



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**APPLICATION OF THE MICROFIBER SENSOR FOR
MONITORING CONCENTRATION OF ACETONE**

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

by

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DECLARATION

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

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

.....

(Project Supervisor)

ABSTRACT

This thesis deals with the analysis on the application of the microfiber sensor for monitoring concentration of acetone. The objective of this thesis is to understand and to analyse the performance of the fiber optic and microfiber sensor as a sensor in identifying the concentration of acetone and also the concept of as an optical fiber and microfiber sensor. Then, it is related to study acetone effect in diabetic detection. This thesis describes the capabilities of microfiber sensor in in modern-electronics bio-medical field for enhancement in blood, uric and breath detection for a contents of a level concentration of acetone.

ABSTRAK

Tesis ini adalah berkaitan dengan analisis pada proses aplikasi sensor mikrofiber untuk mengesan kepekatan acetone. Objektif tesis ini adalah untuk memahami dan menganalisis prestasi sensor fiber optik dan sensor mikrofiber optik sebagai sensor untuk mengenalpasti paras kepekatan acetone dan juga untuk mengenal pasti konsep sensor fiber optik dan mikrofiber. Kemudian, ia juga berkaitan untuk mengkaji kesan acetone di dalam mengenalpasti diabetes (kencing manis). Tesis ini menerangkan kemampuan sensor mikrofiber di dalam bidang elektronik moden perubatan-bio untuk melakukan penambahbaikan di dalam mengesan tahap kepekatan acetone di dalam darah, urine dan hembusan nafas manusia.

DEDICATIONS

This humble effort especially to my beloved parents, Maimunah binti Mohsin and
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siblings, Maizatul, Ashrafy and Nadia,
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LIST OF SYMBOLS AND ABBREVIATIONS

ASE	=	Amplified Spontaneous Emission
OSA	=	Optical Spectrum Analyzer
LED	=	Light Emitting Diode
EMI	=	Electromagnetic Interference
RFI	=	Radio Frequency Interference
OMF	=	Optical Microfiber
SMF	=	Single Mode Fiber
UV	=	Ultra Violet
PPM	=	Part Per Million
POF	=	Plastic Optical Fiber
μ	=	Micro
mV	=	Milli Volts
λ	=	Lambda
T/bit	-	Terabit
dB	=	Decibel
dBm	=	Decibel Milli

CHAPTER 1

INTRODUCTION

1.0 Introduction

This is the first chapter of this research which is responsible to give a general explanation regarding the purpose of this research. In this chapter, it will give an overview about the title of this research, history of the research had done before, the problem statements, the objective of this study and the scopes of study for this research. The overview will only be general information and the details for this research are discussed in other chapter. According to (K.S Thyagarajan., 2007), a flexible and transparent fiber which made of from high quality extruded glass or plastic that operates at higher bandwidth (data rate) than any form of communication as well as permits transmission over longer distances is called fiber optic. Fiber optic technology plays an important role in modern electronic telecommunication system. Besides that, the principle of fiber optic is also applied and used in diverse modern bio-medical electronic fields.

A fiber optic sensor is a sensor that uses optical fiber either as the sensing element ("intrinsic sensors"), or as a means of relaying signals from a remote sensor to the electronics that process the signals ("extrinsic sensors"). Fibers have many uses in remote sensing. Depending on the application, fiber may be used because of its small size, or because no electrical power is needed at the remote location, or because many sensors can be multiplexed along the length of a fiber by using light wavelength shift for each sensor, or by sensing the time delay as light passes along the fiber through each sensor. Time delay can be determined using a device such as an optical time-domain reflectometer and wavelength shift can be calculated using an instrument implementing optical frequency domain reflectometry.

