FABRICATION AND CHARACTERIZATION OF ZINC OXIDE NANOROD BASED PIEZOELECTRIC NANOGENERATOR

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of bachelor of electronic engineering with honours

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

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Supervisor Name : TS. DR. FAIZ BIN ARITH

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DEDICATION

I dedicated my Final Year Project (FYP) of Bachelor's Degree to my supervisor, Ts. Dr. Faiz Bin Arith and my beloved parents Mr. Abdul Rahman Bin Abang Othman and Mrs. Mahanum Binti Muhammad Wahi. Lastly, without forgetting to all people around me for their inspirations.

ABSTRACT

Piezoelectric energy harvester is one of the promising power sources for the future. The use of a ZnO nanorod as an electron transport layer seems promising due to its wide bandgap conduction band, which permits the generation of reduced resistivity due to its greater surface area. In this study, ZnO nanorods are grown hydrothermally at an annealing temperature of 90 °C. The structural characteristics are determined by scanning electron microscopy (SEM) In the meantime, the electrical characteristic is measured using I-V characteristics measurement. SEM images depict the material's surface characteristics. In addition, the I-V characteristic demonstrates that the resistivity varies with the time of ZnO nanorod layer growth. As the result the best growth time is within 7 to 9 hours

ABSTRAK

Penuai tenaga piezoelektrik adalah salah satu sumber kuasa yang baik untuk generasi akan datang. Penggunaan nanorod ZnO sebagai lapisan pengangkutan elektron nampaknya menjanjikan kerana jalur pengaliran celah jalurnya yang luas, yang membenarkan penjanaan kerintangan yang berkurangan kerana kawasan permukaannya yang lebih besar. Dalam kajian ini, nanorod ZnO ditanam secara hidroterma pada suhu penyepuhlindapan 90 °C. Ciri-ciri struktur ditentukan dengan mengimbas mikroskop elektron (SEM) Sementara itu, ciri elektrik diukur menggunakan pengukuran ciri-ciri I-V. Imej SEM menggambarkan ciri permukaan bahan. Di samping itu, ciri IV menunjukkan bahawa kerintangan berbeza dengan masa pertumbuhan lapisan nanorod ZnO. Hasilnya masa pertumbuhan terbaik adalah dalam masa 7 hingga 9 jam

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LIST OF SYMBOLS AND ABBREVIATIONS

ZnO	:	Zinc Oxide Nanorod
ITO	:	Indium Tin Oxide
SEM	:	Scanning Electron Microscopy
PZT	:	Lead zirconate titanate
PET	:	Polyethylene terephthalate
PVDF	:	Ferroelectric Polyvinylidene fluoride
PENG	:	Piezoelectric nanogenerator
TENG	:	Triboelectric nanogenerators
EMG	:	Electromagnetic generator
PMMA	:	Poly (methyl methacrylate)
$BaTiO_3$	:	Barium titanate
FTO	:	Fluoride doped tin oxide
NW	:	Nanowire

CHAPTER 1

INTRODUCTION

This chapter explains the subject matter and problems statement, objectives, scope the of work and significance of the project. The project background and problem statement will be introduced in this chapter regarding the challenge of for the fabrication of piezoelectric by zinc oxide. The outline of the thesis summary is included at by the end of the chapter.

1.1 Introduction

1.1.1 Overview of Piezoelectric

When mechanical stress is applied to some materials, they acquire an electric charge on their surface, which is known as piezoelectricity. In these materials, an applied electrical field causes linearly proportional strain. In 1880, brothers Pierre and Jacques Curie developed the direct piezoelectric effect. The same phenomenon was then seen in reverse, with an induced electric field on the crystal putting stress on its structure. The piezoelectric effect is caused by the fundamental structure of a crystal lattice, which is based on the fundamental structure of a crystal lattice.

During World War I, the first major applications development on piezoelectric devices occurred. P. Langevin and his French colleagues began developing an ultrasonic submarine detector in 1917. Their transducer was a mosaic of tiny quartz crystals cemented between two steel plates (the composite's resonance frequency was around 50 KHz), installed in a submersible enclosure. They did achieve their goal of generating a high frequency "chirp" underwater and determining depth by timing the return echo by working past the conclusion of the war. The strategic significance of their achievement, however, was not forgotten by any industrial nation and development of sonar transducers, circuits, systems and materials has never stopped since.

Most of the traditional piezoelectric applications we are aware with (microphones, accelerometers, ultrasonic transducers, bending element actuators, phonograph pick-ups, signal filters, etc.) were invented and put into reality during this post-World War I resurgence. The materials available at the time often limited gadget performance and certainly restricted commercial exploitation, so keep that in mind.

Research organisations working on improved capacitor materials during World War II revealed that certain ceramic materials (made by sintering metallic oxide powders) had dielectric constants up to 100 times greater than ordinary cut crystals. It was also possible to improve the piezoelectric properties of the same class of materials (known as ferroelectrics). The resurgence of interest in piezoelectric devices was precipitated by the discovery of inexpensive, high-performance piezoelectric ceramics.

Negative and positive charges precisely cancel each other out along the hard planes of the crystal lattice, resulting in a charge balance. When the charge equilibrium in the crystals is broken by physical stress, the energy is transferred to electric charge carriers, resulting in a current in the crystal. The application of an external electric field to the crystal causes the neutral charge state to become unbalanced, resulting in mechanical stress and a small readjustment of the lattice structure.

