Faculty of Electrical and Electronic Engineering Technology

DESIGN OF SURFACE PLASMON RESONANCE SENSOR FOR UREA DETECTION

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Bachelor of Electronics Engineering Technology with Honours

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DESIGN OF SURFACE PLASMON RESONANCE SENSOR FOR UREA DETECTION

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A project report submitted
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I declare that this project report entitled “Design Of Surface Plasmon Resonance Sensor For Urea Detection” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

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Supervisor Name : Pn. NAJMIAH RADIAH BINTI MOHAMMAD

Date : 10 JANUARY 2022

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Name (if any)

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DEDICATION

My appreciation goes out to my friends, family, and classmates who were always together with me and who have always motivated me to complete my final project successfully. Meantime, I devote my project to Madam.Najmiah Radiah Binti Mohamad, my supervisor, who have guided me and motivated me in completing my final year project. I would like to thank my parents and dear family members who kept their faith on me throughout this final year project period and motivated me all the time. Last but not least, I would like to thank my friends and classmates who is always motivating me during my down time.

ABSTRACT

In the past years, the invention of biomedical gadgets has driven a new level achievement inscience and technology. This can actually increase the chances to identify disease in early stage. Urea is a waste which is excreted by kidney can be detected using this Surface Plasmon Resonance (SPR) sensor. To detect urea, the material type and thickness is an important role here as it may affect the sensitivity. In this study, the SPR sensor is tested using two different material which is Silver (Ag) and Gold (Au) with thickness of material from 30nm to 50nm using optical wavelength of 633nm, 670nm and 785nm. This study is continued with Taguchi method to helps in comparing the materials with different wavelength and thickness easily. The SPR curve were compared with water layer initially then with gold and silver material by using Taguchi method. Winspall software is used in getting the SPR curve using refractive index and reflection coefficient. Minitab software then is used to transfer the data that obtained from winspall to display an overall combined curve for clear picture of comparison. The output of this study can be seen with the resonance angle and the FWHM which determine the sensitivity in detecting the presence of urea. The gold material with factor combination A3B3C3D2 shows the best sensitivity in detecting the urea more precisely when comparing to silver material in this study.

ABSTRAK

Pada tahun-tahun lepas, ciptaan alat bioperubatan telah memacu pencapaian tahap baharu dalam sains dan teknologi. Ini sebenarnya boleh meningkatkan peluang untuk mengenal pasti penyakit pada peringkat awal. Urea adalah sisa yang dikumuhkan oleh buah pinggang boleh dikesan menggunakan sensor Surface Plasmon Resonance (SPR) ini. Untuk mengesan urea, jenis bahan dan ketebalan adalah peranan penting di sini kerana ia boleh menjejaskan sensitiviti. Dalam kajian ini, penderia SPR diuji menggunakan dua bahan berbeza iaitu Perak (Ag) dan Emas (Au) dengan ketebalan bahan dari 30nm hingga 50nm menggunakan panjang gelombang optik 633nm, 670nm dan 785nm. Kajian ini diteruskan dengan kaedah Taguchi untuk membantu dalam membandingkan bahan dengan panjang gelombang dan ketebalan yang berbeza dengan mudah. Keluk SPR dibandingkan dengan lapisan air pada mulanya kemudian dengan bahan emas dan perak dengan menggunakan kaedah Taguchi. Perisian Winspall digunakan dalam mendapatkan keluk SPR menggunakan indeks biasan dan pekali pantulan. Perisian Minitab kemudiannya digunakan untuk memindahkan data yang diperoleh daripada winspall untuk memaparkan lengkung gabungan keseluruhan untuk gambaran perbandingan yang jelas. Output kajian ini dapat dilihat dengan sudut resonans dan FWHM yang menentukan sensitiviti dalam mengesan kehadiran urea. Bahan emas dengan kombinasi faktor A3B3C3D2 menunjukkan sensitiviti terbaik dalam mengesan urea dengan lebih tepat apabila dibandingkan dengan bahan perak dalam kajian ini.

