Faculty of Electrical and Electronic Engineering Technology

COOPERATIVE STUDY FOR POWER SPECTRAL TOWARDS DIFFERENT TAPER OPTICAL MICROFIBER FOR SENSING PURPOSE

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Bachelor of Electronics Engineering Technology with Honours

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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 Electrical Engineering Technology with Honours.

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DEDICATION

My special dedication is directed to my parents, siblings and friends who have always supported me and who have always encouraged me to help me complete my final year project successfully. Meanwhile, I am dedicating this thesis to my beloved supervisor, DR.AMINAH BINTI AHMAD and co. supervisor, DR. MD ASHADI BIN MD JOHARI who hasgiven me a lot of guidance and guidance on how to achieve success for my final year project. Thank you very much. I appreciate it. I am grateful for their inevitable sacrifice, tolerance, and consideration in making this effort feasible. I cannot provide the appropriate words that can accurately describe my appreciation for their loyalty, support,and belief in my ability to achieve my dreams.

ABSTRACT

Fiber optics, commonly referred to as optical fiber, is a medium and system for transmitting information as light pulses over a glass or plastic strand. When light signals are transmitted through fiber optic cable, they bounce off the core and cladding in a sequence of zig-zag bounces, a phenomenon known as total internal reflection. Microfiber optic sensors have recently received considerable research due to their high sensitivity, detection speed, and ability to use harsh environments. The objective of this project was to use a fiber optics subclass known as microfiber as a sensor. The different sizes of the taper microfiber may produce different transmitted power values, leading to the sensor's performance. Therefore, different sizes of taper microfiber will be used as a sensor to define the sensing performance. At the end of the project, the best size of taper microfiber is developed and performance tremendously as a sensor.

ABSTRAK

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Gentian optik, biasanya dirujuk sebagai medium dan sistem untuk menghantar maklumat sebagai denyutan cahaya melalui helaian kaca atau plastik. Apabila isyarat cahaya dihantar melalui kabel gentian optik, ia melantun dari teras dan lapisan dalam gerak lantunan zig-zag iaitu dinamakan sebagai fenomena pantulan dalam penuh Selain itu, banyak usaha penyelidikan terhadap sensor gentian optic terhadap tahap kepekaan yang tinggi, kelajuan tahap pengesanan dan keupayaan untuk menggunakan persekitaran yang keras. Objektif projek ini adalah untuk menggunakan subkelas gentian optik iaitu mikrofiber sebagai sensor. Saiz mikrofiber tirus mungkin menghasilkan nilai kuasa dihantar yang berbeza, sekaligus membawa kesan terhadap kekuatan sensor. Oleh itu, saiz mikrofiber tirus yang berbeza akan digunakan sebagai sensor untuk menentukan prestasi penderiaan. Pada penghujung projek, saiz mikrofiber tirus yang terbaik dan berprestasi tinggi akan dibangunkan sebagai sensor.

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μm	-	Micrometer
θ_1	-	The incident angle between the light beam and the normal
θ_2	-	The refractive angle between the light ray and the normal
n_1	-	The refractive index of the medium the light is leaving
n_2	-	Refractive index of the material the light is entering
F	-	Fahrenheit
mm	-	Millimeter
nm	-	Nanometer
dbm	-	Decibels per miliwatt

LIST OF ABBREVIATIONS

EMI	-	Electromagnetic interference
RFI	-	Radio frequency interference
$PMMA$	-	Polymethyl methacrylate
$SiO2$	-	Silicon dioxide
UV	-	Ultraviolet

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CHAPTER 1

INTRODUCTION

1.1 Background

Fiber optics are used to transmit light energy over long distances. Optical fibers are optical grade glass or plastic strands that are as thin as a strand of hair. These fibers are used in photoelectric sensing to transmit and receive light sources from various wavelengths. Layer of cladding material surround a glass or plastic core and (for plastic fibers) jacketing in an optical fiber. Glass fibers are often packaged as bundles. In contrast, plastic fibers are typically packaged as monofilaments. Glass fibers are not coated, and bundles are packed in sheathing made of stainless steel flexible conduit. Still, it might also be PVC or another flexible plastic tubing. A protective steel coil might be utilised beneath the sheath to safeguard the fibre bundle.

An optical microfiber shows various waveguiding properties, including broadly tailorable optical confinement, evanescent fields, and waveguide dispersion, with a diameter close to or below the wavelength of guided light and a high index contrast between the fiber core and the surrounding. Optical sensing has received significant study interest among many microfiber applications due to its ability to realise miniature fiber optic sensors with small footprints, high sensitivity, fast response, high flexibility, and low optical power consumption.

1.2 Problem Statement

Optical technologies are commonly used for chemical, biochemical and many other sensing applications field. As a result, they are attracting increased research attention due to their superior advantages over electrical transducers, such as low cost, compact size, high sensitivity, and immunity to electromagnetic fields. In order to understand the effect of the size and sensitivity of the developed sensor, the research will focus on designing optical microfiber at different sizes and studying the sensitivity's behaviour using the tapering method. The size of the tapered microfiber influences the sensor's performance, which can generate varying levels of transmitted power. Therefore, three different tapered microfiber diameters are used as sensors to determine sensing performance.

