

## Documents

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**Effects of pH on Grain Size and Structure of ZnO Nanoparticle Synthesized via Sol–Gel Method for Enhanced Thermoelectric Materials**

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A. K. M. Asif Iqbal  
Irfan Ahmed *Editors*

# Intelligent Manufacturing and Mechatronics

Selected Articles from iM3F 2023, 7–8  
August, Pekan, Malaysia

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Editors

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August, Pekan, Malaysia

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# Preface

The fourth edition forum of the Innovative Manufacturing, Mechatronics and Materials Forum 2023 (iM3F 2023) organized by Universiti Malaysia Pahang Al-Sultan Abdullah through its Faculty of Manufacturing and Mechatronic Engineering Technology was held on 7 and 8 August 2023. The main field focuses on Manufacturing, Mechatronics as well as Materials.

About 95 submissions were received during iM3F 2023 and were reviewed in a single-blind manner, and 48 papers were advocated by the reviewers to be published in this Springer Proceedings of Materials. The editors would like to express their gratitude to all the authors who submitted their papers. The paper published in this proceeding has been thoroughly reviewed by the appointed technical review committee which consists of various experts in the field of materials and manufacturing engineering.

The conference had brought a new outlook on cutting-edge issues shared through keynote speeches by Assoc. Prof. Ir. Dr. Haji Nik Mohd Zuki Nik Mohamed, Prof. Eng Hwa Yap and Prof. Gian Antonio Susto.

Finally, the editors hope that readers find this volume informative as we thank Springer Proceedings in Materials for undertaking this volume publication. We also would like to thank the conference organization staff and the international program committees' members for their hard work.

Pekan, Pahang, Malaysia  
November 2022

Radhiyah Abd. Aziz  
Zulhelmi Ismail  
A. K. M. Asif Iqbal  
Irfan Ahmed

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# Effects of pH on Grain Size and Structure of ZnO Nanoparticle Synthesized via Sol–Gel Method for Enhanced Thermoelectric Materials

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**Suraya Sulaiman** , Tuan Muhammad Tuan Zahrin, Nadhrah Md Yatim, Mohd Faizul Mohd Sabri & Mohamad Farid Mohamad Sharif

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## Abstract

Zinc Oxide (ZnO) emerges as a potential thermoelectric material with high thermoelectric performance suitable for enhancing power harvesting applications efficiently. However, its intrinsic high thermal conductivity poses a challenge to achieving optimal thermoelectric performance. To address this, the nanostructuring approach has been employed, leveraging the creation of nanometer-scale grains to effectively reduce thermal conductivity. This paper investigates the impact of pH on the size of ZnO nanoparticles grains. The sol–gel method was used to synthesize the ZnO nanoparticles with various pH levels (7, 9, and 12). Subsequently, the resulting powder was then calcined at 800 °C for 1 h to produce pure ZnO powder. X-ray diffraction (XRD) analysis revealed a consistent hexagonal wurtzite structure across all pH levels, with the smallest crystallite sizes observed at pH 12 (34.52 nm), followed by pH 9 (34.72 nm), and pH 7 (40.38 nm). At pH 7 and 12, field emission scanning electron microscopy (FESEM) pictures displayed a hexagonal-like structure, whereas pH 9 revealed a nanorod-like structure. The average particle sizes were determined to be 84.56 nm at pH 12, 97.22 nm at pH 9, and 118.70 nm at pH 7, respectively. Energy-dispersive X-ray spectroscopy (EDX) analysis confirmed the



high purity of the synthesized ZnO nanoparticles, with atomic percentages of Zn and O closely aligning with the stoichiometric composition. These results validate the substantial purity of the ZnO nanoparticles. Overall, the findings demonstrate that increasing the pH values during synthesis leads to a reduction in both crystallite and particle sizes. This decrease in size is associated with lower thermal conductivity, thus offering the potential for improved thermoelectric performance.

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