

OPTICAL PROPERTIES AND PHOTOLUMINESCENCE OF COPPER NITRIDE
THIN FILM PREPARED BY REACTIVE DC SPUTTERING

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UNIVERSITI TEKNOLOGI MALAYSIA

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Specially dedicated to

My beloved husband, **EN. ZUL HUSNI BIN ZAHARI**, my beloved
mother **PN. ROBIAH BINTI NGAH**, my daughter , **SAIDATUL
UMAIRAH BINTI ZUL HUSNI**, my newborn son **MUHAMMAD
IMAN ASYRAF BIN ZUL HUSNI**

And

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ABSTRACT

This research was conducted to prepare copper nitride thin films on glass substrates by reactive DC sputtering technique using a copper plate and nitrogen gas at 20 Pa as source. The Argon pressure 1×10^{-1} mbar and DC voltage of 0.5 kV at room temperature. The deposition time varies from 1.0 hour to 3.5 hours at interval of 0.5 hour. The thickness of films was measured using Ellisprometer, UV-VIS 3101 Spectrophotometer to measure the optical properties of refractive index, n , transmittance, absorbance and reflectance in the visible light region and the photoluminescence property using Luminescence Spectrometer LS55. The films obtained were yellow to reddish-brown depending on the deposition time. For longer deposition time, the thin films turned thicker reddish-brown colour. Thickness of films obtained were in the range 1219.4 nm to 1227.0 nm and the refractive index, n , was about 3.80, constant for all samples. The transmittance increased but absorbance and reflectance decreased as the thickness increased over the wavelength range. The average optical band gap energy, E_g obtained in range of 1.65 to 1.94 eV. The average emission peak for maximum intensity was about 419.0 nm obtained in the photoluminescence emission for all samples. This shows that the luminescence light is that of violet light.

ABSTRAK

Penyelidikan ini dijalankan untuk menyediakan saput filem nipis kuprum nitrat pada substrat kaca dengan teknik “reactive DC sputtering” yang menggunakan plat kuprum tulin dan gas nitrogen pada tekanan 20Pa sebagai sumber. Tekanan Argon iaitu 1×10^{-1} mbar dan voltan arus terus, DC 0.5 kV pada suhu bilik dengan jangka masa 1 jam ke 3.5 jam dalam selang 0.5 jam. Ketebalan filem, d diukur menggunakan *Ellisometer*, UV-VIS 3101 *Spectrophotometer* untuk menentukan sifat-sifat optik seperti indeks bias, n , penghantaran, penyerapan dan pantulan dengan julat panjang gelombang cahaya nampak. Sifat luminisense saput filem tipis ditentukan menggunakan *Luminescence Spectrometer* LS55. Saput filem tipis yang terhasil adalah berwarna kuning kepada coklat kemerahan dan semakin meningkat masa deposit filem cenderung kepada coklat kemerahan. Ketebalan filem, d yang terhasil dengan julat antara 1219.4 nm ke 1227.0 nm dan indeks bias, n , adalah 3.80 yang malar untuk semua sampel yang disediakan. Sifat *penghantaran* meningkat tetapi sifat *penyerapan* dan *pantulan* berkurangan apabila ketebalan saput filem tipis, d meningkat. Ketiga-tiga sifat ini berkurangan dalam julat panjang gelombang cahaya nampak. Purata jurang tenaga optik, E_g saput filem tipis ini antara 1.65 ke 1.94 eV. Purata panjang gelombang puncak pancaran foto luminisense yang paling maksimum untuk semua sampel ialah 419.0 nm yang memberikan warna cahaya violet.

