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ISETC2025

2ND INTERNATIONAL SCIENCE,
ENGINEERING AND TECHNOLOGY
COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A
SUSTAINABLE WORLD

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FACULTY OF APPLIED SCIENCES
UNIVERSITI TEKNOLOGI MARA
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(ISETC 2025)**

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EDITORS

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

Ms. Nurul Nazwa Mohammad

Ms. Rozaina Saleh

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

Ms. Nurul Nazwa Mohammad

Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

FABRICATION OF ALUMINUM DOPED ZINC OXIDE FOR TRANSPARENT CONDUCTIVE APPLICATIONS

Muhammad Fahmi Khairul Azhar¹, Allina Nadzri^{2*}, Junaidah Md Sani¹, Muhammad Najib Harif²

¹Universiti Teknologi MARA Cawangan Pahang, Kampus Jengka, 26400, Jengka, Pahang, Malaysia

²Universiti Teknologi MARA Cawangan Negeri Sembilan, Kampus Kuala Pilah,
70200 Kuala Pilah, Negeri Sembilan, Malaysia

**Corresponding author: allinanadzri@uitm.edu.my*

Abstract: Aluminium-doped zinc oxide (AZO) thin films were deposited on soda-lime glass substrates using the Radio Frequency (RF) Magnetron Sputtering technique with a deposition duration of one hour. Following deposition, the films underwent thermal annealing in a furnace at room temperature (control), 200 °C, 300 °C, and 400 °C for one hour under ambient atmospheric conditions. The effects of annealing temperature on the optical and electrical properties of the AZO films were characterized using UV-Visible (UV-Vis) spectrophotometry and Hall Effect measurements. UV-Vis analysis revealed that all thin films exhibited optical transmittance above 80%. Hall Effect measurements indicated that increasing the annealing temperature led to higher electrical resistivity, accompanied by a decrease in both carrier mobility and electrical conductivity. Among the samples, the film annealed at 200 °C demonstrated the most favourable properties, with an optical transmittance exceeding 80%, carrier mobility of 3.0 cm²/V·s, and electrical conductivity of 24.38 (Ω·cm)⁻¹. These findings suggest that annealing at 200 °C optimizes the balance between optical transparency and electrical performance, making AZO films suitable for transparent conductive applications.

Keywords: Aluminium zinc oxide (AZO), high-vacuum deposition, radio frequency magnetron sputtering, optical and electrical properties

INTRODUCTION

Transparent conductive oxides (TCOs) are integral components in modern optoelectronic devices, including solar cells, touchscreens, and light-emitting diodes (LEDs). Indium Tin Oxide (ITO) remains the dominant material in this domain due to its excellent electrical conductivity and high optical transparency. However, the increasing cost and scarcity of indium have raised concerns about the long-term sustainability of ITO, prompting the search for alternative materials. One such promising candidate is Aluminum-Doped Zinc Oxide (AZO), valued for its low cost, non-toxicity, chemical stability, and comparable performance to ITO in TCO applications. Recent studies have highlighted that AZO films, when fabricated through various deposition techniques and doped appropriately, can achieve high optical transparency (above 80%) and low electrical resistivity (~10⁻³ Ω·cm), making them suitable for integration into optoelectronic systems (Nussupov et al., 2023). Research by (Challali et al., 2020) and (Yang et al., 2010) demonstrated that the structural and electrical properties of AZO films can be finely tuned through annealing and adjustment of deposition parameters. These findings suggest a strong correlation between fabrication methods, thermal treatment, and the resulting film properties.

In this study, AZO thin films were fabricated using the RF Magnetron Sputtering technique. This method allows for control over deposition parameters such as pressure, power, and temperature, which significantly affect the film's properties (Krawczak et al., 2017). Post-deposition, the films were subjected to annealing at three different temperatures: 200°C, 300°C, and 400°C. The samples were then characterized using UV-Vis Spectroscopy to assess optical transmittance, and Hall Effect measurements to evaluate electrical conductivity, resistivity, and mobility. The main findings revealed that all AZO films exhibited high optical transparency, with the sample annealed at 200°C demonstrating the most favorable combination of high transmittance (82.17%) and low resistivity (4.10 × 10⁻² Ω·cm). Higher annealing temperatures led to decreased carrier mobility and increased resistivity, attributed to reduced oxygen vacancies and potential structural degradation.

