Impact of Annealing Time on Structural and Optical Properties of TiO_2 Thin Films Deposited by Spray Pyrolysis Technique

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Abstract - Titanium dioxide (TiO_2) thin films were prepared by Spray Pyrolysis technique on microscopic glass substrates at 350 ºC and 400 ºC with annealing time of 1 hour and 2 hours. The structural study was analyzed by XRD technique, which shows that all the TiO_2 thin films were of anatase phase and nanocrystalline in nature. The absorbance measured using UV-Vis spectroscopic method have notable shift to the lower wavelength region with increase in annealing time. The optical band gap value calculated from Tauc's plot was found to increase with increase in annealing time. The PL study showed emission peaks in visible region attributed to the impurities, defects and oxygen vacancy. The prepared TiO_2 thin films reveal that the annealing time has impact on the structural and optical properties.

Keywords: TiO_2 thin films, Spray Pyrolysis, Annealing time, XRD, UV, PL

1.INTRODUCTION

TiO_2 have been investigated widely and used in many applications due to its good crystalline structure, particle size, surface area, chemical stability, non-toxicity and low cost [1] TiO_2 thin films were synthesized by various methods including Spin coating method, Spray pyrolysis technique, RF-magnetron sputtering, Pulsed Laser Deposition (PLD), Chemical bath deposition etc.,[2]. Among these Spray Pyrolysis method is a simple and low-cost technique which has the capability to produce large area, high quality adherent films of uniform thickness [3].

Thin film properties highly depend on the various parameters involved in the preparation technique and processing factor. Annealing is a heat treatment that alters the physical and chemical properties of the material. It involves heating a material above its recrystallization temperature, maintaining a suitable temperature for a suitable amount of time and then cooling [4].

In the present work TiO_2 thin films were synthesized on glass substrates using Spray pyrolysis technique and the effect of annealing time on the structural and optical properties of the TiO_2 thin films was analyzed.

2. METHODS AND TECHNOLOGY

The Precursor solution was prepared using titanium tetra isopropoxide (TTIP, Sigma Aldrich, 97%), ethanol (AR, 99.9%) and acetyl acetone (AcAc, $CH_3COCH_2COCH_3$, Spectrum, 98%) by the following method. Ethanol was mixed with TTIP in a well cleaned beaker and the mixture was stirred using magnetic stirrer for 10 minutes. Then AcAc was added to this mixture for stabilizing the solution and stirred for 10 minutes. Again ethanol was added to this solution and vigorously stirred for 1 hour. Here the proportion of TTIP, ethanol and AcAc was maintained as 1:10:1 ratio.

Well cleaned microscopic glass slide was placed on the metallic plate and prepared TiO_2 solution was atomized into the Spray unit. TiO_2 solution was sprayed for 1 minute to the glass slide and then the film was annealed at 350 ºC for 10 minutes. Again the solution was sprayed for 1 minute after that the film was annealed at 500 ºC for 1 hour. To analyze the effect of annealing time another sample was prepared which was annealed for 2 hours. The same procedure was followed for coating of the TiO_2 thin films with substrate temperature of 400 ºC and annealing time of 1 hour and 2 hours. The TiO_2 thin films were deposited under the following conditions: Nozzle to substrate distance = 15Cm; Spray deposition rate = 4ml/min; carrier gas = air; carrier gas pressure = 1 bar, Substrate temperature = 350 ºC, 400 ºC.