

## TABLE OF CONTENTS

CHAPTER	PAGE
1 Introduction .....	1
Motivation.....	1
Research Objectives.....	3
Scope and Limitation .....	3
Anticipated Outcomes of the dissertation.....	4
Dissertation structure.....	4
2 Literature reviews.....	5
Principles of Thermoelectric .....	5
Seebeck, Peltier, Thomson Effects.....	5
Thermoelectric figure of merit .....	7
Seebeck coefficient .....	9
Electrical Resistivity .....	10
Thermal Conductivity .....	11
Thermoelectric Applications.....	12
Thermoelectric power Generation .....	12
Magnetron Sputtering Method.....	13
Sputtering .....	13
Magnetron Sputtering .....	15
Features of sputtering.....	16
Thermoelectric Properties measurement and Determination.....	17
Electrical Resistivity of films.....	17
Electrical Resistivity.....	17
Mobility of carriers.....	19
Carriers concentration.....	20

## TABLE OF CONTENTS (Cont.)

CHAPTER	PAGE
The carrier mobility and carrier density by measuring the Hall effect.....	21
AgSbTe compounds.....	24
Thin film characterization.....	29
3 Experimentation and methodology.....	33
Preparation Ag-Sb-Te films .....	33
Investigate Characterization of Ag-Sb-Te films.....	36
Investigate thermoelectric properties Ag-Sb-Te films.....	38
Fabrication and investigating thermoelectric generator prototype of Ag-Sb-Te films.....	38
Fabrication thermoelectric generator prototype.....	38
Investigating thermoelectric generator prototype.....	39
4 Results and discussion.....	42
The results of physical properties of Ag-Sb-Te films.....	42
Phase identification and crystallography of Ag-Sb-Te films.....	42
Morphology Ag-Sb-Te films.....	43
Atomic composition of Ag-Sb-Te films.....	45
The roughness of Ag-Sb-Te films.....	46
The results of thermoelectric properties of Ag-Sb-Te films.....	47
Carrier concentration and mobility of Ag-Sb-Te films.....	47
Electrical resistivity of Ag-Sb-Te films.....	48
Seebeck coefficient of Ag-Sb-Te films.....	49
Power factor of Ag-Sb-Te films.....	50
The results of thermoelectric generator prototype of Ag-Sb-Te films	51

## TABLE OF CONTENTS (Cont.)

CHAPTER	PAGE
5 Conclusion and suggestions.....	55
Conclusion .....	55
Referance.....	56
APPENDIX : The result of maximum output with annealing temperature of Ag-Sb-Te film.....	58
BIAGRAPHY.....	68

มหาวิทยาลัยราชภัฏสกลนคร

## LIST OF TABLES

TABLE	PAGE
1 Deposition condition of Ag-Sb-Te film.....	34
2 The results of maximum output with annealing temperature at 300°C.....	58
3 The results of maximum output with annealing temperature at 350°C.....	60
4 The results of maximum output with annealing temperature at 400°C.....	62
5 The results of maximum output with annealing temperature at 450°C.....	64
6 The results of maximum output with annealing temperature at 500°C.....	66

