UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

COMPLEX ADDITIVES INFLUENCE OF $NiTe_2$ THIN FILM SYNTHESIZE BY ELECTRODEPOSITION

This report is submitted with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Hons.)

by

AKHMAL HAKIM BIN HAKIMI

B051110121

891115-09-5065

FACULTY OF MANUFACTURING ENGINEERING

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DECLARATION

I hereby, declared this report entitled 'Complex additives influence of $NiTe_2$ thin film synthesize by electrodeposition' is the results of my own research except as cited in references.

Signature : ……………………………………

Author's Name : Akhmal Hakim Bin Hakimi

Date : 23^{th} June 2014

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment to the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Materials) (Hons.). The member of the supervisory is as follow:

……………………………………..

(Official Stamp of Principal Supervisor)

……………………………………...

(Official Stamp of Co-Supervisor)

ABSTRACT

Thin film deposition technology can well be regarded as the major key to the creation of devices such as computer, since microelectronic solid state devices are all based on material structure create by deposition technique. Nickel telluride is one of the material involving in thin film technology. This report discussed about the complex additive of $NiTe_2$ thin film synthesized by electrodeposition. The present of additive in the material can give the affect for the material itself. This final year project also explains in detailed the methodology in producing the semiconductor material from the raw material. Electrodeposition process is the selected method to produce $NiTe_2$ thin film due it advantages like large scale production, easy monitoring of deposition process, minimum waste of the component and also large area deposition process. To analyzed the result, it involving thin film thickness measurements by gravimetric weight difference method, structural studies by X-Ray diffractometer (XRD), morphological and composional studies that analyse by scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX) also optical microscope.

ABSTRAK

Teknologi filem nipis pemendapan juga boleh dianggap sebagai kunci utama kepada penciptaan alat-alat seperti komputer kerana peranti yang berkeadaan pepejal mikroelektronik semuanya berasaskan kepada struktur bahan yang dicipta melalui teknik pemendapan. Nikel telluride, $NiTe_2$ merupakan salah satu bahan yang terlibat dalam teknologi filem nipis. Laporan ini membincangkan tentang bahan tambahan yang kompleks untuk filem nipis $NiTe_2$ yang disintesiskan menggunakan teknik elektrik. Kini bahan tambahan dalam bahan tersebut boleh memberi kesan kepada bahan itu sendiri. Projek tahun akhir ini juga menjelaskan dengan terperinci kaedah dalam menghasilkan bahan semikonduktor daripada bahan mentah. Teknik sintesis menggunakan elektrik adalah kaedah yang dipilih untuk menghasilkan filem nipis $NiTe_2$ kerana mempunyai kelebihan seperti pengeluaran berskala besar, pemantauan mudah daripada proses pemendapan, meminimunkan pembaziran komponen dan juga proses pemendapan boleh dilakukan untuk kawasan yang besar. Untuk mendapat keputusan analisis, ia melibatkan ukuran ketebalan filem nipis oleh kaedah perbezaan berat, kajian struktur oleh pembilau sinar-X (XRD), analisis morfologi dan kajian komposisi yang dianalisis dengan mikroskop imbasan elektron (SEM) dan tenaga serakan X -ray (EDX) juga mikroskop optik.

DEDICATION

To my beloved parents and family members for their continuous support throughout my study.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

A	-	Ampere
Å	-	Angstrom
AACVD	-	Aerosol Assisted Chemical Vapour Deposition
AFM	-	Atomic Force Microscopy
APCVD	-	Atmospheric Pressure Chemical Vapour Deposition
Ag/AgCl	-	Argentums/ Argentums Chloride
Cd	-	Cadmium
CVD	-	Chemical Vapour Deposition
CV	-	Cyclic voltammetry
DLICVD	-	Direct Liquid Injection Chemical Vapour Deposition
EDX	-	Energy disperse analysis X-Ray
EDTA	-	Ethylenediaminetetraacetic acid
FV	-	Frank-van der Merwe
Zn	-	Zinc
FKP	-	Fakulti Kejuruteraan Pembuatan
g/cm^3	-	gram per cubic centimeter

