CHAPTER 1

INTRODUCTION

Motivation

Industries in Thailand are throwing their efforts and resources to find solutions for the escalating energy crisis and the threatening global warming. One of the way to solve these issues lies in achieving higher efficient thermal. Rice milling industry is one of the most energy consuming industries. Electricity is the main energy source for these rice mills and is imported from the state electricity board grids. Electricity is used to run motors, pumps, blowers, conveyors, fans, lights, etc. However, the rice mill has many energy source which makes waste heat energy from various machine. The thermoelectric is a promising technique to convert the waste thermal energies into useful power as well as to cool ambience without using harmful chemicals like CFC and moving parts. Thus a huge amount of waste heat from automotive, industry operations, and mankind activities can be converted into the useful energy with Thermoelectric. The essential requirements are high Seebeck coefficient, low electrical resistivity and low thermal conductivity. The performance of thermoelectric materials evaluated by using dimensionless figure of merit, ZT which is defined as follows (Rowe, 2005);

$$ZT = \frac{S^2 T}{\rho(\kappa_e + \kappa_l)}$$

$$\kappa = \kappa_e + \kappa_l$$

where S is the Seebeck coefficient $(\mathrm{V\,K^{-1}})$; T is absolute temperature (K); ρ is the electrical resistivity $(\Omega\,\mathrm{m})$, κ is total thermal conductivity $(\mathrm{W\,m^{-1}K^{-1}})$, κ_e is electron thermal conductivity and κ_l is lattice thermal conductivity, respectively.

Currently, the chalcogenide-based compounds (materials containing sulfur, strontium and tellurium) has been highest thermoelectric performance based on the reported dimensionless figure of merit, $ZT = 1.9$ at 723 K (Fahrnbauer, Souchay, Wagner, & Oeckler, 2015) but these compounds have a problem of toxicity. Furthermore, integrating new materials in actual devices requires intensive studies. Thus, the search for a better material is still a premium in thermoelectric research. Germanium antimony telluride (GST materials) discussed as high-performance thermoelectric properties, because of their good electrical properties and low thermal conductivity, a maximum ZT value of 0.75 at 710 K (Kosuga et al., 2015). The GeTe-Sb_2Te_3 pseudobinary and Sb-Te binary systems form various intermetallic compounds represented by the chemical formula $(GeTe)_n(Sb_2Te_3)_m$ and $(Sb_2)_n(Sb_2Te_3)_m$ (*n*, *m*: integer) (Shelimova, Karpinskii, Zemskov, & Konstantinov, 2000). All of these structures, which are called homologous phases. We was considerable interest in the layered compounds belonging to the homologous series nGeTe・mSb_2Te_3 (n = 1, m = 3). The homologous structure, consisting of two types of slab. This structure is based on the cubic ABC stacking structure with consists of five layers of Sb_2Te_3-type and seven layers of GST. The phase diagram of the $GeSb_6Te_{10}$ and Sb_2Te_3 pseudo binary systems were studied by Abrikosov and Danilova-Dobryakova (Kosyakov, Shestakov, Shelimova, Kuznetsov, & Zemskov, 2000). The result shows many-layered slabs are stacked along the *c*-axis in an ordered manner and are linked mainly by weak, van der Waals forces. The GST exists in various compositions and crystal structures giving different physical properties that affect their functions. In which the composition changes along direction the crystal structure of GST-based material is the $R\bar{3}m$ space group and lattice shown by the *a*- and *c*-axis is represented by atomic layer units (Shelimova et al., 2000). In previous study, it has been report GST prepared using spark plasma sintering (SPS). SPS induced small amounts of Ge-rich precipitates with size of a few micrometers and SPS sample found the arrangement and distribution of some elements leads to change in the crystal structure (Kosuga et al., 2015). In this study, we used GST from commercial company for analysis prepared by using hot-pressing method. Hot pressing (HP) is the simultaneous application of elevated temperature and compressive stress to consolidate fine green presses powders into partially or fully sintered components. Also, hot pressing results in smaller overall grain size, more precise control over the microstructure and the flexibility of functionally grading the compounds layers.

As described earlier, the researchers proposed a new source of renewable energy sources. Overall, this project will focus on researching and developing thermoelectric materials, it has been research needs of industry at a rice mill industry. This will bring the heat lost from the stove fuel using a large baking. Reused to generate electricity. The use of a technology called "thermoelectric generator". However we get cooperate with Sri Sakon Pure-Rice Co.,Ltd. At Sakon Nakhon Province, Thailand for install thermoelectric generator at stove fuel of rice dryer Machine.

Research Objectives

1. To study crystal structure, chemical composition, electronic structure, microstructure and thermoelectric properties of $GeSb_6Te_{10}$ thermoelectric material.

2. To fabricate thermogenerator prototype from $GeSb_6Te_{10}$ thermoelectric material.

3. To apply thermogenerator prototype bring to industry of Sri Sakon Pure Rice Rice Co.,Ltd. at Sakon Nakhon province, Thailand.

Scope and Limitation of the Thesis

1. Thermoelectric properties viz., Seebeck coefficient, electrical conductivity, power factor and dimensionless figure of merit.

2. Inventions thermogenerators uni-leg module by $GeSb_6Te_{10}$ material.

3. Device thermogenerator prototype for generate electricity from stove fuel of rice dryer machine.

Anticipated Outcomes of the Thesis

1. Thermogenertor prototype for generate electricity from stove fuel of rice dryer machine for $GeSb_6Te_{10}$ thermoelectric material.

2. Knowledge for guideline for the development of inventions prototype to commercial.

3. Paper publication in international journals, at least one edition.

Thesis structure

The thesis consists of 5 chapters; Firstly, Chapter 1 introduces motivation, objective, scope, limitation, anticipated outcomes of this thesis and the place for working of the thesis. Secondly, Chapter 2 review the fundamental of thermoelectric theory, history and thermoelectric properties of $GeSb_6Te_{10}$. Thirdly, Chapter 3 shown methodology, apparatus for measurement, how to generate thermoelectric generator from thermoelectric module. Fourthly, Chapter 4 shown the results and discussion of this thesis. Finally, Chapter 5 the conclusion and suggestion for further work.

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