มหาวิทยาลัยราชภัฏวไลยอลงกรณ์

## LIST OF FIGURES

FIGURES		PAGE
1	Seebeck effect: A temperature difference create a potential difference for the junction between materials A and B.....	6
2	Effect of carrier concentration on thermoelectric properties of a material.....	11
3	Illustration of thermoelectric power generation.....	13
4	Schematic of a simple sputtering setup with Ar as sputtering gas.....	14
5	Schematic of a DC magnetron sputtering setup. ....	16
6	The measurement of electrical resistivity while a current flow through a conductor with a cross section constant.....	18
7	The measurement density of carrier by Hall effect. ....	23
8	Crystal structure of AgSbTe <sub>2</sub> compounds.....	25
9	Calculated total energies as a function of volume of AgSbTe <sub>2</sub> , AgSbSe <sub>2</sub> , Pr <sub>3</sub> AlC, Ce <sub>3</sub> AlC, Ce <sub>3</sub> AlN, La <sub>3</sub> AlC and La <sub>3</sub> AlN compounds	26
10	Band structure for high-symmetry directions in the Brillouin zone of AgSbTe <sub>2</sub> compounds.....	27
11	Total and partial DOS of AgSbTe <sub>2</sub> compounds.....	28
12	Charge density distribution in the plan (1 1 0) of AgSbTe <sub>2</sub> compounds.....	28
13	The parallel reflecting planes of crystal lattice, path difference of two reflected wave (red lines) .....	29
14	Diagram of the scanning electron microscope technique.....	31
15	Diagram of the scanning electron microscope technique Atomic force Microscopy.....	32
16	Diagram of research methodology.....	35
17	(a) Grazing-incidence X-ray diffractometer (b) field-emission scanning electron microscopy.....	37
18	Atomic force microscopy.....	37

## LIST OF FIGURES (Cont.)

FIGURES	PAGE
19 ZEM-3 instrument.....	38
20 (a) The schematic design of the thin films thermoelectric generator (b) for deposition thermoelectric thin films and for deposition silver electrode thin films.....	39
21 a) Schematic of thin film thermoelectric generators measured as functions of the temperature difference ( $\Delta T$ ) between the hot and cool junction and (b) experimental setup of the measurement of the output voltage ( $V_{out}$ ) of film thermoelectric generators.....	41
22 XRD patterns of the as-deposition and annealed Ag-Sb-Te films at 300 °C, 350 °C, 400 °C, 450 °C and 500 °C, respectively.....	43
23 The surface images of Ag-Sb-Te films deposited on polyimide substrate at various annealing temperatures.....	44
24 The atomic composition percentages of Ag-Sb-Te films.....	45
25 AFM 3D images of AST thin films surface morphology and roughness with Various annealing temperature: (a) As-deposited (b) 300 °C (c) 350 °C (d) 400 °C (e) 450 °C and (f) 500 °C.....	46
26 Measurements of carrier concentration and mobility of the Ag-Sb-Te film with various annealing temperatures.....	48
27 Measurements of electrical resistivity of the Ag-Sb-Te film with various annealing temperatures.....	49
28 Measurements of Seebeck coefficient of the Ag-Sb-Te film with various annealing temperatures.....	50
29 Measurements of and power factor of the Ag-Sb-Te film with various annealing temperatures.....	51
30 The relationship the difference temperature versus the output voltage of Ag-Sb-Te film.....	52

## LIST OF FIGURES (Cont.)

FIGURES	PAGE
31 The relationship the difference temperature versus the maximum output power of Ag-Sb-Te film.....	53
32 The output voltage of the Ag-Sb-Te film.....	53
33 The maximum output power of the Ag-Sb-Te film.....	54

มหาวิทยาลัยราชภัฏสุราษฎร์ธานี

## LIST OF SYMBOLS AND ABBREVIATIONS

$ZT$	Dimensionless figure of merit
$Z$	Figure of merit
$T$	Absolute temperature
$S$	Seebeck coefficient
$\rho$	Electrical resistivity
$\sigma$	Electrical conductivity
$P$	Power factor
$n$	Carrier concentration
$\mu$	Carrier mobility
$k_B$	Boltzmann constants
$d$	Film thickness
$I$	Electrical current
$B$	Magnetic field
$q$	Carrier charge
DC	Direct current
FE-SEM	Field-emission scanning electron microscopy
Ag-Sb-Te	Silver-Antimony-Tellurium
AST	Ag-Sb-Te
AFM	Atomic force microscopy
EDX	Energy dispersive X-ray spectroscope
GIXRD	Grazing-incidence X-ray diffraction
$S$	Seebeck coefficient
$PF$	Power factor
$V_{output}$	Output voltage
$P_{max}$	Maximum output power
$R_{in}$	Internal resistance
$R_L$	External electrical load resistance