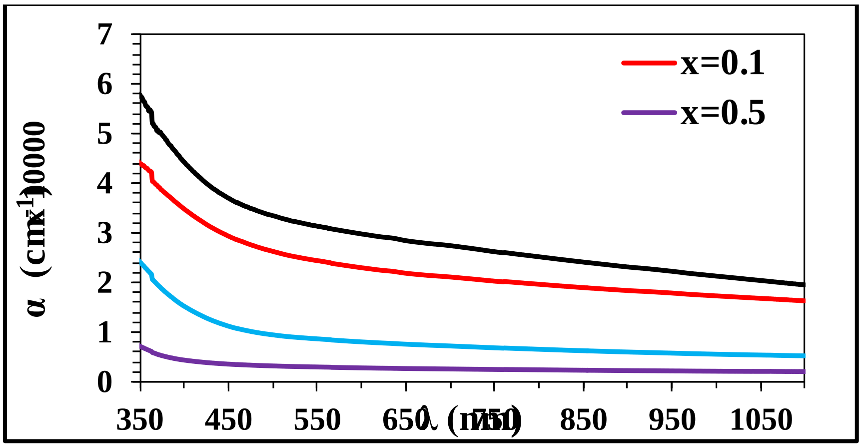


Figure (2) Optical absorption coefficient for V2O5:TiO2 at T=373k.

The Energy Gap

Figure (3). shows the variation of $(\alpha h\upsilon)^2$ as afunction of (hυ) for V_2O_5 doped TiO_2 .By using Tauc equation ($\alpha h\upsilon=B[\ h\upsilon-E_g\ ]^{r}$) calculates a values of E_g of V_2O_5 films to show that relationship $[\alpha h\upsilon]^r$ opposite hυ Photon energy and elect the optimal linear section. It exist that the relations with regard to [r=2]linear approval yields; indicating the permitted direct transition. The optical Energy Band Gap E_g of the Films elect from the linear section of the widget for $[\alpha h\upsilon]^2$ opposite hυ to [α=o] .The optical bandgap of the Films can be evaluated from extrapolating the linear portion to the axis . The values of optical energy gap increases with increasing of TiO_2 content, due to decrease in the absorption and increases in the transmission . E_g increases from [2.44 to 4.07] ev with an increase the TiO_2 ratio from 0.1 to 0.5, respectively as shown in the table (1).

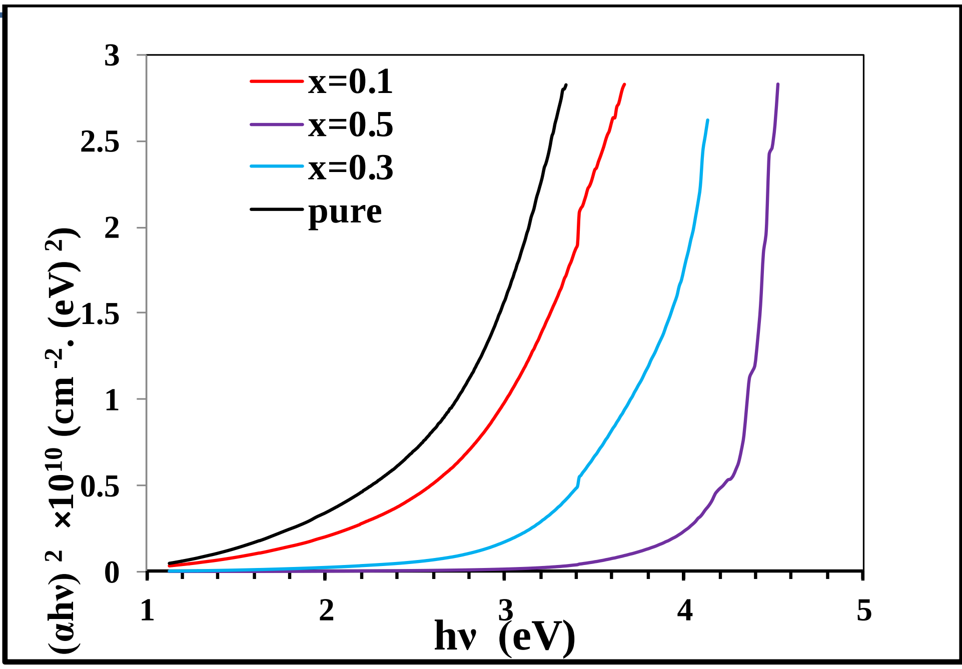


Figure (3) Optical energy gap for V2O5:TiO2 at T=3732k.

Table (1) illustrate the values of Egopt and Optical constants at λc=520 nm for (V2O5)1-x(TiO2)x films with different TiO2 content at T=373k.

T_a (°c)	TiO_2%	T%	α*10^4 (cm^{-1})	direct E_g^{opt}(eV)
T=373k	0	44.438	3.244	2.44
	10	53.028	2.537	2.60
	30	79.720	0.906	3.32
	50	92.530	0.310	4.07

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