UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLICATION OF MICROFIBER SENSOR FOR DETERMINING OLIVE OIL CONCENTRATION

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's of Electronic Engineering Technology of (Telecommunications) with honours.

by

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TAJUK: **Optical Microfiber Sensor for Determining Olive Oil Concentration**

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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 of (Telecommunications) with honours. The member of the supervisory is as follow:

………………………………

(MD ASHADI BIN MD JOHARI)

ABSTRACT

This thesis deals with the analysis on the implementation of microfiber sensor development for olive oil concentration. The objective of this thesis is to introduce, develop and applies the fiber optic sensor for olive oil concentration detection system. The thesis describes the microfiber capabilities in medics field for enhancement in olive oil concentration, which benefits on human health on consumption. Fiber optic, microfiber sensor and olive oil composition were tested on the thesis. Olive oil concentration is being tested and analyzed using appropriate light source for the microfiber and analyzed by Optical Spectrum Analyzer. The design is being planned and set after reviewing related articles and journals, beside discussion with supervisor. Finally, the olive oil concentration were being able to determine indicated by the power loss. From the expected results, the observation on the analysis on the implementation of microfiber sensor development for olive oil concentration.

ABSTRAK

Tesis ini berkaitan dengan analisis mengenai pelaksanaan pembangunan ‘sensor microfiber’ untuk kepekatan minyak zaitun. Objektif projek ini adalah untuk memperkenalkan , membangun dan menggunakan ‘sensor’ gentian optik untuk sistem pengesanan kepekatan minyak zaitun. Tesis ini menerangkan keupayaan ‘microfiber’ dalam bidang medik untuk peningkatan dalam mengenalpasti kepekatan minyak zaitun , yang memberi manfaat kepada kesihatan manusia untuk penggunaannya. Gentian optik , sensor ‘microfiber’ dan komposisi minyak zaitun telah diuji didalam tesis. Kepekatan minyak zaitun diuji dan dianalisis dengan menggunakan sumber cahaya yang sesuai bagi ‘microfiber’ dan dianalisis oleh ‘optic spectrum analyzer’ . Reka bentuk dirancang dan ditetapkan selepas mengkaji artikel dan jurnal yang berkaitan , di samping perbincangan dengan penyelia . Akhir sekali , kepekatan minyak zaitun dapat ditunjukkan oleh kehilangan kuasa dari ‘microfiber’. Daripada keputusan yang dijangkakan, pemerhatian analisis mengenai pelaksanaan pembangunan ‘microfiber sensor’ untuk mengenalpasti kepekatan minyak zaitun dapat dijalankan.

DEDICATIONS

This research was dedicated to:

My parent:

ZOLKIFLIE BIN RASIP

NOR AZIAH BINTI HASBULLAH

Who are always praying and support for my success, always be my side, struggle to give me enough education and always loving me with full of their hearts.

Special thanks to my siblings and friends from 4BETT

Who are always support me in everything that I did, giving me meaningful advice and also help me through the easiness and hardness tune.

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LIST OF SYMBOLS AND ABBREVIATIONS

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

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter will briefly discuss on the project background. This chapter also elaborates the problem statement, the objective of this project, and the scope of this project.

1.2 Project Background

In this modern age, speed of data transmission is being given a prior for human being to perform well in their specific field of task. Speed of data transmitted is being concerned especially for medics and telecommunication, where it helps human being to perform well in their life. Better sensitivity and faster transmission speed make microfiber sensor which is a class of fiber optic sensor a better choice compared to traditional copper cables.

In the past 50 years, fiber-optical sensing has been one of the most successful and powerful applications of both fiber optics and sensing technology. Recently, along with the rapid progress in micro/nanotechnology and increasing demands on optical sensors with higher performances and versatilities, spatial miniaturization has been one of the current trends of fiber-optic sensors. It is obvious that, reducing the size of a sensing structure is usually an essential step to bestow the sensor with faster response, higher sensitivity, low power consumption and better spatial resolution, and an optical microfiber is one of the best candidates for this purpose.

As a combination of fiber optics and nanotechnology, the optical microfiber has been emerging as a novel platform for exploring fiber-optic technology on the micro or nanoscale. Fabricated by taper-drawing of glass or polymer materials (e.g., glass optical fibers), a microfiber usually has a diameter of hundreds of nanometers to several micrometers, excellent diameter uniformity and sidewall smoothness. With high-index contrast between the microfiber material (e.g., glass or polymer) and the surrounding (e.g., air or water), this kind of micro or nanoscale waveguide guides light with low optical loss, outstanding mechanical flexibilities, tight optical confinement and large fractional evanescent fields, making it a novel miniaturized platform for optical sensing with special advantages including faster response, higher sensitivity, low power consumption, hence being a good alternative to being use as a sensor.