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1.3 Project Objective

The main objectives of this project:

a) To study an optical microfiber as a sensor using a tapering method.

b) To develop optical microfiber sensors using different sizes of tapered fiber.

c) To analyse the performance power spectra of different sizes of optical microfiber sensors using the tapering method.

1.4 Scope of Project

The project plans to develop a microfiber sensor using the tapering method. The advanced sensors' performance will also be evaluated. A commercial splicer Fujikura FSM-18R is used to split single mode fibers and splice the fiber optic sensor. Before splicing the fiber, the fibers are cleaned with alcohol to remove dust and cleaved with a Fujikura CT-30 Fiber Cleaver to achieve a smooth cleavage surface and clean end-uncoated fiber. During the testing process, the 1550nm input wavelength was collected from an optical power source, and the output signal was measured in (dBm) units using an optical power meter.

The experiment was repeated with different tapered optical microfiber sizes with size A (21.7nm) ,Size B (28.5nm) and C (10.8nm). For all microfiber sizes, a 1550nm wavelength value was used. By utilising an optical power meter, the findings are converted to watts (dBm). This project guarantees that it is moving on the right path to achieve its objectives

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Table 1.1 Equipment Detail

Equipment	**Experiment Detail**
Round Basin	To concentrate the sensor with liquid material
Fiber Optic	Single mode (Fiber Optic Pigtail)
Size	21.7nm,28.5nm,10.8nm
Hardware	-Optical Power Level (1550nm) -Optical Power Meter -Commercial Splicer Fujikura FSM-18R -Fujikura CT-30 Fiber Cleaver

1.5 Thesis Organisation

Introduction, Literature Review, Methodology, Results, and Conclusions are the five chapters that form the thesis. The classification is briefly introduced in Chapter 1. It includes information on the project's background, problem statement, project objectives, and scope From that, Chapter 2 examines the preceding article's literature review and theory. The project methodology is discussed in Chapter 3. It includes all of the approaches discussed in the preceding article, such as algorithm development, research, and laboratory testing. The initial results are detailed in Chapter 4 and the final chapter, which is the project's conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Modern sensors for many industrial application situations, such as aircraft, infrastructure, transportation, biology, and so on, have emerged in recent years as a result of rising developments in optical sensing technology. Optical fiber sensors (OFS) have played an increasingly important role in the quick development of sensors; to date, Corning has produced the first optical fiber with low attenuation, which has the advantages of being light in weight, compact in size, and low in cost, as well as electromagnetic immunity and excellent security.

Several optical fiber technologies have been developed in past few decades to meet the various requirements of point-type optical fiber sensing, including fiber Bragg grating (FBG), long-period grating (LPG) assisted fiber, photonic crystal fiber (PCF), and multicore fiber (MCF) with surface plasmon resonance (SPR)[1]. However, their uses are limited by their somewhat difficult fabrication, high cost, and low sensitivity. Microfiber, first reported by Tong et al. in 2003, has been thoroughly researched in fiber optics as a combination of fiber optics and nanotechnology, with a diameter constrained to tens of nanometers to several micrometers.

The purpose of this research is to develop the microfiber subclass of fiber optics as a sensor. The sensor's performance is affected by the size of the taper microfiber, which can create various levels of transmitted power. To determine the sensing performance, different diameters of taper microfiber will be employed as sensors. The best size of taper microfiber is generated towards the end of the project, and it performs capably as a sensor.

2.2 Fiber Optic Sensor

Optical fiber technology and applications have grown considerably in recent years. Fiber-optic sensors are used in a variety of areas, including healthcare, the environment, smart buildings, industrial, transportation, retail, security, and defense. Higher sensitivity, wider detection-bandwidth, higher-temperature operation, electromagnetic immunity, inertia in combustible environments, robustness, and an inherent distributed sensing capability are some of the advantages of being light-driven, light read-out, and requiring no wires over their traditional electrical counterparts [2]. The final product size of bent- or coiled-fiber-based sensors is limited by the physical dimensions and minimum bend radius of an optical fiber.

By high bend insensitivity, optical microfibers (OMs) enhance the functionality of fiber-optic sensors, allowing them to be used in applications where working space is limited or physical intrusion must be reduced while keeping the same level of performance despite miniaturisation. Although when the radius and numerical aperture of their cores are matched, small-core microstructure fibers can achieve comparable bend loss to Optical microfibers, the bulkier outer-cladding of exposed-core fibers (ECFs) induces greater compression/tensile stresses that may break first when decreasing the bend radius.

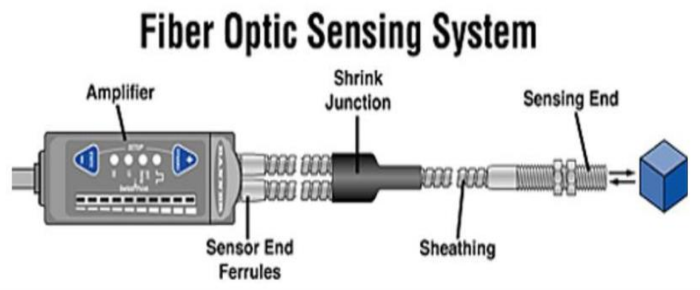

Figure 2.1 Fiber Optic Sensing System