Documents

Sulaiman, S.[a] [b] , Tuan Zahrin, T.M.[a] , Md Yatim, N.[c] , Mohd Sabri, M.F.[d] , Mohamad Sharif, M.F.[a]

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

(2024) *Springer Proceedings in Materials*, 40, pp. 233-242.

DOI: 10.1007/978-981-99-9848-7_21

[a] Faculty of Manufacturing and Mechatronic Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Pahang, Pekan, 26600, Malaysia
[b] Faculty of Engineering, School of Mechanical Engineering, University Teknologi Malaysia, Johor, 81310, Malaysia
[c] Faculty Science and Technology, Universiti Sains Islam Malaysia, Negeri Sembilan, Nilai, 71800, Malaysia
[d] Faculty of Engineering, Department of Mechanical Engineering, Universiti Malaya, Kuala Lumpur, 50603, Malaysia

Funding details
Ministry of Higher Education, MalaysiaMOHE

Correspondence Address
Sulaiman S.; Faculty of Manufacturing and Mechatronic Engineering Technology, Pahang, Malaysia; email: surayas@umpsa.edu.my

Publisher: Springer

ISSN: 26623161
Language of Original Document: English
Abbreviated Source Title: Springer. Proc. Mater.
2-s2.0-85189171293
Document Type: Book Chapter
Publication Stage: Final
Source: Scopus

Springer Proceedings in Materials

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

Intelligent Manufacturing and Mechatronics

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

Springer

Springer Proceedings in Materials

Volume 40

Springer Proceedings in Materials publishes the latest research in Materials Science and Engineering presented at high standard academic conferences and scientific meetings. It provides a platform for researchers, professionals and students to present their scientific findings and stay up-to-date with the development in Materials Science and Engineering. The scope is multidisciplinary and ranges from fundamental to applied research, including, but not limited to:

- Structural Materials
- Metallic Materials
- Magnetic, Optical and Electronic Materials
- Ceramics, Glass, Composites, Natural Materials
- Biomaterials
- Nanotechnology
- Characterization and Evaluation of Materials
- Energy Materials
- Materials Processing

To submit a proposal or request further information, please contact one of our Springer Publishing Editors according to your affiliation:

European countries: **Mayra Castro** (mayra.castro@springer.com)
India, South Asia and Middle East: **Priya Vyas** (priya.vyas@springer.com)
South Korea: **Smith Chae** (smith.chae@springer.com)
Southeast Asia, Australia and New Zealand: **Ramesh Nath Premnath** (ramesh.premnath@springer.com)
The Americas: **Michael Luby** (michael.luby@springer.com)
China and all the other countries or regions: **Mengchu Huang** (mengchu.huang@springer.com)

This book series is indexed in **SCOPUS** and **EI Compendex** database.

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

Intelligent Manufacturing and Mechatronics

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

Springer

Editors
Radhiyah Abd. Aziz
Faculty of Manufacturing and Mechatronic Engineering Technology
Universiti Malaysia Pahang Al-Sultan Abdullah
Pekan, Pahang, Malaysia

Zulhelmi Ismail
Faculty of Manufacturing and Mechatronic Engineering Technology
Universiti Malaysia Pahang Al-Sultan Abdullah
Pekan, Pahang, Malaysia

A. K. M. Asif Iqbal
Department of Mechanical, Materials and Manufacturing Engineering
University of Nottingham Ningbo China
Ningbo, China

Irfan Ahmed
Department of Physics
Government College Balakot
Khyber Pakhtunkhwa, Pakistan

ISSN 2662-3161 ISSN 2662-317X (electronic)
Springer Proceedings in Materials
ISBN 978-981-99-9847-0 ISBN 978-981-99-9848-7 (eBook)
https://doi.org/10.1007/978-981-99-9848-7

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Paper in this product is recyclable.

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

Contents

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

Conference paper | First Online: 18 March 2024

pp 233–242 | Cite this conference paper

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

Part of the book series: Springer Proceedings in Materials ((SPM,volume 40))

Included in the following conference series:
Innovative Manufacturing, Mechatronics & Materials Forum

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.