This extended abstract presents a comprehensive investigation into the fabrication and optimization of AZO thin films, providing evidence that AZO is a viable and scalable substitute for ITO in TCO applications, with RF Magnetron Sputtering offering a reliable production pathway.

MATERIALS AND METHODS

Prior to deposition, soda-lime glass substrates (30 mm × 30 mm) were cleaned using methanol and distilled water in an ultrasonic bath and dried with nitrogen gas. AZO thin films were deposited onto the prepared substrates using RF Magnetron Sputtering at a base pressure of 4×10^{-4} Pa. The process was conducted at room temperature with a 300 W sputtering power and an argon gas flow rate of 30 sccm. After deposition, the films were annealed at 200°C, 300°C, and 400°C for one hour under atmospheric conditions to enhance their crystallinity and electrical performance. Characterization was carried out using UV-Vis Spectroscopy to measure optical transmittance in the 300–800 nm range, and Hall Effect Measurement (Ecopia HMS-3000) to evaluate electrical properties such as resistivity, conductivity, and carrier mobility.

RESULTS AND DISCUSSION

Optical properties of ZnO thin films were investigated using UV-Vis spectroscopy. Figure 1 presents the optical transmittance spectra of AZO thin films annealed at different temperatures. All samples exhibit high transmittance in the visible range (400–800 nm), exceeding 80%, indicating excellent transparency (Najim et al., 2020) which is crucial for optoelectronic applications (Dakhsi et al., 2016). The as-deposited film showed the lowest transmittance, while the film annealed at 200°C achieved the highest, peaking just below 100%. This enhancement is attributed to improved crystallinity and reduced surface defects following thermal treatment. At higher annealing temperatures (300°C and 400°C), a slight decline in transmittance is observed, possibly due to increased surface roughness or defect formation. These results suggest that moderate annealing at 200°C optimizes optical clarity, making the films suitable for transparent conductive applications.

