Review on Vanadium Pentoxide Thin Films Coated by Varying Thickness and Temperatures and Their Obtained Bandgaps

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Abstract: - **In the past decade delectable properties and the utilization of vanadium pentoxide thin films have attracted the attention of most researchers. An important role of V_2O_5 thin film applications, namely cathode material for Li batteries, gas sensors, transistors, resistance (in the form of thin film) and catalysts. This review summarizes the list of a few preparation methods of thin films known till now and different thickness of films, temperature and obtained bandgap from different methods.**

Keywords: **Vanadium pentoxide, vacuum evaporation method, electron beam evaporation, pulsed laser deposition, thickness and temperature.**

I. INTRODUCTION

An engrossing property of vanadium is more than one stable multiple oxide state and the order of oxide compounds isVO_2,V_2O_5,VO, V_2O_3[1-3]. Vanadium pentoxide has certain convenient properties such as thermo-electro chromic behavior, conducting to semiconducting transition and high co-efficient resistance. The wide range of applications of vanadium oxide are optoelectronic device, optical switches, gas sensors and smart windows[1-6]. Well-known vanadium pentoxide manifests insulator to conduct phase transition at the temperature of 257ºC[7]. N-type semiconducting V_2O_5 has 2.3 eV [8].V_2O_5comes under orthorhombic structure unit cell, and the values of lattice parameters a, b, c are (11.510Å, 3.563Å and 4.369Å)[9]. The prepared V_2O_5 thin films recruit from a few techniques, namelyelectron beam evaporation, thermal vacuum evaporation, reactive sputtering, pulsed laser deposition and sol-gel (dip-coating). Amorphous and polycrystalline vanadium have been investigated [10-12]. V_2O_5 is a premium catalyst as a chemical[13]. The shared corners, faces, edges of pentagonal by pyramids, tetrahedral, octahedral and square pyramids are combined to form an excellent variety of structural arrangements [9]

. Table 1. Different methods of V_2O_5 thin films

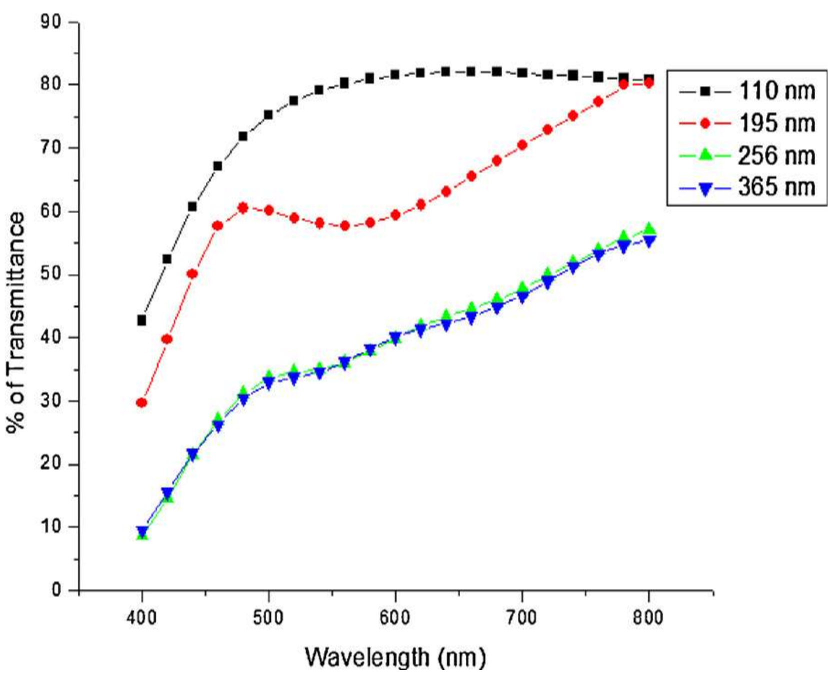
Methods	Application area	Temperature (ºC)	Thickness (nm)	Band gap energy (eV)	Transmittance (in %)
Thermal vacuum evaporation[15]	Thin film batteries	Room Temperature	110 195 256 365	2.40 2.35 2.15 2.02	Not studied
Electron beam Evaporation [21]	Electronic Device	0 573 673 773	62 99 46 48	2.9 2.78 2.82 2.78	Not studied
Electron beam Evaporation [19]	Optical switching	200 250 300 350 400 450 500	200-2500	2.79 2.71 2.64 2.53 2.48 2.30 1.87	Not studied
Electron beam Evaporation [22]	Energy efficient surface	Not studied	50 75 175	Not studied	0.840 ($T_{luminous}$) 0.787(T_{solar}) 0.829($T_{luminous}$) 0.765(T_{solar}), 0.762($T_{luminous}$), 0.719(T_{solar})
Vacuum evaporation[14]	Cathode materials for TFBs	300 & 400	300-1100	Not studied	70 60 45(vis region)

