

SYNTHESIS AND PHYSICAL PROPERTY
CHARACTERIZATION OF NICKEL
NANOWIRES

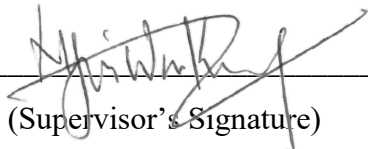
SANTHI A/P ULAKANATHAN

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis, and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

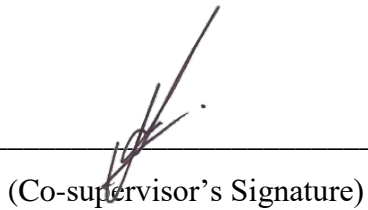


(Supervisor's Signature)

Full Name : TS. DR. NGUI WAI KENG

Position : SENIOR LECTURER

Date : 15/11/2021



(Co-supervisor's Signature)

Full Name : IR. TS. DR. MAHENDRAN SAMYKANO

Position : ASSOCIATE PROFESSOR

Date : 15/11/2021



STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

A handwritten signature in black ink, appearing to be 'Santhi', is written above a horizontal line.

(Student's Signature)

Full Name : SANTHI A/P ULAKANATHAN

ID Number : MSM17004

Date : 15/11/2021

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NANOWIRES

SANTHI A/P ULAKANATHAN

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

College of Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2021

ACKNOWLEDGEMENTS

All praises are to GOD Almighty for the wisdom he bestowed upon me, strength, and countless love for completing my research successfully.

Foremost, I dedicate this accomplishment to my late father, Mr. Ulakanathan, who served as an inspiration to pursue this undertaking and for always believing in me. I would like to extend my deepest gratitude towards my family for giving unfailing support and endless encouragement during the years of study.

My heartfelt thanks to my direct supervisor, Ts. Dr. Ngui Wai Keng, for his undivided attention, guidance, and supervision throughout this study, helped bring this research into success. Also, special thanks to my co-supervisor Assoc. Prof. Ir. Ts. Dr. Mahendran Samykano for imparting his knowledge in this project.

My thanks and appreciation also go to people who have willingly helped me out with their abilities. Completing this dissertation couldn't have been possible without the support and contributions of the kind of people around me. Their contributions had been invaluable, for which I am incredibly grateful.

