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Effect & Growth of TiO2 Thin Films for Solar Cell Applications

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Abstract

Titaniun di-oxide (TiO2) hasmany excellent physical properties such as high dielectric constant a strong mechanical and chemical stability. Tio2 has high refractive index and good insulating properties, as a result it is widely used as protective layer for very large scale integrated(VLSI)circuits and for manufacture of optical elements.Additionally TiO2 films have potential uses for a number of electroniuc device applications such as dye-sensitized photovoltaic celles as well as anti reflective (AR) coatings, gas sensore, electro chromic displays, and planar waveguides.

The nanomaterilas were characterized using x-ray diffraction,UV-visible reflectance spectroscopy.In this paper, we have discussed the groth of the High quality Titanium di oxide (tio2) material and study their optical and lectriacl properties.

***Keywords**: TiO2, XRD, PLD, UV/Vis, ThinFilm, DSSC*

I. Introduction

This Titanium dioxide (TiO2)nanomaterials are used ina wide range of applications such as (photo) catalysis, separations, sensor devices, paints, and dye-sensitized solar cells [1–4]. The material properties of TiO2 nanoparticles are a function of the crystal structure, nanoparticle size, and morphology and, hence, are strongly dependent on the method of synthesis [5–15]. TiO2 exists in three main phases: anatase, brookite and rutile. As a bulk material, rutile is the stable phase; however, solution-phase preparation methods for TiO2 generally favour the anatase structure [8]. Titanium-di-oxide (TiO2) can be grown mainly with anatase (tetragonal), rutile (tetragonal) and brookite(orthorhombic) crystalline structures; among this rutile is the most stable phase The actual efficiency of Titanium-di-oxide (TiO2) depends not only on its phase composition but also in its microstructure, Particle size, morphology and porosity which is turn in controlled by the synthesis method employed.NanocrystallineTiO2 usually exhibitsa wider bandgap than that of the bulk (3.03 eV for rutile and3.20 eV foranatase). Moreover,anatase becomes more stable than rutile when the particle size isdecreased below14 nm. Generally speaking, the functionalproperties of nano-TiO2 are influencedby a large number of factors which includeparticle size, surface area, synthesis method and conditions, and crystalline.Allthe specificproperties ofnanosizedparticles have led to the exploitation of nano-TiO2 for a wide variety of applications in which nano-TiO2 is essentially preferred over conventional TiO2 particles. Such applications include self-cleaning surfaces and textiles,UV-resistant coatings and paints, disinfectant sprays, sunscreens, water treatment agents, anticancer treatments[5]. TiO2 is indeed one of the mostwidely used nanoscale materials. Amongst the multiple uses of nano- TiO2 , two major applications can behighlighted in the field of clean energy, namely photo catalytic water splitting and solar cells. Photo catalytic water splitting into H2 and O2

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using nanostructured TiO2 electrodes is thoroughly investigated as it is an environmentally friendly way toproducehydrogen. Anotherpromising application of the TiO2 semi conductivity is as electrode in dye-sensitized solar cells (DSSCs) in which thehigh surface-to-volume ratio of the nanostructured semiconductor is required to obtain an acceptablepower conversion efficiency.

In this paper, we have discussed the Preparation ofnanostructured Titanium-di-oxide(TiO2) thin film using laser ablation on silicon substratekept in vacuum. Pulse laser Deposition (PLD) isa simple low cost methodto grow oxide films, effect of filmdeposition conditions and structural, electrical and optical properties of films havebeen discussed. The measurement of the BandGap is also discussed using theUV/Vis Spectroscopy Technique ofnanostructured Titanium-di-oxide (TiO2) thin filmusing laser ablation onquartz substratekept in vacuumis studied.

