CHAPTER 1

INTRODUCTION

Introduction of this research is composed the topic of motivation, research objectives, scope and limitation, anticipated outcomes of the dissertation and dissertation structure.

MOTIVATION

Nowadays, the energy requirement is very important as a result of a still increasing demand. Renewable energy development becomes more interesting from research and innovation point of view. In many practical renewable energy generating systems, thermoelectric principles are employed, for example to allow the energy to be used and stored. (Kim, Lee, Lim & Myung, 2016, pp.579-586; Min et al. 2016, pp. 164-169). Cooling systems with low energy consumption are a challenge for innovative developments. Low energy consumption thermoelectric equipment are commonly found in microelectronic applications such as, wireless sensors, used in cooling and heating process in the industry. Recently, there has been advanced progress in nano-technology, and thermoelectric thin film technology. Specifically, thermoelectric developments are interesting because of their low energy consumption and small size (Budak, Guner, Muntele & Ila, 2014).

Advanced themorelectric materials offer new opportunities to recover waste heat more efficiently and economically with highly reliability. A thermoelectric power generation (TEG) device produces voltage when a temperature difference (ΔT) occurs between the two sides of the device because of the thermoelectric effect (TE) in accordance with Seebeck, Peltier, and Thomson effects (Anno et al. 2015).

TE generation has primarily been directed toward increasing the material figure of merit (ZT), which is the standard measure of the TE performance of a material, that is, $ZT = \frac{S^2 \sigma T}{\kappa}$, where S is the Seebeck coefficient, σ is the electrical conductivity, and κ is the total thermal conductivity, and T the absolute temperature, defined as $S^2\sigma$ or S^2/ρ is the thermoelectric power factor where ρ is electrical resistivity (Kim, Lee, Lim & Myung, 2016, pp.579-586 ; Su et al. 2008, pp. 515-518). The power factor should be maximized, whereas the thermal conductivity should be minimized to achieve a highly efficient thermoelectric material.

Early developments in thermoelectric devices used thin-film depositions based on different growth methods, such as molecular beam epitaxy, electrochemical deposition (Kim, Lee, Lim & Myung, 2016, pp.579-586), radio frequency magnetron sputtering (Zheng et al, 2017 ; Fang, Zeng, Yan & Hu, 2013, pp. 1105–1111), flash evaporation (Lee, Han, Eun Lee & Park, 2012, pp.1435-1438) and dry-spray deposition (Song, Choi & Ahn, 2016), to grow single layers and superlattices on various substrates. The present study explores the design of thin films, the enhancement of microfabrication methods, and the related electrical characterizations to improve the performance and integration of microscale TE generators.

In accordance with Jung et al. (2012, pp. 1435-1438), composition-dependent electrical properties of ternary $Ag_xSb_{1-x}Te_y$ thin films synthesized by Cationic eachange reaction on glass substrate, was found having electrical resistivity, Seebeck coefficient and power factor equaling 7.97×10^{-4} Ω m, 138.86 μ V K^{-1} and 5.3×10^{-4} W m^{-1} K^{-2} respectively. However, Budak et al. (2015) reported thermoelectric generators from AgBiTe and AgSbTe thin films modified by high-energy beam on Si and fused silicon (Suprasil) substrate have exhibited electrical resistivity, Seebeck coefficient and power factor as 2.16×10^{-4} Ω m, 718.5 μ V K^{-1} and 552.69 μ W m^{-1} K^{-2}. Recently, Kim et al. (2016, pp. 579–586) reported that optimization of thermoelectric properties of p-type $AgSbTe_2$ thin films via electrochemical synthesis on Ni/Au/Si substrate have electrical resistivity, Seebeck coefficient and power factor as 1.24×10^{-4} Ω m, 360.45 μ V K^{-1} and 1224.37 μ W m^{-1} K^{-2}.

In this study, the Ag-Sb-Te thin film has been prepared by DC magnetron sputtering on flexible polyimide substrates. In the present study, we have focused on Ag-Sb-Te films prepared by DC magnetron sputtering on flexible polyimide substrates. After that, we investigated crystal structure, microstructural, composition and thermoelectric properties of thin films under different annealing temperatures and fabricated thin films thermoelectric generator prototype consisting of Ag-Sb-Te leg and Ag electrodes, and measured the maximum output power of thin films thermoelectric generator to improve the performance of thermoelectric thin film.

RESEARCH OBJECTIVES

1. To prepare Ag-Sb-Te films using direct current (DC) magnetron sputtering.

2. To investigate the crystal structure, microstructure, chemical composition, thermoelectric properties of Ag-Sb-Te films.

3. To fabricate thermoelectric generator prototype of Ag-Sb-Te films.

SCOPE AND LIMITATION

1. Ag-Sb-Te films were deposited on flexible polyimide substrate by DC magnetron sputtering from a 99.99% purity of Ag : Sb : Te (1 : 1 : 1) target 59 mm diameters and 3 mm thick.

2. Characterization of films is composes of phase identification, morphological. Elemental analysis is use grazing-incidence X-ray diffraction (GIXRD), field emission scanning electron microscopy (FE-SEM), atomic force microscopy (AFM), and Energy Dispersive X-ray spectroscope (EDX), respectively.

3. Thermoelectric properties measurement composed of carrier concentration and mobility by Hall Effect measurement system. Seebeck coefficient and electrical resistivity by ZEM-3 into estimate of power factor.

4. Thermoelectric generator prototype of Ag-Sb-Te films was designed as 5 pairs which the leg in 2.0 mm (w) × 20 mm (l) and the spacing between both legs was 2.0 mm, the overall prototype measures 25.40 x 25.40 mm^2 with the thermoelectric leg sandwiched by Ag electrodes.

ANTICIPATED OUTCOMES OF THE DISSERTATION

1. $Ag_xSb_yTe_z$ thin films.
2. Thermogenerator film prototype of Ag-Sb-Te thin film.
3. Paper publication on international journal in ISI base.

DISSERTATION STRUCTURE

The subject of the work presented in this dissertation is thermoelectric properties and thermogenerator prototype of Ag-Sb-Te film.

This dissertation makes the following contribution :

Chapter 1 provides an introduction to thermoelectric material and thermoelectric film.

Chapter 2 describes the principles of thermoelectric include Seebeck coefficient, electrical resistivity, power factor and dimensionless figure of merit for films.

Chapter 3 gives an overview of the experimental techniques used in this research.

Chapter 4 presents the results obtained Ag-Sb-Te. Film prototype, including microstructure preliminary measured by XRD, from the quantitative chemical composition analysis by EDX, Ag-Sb-Te thin film surface investigation by FE-SEM, roughness examination by AFM and thermoelectric properties.

Finally, the conclusions and recommendations for future research are presented in Chapter 5.