Fiber optic sensors are also immune to electromagnetic interference, and do not conduct electricity so they can be used in places where there is high voltage electricity or flammable material such as jet fuel. Fiber optic sensors can be designed to withstand high temperatures as well. Optical fibers can be used as sensors to measure strain, temperature, pressure and other quantities by modifying a fiber so that the quantity to be measured modulates the intensity, phase, polarization, wavelength or transit time of light in the fiber. Sensors that vary the intensity of light are the simplest, since only a simple source and detector are required. A particularly useful feature of intrinsic fiber optic sensors is that they can, if required, provide distributed sensing over very large distances. Fiber optic sensing systems are presently used in harsh industrial environments for the measurement of pressure, temperature, differential pressure, strain, position, vibration, and acceleration. The major technical advantages of fiber optic transducers include small size, inherent safety, immunity to EMI, and continuous use at temperatures up to 1000°F. (Needham, 2010)

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 (also called a nanofiber when its diameter is below 1 μm) 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.

Acetone (systematically named propan-2-one) is the organic compound with the formula $(\text{CH}_3)_2\text{CO}$. It is a colorless, volatile, flammable liquid, and is the simplest ketone. Acetone is miscible with water and serves as an important solvent in its own right, typically for cleaning purposes in the laboratory. About 6.7 million tonnes were produced worldwide in 2010, mainly for use as a solvent and production of methyl methacrylate and bisphenol A. It is a common building block in organic chemistry. Familiar household uses of acetone are as the active ingredient in nail polish remover and as paint thinner.

Acetone is produced and disposed of in the human body through normal metabolic processes. It is normally present in blood and urine. People with diabetes produce it in larger amounts. Diabetes is a complex group of diseases with a variety of causes. People with diabetes have high blood glucose, also called high blood sugar or hyperglycemia.

If the diabetes isn't being managed effectively, there isn't enough functioning insulin to help deliver glucose to your body's cells that need it. Deprived of glucose its main fuel source in human body will launch into a backup plan: burning fat for energy. The breakdown products of the process, called ketones, can accumulate in your blood and eventually in your urine. One type of ketone, called acetone, has a telltale "fruity" smell; if you're making ketones, you'll likely have fruity-smelling breath. (Since acetone is a key ingredient in nail polish remover, it might more accurately be called "nail polish remover breath.")

A high level of ketones is a warning sign that your diabetes isn't under good control. If not treated immediately with insulin, the ketone buildup can progress to a dangerous condition known as diabetic ketoacidosis, and even diabetic coma. Your diabetes care plan should include guidelines for monitoring your ketones—either by testing your blood for ketones or dipping a test strip in your urine. The presence and the importance of acetone and its metabolism in diabetic ketoacidosis has largely been ignored. The concentration of acetone in plasma, urine, and breath, and the rates

of acetone production and elimination in breath and urine were determined and the rates of vivo metabolism were calculated.

1.1 Background

This research entitled as Application of the Microfiber Sensor for Monitoring Concentration of Acetone. The reason why the detection of acetone viscosity system using fiber optic sensor needs to be develop because to determine the concentrated acetone in human body to examine the diabetic. The correlation of diabetes and acetone are is it can detect a somehow person afflicted with diabetes through high level acetone level from respiration of human being and excretion in form of urine which is can determined sugar viscosity in blood.

1.2 Problem Statement

In this modern age, diabetes has being one of the worse case scenario which leads towards a worrying human's health. Diabetes is a group of metabolic diseases in which there are high blood sugar level over a prolonged period. The traditional diabetes which is all diabetes blood tests involve drawing blood at a health care provider's office or commercial facility and sending the sample to a lab for analysis. Lab analysis of blood is needed to ensure test results are accurate. Glucose measuring devices used in a health care provider's office, such as finger-stick devices, are not accurate enough for diagnosis but may be used as a quick indicator of high blood glucose (Anon., n.d.). This traditional method are take a relatively long time to get the result. Technologies help doctors and medics to detect diabetes's symptoms by analysing the concentration of acetone from human's urine and respiration process is another method of to analyze the diabetes in a rather short period. This kind of analyze testing for diabetic is an to upgrade from traditional process. High level acetone from test indicates that the patients may being diagnosed with diabetes.