This project is to analyze sensitivity of microfiber in determine the concentration of olive oil with different dilution. Microfibers are more sensitive and faster transmission compared to single mode optical fiber in transmitting and producing more efficient analysis of olive's oil concentration. Faster transmission and higher sensitivity of the sensor helps in increase the efficiency of the analysis of olive oil's concentration. This analysis may being a useful technology to being used in oil and gas sector.

Olive oil is a fat obtained from the olive, a traditional tree crop of the Mediterranean Basin. The oil is produced by pressing whole olives. It is commonly used in cooking, cosmetics, pharmaceuticals and soaps and as fuel for traditional lamps. Olive oil is used throughout the world and is especially associated with Mediterranean countries.

Olive oil is composed mainly of triacylglycerols (triglycerides or fats) and contains small quantities of free fatty acids (FFA), glycerol, phosphatides, pigments, flavor compounds, sterols, and microscopic bits of olive. Triacylglycerols are the major energy reserve for plants and animals. Chemically speaking, these are molecules derived from the natural esterification of three fatty acid molecules with a glycerol molecule. The glycerol molecule can simplistically be seen as an "E-shaped" molecule, with the fatty acids in turn resembling longish hydrocarbon chains, varying (in the case of olive oil) from about 14 to 24 carbon atoms in length.

Olive oil benefits are so extensive that it is considered a functional food with components that contribute to its overall therapeutic qualities including a reduction of risk factors of coronary heart disease, the prevention of cancers, and alterations of immune and inflammatory responses.

This project is being established to study the capability of microfiber to acts as a sensor for various olive oil concentrations**.**

1.3 Objectives

The objectives of this project are as stated below;

1. To understand microfiber communications.
2. To understand the concept of fiber optic sensor.
3. To understand the concept of production of microfiber as a sensor.
4. To analyze the performance of microfiber as a sensor in identifying the concentration of olive oil.

1.4 Problem Statements

Nowadays, health is being a priority for mankind to live well. Health affected the quality of human's performance in their life and more precious and valuable than money and prosperity. Human's health is being control and measure with the amount of fat inside our body, whether saturated or non-saturated fat. Olive oil is one of the essential elements which act as an agent to enhance a better health. The health benefits of olive oil from a conducted experiment shows that olive oil in cooking which replace a normal cooking oil are useful in prevention of myriad diseases and counter effects of aging. Olive oil is a healthier option than butter as olive oil contains only 33% saturated fat while butter is composed of 66% saturated fat, beside olive oil has no cholesterol, while a serving of butter has 33mg of cholesterol. Olive oil are healthy to be used on certain concentration, thus this analysis are being conducted to study the capability of microfiber sensor to identify the appropriate concentration of olive oil towards human bodies.

1.5 Project Scope

The concept of microfibers connection to become a sensor needs special coordinated scope of work. As this project scope of project to be determined so that the main objective can be achieved.

The scopes of work in this project are given:

1. Study on the compatibility of microfiber optical as sensor to identify the concentration of olive oil.
2. Analyzing the system establishment for microfiber as sensor.
3. Data will be analyzed by the power loss of the microfiber, where general hypothesis may be made.

4. Analysis will be conducted by varying the parameters which is the concentration of olive oil in order to obtain the experiment results which are closed to the theoretical result.
5. The result can be analyzed and studied.

1.6 Project Limitation

The limitations of this project are:

1. Microfiber sensors functioning well to identify the concentration of olive oil.
2. Appropriate concentration of olive oil has being identified and analyzed.

CHAPTER 2

THEORETICAL BACKGROUND

2.1 Introduction

Literature review was carried out throughout the whole project to obtain realistic information in completing this project. The main sources for this project are previous projects carried out by scientist and other sources such as books, journals and articles, where being obtained from SciVerse Science Direct and other reliable sources on fiber optics, fiber optics sensors and microfiber. This chapter also elaborates about related research which being conducted from previous project.

2.2 Fiber Optic

Optical Fibers, or Fiber Optics, are often used in data transmission or light guide applications. Optical Fibers used in light guide applications transmit safe, no-heat light, which is ideal for medical, inspection, automotive, or display applications. A single Optical Fiber utilizes total internal reflection to transmit light, allowing bends along its path. Minimal light loss during transmission allows Optical Fibers to transmit light or data quickly over long distances. When bundled, Fiber Optics can transmit large quantities of data for telecommunication applications.

The basic principle of light transport through an optical fiber is total internal reflection. This means that the light within the numerical aperture of a fiber (NA = input acceptance cone) will be reflected and transported through the fiber. The size of the numerical aperture depends on the materials used for core and cladding.