References

1. Sulaiman S, Izman S, Uday MB, Omar MF (2022) Review on grain size effects on thermal conductivity in ZnO thermoelectric materials. RSC Adv 12:5428–5438

Article PubMed PubMed Central Google Scholar

2. Singh S (2021) Energy: crises, challenges and solutions. Wiley, pp 1–17

Google Scholar

3. Sulaiman S, Izman S, Uday MB, Omar MF (2022) Review of the nanostructuring and doping strategies for high-performance ZnO thermoelectric materials. Crystals 12:1076

Article Google Scholar

4. Zaferani SH, Jafarian M, Vashaee D, Ghomashchi R (2021) Thermal management systems and waste heat recycling by thermoelectric generators—an overview. Energies 14:5646

Article Google Scholar

5. Jantrasee S, Moontragoon P, Pinitsoontorn S (2016) Thermoelectric properties of Al-doped ZnO: experiment and simulation. J Semicond 37:092002-1–092002–8

Google Scholar

6. Orr B, Akbarzadeh A, Mochizuki M, Singh R (2016) A review of car waste heat recovery systems utilising thermoelectric generators and heat pipes. Appl Therm Eng 101:490–495

Article Google Scholar

7. Jouharaa H, Khordehgaha N, Almahmoud N, Delpech B, Chauhan A, Tassou SA (2018) Waste heat recovery technologies and applications. Therm Sci Eng Progress 6:268–289

Article Google Scholar

8. Jouharaa H, Zabnienska-Gora A, Khordehgaha N, Doraghia Q, Ahmada L, Normana L, Axcella B, Wrobella L, Daid S (2021) Thermoelectric generator (TEG) technologies and applications. Int J Thermofluids 9:100063

Article Google Scholar

9. Jood P, Mehta RJ, Zhang Y, Peleckis G, Wang X, Siegel RW, Borca-tasciuc T, Dou SX, Ramanath G (2011) Al-doped zinc oxide nanocomposites with enhanced thermoelectric properties. Nano Lett 11:4337–4342

Article PubMed Google Scholar

10. Yin Y, Tudu B, Tiwari A (2017) Recent advances in oxide thermoelectric materials and modules. Vacuum 146:356–374

Article Google Scholar

11. Ren G, Lan J, Zeng C, Liu Y, Zhan B, Butt S, Lin YH, Nan CW (2015) High performance oxides-based thermoelectric materials. JOM 67:211–221

Article Google Scholar

12. Kusumawati AD, Suprayogi T, Diantoro M, Dasna I, Subakti (2018) New simple synthesis, crystal system and physical properties of Zn_5S_2 compound. J Phys Conf Ser 1040:1–8

Google Scholar

13. Zahra R, Mahmood K, Ali A, Rehman U, Amin N, Arshad MI, Hussain S, Mahmood MHR (2019) Growth of Zn_2GeO_4 thin film by thermal evaporation on ITO substrate for thermoelectric power generation applications. Ceram Int 45:312–316

Article Google Scholar

Acknowledgements

The author acknowledges the support and funding provided by the Ministry of Higher Education of Malaysia (MOHE) through the Fundamental Research Grant Scheme (FRGS) under Grant No. FRGS/1/2022/STG05/UMP/03/1. (University reference RDU220130) and Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA) for laboratory facilities as well as additional financial support under Sustainable Research Collaboration Grant funded by UMPSA, IIUM & UiTM under Grant No. RDU200744. The author also expresses gratitude to the Faculty of Manufacturing and Mechatronic Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA). Their contributions and support were invaluable in the successful completion of this research project.

Author information

Authors and Affiliations

Faculty of Manufacturing and Mechatronic Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26600, Pekan, Pahang, Malaysia

Suraya Sulaiman, Tuan Muhammad Tuan Zahrin & Mohamad Farid Mohamad Sharif

Faculty of Engineering, School of Mechanical Engineering, University Teknologi Malaysia, 81310, Johor, Malaysia

Suraya Sulaiman

Faculty Science and Technology, Universiti Sains Islam Malaysia, 71800, Nilai, Negeri Sembilan, Malaysia

Nadhrah Md Yatim

Faculty of Engineering, Department of Mechanical Engineering, Universiti Malaya, 50603, Kuala Lumpur, Malaysia

Mohd Faizul Mohd Sabri

Corresponding author

Correspondence to Suraya Sulaiman .

Editor information

Editors and Affiliations

Faculty of Manufacturing and Mechatronic Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Pekan, Pahang, Malaysia

Radhiyah Abd. Aziz

Faculty of Manufacturing and Mechatronic Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Pekan, Pahang, Malaysia
Zulhelmi Ismail

Department of Mechanical, Materials and Manufacturing Engineering, University of Nottingham Ningbo China, Ningbo, China
A. K. M. Asif Iqbal

Department of Physics, Government College Balakot, Khyber Pakhtunkhwa, Pakistan
Irfan Ahmed