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# Influence of Morphology on the Thermoelectric Performance of Aluminum-Doped Zinc Oxide (AZO) on Diverse Substrate Material

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[Hairin, Assayidatul Laila Nor](#)<sup>a</sup> ; [Nor, Naurah Sabihah Mohamad](#)<sup>a</sup>; [Othman, Raihan](#)<sup>b</sup>; [Salleh, Mohd Faiz Mohd](#)<sup>c</sup>; [Mustaffa, Ubaidah Muhammad Syafiq](#)<sup>d</sup>; [+1 author](#)

<sup>a</sup> Department of Manufacturing and Materials Engineering, Faculty of Engineering, International Islamic University Malaysia, Malaysia

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## Abstract

Aluminum-doped zinc oxide (AZO) thin films for thermoelectric solar energy conversion are investigated in this work. It examines how different substrates and sputtering powers affect the morphology and thermoelectric characteristics of AZO thin films. Polyimide, quartz, and fused silica were selected as substrates to explore this interaction. Utilizing radiofrequency (RF) magnetron sputtering, AZO thin films were deposited onto the substrates. The impact of the sputtering power on the films was examined by varying it between 200 W, 250 W, and 300 W. The distance between the target and substrate was kept at 5 cm, the argon gas flow rate was kept at 10 sccm, and the sputtering period was fixed at one hour. All other deposition parameters were kept constant. The SEM study showed that thicker AZO thin films and a rougher surface texture were the outcomes of increasing the sputtering power. On the other hand, the EDS analysis confirmed that all predicted components

were consistently present in the AZO composition for every substrate that was examined. In addition, the Seebeck coefficient, electrical conductivity, and thermoelectric power factor (PF) were measured using a specially designed experimental setup to characterize the thermoelectric properties. The results revealed that the substrate material significantly influenced the morphology of the AZO thin film, which subsequently impacted their thermoelectric properties. Fused silica yielded the most promising results, achieving a power factor of 9.362 nW/mK<sup>2</sup>, conductivity of 2.817 S/m, and Seebeck coefficient of -56.58 μV/K at 150° C and a sputtering power of 300 W. The study highlights the critical role that substrate selection and deposition parameters play in optimizing the thermoelectric performance of oxide-based thin films. Higher sputtering power generally improved film thickness and conductivity but also introduced surface roughness that varied depending on substrate smoothness. Polyimide, due to its naturally rougher surface, exhibited more irregular AZO film growth compared to quartz and fused silica. These structural differences translated into noticeable variations in the thermoelectric behavior. The findings suggest that optimizing both deposition power and substrate type can enhance the efficiency of AZO thin films in solar-thermal energy harvesting applications. This work contributes to ongoing efforts to develop cost-effective, non-toxic, and stable thermoelectric materials suitable for integration in flexible and transparent energy systems. © 2025, National University of Malaysia. All rights reserved.

## Author keywords

Aluminum Zinc Oxide thin film; fused silica; polyimide; power factor (PF); quartz

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# Corresponding authors

Corresponding  
author

A.L.N. Hairin

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Affiliation

Department of Manufacturing and Materials Engineering, Faculty of  
Engineering, International Islamic University Malaysia, Malaysia

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Email address

assayidatul\_laila@iium.edu.my

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