II. Thin Film Technology

The field of material science and engineering community’s ability to conceive the novel materials with extraordinary combination of chemical, physical and mechanical,properties has changed the modern society. There isa increasing technological progress. Modern technology requires thin films for different applications [1]. Thin film technology is the basic of outstanding development in solid state electronics. The usefulness of the opticalproperties of metal films, and scientific curiosity about thebehavior of two-dimensional solidshas been responsible for the immense interest in the study science and technology of the thin films. Thin film studies have directly or indirectly advanced manynew areas of research in solid statephysics and chemistry which are based on phenomena uniquely characteristic of the thickness,geometry, and structure of the film. Whenwe considera very thin film of some substance,wehavea situation in which the two surfaces are so closeto eachother that they can haveadecisive influence on the internal physical properties andprocesses of the substance, which differ, therefore, inaprofoundway from those ofa bulk material. Thedecrease in distancebetween the surfaces and their mutual interaction can result in the rise of completely new phenomena.Here the one dimension of the material is reduced to an order of several atomic layers which creates an intermediate system between macro systems and molecular systems, thus itprovides us a method of investigation of the microphysical nature of various processes. Thin films are especially appropriate for applicationsinmicroelectronicsand integrated optics [6].However thephysical properties of the films like electrical resistivity do not substantially differ from theproperties of the bulk material. Fora thin film the limit of thickness is considered between tenths of nanometer and severalmicrometers.

Thin film materials are thekey elements of continued technological advances madeinthefields of optoelectronic,photonic, and magnetic devices. Theprocessing of materials into thin films allows easy integration into various types of devices. Theproperties of material significantly differ when analyzed in the form of thin films. Most of the functional materials are rather applied in thin film form dueto their specific electrical, magnetic, optical properties orwearresistance. Thin film technologies makeuse of the fact that the properties can particularlybe controlledby the thicknessparameter. Thin films are formed mostly bydeposition, eitherphysical or chemical methods. Thin films, both crystalline and amorphous, have immense importance in the age ofhigh technology. Few of them are: microelectronic devices, magnetic thin films in recording devices, magnetic sensors,gas sensor, photoconductors, IR detectors, interference filters, solar cells,polarizer’s, temperature controller in satellite, superconducting films, anticorrosive anddecorative coatings.

III. Experimental Details

Thin films were deposited using pulsed laser deposition unit by employing a Q switched: KrF laser at wavelength 248 nm with 220 mJ of laser energy, pulse width 8 ns and repetition frequency10 Hz. Uniform ablation was ensured by rotatingthe target at a constant speed. Thoroughly cleaned fused amorphous quartz plates were used as substrates. Time of deposition was fixed to be 30 min. Substrate heating was provided in the temperature range Ts =600o C. Pressure inside the deposition chamber was reduced to ~10−6 mbar before deposition. The deposition process was repeated by varying substrate-target (DS-T) distance from 4 to 6 cm. The structure and crystalline of the films were analyzed by X-ray diffraction (XRD) technique using D8 Advance diffractometer operated with a monochromatic Cu Kα radiation source (α = 0.15418 nm). Optical measurements were conducted in the wavelengthrange 300 to 900 nm using a PerklinAlimer US Lambda 950, UV- Visible spectrophotometer.

IV. Result s and Discussion:

A. XRD Pattern of Pure Silicon (Si) Substrate

The XRDpatternofthe PureSilicon (Si) Substrateis shown in Figure 1.

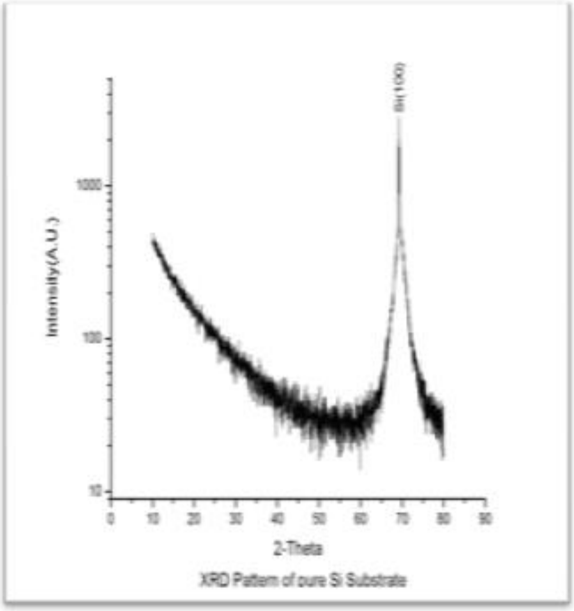


Figure 1. XRD Pattern of Pure Silicon(Si)

