UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLICATION OF MICROFIBER SENSOR FOR ETHANOL CONCENTRATION MEASUREMENT

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunication) (Hons.)

by

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930813-08-6421

FACULTY OF ENGINEERING TECHNOLOGY
2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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TAJUK: **APPLICATION OF MICROFIBER SENSOR FOR ETHANOL CONCENTRATION MEASUREMENT**

SESI PENGAJIAN: **2014/15 Semester 2**

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I hereby, declared this report entitled “Application of Microfiber Sensor for Ethanol Concentration Measurement” is the results of my own research except as cited in references.

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Date : ………………………

APPROVAL

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

……………………………….

(Md Ashadi bin Md Johari)

ABSTRACT

Among different microfiber applications, optical detecting has been attracting in expanding research enthusiasm because of its conceivable outcomes of acknowledging optical fiber sensor with high sensitivity, quick reaction, high adaptability and low optical power consumption. Here is research progression in optical microfiber sensors with respect to their performance on measuring ethanol concentration. Typical microfiber-based detecting structures, including tapers, sensitivity and linearity on diverse wavelength, are summarized. Sorted by optical microfiber sensors for sensitivity and linearity on identifying ethanol concentration are evaluated. This thesis is about application of optical microfiber sensor for ethanol concentration measurement. Ethanol has been chosen as the parameter is to measure the rate of ethanol in human body. Single-mode fiber has been used in this project is because of its high transmission rate and less dispersion. The optical microfiber is developed using tapering process because of its flexibility in controlling the fiber stretch. After done on completing the optical microfiber sensor, an analysis on various ethanol concentrations has been made. From the result table, 1300nm wavelength has the highest sensitivity compare to other wavelength. This make the optical microfiber sensor with 1300nm wavelength is the most suitable for ethanol concentration measurement.

ABSTRAK

Antara perbezaan aplikasi gentian miko, optik pengesan telah menarik dalam perkembangkan semangat penyelidikan kerana hasil yang dapat difikirkan iaitu diakui pengesan gentian optik dengan kepekaan yang tinggi, tindak balas yang cepat, keupayaan menyesuaikan diri yang tinggi dan penggunaan kuasa optik rendah. Berikut adalah perkembangan penyelidikan dalam pengesan gentian mikro optik berkenaan dengan prestasi mereka dalam mengukur kepekatan etanol. Struktur mengesan berdasarkan gentian mikro-biasa, termasuk dian, kepekaan dan kelinearan pada pelbagai panjang gelombang, diringkaskan. Disusun mengikut pengesan getian mikro optik untuk kepekaan dan kelinearan mengenal pasti kepekatan etanol yang dinilai. Tesis ini adalah mengenai aplikasi pengesan gentian mikro optik untuk mengukur kepekatan etanol. Etanol telah dipilih sebagai parameter adalah untuk mengukur kadar etanol dalam badan manusia. Gentian mod tunggal telah digunakan dalam projek ini adalah kerana kadar penghantaran yang tinggi dan kurang penyebaran. Gentian mikro optik dibangunkan menggunakan proses pengurangan kerana fleksibiliti dalam mengawal regangan gentian. Setelah selesai menyiapkan pengesan gentian optik, analisis dalam pelbagai kepekatan etanol telah dibuat. Daripada jadual keputusan, panjang gelombang 1300nm mempunyai kepekaan yang paling tinggi berbanding dengan panjang gelombang yang lain. Ini membuat pengesan gentian mikro optik dengan panjang gelombang 1300nm adalah yang paling sesuai untuk mengukur kepekatan etanol.

DEDICATIONS

To my beloved parents, family members and my fellow friends who are never give up on supporting me.

ACKNOWLEDGMENTS

In the name of Allah SWT who has given me the strength and ability to complete this thesis.

It would not have been conceivable to compose this theory without the assistance and backing of the kind individuals around me, to just of some of whom it is conceivable to give specific notice here.