The concentration of breath acetone has been found to correlate with the β -hydroxybutyrate concentration of venous blood in fasting obese patients. Overnight fasting levels of both breath acetone and blood-sugar were measured in 251 diabetics, after which the patients were grouped for analysis by the type of diabetic management and the fasting blood-sugar found (Dept. of Medicine, n.d.)

Main problem is to analyze the diabetes which used to detect level of glucose in blood is not stable. There is need the device to detect the diabetes with a continuous stability and precise testing result. Optical microfiber as sensor helps medics to detect diabetes in patient's bodies as a faster transmission and high sensitivity by microfiber sensor to detect the concentration of acetone.

1.3 Objectives

The objectives of this project are to:

- i. To understand the concept of fiber optic sensor and microfiber sensor.
- ii. To study acetone effect in diabetes detection.
- iii. To develop fiber optic acetone sensor.
- iv. To analyze the performance of microfiber as a sensor in identifying the concentration of acetone.

1.4 Scope of Study

Before a new technology or technique is applied, the system must be tested so that the performance of the design and analysis can be known. However, for any project to be done, the limitation of the scope of work must be very realistic and applicable. In order to achieve the objective of study, the following were outline as follows :

- i. Study on the correlation of type of diabetes and acetone in human breath, in urine and in blood testing.
- ii. Analyze on microfiber sensor capability.
- iii. Design and develop the microfiber sensor to detect the concentration of acetone.
- iv. Applying the various acetone concentration and obtain the result required which are closed to the theoretical results.
- v. Analyze the data obtained and select the data that have optimum results.
- vi. Report writing.

1.5 Limitation

The limitations of the study are those characteristics of design or methodology that impacted or influenced the interpretation of the findings from a research. They are the constraints on generalizability, applications to practice, and/or utility of findings that are the result of the ways in which there initially chose to design the study and/or the method used to establish internal and external validity. Some of limitation are:

- i. Microfiber sensor is going to be used.
- ii. Sensor can detect the acetone.

CHAPTER 2

THEORETICAL BACKGROUND

2.0 Introduction

In this chapter, the research has been done by other persons which are related with this research were discussed. The facts from their research were used to guide this research in correct way. The source came from the journals and articles wrote by the previous researchers which related to this project. Their theory and results help this research as they can be a comparison between this research and theirs.

2.1 Fiber Optic

2.1.1 Fiber-Optic Communications: OFC Postdeadline Highlights Include 100 T/bit Fiber Transmission (Hecht, 2011)

Demonstrations of high-speed fiber-optic transmission reached a major milestone at the March 10 post deadline session of this year's Optical Fiber Communications Conference (OFC; Mar. 6–10, 2011, Los Angeles, CA). Two groups reported sending more than 100 Tbit/s through single optical fibers using different techniques. That caps three years of rapid increases in fiber-optic speed records following a hiatus in hero experiments during the post-telecom-bubble years.

Those transmission rates are far beyond the installed capacities of current backbone or submarine cables, says Tim Strong of Telegeography (Washington, DC). But with traffic growing at about 50% each year, carriers need to upgrade their networks. Submarine cable operators have begun moving to 40 Gbit optical channels, and a little over a year ago Verizon switched on the first operational 100 Gbit optical

channel between Paris and Frankfurt. At the end of March, Verizon announced it would install the first three 100 Gbit optical channels in US long-haul systems.

i. **Superchannels**

How to further upgrade that capacity has been an issue. At the OFC postdeadline sessions, a team from Verizon (Richardson, TX) and NEC Labs (Princeton, NJ) described mixing 100 Gbit/s optical channels with “superchannels” transmitting 450 Gbit/s and 1.15 Tbit/s across wider spectral regions through 3560 km of fiber in the Verizon network. The superchannels combined orthogonal frequency-division multiplexing (OFDM) with dual-polarization quadrature phase-shift key (DP-QPSK) modulation of multiple subcarriers within the transmission band. Tiejun Xia of Verizon and colleagues reported that the superchannels “provide higher channel capacity and higher spectral efficiency than the existing 100 Gbit/s system” in installed fiber. That shows the feasibility of upgrading existing networks to terabit transmission, says Ting Wang, manager of NEC Labs’ optical networking department.

