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Progress Report

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Department	Physics	Research Topic	Smart thin films for light emitting display applications
Level	Senior		

Date:
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Student's Signature

Advisor's Signature

Introduction and Literature Review

Light emitting displays have become an integral part of modern-day electronics, ranging from smartphones to large-scale advertising screens. The efficiency and performance of these displays heavily relies on the quality of the thin film layers used in their fabrication. For example, in the case of solid oxide fuel cells (SOFC), dip-coating displays outstanding contact quality between the thin-film layer and the anode support layer (ASL), which leads to limited de-lamination failure of the thin-film layer after sintering the cell1. Similarly, lower photonic conversion efficiency along with complexity of fabrication are primary constraints for cost-effective thin film solar cell production [1-3]. However, the traditional methods of fabricating these thin film layers are often complex, time-consuming, and expensive, they are associated with ultrahigh vacuum systems and complicated and expensive instrumentation and may involve toxic or corrosive chemical precursors [4-6]. In this proposal, we aim to overcome these challenges by exploring low-cost and easy-to-handle techniques for developing smart thin films that can be utilized in light emitting display applications. Our goal is to create a more accessible and efficient approach to thin film fabrication, which will help to revolutionize the display industry.

Thin film technologies have become an increasingly important field of research in recent years. Three papers in particular highlight the potential of these technologies for enhancing the performance and reliability of various systems:

In their investigation, Johansson et al. (2019) examined the potential of transparent ZnO and TiO_2 thin films for ultraviolet (UV) protection in photovoltaic (PV) modules [7]. They utilized spray pyrolysis to deposit these films on soda lime silicate float glass as functional layers for PV cover glass. The study revealed significant findings, with the ZnO coating causing a shift in the optical bandgap towards longer wavelengths. Consequently, this shift resulted in a remarkable ~85% reduction in the transmittance of destructive UV radiation. Similarly, the TiO_2 coated glasses exhibited an increased UV cutoff, leading to a reduction of destructive UV transmittance by up to 75%. Notably, the deposition of both ZnO and TiO_2 coatings resulted in a decrease in the amount of transmitted light that can be converted by PV modules, with reductions of 12.3%

and 21.8%, respectively. These outcomes hold implications for the lifetime expectancy and efficiency of PV modules, providing a cost-effective and durable solution for UV protection.

Jeon et al. (2022) provide a comprehensive review of multifunctional encapsulation technologies for enhancing the reliability of organic light-emitting diodes (OLEDs)[8]. This study highlights the challenges associated with OLED reliability and the need for effective encapsulation to protect against external environmental factors such as moisture, oxygen, and light. By evaluating various encapsulation techniques, the review covers solutions to existing technical difficulties in flexible encapsulations, including the use of atomic layer deposition (ALD) technology. It also discusses research on customized multi-functional encapsulation technology for display applications, including the utilization of nanolaminates, optical Bragg mirrors, and interfacial engineering between layers. The goal of these technologies is to guarantee the reliability of the display and accelerate the realization of advanced displays.

Sasani Ghamsari et al. (2016) conducted a study on the use of nanostructured ZnO thin films for UV protection in various applications. Their investigation focused on the effect of exposure time on the protective properties of ZnO [9]. The results of their study revealed that sol-gel derived thin ZnO films exhibited excellent UV-protection ability, with a UV-protection factor exceeding 50. These films also displayed transparency in the visible wavelength region and demonstrated significant light absorbance in the UV range. Moreover, the prepared samples exhibited promising antibacterial potential, highlighting their potential for applications in the health care field. The findings from this study provide compelling evidence that ZnO thin films offer a cost-effective and efficient solution for UV protection, presenting exciting prospects for their future utilization in various fields.

Overall, these studies demonstrate the potential of thin film technologies for addressing a range of challenges in different applications. The studies highlight the importance of optimizing thin film fabrication and performance for enhancing their efficiency and reliability, and present exciting opportunities for future research in this field.

1. Problem Statement and Research Objectives

As stated in the introduction, UV radiation degrades thin films, and is a main challenge to overcome. The main objective of this research is to find the optimized composition for ITO thin films that has three main characteristics; High UV absorbance, Transparent and Flexible.