Pulsed laser Deposition[9]	Nano electronics	220 (substrate)	100	2.53	Not studied
Thermal evaporation [21]	Thermo electric property	500 (post annealing)	<100	2.8	> 60

II. PREPARATION METHOD OF V_2O_5 THIN FILMS

2.1 Vacuum evaporation technique

Nowadays thermal evaporation method is widely used to prepare V_2O_5 thin films. Vanadium is a stable multiple oxide having more than one state and VO, VO_2,VO_3,V_2O_5 are oxide forms. Aqueous electrolytes present in conventional bulk batteries are involved in charge and discharge process and it is responsible for the formation of dendrite phases, which are not present in TFBs[14]. V_2O_5has high capacity, good cycle performance, high energy density and high potential, so it is a delectable candidate for TFBs[14]. The properties of vanadium pentoxide films are mostly dependent on deposition conditions, namely deposition temperature, vacuum, residual gases in the chamber during the deposition process and deposition rate as well as deposition technique[14]. Transmittance of V_2O_5 thin films decrease with the increase in its thickness [15].

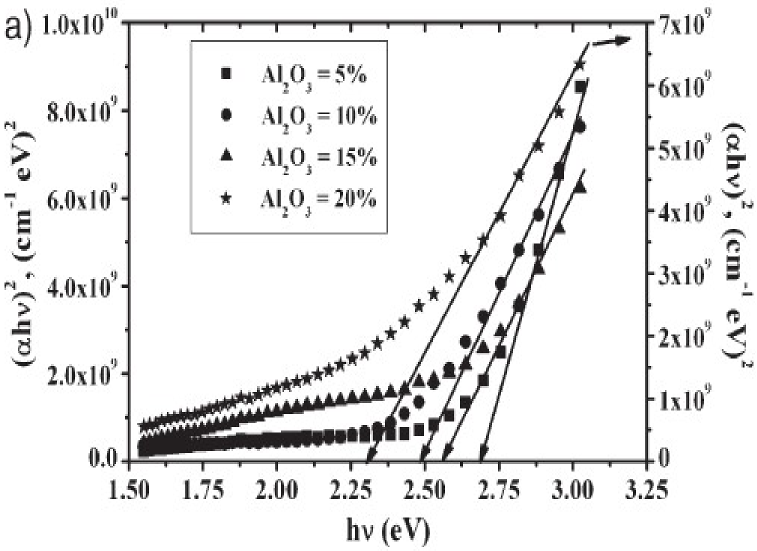


Ref[15]:Sengodan Raja, Gopal subramani, Dinesh Bheeman, Ranjithkumar Rajamani, ChandarShekar Bellan, Structural and Opitcal properties of vacuum evaporated V2O5 thin films, Optik 127(2016)461.

Fig.1: Transmittance spectral analysis of vanadium pentoxide films deposited at various thicknesses [15].

