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

By Hairin, ALN (Hairin, Assayidatul Laila Nor) ; Nor, NSM (Nor, Naurah Sabihah Mohamad) ; Othman, R (Othman, Raihan) ; Salleh, MFM (Salleh, Mohd Faiz Mohd) ; Mustaffa, UMS (Mustaffa, Ubaidah Muhammad Syafiq) ; Abd Aziz, R (Abd Aziz, Radhiyah)

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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 ofAZO 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/mK2, conductivity of 2.817 S/m, and Seebeck coefficient of-56.58 mu V/K at 150 degrees 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.

Keywords

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

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Addresses

[1] Int Islamic Univ Malaysia, Dept Mfg & Mat Engn, Fac Engn, Kuala Lumpur, Malaysia

[2] Int Islamic Univ Malaysia, Fac Engn, Dept Sci Engn, Kuala Lumpur, Malaysia

[3] Univ Malaya, Fac Engn, Dept Elect Engn & Telecommun, Kuala Lumpur, Malaysia

[4] Natl Univ Malaysia, Solar Energy Res Inst, Bangi, Malaysia
[5] Univ Malaysia Pahang Al Sultan Abdullah, Fac Engn, Dept Mech Engn, Pekan, Malaysia

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