NEC Labs stretched the superchannel approach to demonstrate 101.7 Tbit/s transmission over three 55 km lengths of standard single-mode fiber. They started with 370 laser transmitters spaced at 25 GHz intervals in the C-band at 1527.4 to 1565.7 nm and the L-band at 1570 to 1607 nm. They modulated odd and even channels independently, and partitioned each 25 GHz band into four subbands, each carrying a 6-GHz-wide OFDM signal, with 1 GHz left as a guard band. They modulated and combined those signals, with polarization-division-multiplexed 128QAM applied to each subcarrier. This built up a 294 Gbit/s signal for each of the 370 transmitting lasers, a raw data rate of 108.8 Tbit/s, which corresponds to 101.7 Tbit/s after error correction is done. Dispersion was compensated electronically.

ii. **Seven-core fiber**

Immediately after Qian’s postdeadline talk, Jun Sakaguchi of Japan’s National Institute of Information and Communications Technology (NIICT; Tokyo, Japan) described a different approach to 100 Tbit transmission: spatial-division multiplexing by splitting the signals among seven separate cores in the same fiber (see figure).³

Multicore fibers have become a hot topic in the past couple of years as developers look for new ways to increase fiber capacity. Sakaguchi and colleagues from Sumitomo Electric's R&D Lab (Yokohama, Japan) and Optoquest (Saitama, Japan) described WDM of 10 Gbit/s signals in seven-core fibers during the regular sessions.

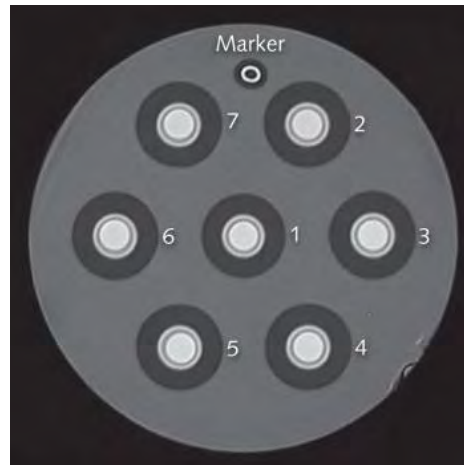


Figure 2.1: A seven-core optical fiber (*Courtesy of NICT*)

In the postdeadline sessions, Sakaguchi reported a big step forward: transmitting 97 WDM channels on a 100 GHz grid, each carrying DP-QPSK signals at 172 Gbit/s, through all seven cores. The raw data rate adds up to 15.6 Tbit per core or 109 Tbit/s through the entire fiber, excluding the overhead for forward-error correction. The experiments divided output from a single WDM transmitter among all seven cores, with different time delays added between the transmitter and the optics that focused the light into each of the singlemode cores, which were spaced on 45 μm centers in a 150 μm cladding. The signals then went through 16.8 km of the multicore fiber without amplification before being demultiplexed.

OFC also recorded a terabit milestone on a different scale: the fastest-ever passive optical network (PON), transmitting 1.2 Tbit/s through 90 km of fiber. Neda Cvijetic of NEC Labs says the goal is building a PON that could provide a thousand homes with the gigabit service that Google has proposed. At OFC, she reported transmitting 48 Gbit/s on 25 wavelengths through standard singlemode fiber with passive branching to 32 delivery fibers. She says the design could be a next-generation standard to follow the recently approved 10 Gbit PON standard. —*Jeff Hecht*