Optical, Electrical and Structural Investigation on Different Molarities of Titanium Dioxide (TiO_2) via Sol-Gel Method

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***Abstract*—Titanium dioxide (TiO_2) solution having different molarities were synthesized and deposited on glass substrates by using sol-gel spin-coating method. The variation in thickness, optical, electrical and structural properties of TiO_2 thin films were investigated by surface profiler (SP), UV-Vis spectroscopy, two-point probes and atomic force microscopy (AFM), respectively. The result show that the thickness of TiO_2 thin film increases as the molarities increases. The optical band gap energy decreases from 3.78 eV to 3.07 eV as the TiO_2 molarities increases from 0.01M to 0.20M. The maximum value of the absorption coefficient was 16.27 x 10^4 cm^{-1} at 0.20M with surface roughness of 21.45 nm. Thin films deposited with 0.01M show lower absorption coefficient (3.87 x 10^4 cm^{-1}) within visible region with surface roughness of 5.21 nm. The improvement in optical and structural properties of TiO_2 thin films affects the electrical properties as the highest conductivity 9.62 x 10^2 S/m is obtained by 0.20M.**

***Index Terms*—Sol-Gel; TiO_2; Thin Film; Properties.**

I. INTRODUCTION

Titanium dioxide (TiO_2) is an insulator metal oxide of material that used in many areas including solar energy [1]. It also known as titania which exists in amorphous and phases of crystalline structures (anatase, rutile and brookite) which exhibit different photocatalytic characteristics [2]. The anatase crystal phase (E_g = 3.32 eV) is usually used for production of photocatalyts [3,4]. Under illumination, it can help break down hazardous gases and organic pollutants via photo-catalysis [5]. In nano titanium dioxide, high purity can be obtained and enhance UV absorption due to the average particle size of less than 100nm [6]. Absorption coefficient in thin film is momentous in photocatalytic application as it indicated how much photons or UV light can be absorbed in average distance travelled by a photon before it gets absorbed by the thin film [7]. The magnitude of absorption coefficient in TiO_2 is influenced by many factors such as; changes in phase-transformation, grain sizes, thickness of thin film and others [8-10].

Sol-gel process is a liquid-phase method of synthesizing inorganic, organic-inorganic network such as powders, ceramics, glasses, films at ambient temperature. The sol-gel process is unique due to the ability to produce TiO_2 at low-processing temperature compared to plasma synthesis and flame pyrolysis [10,11]. Sol-gel involved the process of solid nanoparticles dispersed in a liquid and agglomerate together to form a continuous three-dimensional network and extending throughout the liquid. The main advantage of this process is the desired properties are easily obtained by modifying the microstructure through the process of sol-gel. Sol-gel process involved the hydrolysis of titanium (IV) isopropoxide precursor through condensation, forming the titanium dioxide nanoparticles [12]. There are many factors that influence the changes in microstructure of TiO_2 nanoparticles synthesize by sol-gel such as the nature of precursor and solvent, hydrolysis ratios, pH and synthesizing temperature [13-16]. Owing to the fact that TiO_2 is a wide-band gap semiconductor, it contributes to low absorbance of light and has limited to UV range of the electromagnectic spectrum [17-18]. In this work, molarity of TiO_2 solution is being controlled to improve the microstructure to enhance the absorbance of light. The effect of different TiO_2 molarities by sol-gel process was presented and their influences on the performance of thin films were discussed.

TiO_2 nanoparticles is further growing and form a soul that can be deposited on the substrates to form a film by using spin-coating, dip-coating, doctor-blading and spray-pyrolysis [19-22]. By using spin-coating to deposit thin film, it has ability to produce uniform films and control thickness from a nanometers to a microns. It is used for coating substrates for transparent conductive oxide (TCO), insulators, photoresists, nano-materials, organic semiconductors and metal oxides precursors [23].

II. EXPERIMENTAL PROCEDURE

A. Glass Substrates Preparation

Glass substrates were cut in dimension of 2.5cm x 2.5cm. Then, the glass substrates were ultrasonically cleaned in methanol, acetone and distilled water in 10 minutes each. The substrates were dried using nitrogen gas (N_2) blower.

B. Synthesis of TiO_2 by Sol-Gel Method

Synthesizing of TiO_2 nanoparticles were done by sol-gel that used titanium isopropoxide ($C_{12}H_{28}O_4Ti$) as main