

Original Article

Deposition of TiO_2 Thin Film by the Spin Coating Method

Pratibha R. Nikam¹, Lokesh D. Sonar²

¹ Department of Physics, Moolji Jaitha College, Jalgaon, Maharashtra, India

² Department of Applied Sciences and Humanities, SVKM's College of Engineering, Shirpur, Maharashtra, India

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Correspondence Address:

Lokesh D. Sonar
Department of Physics, Moolji
Jaitha College, Jalgaon,
Maharashtra, India,
Email: lokeshsonar6@gmail.com

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Abstract

Titanium dioxide (TiO_2) thin films were fabricated via the sol-gel spin-coating method and subsequently evaluated as photoanodes for dye-sensitized solar cell (DSSC) applications. The precursor sol was formulated using commercial P-25 TiO_2 powder (Degussa, Germany) with ethanol and acetyl acetone as solvents and titanium tetrachloride as a chelating agent. Films produced were subjected to annealing at 500 °C to enhance crystallization and facilitate the development of porosity. Optimised sol-gel parameters and annealing conditions yield TiO_2 thin films with excellent transparency, high surface area, and efficient light-harvesting capability, making them promising candidates for next-generation photovoltaic and photocatalytic applications.

Keywords: TiO_2 , Annealing, DSSC, Spin Coating Method.

Introduction

Around 1.3 billion people worldwide still lack access to electricity, underscoring the urgent need for sustainable energy solutions such as solar power [1]. Solar cells operate on the photovoltaic effect, and titanium dioxide (TiO_2) has emerged as a key material in photovoltaic applications due to its chemical stability, low cost, transparency, and high catalytic activity [2]. Dye-sensitized solar cells (DSSCs), first reported by Grätzel and O'Regan, utilise nanostructured TiO_2 photoanodes and offer a simple, cost-effective alternative to conventional solar cells, achieving power conversion efficiencies up to 15.2% under simulated sunlight and high efficiency under ambient lighting [3,4]. Among TiO_2 crystalline phases, anatase and rutile are most commonly used, with anatase exhibiting superior photocatalytic activity due to improved charge transport and reduced recombination [5-9]. Various thin-film deposition methods exist, but spin coating is particularly attractive because of its simplicity, reproducibility, and low cost, making it well-suited for fabricating TiO_2 thin films for photovoltaic applications [10-20].

Methodology

Materials

The Commercial TiO_2 powder P25 (Degussa AG, Germany), consisting of mixed phases of 70 % anatase and 80 % rutile, was obtained from Degussa, Germany, acetyl acetone (Sigma Aldrich), titanium tetrachloride, and ethanol absolute. Every chemical utilised was of analytical reagent (AR) quality and didn't require any additional purification.

Preparation of the TiO_2 precursor solution

TiO_2 thin films were fabricated on glass substrates using the sol-gel spin coating technique. Degussa P-25 TiO_2 was used as the precursor, with ethanol and acetyl acetone as solvents and titanium tetrachloride as the catalyst. The TiO_2 sol was prepared by mixing 0.2 g of P-25, 4 ml of ethanol, 1 ml of acetyl acetone, and a few drops of titanium tetrachloride, followed by stirring at 500 rpm at room temperature and ultrasonication for 1 hour in an ice bath. Subsequently, 1 ml of the prepared sol was deposited at the centre of the glass substrate and spin-coated at 2000–2500 rpm for 1 min to obtain a uniform film. The coated films were then annealed at 500 °C, as schematically illustrated in Figure 1.