Hz	-	Hertz
ITO	-	Indium Tin Oxide
Kg/dm^3	-	Kilogram per cubic decimeter
Kpa	-	Kilo pascal
LPCVD	-	Low Pressure Chemical Vapour Deposition
MgSe	-	Magnesium Selenide
Mo	-	Molybdenum
mm	-	Milimeters
Mpa	-	Mega pascal
MOCVD	-	Metal Organochemical Deposition
MPCVD	-	Microwave Plasma-assisted Chemical Vapour Deposition
Ni	-	Nickel
NiSe	-	Nickel selenide
$NiSO_4$	-	Nickel Sulphate
$NiTe_2$	-	Nickel Telluride
PEC	-	Photoelectrochemical
P/M	-	Powder Metallurgy
PECVD	-	Plasma Enhance Chemical Vapour Deposition
PSA	-	Particle Size Analyzer
PVD	-	Physical Vapour Deposition
S	-	Sulfur

Se	-	Selenium
SEM	-	Scanning Electron Microscopy
Si	-	Silicon
SiC	-	Silicon Carbide
TEA	-	Triethanolamine
Te	-	Tellurium
TeO_2	-	Tellurium dioxide
TFSC	-	Thin Film Solar Cell
TFPV	-	Thin Film Photovoltaic Cell
TMC	-	Transition Metal Chalcogenides
UHVCVD	-	Ultra High Vacuum Chemical Vapour Deposition
UTeM	-	Universiti Teknikal Malaysia Melaka
VW	-	Volmer-Weber
W	-	Tungsten
Wt	-	Weight percent
XRD	-	X-ray diffractometer
Zn	-	Zinc
%	-	Percent
$^{\circ}C$	-	degree celcius
µm	-	Micrometre
λ	-	Lambda

CHAPTER 1

INTRODUCTION

1.1 Research Background

A thin-film solar cell (TFSC) is a solar cell that is made by depositing one or more thin layers (thin film) of photovoltaic material on a substrate. It also knows as a thin photovoltaic cell (TFPV). Recently, there has been a growing interest in multilayered semiconducting compounds basically consisting of transition metal dichalcogenides MX_2 (M = Mo, W, Ni, Cd, Zn etc and X = S, Se, Te) (Anand, 2009). Thin film is the right and suitable material in the photovoltaic industry. Thin film is also suitable for the development of photoelectrochemical (PEC) and solar cell panels due to the semiconductor properties and also optical characteristic. A new thin film material such as transition metal chalcogenides NiX_2 was introduced for solar energy to replace the conversional material.

Electrodeposition is a technique in thin film preparation because of its advantages such as the possibility for large scale production, minimum waste of component and easy monitoring of deposition process. This technique is also more cost effective rather than those physically prepared method. The composition of the electrolytes throughout the electrodeposition process influences the quality of the film formed (Zainal *et al.*, 2005). The parameters of the electrodeposition process such as the growth rate, deposition temperature, compositional, optical and semiconductor properties also will studied in thin film.

1.2 Problem statement

This project is to study on the effect of additives for nickel telluride. Tellurium is difficult to deposit. The use of the additive is to improve adhesion of telluride and to produce the uniform coating. The other factor is the cost of its implementation for photovoltaic application. Solar panel including their component such as silicon is much more expensive compared to the other material.

1.3 Objective

a) To study the effect of additive influencing $NiTe_2$ thin film by electrodeposition method along with deposition parameters.
b) To confirm the effectiveness of the additives in the thin film based on characterization technique using XRD and SEM/EDX.
c) To study the effect of annealing of $NiTe_2$ thin film prepared by electrodeposition process.

1.4 Scope

The scope of this project lies on the effect of additives for nickel telluride thin film. Tellurium has the difficulty that is not easy to deposit. Other than that, experimental procedures and characterization technique also can be determined. The microstructural analysis is to be conducted by using scanning electron microscope (SEM), EDX and X-Ray Diffractometer that are capable to analyzing the sample.

