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

NOOR AZIZUN BINTI MOHAMMED ARIFF

UNIVERSITI TEKNOLOGI MALAYSIA

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NOOR AZIZUN BINTI MOHAMMED ARIFF

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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 HUSN**I

And

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Also all my clicks

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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 1x 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 Ellisopmeter, 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 avaege optical band gap energy, E_q obtained in range of 1.65 to 1.94 eV. The averange emmission 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 $1x10^{-1}$ 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 *Ellisopmeter*,, UV-VIS 3101 *Spectrophotometer* untuk menentukan sifat-sifat optik seperti indeks bias, *n*, penghantaran, penyerapan dn pantulan dengan julat panjang gelombang cahaya nampak. Sifat luminisene saput filem tipis ditentukan menggunaan *Luminescence Spectrometer* LS55. Saput filem tipis ang terhasil adalah berwarna kuning kepada coklat kemerahan dan semakin meningkat masa deposit filem cenderung kepada coklat kemerahn. 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.

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A	-	Absorptivity
□	-	Absorption Coefficient
A1	-	First Analyzer Reading
A2	-	Second Analyzer Reading
P1	-	First Polarizer Reading
P2	-	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 & Dorranian *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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