TABLE OF CONTENTS

| CHAPTER | CONTENT | PAGE |
|---------|---|------|
| | TITLE | i |
| | DECLARATION | ii |
| | DEDICATION | iv |
| | ACKNOWLEDGEMENT | v |
| | ABSTRACT | vi |
| | ABSTRAK | vii |
| | TABLE OF CONTENT | viii |
| | LIST OF FIGURE | xii |
| | LIST OF TABLE | xv |
| | LIST OF SYMBOL | xvii |
| 1 | INTRODUCTION | |
| | 1.1 Introduction | 1 |
| | 1. 2 Background of Research | 2 |
| | 1.3 Problem Statement | 3 |
| | 1.4 Research Objectives | 4 |
| | 1.5 Research Scope | 4 |
| 2 | LITERATURE REVIEW | |
| | 2.1 Introduction | 6 |
| | 2.2 Introduction of Thin Film | 6 |
| | 2.2 Copper Nitride, Cu ₃ N Characteristics | 8 |
| | 2.2.1 Copper Nitride, Structure | 9 |
| | 2.3 Physical Vapour Deposition of Thin Film | 12 |
| | 2.3.1 Physical Sputtering | 12 |
| | 2.3.2 Sputtering System | 14 |

| | | |
|-------|---|----|
| 2.4 | Reactive DC Sputtering Technique | 16 |
| 2.4.1 | Process of Reactive Sputtering | 17 |
| 2.4.2 | Film Deposition Rates, Stoichiometry, and Properties by Reactive Sputtering Technique | 21 |
| 2.5 | Optical Properties | 23 |
| 2.5.1 | Refractive Index, n | 23 |
| 2.5.2 | Absorption Coefficient, a | 25 |
| 2.5.3 | Energy Band Gap | 27 |
| 2.6 | Instrumentation of Characterization of Thin Films | 31 |
| 2.6.1 | Spectroscopic Ellipsometry | 31 |
| 2.7.2 | UV-Vis Absorption Spectroscopy | 35 |
| 2.7 | Photoluminescence Spectrum | 39 |

3

METHODOLOGY

| | | |
|---------|--|----|
| 3.1 | Introduction | 43 |
| 3.2 | Substrate Preparation | 45 |
| 3.2.1 | Cutting Substrate | 45 |
| 3.2.2 | Cleaning the Substrates | 47 |
| 3.2.2.1 | Pre-Cleaning the Substrates | 47 |
| 3.2.2.2 | Acid Cromic | 48 |
| 3.2.2.3 | Desiccations Process | 49 |
| 3.3 | Reactive DC Sputtering Deposition | 49 |
| 3.3.1 | Deposition | 50 |
| 3.4 | Measurement of Optical Properties | 53 |
| 3.4.1 | Introduction of Spectrophotometer UV-3103-PC | 53 |
| 3.3.1.1 | UV-3103-PC Spectrophotometer | 53 |
| 3.4.2 | Thickness Measurement Using Ellipsometer | 55 |
| 3.4.2.1 | Measurement Procedure | 56 |
| 3.4.3 | Photoluminescence Spectrum | 58 |
| 3.5 | Storage of Cooper Nitride, Cu_3N Thin Film | 59 |

| | | |
|---|--|----|
| 4 | DATA ANALYSIS AND RESULT | |
| | 4.1 Introduction | 61 |
| | 4.2 Copper Nitride Thin Film Deposition Process | 62 |
| | 4.3 Determination Thickness of Copper Nitride Thin Films | 63 |
| | 4.4 Determination Optical Properties of Copper Nitride Thin Films | 66 |
| | 4.4.1 Refractive Index, n of Copper Nitride Thin Films | 66 |
| | 4.4.2 Transmittance Spectrum of Copper Nitride Thin Films | 68 |
| | 4.4.3 Absorption Coefficient, a of Copper NitrideThin Films | 70 |
| | 4.4.4 Optical Bandgap Energy, E_g Copper Nitride Thin Films | 71 |
| | 4.4.5 Absorbance of Copper Nitride Thin Films | 75 |
| | 4.4.6 Reflectance of Copper Nitride Thin Films | 76 |
| | 4.5 Photoluminescence Spectrum of Copper Nitride Thin Films | 77 |
| 5 | CONCLUSIONS AND SUGGESTIONS | |
| | 5.1 Introduction | 86 |
| | 5.2 Conclusion | 87 |

