# CHAPTER 1

# INTRODUCTION

## MOTIVATION

In current science and technology are important for industry. The most industries have waste heat from compressor and condenser of high temperature effect to equipment cause damage. The waste heat can recycle for increase performance thermal efficiency and cost savings by thermoelectric (TE) sensor. So, TE materials can detect temperature from waste heat to reduce erosion of equipment. This is probably the answer in the experiment which a researcher wishes to improve automation (sensor). The sensor is device measurement signal or physical quantities such as temperature, voice, light, mechanical strength, pressure, displacement, speed, accelerate, fluid and flow rates. Then it turns into signal or output from the measurement.

TE materials have been earned heat into electricity as well as it much interested for their potential application in power generation and refrigeration (Zhi Ren A, A. Taskin, Satoshi Sasaki, Kouji Segawa & Yoichi Ando, 2011). The performance of (TE) materials is related to a parameter called the figure of merit, *Z* (David Michael Rowe, 2005)

$$Z = \frac{S^2\sigma}{(\kappa_e + \kappa_L)} \tag{1.1}$$

where $S$ is the Seebeek coefficient (V $K^{-1}$); $\sigma$ is electrical conductivity ($\Omega$m), $K_e$ is the thermal conductivity (W $m^{-1}$ $K^{-1}$) and $K_L$ is the lattice thermal conductivity of the TE materials. Bismuth telluride ($Bi_2Te_3$) bested TE materials operating at a close low temperature and widely used for many TE applications. The crystal structure of $Bi_2Te_3$

materials is a hexagonal structure, space group number 166 and lattice parameter *a* = *b* = 4.38 Å and *c* = 30.48 Å (Y. Feutelais, B. Lendre, N. Rodier & V. Agafonov, 1993). $Bi_2Te_3$ is popular in TE property studies in country. All researchers have synthesis $Bi_2Te_3$ various methods such as solid state, spark plasma sintering (SPS) and hot press (HP). These things can be applied to daily life and industrial work. D.Li et al. reported TE properties of n–$Bi_2Te_3$ and p–$Sb_2Te_3$ prepared by spark plasma sintering and characterization TE properties of $Bi_2Te_3$ and $Sb_2Te_3$. The electrical conductivity was significantly increased and thermal conductivity was decreased, the maximum ZT=1.33 at 398 K (D.Li, R.R, Sun & X.Y. Qin, 2011). These method include the hot deformation process, leading to point defect engineering (ZT = 1.3 at 380 K) (L.Hu, T. Zhu & X. Zhao, 2015), hot pressing of ball milled Nano–powders (ZT = 1.4 at 373 K) (B. Pouel, Q. Hao & Z.Ren, 2008), spark plasma sintering of melt spun ribbons (ZT = 1.56 at 300 K) (W. Xie, X. Tang & Q. Zhang 2009), and a melt spun, spark plasma sintering process of $Bi_xSb_{2-x}Te_3$ with excess Te resulting in dens dislocation arrays though liquid phase compaction ZT = 1.86 at 320 K (S.I. Kim, K.H. Lee, 2015) but these compounds have a problem of toxicity.

In this thesis, the p–$Bi_{0.4}Sb_{1.6}Te_{3.4}$ and n–$Bi_2Te_3$ thermoelectric materials developed to temperature sensor with Arduino for reduce erosion of equipment in Korn Det industry, Sakon Nakhon, Thailand.

## Research Objectives

1. To fabricate thermoelectric cell p-$Bi_2Te_3$ and n-$Bi_2Te_3$.

2. To build temperature sensor from thermoelectric cell p-$Bi_2Te_3$ and n-$Bi_2Te_3$.

3. To setup temperature sensor in Korn Det industry, Sakon Nakhon, Thailand.

## Scope and Limitation of the Thesis

1. Synthesis thermoelectric materials by hot press method.

2. Characterization and thermoelectric properties.

2.1 Micro Vickers Hardness ($H_V$), Shimadzu, Japan.

2.2 Density, Density kit MS.DNY-54.

2.3 X-Ray diffractometer; (XRD), XRD-6100 Shimadzu, Japan.

2.4 Scanning Electron Microscope; (SEM), JEOL FE-SEM LSM-6710F.

2.5 Seebeck coefficient; ($S$), ZEM-3, ADVANCE RIKO, Japan.

2.6 Electrical conductivity; ($\sigma$), ZEM-3, ADVANCE RIKO, Japan.

2.7 Thermal conductivity; ($\kappa$), HZ-7039, Japan.

3. Temperature sensor design with SolidWork program.

4. Using Arduino circuits for analysis temperature and processing.

5. Fabrication and testing temperature sensor from thermoelectric cell.

6. Setup and testing of temperature sensor from waste heat of compressor and condenser in Korn Det industry.

7. Setup and testing of temperature sensor in Korn Det industry.

8. Research report.

9. Dissemination research.

9.1 Patent of temperature sensor device.

9.2 Published in international journals.

## Anticipated Outcome of the Thesis

1. The economic value obtained from research or problem-solving.

Reduce erosion of equipment in Korn Det industry.

2. New knowledge

2.1 Thermoelectric cell p-$Bi_{0.4}Sb_{1.6}Te_{3.4}$ and n-$Bi_2Te_3$ prepared from own in Thermoelectric Laboratory, Center of Excellence in Alternative Energy (CEAE), Sakon Nakhon Rajabhat University.

2.2 Temperature sensor.

3. Patent of temperature sensor device.

4. Published in international journals.

## Thesis Structure

The thesis consists of 5 chapters; Chapter 1 introduces motivation, objective, scope, limitation, anticipated outcomes of this thesis and the place for working of the thesis. Chapter 2 review the fundamental of thermoelectric theory, history and thermoelectric properties of $Bi_2Te_3$ and thermoelectric sensor. Chapter 3 shown methodology, apparatus for measurement, how to fabrication of thermoelectric cell for thermoelectric sensor. Chapter 4 shown the results and discussion of this thesis. Chapter 5 the conclusion and suggestion for further work.

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