2. Research Plan and Execution

Methodology:

The methodology employed in this study involves a series of tasks aimed at preparing ITO-doped films and characterizing their properties. The process includes the deposition of ITO on a glass substrate, followed by the deposition of Titanium and Nitrogen. Additionally, annealing of the films at different temperatures is performed. The characterization of the films involves several analytical techniques, such as UV-Vis spectroscopy, profilometry, and X-ray diffraction (XRD). Finally, the obtained results are analyzed, and the films are optimized by adjusting various parameters.

Execution:

With the help of the supervisor, I successfully fabricated ITO then doped it with Titanium, and Nitrogen. Then, I carried out the annealing and the UV-Vis measurements. I have successfully analyzed over 88 samples for their UV-Vis data, to report the trends of the effects of the different concentrations of the dopants, as well as the trends of the effects of annealing; with their effects on the bandgap. I was also tasked to identify the best samples that has:

1- High UV absorption & Low transmission.
2- Low Visible light absorption and High transmission.

3. Conclusion

After carrying out the fabrication process, which includes the usage of sputtering and furnace instruments, and the characterization which includes the usages of UV-Vis and DektakXT instruments, we found out that when annealing ITO doped with Titanium at 75W power at 400°C and above, the transmission of the Visible light improves drastically, as it is shown in Fig. 1 and Fig. 2:

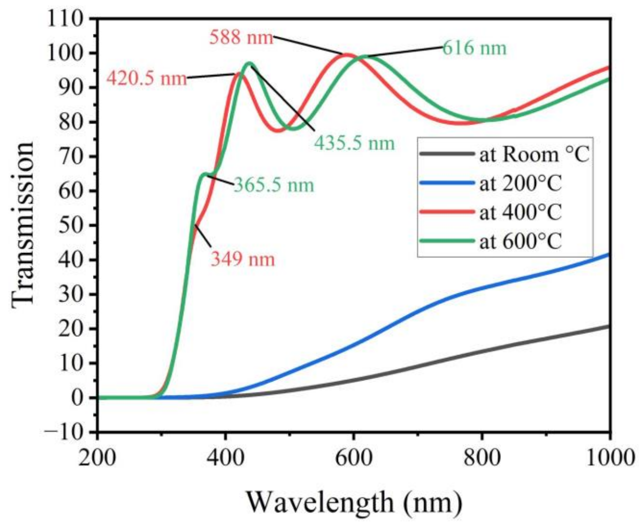

Figure 1: Transmission Vs Wavelength for I-Ti75 sample

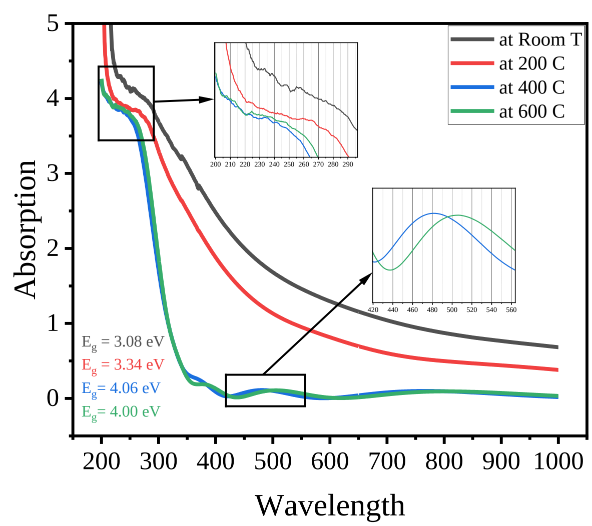

Figure 2: Absorption Vs Wavelength for I-Ti75 sample

I have learned how to fabricate thin films via the sputtering coater, as well as how to characterize them using UV-Vis spectroscopy as well as DektakXT profilometer. Moreover, the research methodology and the practical skills of running a thin film lab. Additionally, I have mastered the use of the software Origin in the process of data analyzing our samples.

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