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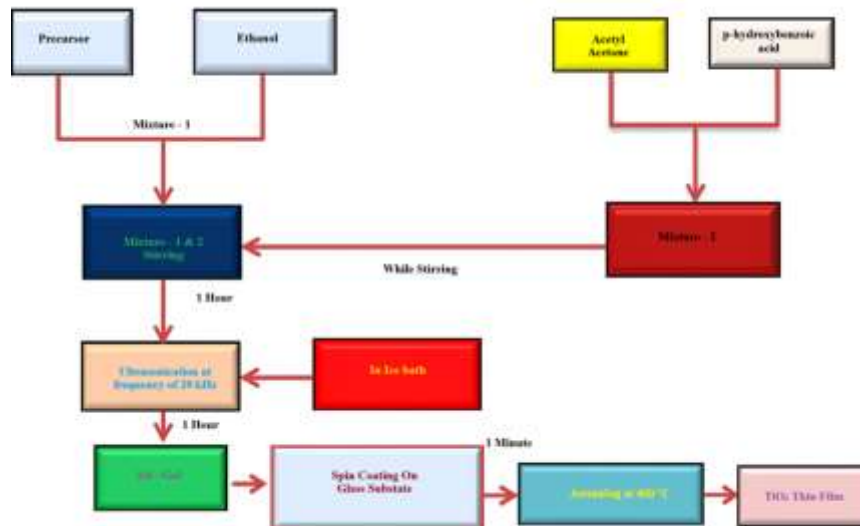


Figure 1: A Schematic of the steps used to make chemical compositions.

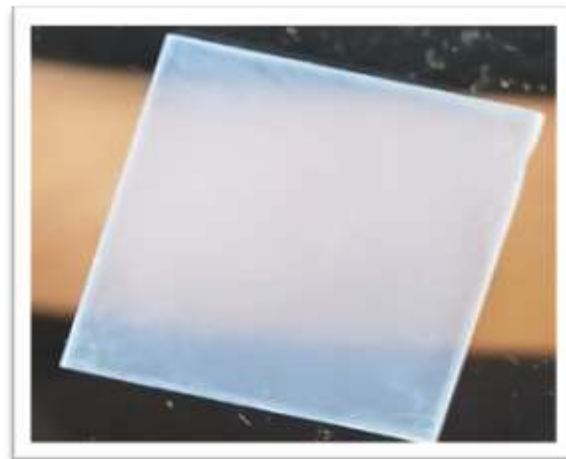


Figure 2: Thin film of TiO_2 on glass substrate

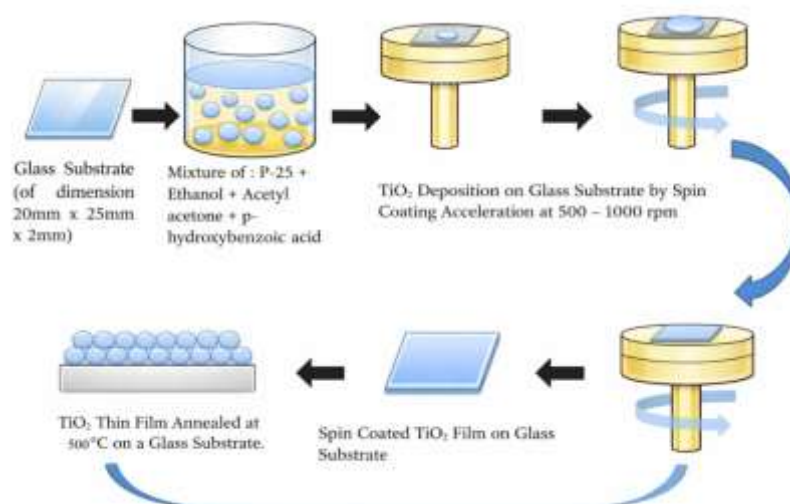


Figure 3: Deposition of TiO_2 by Spin Coating Method

Conclusion

The present study demonstrates a reproducible and cost-effective sol-gel spin-coating approach for the fabrication of nanostructured TiO_2 thin films suitable for photoanode applications in DSSCs. The prepared films exhibit a polycrystalline anatase phase with nanoscale crystallite dimensions, which promote efficient electron transport and reduce charge recombination.

Consequently, the synthesised TiO₂ thin films show promising potential for use in efficient, stable, and low-cost optoelectronic and DSSC applications.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper

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