B. XRD Pattern of Pure TargetTitanium-di-oxide (TiO2)

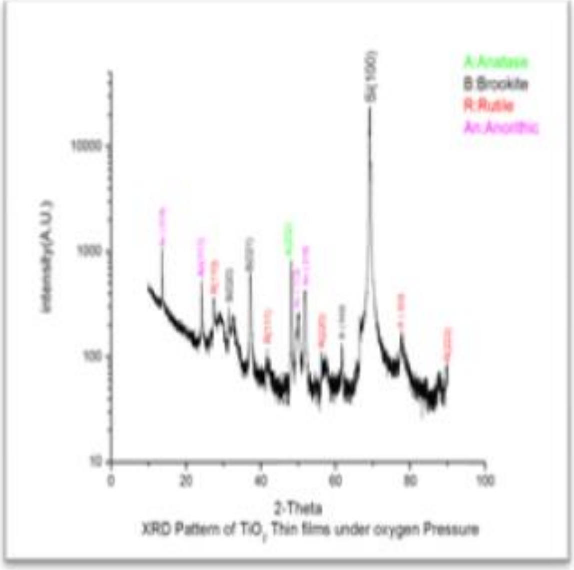


Figure 2. XRD Pattern of Pure Target Titanium-di-oxide (TiO2)

The XRD pattern of the Pure TargetTitanium-di-oxide is shown in Figure 2.

C. XRD Pattern of TiO2 Thin films under oxygen pressure

The XRD pattern of the TiO2 films deposited by Pulse laser Deposition under different conditions is shown in Figure 3.

All these films were indexed and Matched with TiO2 Phase as in JCPDS Card (No. 89-4920) ,JCPDS Card (No. 89-4921), JCPDS Card (No. 76-1937) , JCPDS Card (No. 85-1060).The fig XRD Pattern indicates that these films have Polyphase contribution witha weak peak indicating the (R) rutile phase formation, (A) Anatase phase formation, (B)Brookite Phase Formation and AnotherPhase (An) Anorithic Phase Formation alsoPresent.

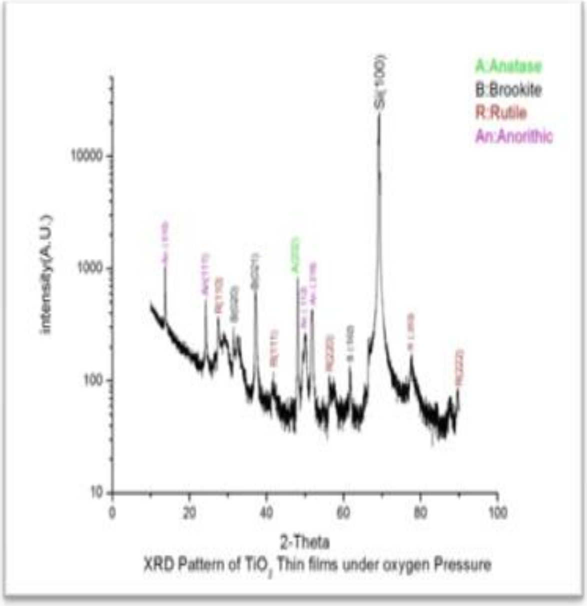
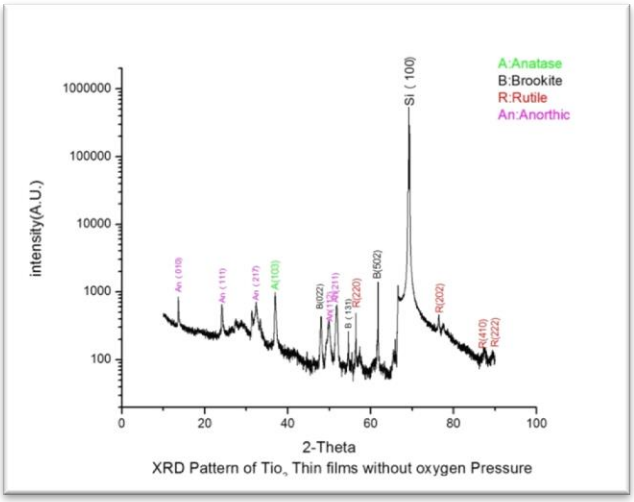