5.3 Suggestion

REFERENCE

LIST OF FIGURES

| NO. FIGURE | TITLE | PAGE |
|------------|---|------|
| 2.1 | Crystal Structure of Cu ₃ N (Borsa & Boerma, 2004) | 9 |
| 2.2 | The Copper Nitride thin films result for optical properties (Odeh, 2008) | 11 |
| 2.3 | Schematics of simplified sputtering systems: (a) DC, (b) RF (Ohring,2002) | 16 |
| 2.4 | A typical reactive sputter deposition system. | 18 |
| 2.5 | The deposition rate and (bottom) the discharge voltage as a function of reactive gas flow for the experiment shown in Figure 2.4 (Rossnagel, 1997) | 19 |
| 2.6 | Influence of nitrogen, electrical resistivity and Temperature coefficient of resistivity of reactively Sputtered Ta film (Ohring, 2002) | 22 |
| 2.7 | The Energy Band Model | 28 |
| 2.8 | Direct Band (left) and Indirect Band (right) | 30 |
| 2.9 | Schematic drawing of an ellipsometer | 33 |

| | | |
|------|---|----|
| 2.10 | Diagram component of UV-Visible Spectrophotometer | 37 |
| 2.11 | Singlet and triplet states | 41 |
| 2.12 | Photoluminescence process | 43 |
| 3.1 | Dimension of the Substrate Glass | 46 |
| 3.2 | The equally divided glass substrates after cutting | 46 |
| 3.3 | Ultrasonic Branson 3210 cleaner | 48 |
| 3.4 | Reactive DC Sputtering Process | 52 |
| 3.5 | UV-3103-PC Spectrophotometer | 55 |
| 3.6 | An Ellipsometer | 44 |
| 3.7 | Luminescence spectrometer LS55 | 59 |
| 3.8 | Dessicator for thin film storage | 60 |
| 4.1 | The Samples in reddish- brown color after deposition Process | 63 |
| 4.2 | Graph of Refractive Index, n versus Thickness, d of films | 67 |
| 4.3 | Graph of % Transmittance versus wavelength (nm) | 68 |
| 4.4 | Graph of % Transmittance versus Thickness of films, d for one wavelength, $\lambda=650\text{nm}$ | 69 |
| 4.5 | Absorption Coefficient, a against wavelength, λ | 70 |
| 4.6 | Graph of $(ah\nu)^{1/2}$ against energy, $h\nu$ | 71 |
| 4.7 | Graph of $(ah\nu)^{1/2}$ against energy, $h\nu$ for sample S6 | 73 |

| | | |
|------|--|----|
| 4.8 | Graph of optical bandgap energy against thickness of Thin films | 74 |
| 4.9 | Graph of Absorbance versus wavelength (nm) | 75 |
| 4.10 | Graph of % Reflectance versus Wavelength (nm) | 76 |
| 4.11 | Photoluminescence spectra for all copper nitride samples | 78 |
| 4.12 | Graph of Emission peak for each sample at maximum Intensity | 85 |

LIST OF TABLE

| NO. TABLE | TITLE | PAGE |
|------------------|--|-------------|
| 4.1 | 6 Samples deposited by using reactive DC sputtering system | 62 |
| 4.2 | Thickness of the samples | 64 |
| 4.3 | Thickness and deposition time of the samples | 65 |
| 4.4 | Relationship between thickness of film and refractive index, n value | 66 |
| 4.5 | Thickness of films, d and Transmittance Thickness of films, d for one wavelength, $\lambda=650\text{nm}$ | 69 |
| 4.6 | Values of optical band gaps at different deposition time | 72 |
| 4.7 | Emission Peak for sample S1 | 79 |
| 4.8 | Emission Peak for sample S2 | 80 |
| 4.9 | Emission Peak for sample S3 | 80 |
| 4.10 | Emission Peak for sample S4 | 81 |
| 4.11 | Emission Peak for sample S5 | 82 |

| | | |
|------|---|----|
| 4.12 | Emission Peak for sample S6 | 83 |
| 4.13 | Emission Peak for maximum intensity for all samples | 84 |

LIST OF SYMBOL

| | | |
|-----------|---|--------------------------|
| A | - | Absorptivity |
| \square | - | Absorption Coefficient |
| A_1 | - | First Analyzer Reading |
| A_2 | - | Second Analyzer Reading |
| P_1 | - | First Polarizer Reading |
| P_2 | - | Second Polarizer Reading |
| DC | - | Direct Current |
| T | - | Transmittance |
| R | - | Reflectance |
| E_g | - | Optical Bandgap Energy |
| I_0 | - | Initial Intensity |
| I | - | Intensity |

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter of introduction introduces on some general information about background of research, problem statement, research objectives and the scope of the research.