Most importantly, I am profoundly obligated to my supervisor, Md Ashadi bin Md Johari, for the tolerance and direction he demonstrated to me through the course of my Degree study. His significant learning of both optics and electronic has been precious to me. Not just did he give me the opportunity to investigate all alone, yet he generally there to offer when I some assistance with encountering challenges. One basically couldn't wish for a superior of friendlier supervisor.

Progress in this work would not have been possible without the help from classmates, housemates and all my fellow friends.

Last but not least, I like to thank my parents that has been support me all the times.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF SYMBOLS AND ABBREVIATIONS

λ	=	Wavelength
β	=	Propagation Constant
EMI	=	Electromagnetic Interference
ASE	=	Amplified Spontaneous Emission
OSA	=	Optical Spectrum Analyzer
dB	=	Decibel
V	=	Voltage
WSS	=	Wavelength Selective Switch
LIF	=	Laser Induced Fluorescence
SVEA	=	Slowly Varying Envelope Approximation
FBG	=	Fiber Bragg grating
ASE	=	Amplified Spontaneous Emission
RI	=	Refractive Index

CHAPTER 1
INTRODUCTION

1.0 Introduction

Ethanol is an unmistakable, dismal fluid with a trademark, pleasant smell. In weaken fluid arrangement, it has a to some degree sweet flavour, yet in more focused arrangements it has a blazing taste. Optical microfiber is optical fiber with diameter across near or littler than the wavelength of the guided light. Optical microfiber are understood as low-loss silica waveguides in the types of loops, knots, or coils, and have been exhibited for distinctive applications incorporate include drop channels, lasing frameworks, nonlinear optical frameworks, and detecting device. Due to the small diameter of microfiber, the evanescent field in the surrounding of microfiber is large and thus the microfiber devices are sensitive to changes in of the surrounding medium, particularly the refractive index (RI) of the medium. This research is to learn about the optical microfiber sensor. At that point, try to understand about the optical microfiber for sensor and its ability. Finally, develop an optical microfiber sensor for ethanol concentration estimation.

1.1 Background

Individuals have utilized light to transmit data for many years. Then again, it was not until the 1960s, with the creation of the laser, that wide spread interest in optical (light) systems for information interchanges started. The development of the laser provoked analysts to consider the capability of fiber optics for information interchanges, detecting, and different applications. Laser systems could send a much bigger measure of information than phone, microwave, and other electrical systems. The first trial with the laser included letting the laser beam transmit unreservedly through the air. Scientists likewise directed tests letting the laser beam transmit through distinctive sorts of waveguides. Glass fibers, gas-filled pipes, and tubes with focusing lenses are examples of optical waveguides.

1.2 Problem Statement

Innovation today has made such a large number of development gadgets made with its own particular usefulness and application. In any case, not all device are accessible or/and suitable on the grounds that there just three sort of ethanol detector that accessible on market that are through skin sensor, liquor sniffer, and breath and sweat sensor. Why need to check ethanol? Ethanol some way or another has been abused by a few individuals. A great deal of dosage of ethanol in individual's body can convey harm to body system. That is the reason we utilize ethanol as a parameter in this task that is to measure the concentration in human blood. How to quantify the convergence of ethanol in blood? It is requires a ton of work and strategy. The gadget that been utilized today is not sufficiently productive to gauge it. Moreover, the exactness of the gadget can be contended. Through this study, it appeared there an absence of gadget to quantify the concentration in blood.

1.3 Objective of Research

1. To understand about optical microfiber sensor.
2. To understand about optical microfiber for sensor and its ability.
3. To develop an optical microfiber sensor for ethanol concentration measurement.
4. To analyze the performance of optical microfiber sensor in measuring ethanol concentration

1.4 Scope of Research

In this project, the limitation of the scope work has to realistic. The project scope is listed out to make sure that the project is going on course and achieve all the objectives. There are the following outlines to achieve the objective of the study:

1. Study the capability of optical microfiber sensor.
2. Design the optical microfiber sensor that could detect and measure ethanol concentration.
3. Applying several ethanol concentrations to get the results which are closed to theory.
4. Study and analyze sensitivity and linearity of sensor.
5. Write the report.