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n – Refractive Index

k – Extinction Coefficient

LIST OF ABBREVIATIONS

SPR	-	Surface Plasmon Resonance
FWHM	-	Full Width at Half Maximum
PMMA	-	Polymethyl Methacrylate

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Plasmon Resonance (SPR) also known as biosensor often used in determining medical stuffs. This sensor is proving many beneficial especially to medical authorities as it works much simpler. SPR sensors have been getting more attention as it is sensitive and label free of the molecules and can detect any target no matter from small molecules to microorganisms [11]. The advantage of implementing this SPR sensor is cheap and environmentally friendly. Recently many studies have been conducted on SPR sensors to determine its performance in applications. It is used to detect the changes in refractive index. With light source on wavelength and metal thin surface, certain refractive index may trigger the SPR curve shift. By now many types of biosensors have and keen to be developed for clinically relevant work.

Kidney disease often remain undiagnosed because of the severity of the disease which can be prevented earlier by using earlier detection gadgets or sensors. One can simply overcome this problem by inventing or improvising urea detector sensor to advance level. The earlier detection of kidney problem can save millions of live out there which only cost them few hundred ringgits for treatment. Besides that, urea detector plays an important role in hospital asit helps doctors in detecting diabetic disease. SPR sensor is used in this study to determine the sensitivity of materials by refractive index and layer thickness. Gold and silver are the most used metal nanofilm because of their behavior in this SPR sensor.

1.2 Problem Statement

Determining urea level is quite difficult as the process takes time and not cost efficient. The clinical method of determining urea level of a person is plasma/serum concentration. This method is slow as there are so many processes to pass through in order to get the urea level. By using SPR sensor it will be much easier like scanning the barcode, in a blink of an eye urea level can be determined. Even though SPR is easier than the clinical method but it has not been fully researched. The precise material value and thickness ofmaterial yet to be debated in this context. The total cost for SPR sensor is quite expensive due to the material that were using in this design.

1.3 Project Objective

The aim of this study is to detect the exact urea level in human body precisely. Hence theobjectives are as follow

a) To identify the best nanomaterial that can be used in detecting the urea accurately.

b) To evaluate the detection of urea using different wavelength to make it more sensitive.

c) To analyze the difference in thickness of material that can affect the sensitivity in detecting the urea.

1.4 Scope of Project

The scope of this study mainly focuses on developing efficient way to detect the urea using SPR sensor. In order to accomplish the objectives, there are several scopes that have been specified.

a) The study will be carried through two different materials which is Gold (Au) and Silver (Ag). The thickness of material is from 30nm to 50nm. Gold and Silver is good in conductivity and chemical stability.

b) The wavelength that used in this study is 633nm, 670nm and 785nm.

c) The development of this study is carried out by using winspall software. This software will be used to alter and form the spr curve by using different wavelength and thickness of materials. Certain parameter has been controlled in this study.

d) The Taguchi's orthogonal array L9 (3^4) is used in order to estimate the factor combination and analyzing matrix experiments.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the important details and information that are found from different study and research which is related to this title. The discussion starts with the study of development in biosensor. It is really important to study these concepts because they are the core of this project. This chapter end by comparing the related previous papers.

2.2 What is biosensor?

Biosensor is a term that is used for a device that detect the biomolecules at surface. It is ananalytical device that comprise biological element and physicochemical transducer. Biosensors usually working for monitoring disease, discovery of drugs and pollution detection. A biosensor normally consists of analyte, bioreceptor, transducer, electronic and display.

Analyte is a substance where it needs a detection. For example, let's take urea which is known as analyte that designed in biosensor to detect urea. Bioreceptor is a kind of molecule where its function is to immediately recognize the analyte in biosensor. For transducer, it's an element whose role is to transform energy from one to another. In this biosensor, its function is to convert bio sensors to signal that can be measured. Electronic is processing part where signals were transduced and preparing it to send for display. This part performs amplification of signals from analog to digital which is machine friendly. Lastly

display part is where the system displays numbers that can be understand by human. It's the most final part of showing the results from biosensor.

2.3 Surface Plasmon Resonance (SPR) sensor

It is a biosensor which is used to study all kind of biomolecule and biochemical in real time. Using this Surface Plasmon Resonance one can easily identify the speed of molecule associate and dissociate, the interaction between molecules and concentrations. The working phenomenon of SPR sensor is by monitoring the changes in refractive index value. To understand better, Snell's law will play a role in explaining it where the light pass through a prism. By using Snell's law theory, refraction occurs when light ray is below critical angle upon exiting prism [9].