Briscoe and Dunn defined piezoelectricity as “electric charge that accumulates in response to applied mechanical stress in materials that have non-centrosymmetric crystal structures”, while Erturk and Inman defined piezoelectricity as “a form of coupling between the mechanical and electrical behaviors of ceramics and crystals belonging to certain classes”. The Greek origin of the word “piezoelectricity” is “squeeze or press”, which refers to the propriety of the piezoelectric materials to generate an electric field when a mechanical force is applied, a phenomenon called the direct piezoelectric effect.

The piezoelectric effect is divided into two phenomena: the direct piezoelectric effect and the converse piezoelectric effect. The property of some materials to generate an electric field when a strain is applied (direct piezoelectric effect) was discovered by Pierre and Jacques Curie in 1880. The converse or inverse piezoelectric effect was mathematically deduced from the principles of thermodynamics a year later by Lippmann and it states that a piezoelectric material will deform if an electric field is applied to it. These two effects coexist in a piezoelectric material, therefore ignoring the presence of one effect in an application would be thermodynamically inconsistent. Efforts are underway to find the best piezo product potential. According to the rise in global activity and the triumphs of the last part of the twentieth century, significant economic and technological improvements are almost inevitable.

1.2 Problem statement

The primary issue that currently happening in the world is a high dependency on battery to energize electronic devices. Some crucial solutions have been taken such as replacing the alkaline batteries with lithium-ion batteries. However, lithium-ion battery leads to another major environmental problem as the mining process of the lithium affects the local ecosystem that causa havoc.

Besides the low cost to produce a piezoelectric also is highlighted the higher cost to create a battery has become the main issue of the problem. To produce a piezoelectric environmentally friendly material as most of the piezoelectric is made if lead material that are harmful. Lead poisoning has long been considered as an environmental health hazard, for its adverse effects on intellectual and neurological development

Researchers have turned their attention to the idea of gathering energy from ambient sources. The piezoelectric energy harvester mechanism is widely used as it can generate energy from kinetic energy. Energy harvesting has the potential to extend the life of electronics, especially those that are inaccessible or require expensive maintenance.

1.3 Objectives

For this project, some objectives need to be achieved. The objectives are listed below:

i. To synthesize the Zinc Oxide Nanorods for energy harvester nanogenerator application.

ii. To characterize the structural performance of Zinc Oxide nanorod using Scanning Electron Microscopy (SEM) and analyze the electrical performance of the ZnO nanorod

1.4 Scope of project

At the beginning of this project, the focus is the synthesization of the piezoelectric synthesize the piezoelectric nanogenerator using the hydrothermal technique on Indium Tin Oxide (ITO) PET substrate. After that, the characterization and analysis of the zinc oxide by using Scanning Electron Microscopy (SEM). Next, the I-V characteristics of the ZnO will be carried out during this project to find the electrical performance using the Keithley multimeter

1.5 Thesis Outline

This thesis contains five chapters to describe the project entitled Fabrication and characterization of Zinc Oxide Nanorod-based piezoelectric nanogenerator. The first chapter is Introduction and followed by Background Study, Methodology, Result & Discussion and Conclusion. The summary of the content for each chapter is shown in below:

i) Chapter 1 – Introduction

This chapter will explain overview about the piezoelectric. This chapter covers on the introduction of the project title, problem statement, objectives to be achieved by the end of the project and the scope of work when implement this project.

ii) Chapter 2 – Background study

For chapter 2, it is divided into three parts which is introduction, previous work and conclusion. Literature review consists of the background study and past or current research before developing this project. In introduction part, it will explain generally about the materials use, the characteristics of the materials, the process takes place in this project and others. In previous work, it contains of the background studies such as the information about the materials, process added and the methods use.

iii) Chapter 3 – Methodology

This chapter will describe about the methods and equipment that use in this project. The flowchart is necessary for this chapter to arrange the steps in this project development.

iv) Chapter 4 – Results and Discussion

For chapter 4, it will present the findings and analysis from the project. There are two properties observe and measure to obtain better efficiency which are structural and electrical. Different properties use different equipment to obtain the analysis and results.

v) Chapter 5 – Conclusion and Future work

This chapter will discuss about the conclusion that can be drawn from the project. Therefore, it also consists of summary of the project and will discuss about the recommendations for future work purposes which can be improve in some ways to obtain better results and performance.

CHAPTER 2

BACKGROUND STUDY

This chapter covers the literature review of the project. In this chapter it discusses the literature review that includes the information gathered to get knowledge and ideas for the project's completion. Several sources, such as books, thesis and journal, have taken as a resource for this project. Method and approaches that used also take from the resource as reference and guideline.

2.1 Introduction

2.1.1 Types of Nanogenerator

The use of renewable and green energy sources is becoming increasingly important as social concerns about global energy needs and the effects of global climate change develop at a rapid pace. Furthermore, there is a need to lessen the dependency on batteries to power electronic devices and the Internet of Things. As a result, nanogenerators are being examined for harvesting a variety of energy [1]. Several techniques and mechanisms, such as the photovoltaic effect, triboelectric