Two basic types of silica fibers can be distinguished; single-mode and multi-mode fibers, depending on the propagation state of the light, traveling down the fiber. For most spectroscopic applications multi-mode fibers are used. Multi-mode fibers can be divided into 2 subcategories, step-index and graded-index. A relatively large core and high NA allow light to be easily coupled into the fiber, which allows the use of relatively inexpensive termination techniques. Step-index fibers are mainly used in spectroscopic applications. Graded-index multimode fibers have a refractive index gradually decreasing from the core out through the cladding. Since the light travels faster in material with lower refractive index, the modal dispersion (amount of pulse-spreading) will be less. These graded-index fibers are mainly used in telecommunication application, where dispersion at long distance (2-15 km) plays an important role.

Optical fiber can be used as a medium for telecommunication and computer networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fiber with little attenuation compared to electrical cables. This allows long distances to be spanned with few repeaters.

The per-channel light signals propagating in the fiber have been modulated at rates as high as 111 gigabits per second (Gbit/s) by NTT, although 10 or 40 Gbit/s is typical in deployed systems. In June 2013, researchers demonstrated transmission of 400 Gbit/s over a single channel using 4-mode orbital angular momentum multiplexing.

Each fiber can carry many independent channels, each using a different wavelength of light (wavelength-division multiplexing (WDM)). The net data rate (data rate without overhead bytes) per fiber is the per-channel data rate reduced by the FEC overhead, multiplied by the number of channels (usually up to eighty in commercial dense WDMsystems as of 2008). As of 2011 the record for bandwidth on a single core was 101 Tbit/s (370 channels at 273 Gbit/s each). The record for a multi-core fiber as of January 2013 was 1.05 petabits per second. In 2009, Bell Labs broke the 100 (petabit per second)×kilometer barrier (15.5 Tbit/s over a single 7000 km fiber).

For short distance application, such as a network in an office building, fiber-optic cabling can save space in cable ducts. This is because a single fiber can carry much more data than electrical cables such as standard category 5 Ethernet cabling, which typically runs at 100 Mbit/s or 1 Gbit/s speeds. Fiber is also immune to electrical interference; there is no cross-talk between signals in different cables, and no pickup of environmental noise. Non-armored fiber cables do not conduct electricity, which makes fiber a good solution for protecting communications equipment in high voltage environments, such as power generation facilities, or metal communication structures prone to lightning strikes. They can also be used in environments where explosive fumes are present, without danger of ignition. Wiretapping (in this case, fiber tapping) is more difficult compared to electrical connections, and there are concentric dual-core fibers that are said to be tap-proof.

Fibers are often also used for short-distance connections between devices. For example, most high-definition televisions offer a digital audio optical connection. This allows the streaming of audio over light, using the TOSLINK protocol.

The advantages of optical fiber communication with respect to copper wire systems are:

Broad bandwidth

A single optical fiber can carry 3,000,000 full-duplex voice calls or 90,000 TV channels.

Immunity to electromagnetic interference

Light transmission through optical fibers is unaffected by other electromagnetic radiation nearby. The optical fiber is electrically non-conductive, so it does not act as an antenna to pick up electromagnetic signals. Information traveling inside the optical fiber is immune to electromagnetic interference, even electromagnetic pulses generated by nuclear devices.

Low attenuation loss over long distances.

Attenuation loss can be as low as 0.2 dB/km in optical fiber cables, allowing transmission over long distances without the need for repeaters.

Electrical insulator

Optical fibers do not conduct electricity, preventing problems with ground loops and conduction of lightning. Optical fibers can be strung on poles alongside high voltage power cables.

Material cost and theft prevention

Conventional cable systems use large amounts of copper. In some places, this copper is a target for theft due to its value on the scrap market.

2.3 Fiber Optic Sensor [1]

The cost of a single channel fiber optic sensor is relatively high. Fortunately, aggregation of the sensors results in their cost reduction, given that it would be possible to share either the source of light, system of detection, or, preferably, both. Furthermore, the most suitable transmission medium for the signals generated by the fiber sensors is also optical fiber, from which follows that all the advantages of the fiber-based networks are also directly applicable to the fiber optic sensor networks.

Multiplexing is the simultaneous transmission of two or more information channels along a common path. A fiber sensor system includes three main parts or subsystems: the sensing elements or transducers, the optical fiber channel and the optoelectronic unit. Because the last subsystem uses to be the most expensive one, when is possible to multiplex a high number of sensing points in the same optical fiber network using a common optoelectronic unit, the cost per sensing element decreases. Trends for the network implementation using sensor multiplexing are just as much, or even more widespread than those of the fiber transmission networks.

Multiplexing of optical fiber sensors is a concept that includes three basic tasks

1. Launching of optical signals with the correct power level, spectral distribution, polarization and modulation into the network.
2. Detection of the portion of optical power codified or modulated by the sensor element, which is sent by means of transmission or reflection.
3. Unique identification of the information corresponding to each sensor in the network, by means of proper addressing, polling and decoding.

Because of this, in the realization of the sensor networks it is possible to utilize the following: various modulation techniques of diverse parameters of the optical signal, different network topologies and simple or complex decoding methods of the received signal. And all of these as a function of the type of sensors multiplexed within the same network