CHAPTER 1

INTRODUCTION

1.1 Introduction

Electricity is generated from non-renewable natural sources such as fossil fuel, coal, natural gas, and petroleum. The electricity is being used in many fields such as automotive, health care and communication devices. For example, for application in medical science, nano-devices and wireless sensors require electricity for their power sources. To use in powering the wireless nano-devices, the regular energy source, battery is facing the limitation due to its big size, heavy weight and short operation lifetime (Prashanthi, et al., 2013; Kumar & Kim, 2012). Even though battery has high capacitance, it is not energy efficient. Most of the energy input has been lost as heat, light, sound or vibration. Battery has low power density. In addition, battery is not environmental friendly power resource. Therefore, it has drawn the emergence of research in alternative energy sources to fulfill the needs of wireless sensing problem.

Moreover, these non-renewable natural sources have caused the depletion of ozone layer and global warming. To maintain sustainably development for human civilization, many researches are now focusing on searching renewable alternative way to solve the shortage of natural resources and reduce the pollution (Aricò, Bruce, Scrosati, Tarascon, & Schalkwijk, 2005).

To break through the insufficiency of traditional power sources and achieve green energy technology, energy harvesting has drawn attention from scientist. Energy harvesting is a device that can convert the unused ambient energy to electricity. The
type of energy harvesting depends on the type of energy and applications. Energy harvesting is distinguished as radiant energy harvesting, mechanical energy harvesting, thermal energy harvesting, vibration energy harvesting and others. Energy harvesting is mostly used for low-powered electronic applications, such as wireless devices. This technologies use material at micro- or nano-scale to charge wireless devices and wireless sensor networks.

There are many benefits of energy harvesting. One of the benefits is to reduce usage of battery power. Device with low-powered can be charged by energy harvester and rely on internal energy storage rather than rely on battery power. Self-powered wireless sensor is easy to install. Therefore, it can reduce installation cost. Energy harvesting also can reduce maintenance cost as there is not necessary to replace battery. Self-powered device can be used in long term as long as the ambient energy is available. Energy harvester also reduces environmental impact (Chen, He, & Sun, 2014; Wong & Dahari, 2015).

Among these few types of energy harvesting, vibration energy harvester has drawn more attention in the world as it is available almost everywhere at all times. It can be used in many fields such as implanted devices, electronic devices, mobile devices and wireless sensor devices (Khaligh, Zeng, & Zheng, 2010). There are three ways to generate electrical energy from vibration energy which are electromagnetic, piezoelectric and electrostatic. It is hard to fabricate the circuit of electromagnetic as it has low voltage and cannot produce high current. Electrostatic cannot be used in practical as it requires external voltage sources (Shang, Li, Wen, & Zhao, 2013). Therefore, piezoelectric vibration harvester has been focused more.

The piezoelectric effect converts mechanical energy (vibration, air flow and human physical motion (Kumar & Kim, 2012)) into electrical energy. In 1880, Curie and his brother discovered the piezoelectric effect. During World War I, the application of piezoelectric effect in solar device had been launched. After that, new applications such as microphones, accelerometers, actuators and ultrasonic motors were developed (Spies, Pollak, & Mateu, 2015). Nuffer and Bein proposed that piezoelectric energy harvester acts as a knock sensor to detect irregular combustion in transportation industry.
(Nuffer & Bein, 2006). It has become common and easy to find the application of piezoelectric material.

Thin film technology has great potential to produce micro- or nano-scale devices as piezoelectric thin film. Thin film is a 2D nanomaterial which means that two of the dimensions are not confined to the nanoscale. Thin film exists in platelike shape. It offers many benefits in various applications for example, high energy density harvester, high sensitivity but low power sensors and high resolution circuit board. Moreover, compare to bulk piezoelectric materials, piezoelectric thin films are more suitable to be integrated into micromechanical systems (MEMS) or nanoelectromechanical systems (NEMS) (Eom & Trolier-Mckinstry, 2012).

1.2 Problem Statement

There are many novel ideas of renewable energy harvesting application. However, the major challenges faced by developers are to construct an energy harvester that is cheap, efficient and can work all the time especially when the ambient unused energy is absent. From this case, the combination of semiconductor and piezoelectric plays an important role in energy harvesting.

Piezoelectric semiconducting materials (ZnO, AlN, ZnS, GaN) have been used in many fields to generate power. Among these materials, ZnO has been focused more due to its favorable properties (high electron mobility, high power stability and inherent piezoelectric properties).

There are many studies revealed that the characterization and vibration sensing performance of ZnO nanostructures as piezoelectric energy harvester under different annealing temperature, but the energy harvester based on ZnO thin film was rarely reported.

This paper presents the fabrication process of ZnO thin film by spin coating and the measurement of the energy harvester based on ZnO thin film. The characterizations (crystallographic orientation, composition of ZnO, thickness of thin film and the current