Preparation & Characterization of TIO_2 Thin Films for VLSI Approach

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Abstract- *Crystalline oxide films are important components in a wide array of electronics and optical Devices, and their study and their manufacture involves major aspects of current science and Technology. Nano crystalline Titanium-di-oxide (TiO2) is a multifunctional material that has many important applications including photo catalysis and antireflection coatings. High refractive index and large band gap make Titanium-di-oxide (TiO2) a suitable material for important applications in photovoltaic devices including solar cells. Nanostructure Titania has been used as an active material for the fabrication of micro sensors of volatile organic compounds. In the present work, Preparation of nano structured Titanium-di-oxide (TiO2) thin film using laser ablation on silicon substrate kept in vacuum is studied. Pulse laser Deposition (PLD) is a simple low cost method to grow oxide films, effect of film deposition conditions and structural, electrical and optical properties of films have been discussed. The measurement of the Band Gap is also discussed using the UV/V is Spectroscopy Technique of nano structured Titanium-di-oxide (TiO2) thin film using laser ablation on quartz substrate kept in vacuum is studied.*

Keywords- TiO_2 (Titanium dioxide) Material, Dye-sensitized solar cell, PLD, UV/V Spectroscopy

I. INTRODUCTION

Crystalline oxide films are important components in a wide array of electronics and optical Devices, and their study and their manufacture involves major aspects of current science and Technology. Nanocrystalline Titanium-di-oxide (TiO2) is a multifunctional material that has many important applications including photo catalysis and antireflection coatings. High refractive index and large band gap make Titanium-di-oxide (TiO2) a suitable material for important applications in photovoltaic devices including solar cells. Nanostructure Titania has been used as an active material for the fabrication of micro sensors of volatile organic compounds. 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. Titanium-di-oxide (TiO2) has many excellent physical properties such as a 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 electronic device applications such as dye-sensitized photovoltaic cells as well as antireflective (AR) coatings, gas sensors, electro chromic displays, and planar waveguides. The high dielectric constant of TiO2 allows its consideration as an alternative to silicon dioxide for ultra-thin gate oxide dielectrics used in memory and logic devices. The band structures reveal the character of the crystalline structure, with rutile and anatase being the most common form. The size effect is relevant when the size of the crystals is small enough to create a quantum size effect. In short, the activity of photo catalysis in a pure titanium dioxide thin film depends upon the character of rutile and anatase in the structure. The optical properties also vary, depending on the size of the crystal grains and their orientation even within the same crystal structure. Furthermore, a properly balanced mixture of rutile and anatase may provide good optical properties by drawing upon the advantages of each structure. Pulsed laser deposition (PLD) is suitable as a way to prepare titanium dioxide thin films.

II. PROBLEM

Nanocrystalline TiO2 usually exhibits a wider band gap than that of the bulk (3.03 eV for rutile and 3.20 eV for anatase) .Moreover, anatase becomes more stable than rutile when the particle size is decreased below 14 nm .Generally speaking, the functional properties of nano-TiO2 are influenced by a large number of factors which include particle size, surface area, synthesis method and conditions, and crystalline. All the specific properties of nano sized particles 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. TiO2 is indeed one of the most widely used nano scale materials. Amongst the multiple uses of nano-TiO_2, two major applications can be highlighted in the field of clean energy, namely photo catalytic water splitting and solar cells. Photo catalytic water splitting into H2 and O2 using nano structured TiO2 electrodes is thoroughly investigated as it is an environmentally friendly way to produce hydrogen. Another promising application of the TiO2 semi conductivity is as electrode in dye-sensitized solar cells (DSSCs) in which the high surface-to-volume ratio of the nano structured semiconductor is required to obtain an acceptable power conversion efficiency.

III. PROPOSED SCHEME

In the present work, Preparation of nano structured Titanium-di-oxide (TiO2) thin film using laser ablation on silicon substrate kept in vacuum is studied. Pulse laser Deposition (PLD) is a simple low cost method to grow oxide films, effect of film deposition conditions and structural, electrical and optical properties of films have been discussed. The measurement of the Band Gap is also discussed using the UV/Vis Spectroscopy Technique of nano structured Titanium-di-oxide (TiO2) thin film using laser ablation on quartz substrate kept in vacuum is studied . Crystalline oxide films are important components in a wide array of electronic and optical devices, and their study and manufacture involve major aspects of current science and technology. Nano crystalline TiO2 is a multifunctional material that has many important applications including photo catalysis and antireflection coatings. High refractive index and large band gap make titanium oxide (TiO2), a suitable material for important applications in photovoltaic devices including solar cells. TiO2 has an important role in the field of spintronics too. Nanostructure Titania has been used as an active material for the fabrication of micro sensors of volatile organic compounds TiO2 can be grown mainly with anatase (tetragonal), brookite (orthorhombic) and rutile (tetragonal) crystalline structures; among this rutile is the most stable phase. The actual efficiency of TiO2 depends not only on its phase omposition, but also on its microstructure, particle size, morphology and porosity, which in turn is controlled by the synthesis method employed.

There have been many studies of electronic and structure properties of TiO2 both experimental & theoretical aspects. However the rutile phase has been studied extensively .The main reason is the most crystal growth techniques basically yield TiO2 in the rutile phase. Also rutile has the simplest and the best known structure. In contrast to rutile phase, there is few theoretical investigation of antase phase. For brookite, to best of our knowledge, no theoretical study of electronic and optical properties have been reported so far .This is probably due to the difficulty in the calculation caused by the large number of atoms in the unit cells of this phase.

Some are different experimental techniques system which we have used to carry out our present work. This chapter describes a detailed description of sample preparation and various characterization techniques.