CHAPTER 2

THEORETICAL BACKGROUND

2.0 Introduction

There are many innovations that has been found and created these days that lead a new knowledge. The studies and research has been done before will be the reference in the flow of this project. Many research has been made in the past have been guide in this project. Although the literatures cover a wide range of theories, this part will focus on the main elements that will emerge repeatedly throughout the project. In this paper will focus on the application and function of element that will be used in this project.

2.1 Optical Fiber

An optical fiber is a cylindrical dielectric waveguide made of low-loss materials such as silica glass. It has a central core in which the light is guided, embedded in an outer cladding of slightly lower refractive index. Light rays incident on the core-cladding boundary at angles greater than the critical angle undergo total internal reflection and are guided through the core without refraction. Rays of greater inclination to the fiber axis lose part of their power into the cladding at each reflection and are not guided. As a result of recent technological advances in fabrication, light can be guided through 1 km of glass fiber with a loss as low as = 0.16 dB (=3.6%). Optical fibers are replacing copper coaxial cables as the preferred transmission medium for electro- magnetic waves, thereby revolutionizing terrestrial communications. Applications range from long-distance telephone and data communications to computer communications in a local area network. Single-mode fibers are used in applications in which low signal loss and high data rates are required, such as in long spans where repeater/amplifier spacing must be maximized. Because single-mode fiber allows only one mode or ray to propagate (the lowest-order mode), it does not suffer from modal dispersion like multimode fiber and therefore can be used for higher bandwidth applications. However, even though single-mode fiber is not affected by modal dispersion, at higher data rates chromatic dispersion can limit the performance. This problem can be overcome by several methods. One can transmit at a wavelength in which glass has a fairly constant index of refraction (~1300 nm), use an optical source such as a distributed feedback laser (DFB laser) that has a very narrow output spectrum, use special dispersion compensating fiber, or use a combination of all these methods. In a nutshell, single-mode fiber is used in high-bandwidth, long-distance applications such as long-distance telephone trunk lines, cable TV head-ends, and high-speed local and wide area network (LAN and WAN) backbones. The major drawback of single-mode fiber is that it is relatively difficult to work with (i.e., splicing and termination) because of its small core size. Also, single-mode fiber is typically used only with laser sources because of the high coupling losses associated with LEDs. Graded-index fiber is a compromise between the large core diameter and N.A. of multimode fiber and the higher bandwidth of single-mode fiber. With creation of a core whose index of refraction decreases parabolic ally from the core center toward the cladding, light traveling through the center of the fiber experiences a higher index than light traveling in the higher modes. This means that the higher-order modes travel faster than the lower-order modes, which allows them to “catch up” to the lower-order modes, thus decreasing the amount of modal dispersion, which increases the bandwidth of the fiber.