1.2 Background of Research

Thin films technology is important due to miniaturization of mainly electrical appliances such as hard disk, hand phone, home appliances and car electronics. The characteristics of thin films are almost the same with material in bulk form. Experts keep study ways to improve the characteristics of thin films. Thin films technology is used for coatings and decorative parts too. Among advantages of thin films devices are low power consumption, relatively small and reduction occupied space and higher speed performance (Sakrani, 2004).

In recent years, copper nitride (Cu_3N) thin film has been attracting considerable attention as a new material applicable for optical storage devices and high-speed integrated circuits. Copper nitride is semiconductor and its optical reflectivity in the visible and infrared range is far smaller than that of pure Cu (Murayama *et al* 1996 & Dorranean *et al* , 2010). It is known that copper nitride, Cu_3N is stable at room temperature but starts to decompose into Cu and N_2 above 300°C . The low decomposition temperature and discriminating optical properties of the compound compared to those of Cu are applicable for optical read-only memory disks by generating microscopic Cu-metal spots on copper nitride, Cu_3N film under local laser heating (Asano, 1985). Copper nitride is one of the important covalent metal nitride compounds and has been scarcely studied. Copper nitride, Cu_3N films can also be used as buffer layers for depositing Cu-metal lines on Si wafers to achieve higher signal speed than existing Al-metal lines in integrated-circuit fabrication processes. The crystal structure of copper nitride, Cu_3N is also interesting as it has the cubic anti- ReO_3 structure in which Cu atoms do not occupy the *fcc* (face centered cubic) close-packing sites. Hence another metallic atom can be inserted into the body center of the cubic unit cell to induce significant changes in the electrical

properties (Moreno *et al*, Fan *et al* & Pierson *et al*, 2007). Furthermore, the photoluminescence property has been scarcely studied for references now.

Maya (1993) developed the film by Direct Current (DC) sputtering and have shown its potential use in maskless laser writing (Maya, 1993). Copper nitride will be prepared by reactive DC sputtering as this technique has the following advantages. First, deposition rate is very high compared with RF magnetron sputtering using ceramic target by about 10 times (Ko and *et al* ,2008 & Li,X *et al* , 2003). Second, the deposition area can be enlarged by means of using large sputtering target. Third, the deposition technique uses a low priced metallic target compared with PLD or RF magnetron sputtering. By virtue of above advantages, reactive DC sputtering is suitable for commercial use (Kim *et al*,2009). Furthermore, reactive sputtering with a metal cathode has received the most attention because of the opportunity for high rate, controlled deposition, as well as the ability to use DC rather than RF power.

1.3 Problem Statement

It is important and interesting to study the optical properties for copper nitride thin films (Asano, 1990 & Borsa, 2002). Examples are refractive index, the transmittance, absorbance, reflectance and optical band gap. Furthermore, there is scarcely references regarding the photoluminescence property of the copper nitride thin films as alternative material for example as safety warning that very useful for field of technology, industry and etc nowadays.

1.4 Research Objectives

Main objectives are:

1. To prepare copper nitride thin films at different deposition time by reactive DC sputtering technique.
2. To investigate the optical properties of copper nitride thin films.
3. To investigate the photoluminescence property of copper nitride thin films.

1.5 Research Scope

This research involve the preparation of copper nitride thin films using reactive DC sputtering technique at the room temperature and pressure of chamber at 1×10^{-1} mbar with present of nitrogen gas at 20 Pa as the reactive gas into chamber during deposition process. The interests of this research to investigate the optical and photoluminescence properties of copper nitride thin films.

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