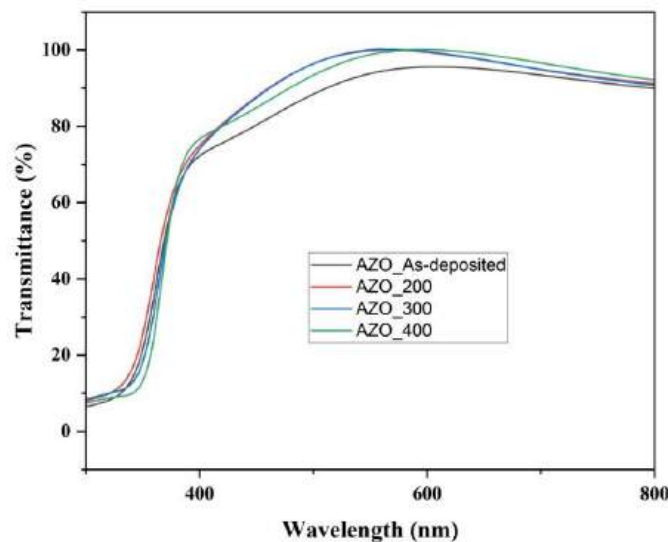


Figure 1. Graph Wavelength (nm) vs Transmittance (%) for all samples

Table 1 and Figure 2 illustrate the electrical properties of AZO thin films as a function of annealing temperature. The as-deposited film exhibited the lowest resistivity ($1.83 \times 10^{-2} \Omega \cdot \text{cm}$) and highest conductivity ($54.73 \text{ 1}/\Omega \cdot \text{cm}$), along with the highest carrier mobility ($6.81 \text{ cm}^2/\text{Vs}$). Upon annealing, a clear trend emerges which revealed resistivity increases while conductivity decreases with rising temperature. Notably, the film annealed at 200°C showed a moderate balance, with acceptable resistivity ($4.10 \times 10^{-2} \Omega \cdot \text{cm}$) and mobility ($3.03 \text{ cm}^2/\text{Vs}$). An electrical conductivity of $24.38 (\Omega \cdot \text{cm})^{-1}$ is also a strong result, indicating that the film can effectively conduct electricity, which is crucial for its use in various electronic devices. At higher temperatures (300°C and 400°C), resistivity rose sharply, and conductivity dropped significantly, suggesting degradation in carrier concentration likely due to reduced oxygen vacancies. These results indicate that lower annealing temperatures help preserve favourable electrical characteristics, with 200°C being the most effective among the tested conditions.

Table 1. Electrical Parameters of AZO thin films at different temperatures obtained from Hall Effects measurement

Annealing Temperature (°C)	Hall Effect Measurement		
	Resistivity ($\Omega \cdot \text{cm}$)	Conductivity ($1/\Omega \cdot \text{cm}$)	Mobility (cm^2/Vs)
As-deposited	1.83×10^{-2}	54.73	6.81
200	4.10×10^{-2}	24.38	3.03
300	2.13×10^{-1}	4.70	2.66
400	7.45×10^{-1}	1.34	2.85

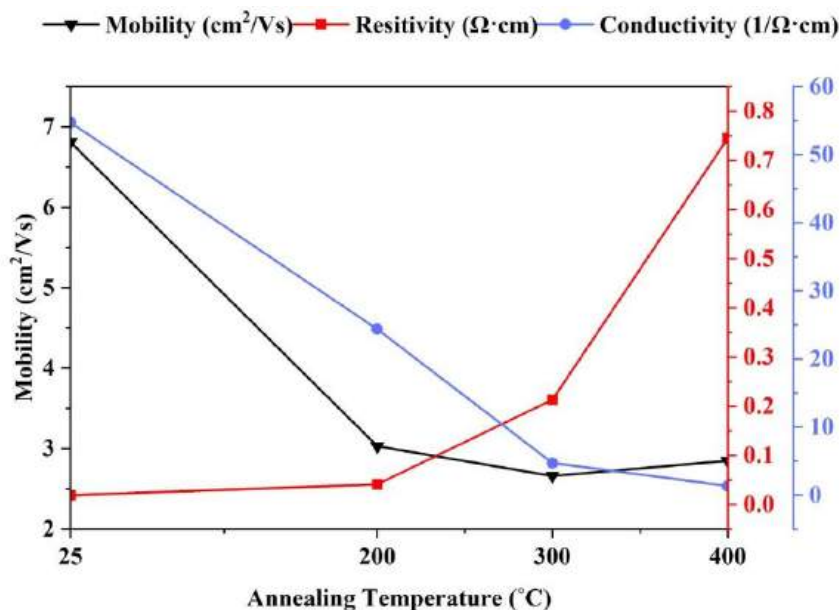


Figure 2. Annealing temperature vs resistivity, conductivity and mobility

CONCLUSIONS

Overall, this study confirms that AZO thin films fabricated via RF Magnetron Sputtering and annealed at moderate temperatures is effective for producing AZO thin films with desirable optical and electrical properties for TCO applications. All films showed high visible transmittance ($>80\%$), with the 200°C annealed sample exhibiting the best combination of optical and electrical performance. These improvements are attributed to enhanced crystallinity and reduced defects through controlled annealing. However, films annealed at 300°C and 400°C showed increased resistivity and decreased conductivity, likely due to reduced oxygen vacancies. This highlights a thermal limit beyond which electrical performance declines, making 200°C an optimal annealing condition. In conclusion, AZO is a viable, cost-effective alternative to ITO. Future studies should explore varying doping levels, alternative substrates, and advanced characterizations to further optimize film properties for practical applications.

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Prof. Madya Dr. Nur Hisham Ibrahim
Rektor
Universiti Teknologi MARA
Cawangan Perak

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Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Setuju.

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