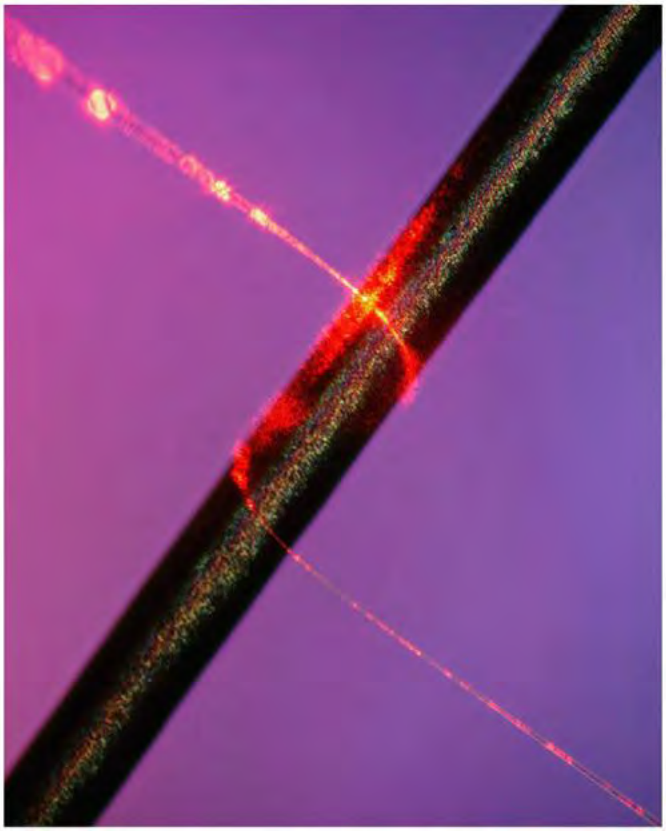

Figure 2.1: Optical Microscope Image of 500-Nm-Diameter Silica MNF Guiding A 633-Nm-Wavelength Light Around A Human Hair Of 60 Mm In Diameter

2.2 Benefits of Optical Fiber

Flexibility optical fiber systems have many advantages over metallic-based communication systems. These advantages include:

Long-distance signal transmission:

- The low attenuation and superior signal integrity found in optical systems allow much longer intervals of signal transmission than metallic-based systems. While single-line, voice-grade copper systems longer than a couple of kilometers (1.2 miles) require in-line signal for satisfactory performance, it is not unusual for optical systems to go over 100 kilometers (km), or about 62 miles, with no active or passive processing.

Large bandwidth, light weight, and small diameter:

- Today's applications require an ever-increasing amount of bandwidth. Consequently, it is important to consider the space constraints of many end users. It is commonplace to install new cabling within existing duct systems or conduit. The relatively small diameter and light weight of optical cable make such installations easy and practical, saving valuable conduit space in these environments.

Non-conductivity:

- Another advantage of optical fibers is their dielectric nature. Since optical fiber has no metallic components, it can be installed in areas with electromagnetic interference (EMI), including radio frequency interference (RFI). Areas with high EMI include utility lines, power-carrying lines, and railroad tracks. All-dielectric cables are also ideal for areas of high lightning-strike incidence.

Security:

- Unlike metallic-based systems, the dielectric nature of optical fiber makes it impossible to remotely detect the signal being transmitted within the cable. The only way to do so is by accessing the optical fiber. Accessing the fiber requires intervention that is easily detectable by security surveillance. These circumstances make fiber extremely attractive to governmental bodies, banks, and others with major security concerns.

Designed for future applications need:

- Fiber optics is affordable today, as electronics prices fall and optical cable pricing remains low. In many cases, fiber solutions are less costly than copper. As bandwidth demands increase rapidly with technological advances, fiber will continue to play a vital role in the long-term success of telecommunication.

2.3 Optical Microfibers as Sensor

With diameter close to or below the wavelength of guided light and high index contrast between the fiber core and the surrounding, an optical microfiber shows a variety of interesting waveguiding properties, including widely tailorable optical confinement, evanescent fields and waveguide dispersion. Among various microfiber applications, optical sensing has been attracting increasing research interest due to its possibilities of realizing miniaturized fiber optic sensors with small footprint, high sensitivity, fast response, high flexibility and low optical power consumption. Here a review recent progress in microfiber optical sensors regarding their fabrication, waveguide properties and sensing applications. Typical microfiber-based sensing structures, including biconical tapers, optical gratings, circular cavities, Mach-Zehnder interferometers and functionally coated/doped microfibers, are summarized. Categorized by sensing structures, microfiber optical sensors for refractive index, concentration, temperature, humidity, strain and current measurement in gas or liquid environments are reviewed. The basic model for microfiber optics in which the refractive indices of the microfiber and the surrounding are assumed to be n1 and n2, respectively. With the microfiber radius of ρ, the step-index profile of a waveguiding microfiber is then expressed as:

$$n(r) = \begin{cases} n_1, & 0 < r < \rho, \\ n_2, & \rho \leq r < \infty \end{cases} \tag{1}$$

For non-absorptive materials, the waveguide parameters are determined by analytically solving the Helmholtz equations:

$$n(r) = \begin{cases} n_1, & 0 < r < \rho, \\ n_2, & \rho \leq r < \infty \end{cases} \tag{2}$$

where k = 2π/λ, λ is the wavelength of the light in vacuum, and β is the propagation constant.