A. Introduction to Pulsed Laser Deposition (PLD)

PLD is a thin film deposition technique, in which high energy laser pulses are used to ablate solid target of any material in high vacuum chamber. PLD have certain advantages over other deposition techniques and it can be used to deposit a wide variety of material in thin film form. The process of thin film deposition through PLD can generally be divided into four stages:

- Laser ablation of the target material and creation of plasma.
- Dynamic of plasma.
- Deposition of the ablation material on the substrate.
- Nucleation and growth of the film on the Substrate surface.

In PLD, A pulse laser beam strikes the surface of the target material and the energy from the laser evaporates the target's surface. In the last, ejected plasma plume is deposited on the heated substrate. In most materials, the ultra violet radiation is absorbed only by the outermost layers of the target, during the process of laser target interaction, the temperature of the surface of the target rises rapidly to thousands of degree Celsius. A proper film growth requires that the ablation process takes place in a vacuum chamber where the emitted particle can freely expand.

IV. SIMULLATION RESULT

The pellets used in the ablation process were prepared from 99.99% pure titanium oxide powder from Sigma Aldrich Company. The powder was thoroughly grinded in an agate mortar and pressed into the form of pellets in a hydraulic press. Pellets were sintered at 1000^oC for 4 h. 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 epetition frequency 10 Hz. Uniform ablation was ensured by rotating the 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 (*D*S-T) distance rom 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) and Raman spectroscopy using a laser power of 10 mW with Horiba Jobin (Yvon) instrument. Optical measurements were conducted in the wavelength range 300 to 900 nm using a Perklin Alimer US Lambda 950, UV- Visible spectrophotometer. Thicknesses of the films were measured using stylus profilometer (XP-1) bench-top surface profiler.

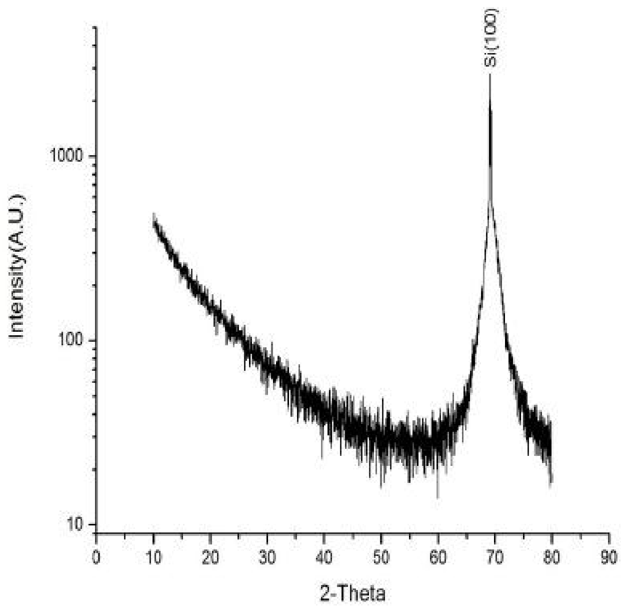

Figure: XRD Pattern of Pure Silicon (Si) Substrate

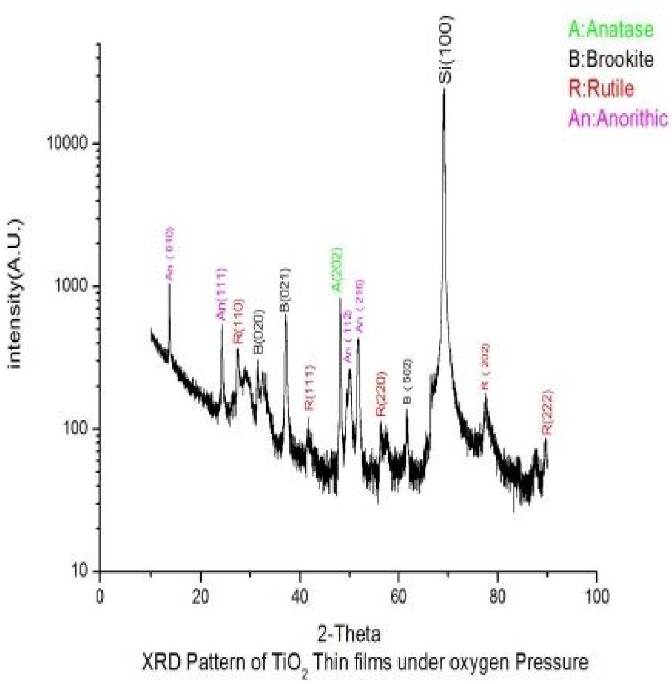

Figure: XRD Pattern of Pure Target Titanium-di-oxide (TiO2)

V. CONCLUSION

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 having bright future in solar cell fabrication by thin film deposition methods through deposition in precise controlling parameters, band gap of solar cell also may be controlled through deposition parameters. Powdered TiO2 in photo catalysis the problem of light-assisted water splitting has also been focused with the photo catalytic approach i.e. essentially with photo electrochemistry but without an external circuit. Conceptually, this is similar to the process of corrosion.

TiO2 film is very useful in photo catalysis under weak UV light,TiO2 coated material play important role in self-cleaning function, anti-fogging function .TiO2 having the feature of Photo catalytic anti-bacterial effect of copper and/or silver-deposited TiO2 film,TiO2 is a visible-light sensitive which is best suitable for solar cell application. Important use of TiO2 may be detoxification of waste water used for rice hull disinfection, Water treatment of hydroponic culture system, Treatment of volatile chlorinated organic compound polluted soil.

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