1.5 Outline of Project

The outline of this project included is divided into five chapter comprising of introduction, literature review, methodology, results and discussion as well as conclusion and future work respectively. The introduction chapter elaborates about the research background, problem statement, objective, scope of study and the outline of the project.

Chapter two is a literature review presents the published literatures that are relevant to particular topic of this research, demonstrating the knowledge of any work before and the related theories and debates. In this chapter also provides the background of the new research, linking the new research to what preceded it.

In chapter 3, it will discuss the review of the methodology of the research. For example it explains more about the suitable method that are using for the experimental process. This chapter also include the review of the methodology carried out in order to produce the desired product or outcome of the project. The most appropriate method was chosen, allowing the sample to be further analyzed by suitable material characterization method.

In chapter 4 included the result and the conclusion for the experiment. The result can be determined after do the experiment.

The conclusion and recommendation about this study are discussed in chapter 5. Including all chapters and recommending getting more satisfactory outcome in the future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter describe substrate preparation of any thin film deposition technique or process and the best optimized parameters to synthesize the thin film. The step in thin film formation, the types of thin film coating methods and the complex additive that influence $NiTe_2$ also will be discussed. Major factor controlling the deposition process were briefly described.

2.2 Thin Film

A thin-film solar cell (TFSC) is a cell that is made by depositing one or more thin layers (thin film) of photovoltaic material on a substrate. It also called a thin film photovoltaic cell (TFPV). A thin film is known as a low dimensional material synthesized by condensing, one by one, atomic, molecular, ionic species of matter. The electronic devices, optical coatings, instrument hard coatings and decorative parts in thin films have been used for more than a half century (Wasa *et al.,* 2004).

The thin film is a traditional well established material technology. However, thin film technology are emerging on daily since it is a key in the twenty first century development of new materials such as nanometer materials or a man-made superlattice (Wasa *et al.,* 2004). Thin film processing also can saves on the energy consumptionin production and is considered an environmentally benign material technology for the next century (Bull, 1995).

Transition metal chalcogenides (TMCs) are semiconductors that can be used as an efficient photovoltaic material in the solar cells application. These chlcogenides have shown it potential on the solar cells application and actual application in thermoelectric, photoelectric devices, optoelectronics and also solar selective coatings (Ubale *et al*., 2013). The expected result has been obtained in the realization of photoelectrical solid state devices or solar cells by using TMC crystals. The thickness range of such a layer is wide and varies from a few nanometers to tens of micrometers. The thickness is typically less than several microns. Thin films are different from thick films. A thick film is defined as a low dimensional material created by thinning a three dimensional material or assembling large clusters, aggregats, and grains of atomic, molecular and ionic species (Wasa *et al.,* 2004).

Transition metal nickel chalcogenides NiX_2 (X – Se, S and Te) is a new thin film material for solar energy to replace the convensional material. Transition metal chalcogenide compound such as thin film can besuitablein the photovoltaic industry for the development of photoelectrochemical (PEC) and solar cell panels due to its characteristic by the semiconductors properties and also optical. This development has been proven by the high number of research publication on the application of TMC compounds in the PEC and solar cell industry (Mattox, 2010). The thin film development is more economical for the manufacturer because it reduces cost, energy required of the material and also their handling. A solid material is said to be in thin film form when it is grown as a thin layer on a solid substrate by controlled condensation of the individual atomic, molecular, or ionic species either by physical process or ultra chemical reactions. Basically, thin film deposition techniques are either purely physical such as evaporative method. The purely chemical method is such as gas and liquid phase chemical processes (Singh,n.d)

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Among the materials of great interest are polycrystalline metal chalcogenides. The thin film material which is has a semiconducting, metallic, insulating or optical properties are widely used in industry, medical science and technology. Transition metal chalcogenides are suitable and also received remind because of their special tunable properties on the material itself. These materials when is in thin film form are often important candidates for photovoltaic conversion. This is due to match able band gap with solar spectrum, high optical absorption band gap and good electrical conductivity. It also shows interesting electric and magnetic properties in this material. Polycrystalline electrodes are economically justified for solar cell applications where the large areas of substrates are necessary. Thus, the electrodeposition method is use to obtaining nickel telluride in the thin film form. The common preparation techniques that are used to deposition process are electrodeposition, chemical vapour deposition, spray pyrolysis, chemical bath deposition and sputtering (Hankare *et al*., 2010).