Figure 3. XRD Pattern of TiO2 Thin Films Under Oxygen Pressure

D. XRD Pattern of TiO2 Thin films without oxygen pressure

The XRD pattern of the TiO2 films deposited by Pulse laser Deposition under different conditions is shown in Figure 4.

All these films were indexed and Matched with TiO2 Phase as in JCPDS Card (No. 89-4920) ,JCPDS Card (No. 89-4921), JCPDSCard (No. 76-1937), JCPDS Card (No. 85-1060).The fig XRD Pattern indicates thatthese films have Polyphase contribution with a weak peak indicating the (R) rutile phase formation, (A) Anatase phase formation, (B) Brookite Phase Formation and Another Phase (An) Anorithic Phase Formation also Present.



XRD Pattern of TiO_2 Thin films without oxygen Pressure

Figure 4. XRD Pattern of TiO2 Thin Films without Oxygen Pressure

E. Band Gap Measurement of TiO2 ThinFilm Deposited on Quartz Crystal (SiO2)

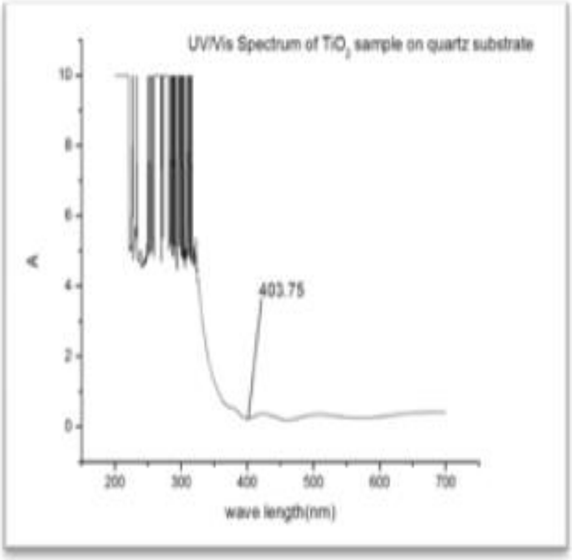


Figure 5. TiO2 UV/Vis Spectrum Obtained in this Work

Calculations:

BandGap Energy (E)= h*C/λ

h=6.626x10-34 Joules sec

C =3.0x108 meter/sec

λ==403.75x10-9 meters

E=0.049233x10-17 =3.07 eV

V. Conclusions

Semitransparent and nanostructured highly conducting TiO2 (Titanium-di-oxide) thin films were prepared using Pulse laser deposition (PLD) technique, in this Study. The Thin film has been deposited by Pulse laser deposition (PLD) technique under different oxygen fluence. The Variation of oxygen pressure indicates the different phases or different growth of TiO2 thin films are present. The Substrate used is silicon [si (100)]. The Structure is Characterized by the Bruker D-8 Advance X-ray diffractometer. The X-Ray Pattern suggested that it is crystalline in nature. The Film growth is found Polycrystalline in nature is A (Anatase), B (Brookite), R (Rutile) Phases are well matched by Standard data base files in the vacuum condition. The Phase Anorthic has are going to increasing the oxygen Pressure. The TiO2 Thin films phases Anatase and Anorthic has been dominant. This is clearly visible in X-Ray Diffractometer Pattern .The Tio2 Thin films growth is the Polycrystalline. TiO2 thin films as they are prepared using the Pulse laser Deposition (PLD) Technique. The Tio2 Thin films growth is the Polycrystalline. The energy Band gap is found 3.07eV. The quality of TiO2 also can be determined. The XRD characterictristic clearly show the Thin film is applicable for the fabricating a solar cell.

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