ABSTRAK

Satu dimensi wayar nano nikel merupakan struktur nano logam yang dipercayai menyumbang dengan ketara untuk kemajuan bidang bahan saintifik berikutan ciri-ciri kimia, mekanikal and magnetik yang unik. Maka, adalah penting untuk memastikan kajian diteruskan supaya kesemua sifat unik wayar nano nikel dapat digunakan dengan optimum untuk menghasilkan product berteknologi tinggi. Oleh itu, objektif kajian ini adalah seperti berikut; untuk menjana satu dimensi wayar nano nikel melalui teknik pemendapan kimia menggunakan templat aluminium oksida pada pelbagai suhu pemendapan larutan elektrokimia dan kepekatan asid borik; mengkaji pengaruh pelbagai suhu pemendapan dan asid boric terhadap sifat fizikal wayar nano nikel yang dihasilkan dan untuk membina persamaan matematik menggunakan kaedah RSM (Response Surface Methodology) untuk mengaitkan sifat fizik wayar nano nikel terhadap keadaan sintesis yang berbeza. Dalam kajian ini, kepekatan asid borik diubah daripada 6, 40, dan 70 g/l manakala suhu pemrosesan diubah pada 30, 70 dan 110 °C. Sifat fizikal wayar nano nikel yang dijana dikaji menggunakan pelbagai teknik dan peralatan dan kedua-dua analisis kualitatif dan kuantitatif dibincang dengan terperinci. Kajian menggunakan teknik FESEM (Field Emission Scanning Electron Microscopy) merumuskan bahawa tekstur permukaan wayar nano nikel semakin kasar dengan peningkatan suhu pemendapan dan kepekatan asid boric. Imej FESEM juga menunjukkan bahawa wayar nano nikel memanjang dengan peningkatan suhu tetapi memendek dengan peningkatan kepekatan asid borik. Analisis unsur asas menggunakan EDX (Energy Dispersive X-ray Detector) pula membuktikan penghasilan wayar nano nikel yang bertulin tinggi dengan ketulinan atom nikel sebanyak 97.97 %. Hasil kajian XRD (X-ray Diffraction) memaparkan ciri polikristal untuk wayar nano nikel yang dijana dan orientasi kristal tidak berubah pada keadaan sintesis yang berlainan. Tetapi, saiz kristal mengecil dengan peningkatan kepekatan asid borik dan membesar dengan peratusan yang sedikit dengan peningkatan suhu pemendapan. Persamaan matematik dibentuk dengan kaedah RSM untuk mengaitkan panjang wayar nano dan saiz kristal terhadap proses parameter yang digunakan dalam kajian ini. Analisis menunjukkan bahawa suhu mempengaruhi pemanjangan wayar nano nikel dengan berkesan pada 76.82%. Manakala, saiz kristal dipengaruhi oleh kepekatan asid boric pada 39.49% dan suhu pemendapan pada 53.44%. Ralat nilai data eksperimen berbanding ramalan nilai sebenar untuk panjang wayar ialah 1.0 % dan untuk saiz kristal adalah 0.55 %. Persamaan matematik yang dibentuk ini membolehkan ramalan parameter pemrosesan yang selanjutnya pada keadaan sintesis yang tertentu, tanpa keperluan untuk mengulangi eksperimen di mana ia menyumbang mengurangkan kos dan menjimatkan masa.

ABSTRACT

1D (one-dimensional) Ni (Nickel) NW (nanowire) is a metallic nanostructure that is anticipated to contribute substantially to material scientific advancement due to its unique chemical, mechanical, and magnetic properties. Hence, it is essential to ensure continuity of researches to utilize and optimize the exclusive properties of Ni NWs to develop high technology products. Therefore, the objectives of this research are as follows: to synthesize 1D Ni NWs using AAO (anodic aluminium oxide) template-assisted electrodeposition technique at various electrolyte bath temperatures and boric acid concentrations; to investigate the influence of electrolyte bath temperatures and boric acid concentrations towards physical properties of Ni NWs synthesized and to develop a mathematical equation using RSM (Response Surface Methodology) to correlate physical properties of Ni NWs towards synthesis condition. In this research, boric acid concentration was varied at 6, 40, and 70 g/L while the processing temperature was varied at 30, 70, and 110 °C. Physical properties of Ni NWs synthesized were analyzed using different characterization tools and both qualitative and quantitative findings were discussed in detail. Investigation using FESEM (Field Emission Scanning Electron Microscopy) showed the surface morphology became rougher with increasing electrolyte bath temperature and boric acid concentration. FESEM images also revealed that there is a growth in Ni NW length when the temperature increases but the NWs became shorter with high boric acid concentration. The elemental composition analysis using EDX (Energy Dispersive X-ray Detector) proved successful fabrication of high purity Ni NWs with 97.97 % Ni atom. XRD (X-ray Diffraction) finding showed the Ni NWs produced are in polycrystalline structure and the crystal orientation remains unchanged with different processing conditions. However, the crystal size became smaller with increasing boric acid concentration and grows bigger in a small percentage with higher deposition temperature. The mathematical equation was developed using RSM to correlate Ni NW growth length and crystal size towards the processing parameters employed in this research. The analysis showed that the temperature influences Ni NW growth length significantly, at 76.82 %. Meanwhile, the crystal size was influenced by boric acid concentration at 39.49% and electrodeposition bath temperature at 53.44 %. The error of experimental data versus predicted data for NWs growth length is 1.0 %, and for crystal size is 0.55 %. The established mathematical equation enables prediction of future values for specified processing conditions, thus eliminate the need to repeat the experiments and offers cost and time savings benefits.

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