2.2 The Electron beam evaporation technique

It is a perfect tool for making vanadium pentoxide thin films such as anti-reflecting, scratch resistant filters and coating lenses[16]. Vanadium pentoxide thin films fabricated by this method were pinhole-free well-adherent and uniform to substrate surface[17]. The freshly prepared vanadium pentoxide films were yellow at room temperature, and when substrate temperature (303 to 603K) was increased, it changed from yellow to orange yellow[17]. Livage et al. reported that the V_2O_5 films deposited at room temperature were readily dissolved in water giving a clear yellow solution, which confirmed the amorphous nature of the films[18]. In this method when electron beam bombards the target surface it converts kinetic energy of the electron into thermal energy[16]. Co-deposition and sequential configuration, excellent material utilization of film composition and deposition rate can be precisely controlled by electron beam evaporation method. Low energy atom flux can be achieved with minimum impurity by this method [16]. Higher deposition rate may be attained with a fine structural and morphological control [16]. H.M Ali et al. absorbed the optical bandgap ranges from 1.82 to 2.83 eV, and for different ratios of Al_2O_3 the bandgap decreases with an increase in annealing temperature[19].

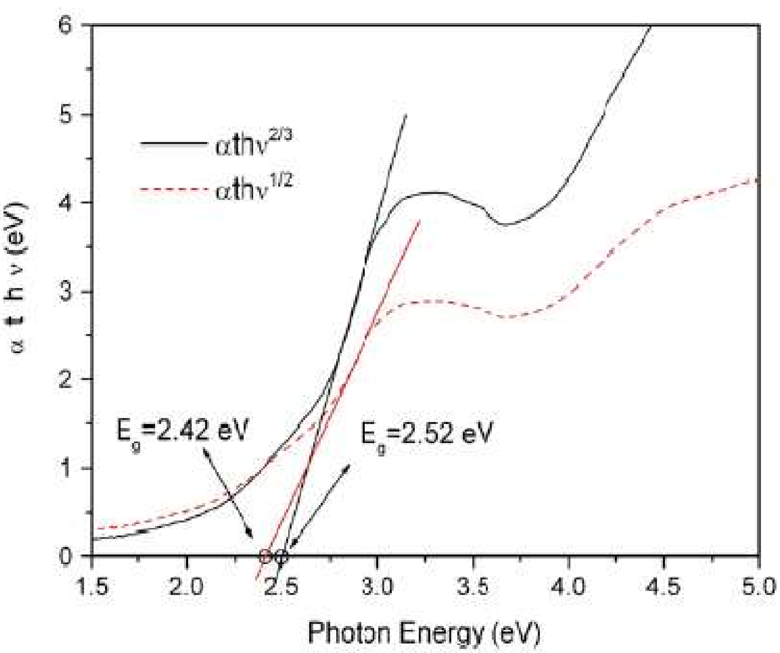


Ref[19]: H.M.Ali and A.M.Abdel Hakeem, Structural and optical properties of electron-beam evaporated Al2O3-doped V2O5 thin films for various applications Physica Status Solidi A207(2010)132.

Fig:2. Plot of the Urbach energy and the corresponding bandgap of aluminium oxide $(Al_2O_3)x$ films [19].

2.3 Pulsed laser deposition technique

PLD is a superior method for the preparation of clusters in the range of 10^{-9}[9]. Compared to other deposition methods, it is better because in this method V_2O_5 can be deposited at low temperature (220 ºC)[9]. In this technique, from the target a vapour flux is produced by the erosion of a material due to an array of high energy laser pulses[16].Due to its versatility and flexibility it is mostly applicablein complex oxide thin film deposition[16]. Borek et al. reported the first PLD ablated vanadium monoxide deposition[20]. S.Beke et al. estimated the optical bandgap (2.52 eV) and also the Bohr radius was found to be 4.52 for vanadium pentoxide [9].



Ref[9] : S.Beke, S.Giorgio, L.Korosi, L.Nanai, W.Marine, Structural and optical properties of pulsed laser deposited V2O5 thin films, Thin Solid Films

Fig:3. αthν vs. hν [9].

III. CONCLUSION

In this paper, orthorhombic structure of vanadium pentoxide thin films coated by different methods namely electron beam evaporation, pulsed laser deposition and thermal evaporation has been investigated. In this case all the developed methods contributed to a wide range of vanadium pentoxide thin film applications, whereas V_2O_5mainly differed with structural, electrical, and optical properties. The overall SEM study reveals the amorphous nature of V_2O_5thin film. This review investigated different thicknesses, temperature and bandgaps of V_2O_5thin film. Regarding the future, the research and applications of V_2O_5 thin film will be focused primarily on gas sensing and catalytic properties.

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