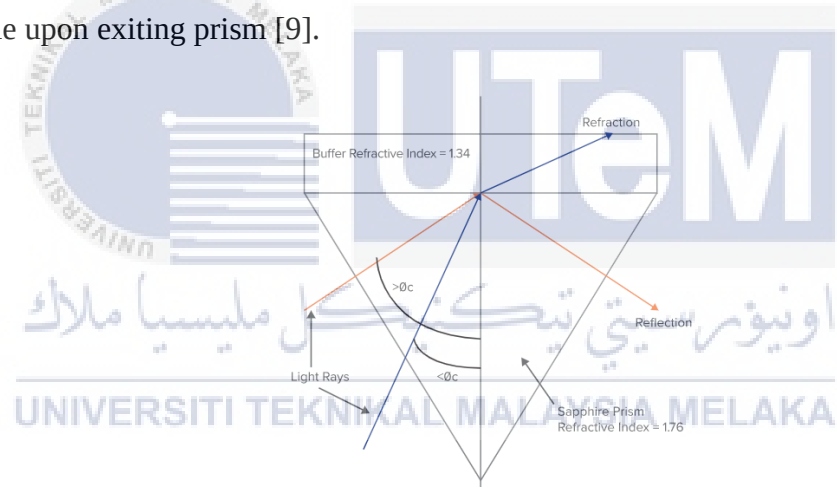

Figure 2. 1 Working principle of light using Snell's Law

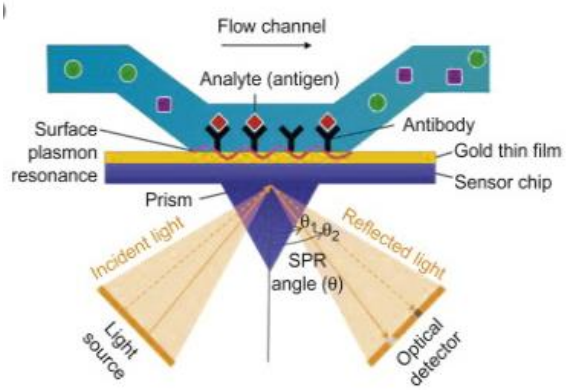

Figure 2. 2 Layer of SPR sensor [9]

SPR sensor is rapidly improving and gaining a lot of attention from all over the world. This is because the applications that using SPR is really in need. Surface Plasmon Resonance is available in cheap and expensive version where different material with]different sensitivity is applied [9].

Electromagnetic wave propagates through a metal layer using optical phenomenon in SPR. Surface Plasmon can vary with incidence angle or by wavelength at optical beam. This technique is commonly known as Kretschmann configuration where light go through prism and into internal reflection which excite on metal surface. The SPR result can be seen by dip in resonance that responds according to reflectivity in real time. The best dip can be measured by looking at shifting in resonance angle.

2.4 Dip to real time measurement

Plasmon Resonance can be said as the excellent way to see the changes occurred with difference refractive index for metal layers. This is possible because the angle will shift according to the changes on refractive index. SPR also can monitor changes in time which follows the shift of resonance angle [10].

2.5 Implementation

Surface Plasmon use incident light (visible light and infrared light) to penetrate into our skin. The light that entering has to match its momentum to that plasmon. Polarization is a process applying transverse wave that specifies the geometrical orientation of the oscillations [6].

2.6 Application

Surface plasmon is developed to enhance the sensitivity of Raman scattering, second harmonic and fluorescence. SPR reflectivity measurements, in their most basic form, can be used to detect molecular adsorption, such as polymers, DNA, or proteins. The angle of minimum reflection is usually used to measure. The angle change in 0.1 degree during thinfilm adsorption. Besides the angle, the changes in wavelength is also one factor in SPR sensor that affect the sensitivity graph.

2.7 Data Interpretation

Fresnel formula, a formula that describe the reflection and transmission of light on optical media. Fresnel determined that behavior of waves and polarization incident differs due to different material interface. Fresnel formula says the thin films formed is infinite and continuous dielectric layers. This results in multiple possible refractive index and thickness value. In this case, two SPR curves are formed by using different wavelength which gives different solution for thickness and refractive index. Figure below shows the spr adsorption data.