2.3 Thin Film and Bulk Material

Thin film is generally defined as a thin layer of material on a substrate. For without the substrate, a thin layer of the material would be called a foil (Christensen, 2000). Thin film is more different compared to bulk material due to its properties. Thin film not fully dense and it have different structures that have defect from bulk material and its properties are strongly influenced interface and surface effect (Christensen, 2000). These special properties of thin film make them difficult in electrical, magnetic, optical, thermal and mechanical properties than bulk material.

Thin film and bulk material usually have different composition, phase and microstructure and also formation process. In thin film, it must be taken in to account such as thermal treatment, oxidation, implantation and deposition (Stanimivovic, 2009). Many functional electronic thin films are prepared and integrated onto silicon wafers and other substrates film develop on orientation or texture which may be advantageous for particular application. Thin film material with semiconducting, metallic or insulating properties is manufactured for application in production industries, medical science and also for technology.

2.4 Thin Film Material

Thin films are deposited on a substrate by thermal evaporation, chemical decomposition, and the evaporation of source materials by their radiation of energetic species or photons. Thin-film growth exhibits the following features:

a) The birth of thin films of all materials created by any deposition technique starts with a random nucleation process followed by nucleation and growth stages.
b) Nucleation and growth stages are dependent upon various deposition conditions, such as growth temperature, growth rate and substrate chemistry.
c) The nucleation stage can be modified significantly by external agencies such as electron or ion bombardment.
d) Film microstructure, associated defect structure, and film stress depend on the deposition conditions at the nucleation stage.
e) The crystal phase and the orientation of the films are governed by the deposition conditions.

The features of thin film process have been shown to be the better material for solar cell applications and technologies as listed below.

a) The availability of variety of chemical, physical, electrochemical, plasma based and also hybrid deposition.
b) Microstructure of the thin film of most material can be varied from amorphous or noncrystalline to a highly oriented or epitaxial growth, depending on the technique, deposition parameter and substrate.
c) A wide selection of sizes, area, shapes and substrate are widely available.
d) Relaxed solubility condition and phase diagram, allowing alloying and doping process with well-matched materials.
e) Possible and practical to achieve easily different type of electronic function, single and tandem junction.
f) To meet the requirement of a particular solar cell, the graded composition, graded bandgap, graded lattice constant and other can be obtained.

g) Bandgap, composition and other optoelectric properties can be graded in desired manner in case of multi component materials.
h) Both surface and interface can be customized to provide surface electro field and interlayer diffusion barrier.
i) The desired optical reflectant or transmission characteristic, haze and optical trapping effects are achievable by modifying the surface
j) Intergration of unit process for manufacturing solar cell and intergration of individual solar cells can be easily accomplished.
k) Thin film process is classified as eco friendly, ‘green’ process (Chopra *et al.*, 2004).

2.5 Factor that Affect Film Properties

According to the Handbook of Physical Vapour Deposition (PVD) Processing by Donald M. Mattox, deposited thin films and coatings generally have unique properties compared to the material in bulk form. The four factors that affected the properties of a film of an exact material formed by an atomistic deposition process are:

a) Substrate the surface condition before and after cleaning and surface adjustment. For example surface morphology (roughness, inclusions, particulate contamination), surface chemistry (surface composition, contaminants), mechanical properties, surface flaws, outgassing, preferential nucleation sites, and the stability of the surface.
b) Details of the deposition process and system geometry. For example deposition process used angle-of-incidence distribution of the depositing adatom flux, substrate temperature, deposition rate, and gaseous contamination, concurrent energetic particle bombardment (flux, particle mass, and energy).
c) Details of film growth on the substrate surface. For example condensation and nucleation of the arriving atoms (adatoms), interface formation, interfacial flaw generation, energy input to the growing film, surface mobility