UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPLEMENTATION OF MICROFIBER OPTICAL CONCEPT FOR TEMPERATURE SENSOR DEVELOPMENT BY USING ALUMINIUM ROD

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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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Implementation of Microfiber Optical concept for Temperature Sensor development by using Aluminium Rod

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

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(Md.Ashadi Bin Md Johari)

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(Md. Ashadi Bin Md. Johari)

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ABSTRAK

Satu rekabentuk ringkas pengesan suhu digunakan dan penggunaan sensor sesaran gentian optik ditunjukkan berdasarkan teknik modulasi keamatan. Sensor dicadangkan menggunakan gentian optik silika sebagai satu kajian menggunakan rod aluminium sebagai satu sasaran. Rod aluminium diletakkan dalam julat linear. Mengambil dan merekod suhu rod aluminium sekitar 25ºC kepada 90ºC. Sensor yang dicadangkan menunjukkan satu tahap kestabilan yang tinggi. Kesederhanaan reka bentuk, ketepatan, julat dinamik fleksibel , dan kos rendah rekaan ialah ciri – ciri sensor yang bermanfaat untuk kegunaan industri.

ABSTRACT

A simple design of a temperature sensor is proposed and demonstrated using a Microfiber Optical based on an intensity modulation technique. The proposed sensor uses a silica fiber probe in conjunction with a flat surface aluminium rod as a target. The aluminium rod is placed within the linear range of the sensor's displacement curve. The sensor is capable of measuring the temperature of an aluminium rod ranging from 25°C to 90°C. The proposed sensor also shows a high degree of stability and good repeatability.

DEDICATION

Special dedication to my parents, lecturer, siblings and friends for giving me all their knowledge's and moral support for me to completion the project and report.

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In the name of Allah S.W.T, The most Merciful and The most passionate, I am thankful to Allah for enabling me to complete this final year project and report.

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Last but not least, I would like to thank you for those who are directly or indirectly involved during this project and completion of this report. All of your kindnesses are very much appreciated.

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ASE	-	Amplified Spontaneous Emittion
OSA	-	Optical Spectrum Analyser
UV	-	Ultraviolet
Al	-	Aluminium
RTDs	-	Resistance Temperature Detectors
LED	-	Light Emitting Diode
FC	-	Fiber Connector
UPC	-	Ultra Physical Contact
EDFA	-	Erbium-Doped Fiber Amplifiers
SMF	-	Single Mode Optical Fiber
^{o}C	-	Celcius
dB	-	Decibel
μ	-	Micro

LIST OF FIGURES

CHAPTER 4

LIST OF TABLES

TABLE OF CONTENT

CHAPTER 5: CONCLUSION & FUTURE WORK

CHAPTER 1
INTRODUCTION

This chapter contains of background of study, the problem statement, objective of the study, and scope and limitation of the study.

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1.1 Background of Study

A simple design of a temperature sensor is proposed and demonstrated using a Microfiber Optical based on an intensity modulation technique. The proposed sensor uses a silica fiber probe in conjunction with a flat surface aluminium rod as a target. The aluminium rod is placed on hotplate to transfer the heat to the Microfiber through aluminium rod. The sensor is capable of measuring the temperature of an aluminium rod ranging from 25°C to 90°C. The sensor also shows a small diameter waist (4μm) is more sensitive compare to (7μm).

Recent works have mainly focused on temperature sensors that satisfy user requirements for specific applications, and the main considerations are performance, dimension and reliability. In this project, a temperature sensor is demonstrated based on one techniques; intensity modulation technique. The first sensor is based on a rugged, low cost and very efficient silica fiber utilizing a microfiber optical as a probe and a linear thermal expansion of aluminium.

By knowing this advantages, the aims of this study is to verify the performances and efficiency of the temperature sensor development (aluminium rod) by using fiber optic concept.

1.2 Problem Statement

Based on-site observation, this system must be able to observe the efficiency and performance of the parameters (Sensitivity, Linearity and Linear range). However, existing temperature sensor has a problem which is :

1) Accuracy – The accuracy or reading of the sensor is not fix.
2) Response Time – The response time for existing sensor is slow.
3) Size – The size for existing sensor is not portable, overall using a huge of size.
4) Durable – The sensor also is not durable for example thermometer is fragile. If broke once it become dangerous for user because of the hazard of mercury that use in thermometer.

1.3 Objectives of Study

To provide solution for the above mentioned problems, this study is carried out to achieve the following objectives:

1) To fabricate different tapered waist of silica optical fiber sensor.
2) To demonstrate experimentally different tapered waist of optical sensor for temperature measurement.
3) To analyse performances of different tapered waist of silica optical fiber sensor for temperature measurement.

1.4 Scope and Limitation of Study

This project performs to study on microfiber optical. Furthermore, make a designing the structure, parameter and the process of the project. This experiment was conducted to verify the performance and efficiency using Silica Fiber. Moreover, this experiment focuses in fiber optic concept and using a Microfiber Optical. Besides that, this study is to verify the relationship between the output power and aluminium rod temperature.

As a limitation of the study, the temperature measurement focuses on performance parameters which are sensitivity, linear range and linearity. In other words, there is experimentally and theoretically done for the experiment.

CHAPTER 2
LITERATURE REVIEW

While the previous chapter introduces the background of the study, this chapter continues with the literature review on the following subjects: the performance of Silica optical fiber. The information and knowledge are obtained through hardbound and online journals, relevant articles and reference texts.

2.1 Silica optical fiber in sensing applications

2.1.1 Silica optical fiber sensors

Nowadays, silica optical fiber is widely use in telecommunication system. For well development for this technology, the accuracy and measurement capabilities is being focus due to it have many potential applications. Silica optical fiber sensors or optical sensors are easily multiplexed. It allows many sensors to share a single link for control the system. Thus, it can save the cost and reducing complexity. Besides that, the optically base is not required electricity at the sensing point so it can operate in chemically hostile or explosive environments as well as have a low susceptibility to electromagnetic interference (Kersey, 1996).

2.1.2 Optical Microfibers

Optical microfibers also known as optical/photonic microwires, are optical fiber tapers with a uniform waist region size comparable to the wavelength. Microfibers are usually manufactured by heating and stretching regular-sized optical fibers. The result is a biconical taper that provides a smooth lossless connection to other fiberized components. By controlling the pulling rate during the fabrication process, the taper profile can be fine tuned to suit the application. Optical materials other than silica have been used to manufacture Microfibers, including phosphate, tellurite, lead silicate, bismuthate and chalcogenide glasses and a variety of polymers. The remarkable optical and mechanical properties exhibited by Microfibers are constantly exploited for optical sensing and include large evanescent fields, strong optical confinement, flexibility, configurability and robustness. Such desirable characteristics have gathered much attention in recent years and it is what makes Microfibers an excellent platform for optical sensors(George, 2013).

2.1.3 Amplified Spontaneous Emission (ASE)

ASE may obtain a substantial output power in any wavelength region where the amplifier gain is high, even if we do not inject any input signal. That ASE light is relatively broadband, it is actually used in some superluminescent sources. Moreover, if ASE copropagates with a signal, it constitutes a broadband noise for that signal. Strong ASE can cause substantial gain saturation via stimulated emission, it lowers the excitation density and thus the amplifier gain. It causes a kind of soft gain clamping, more pump power still increases the gain, but only slightly, as the ASE powers grow rapidly with increasing gain. Amplified spontaneous emission can seriously degrade. To characterize, and thus be able to mitigate, amplified spontaneous emission, a closed-form model is developed (Ribierre, 2007).

By employing a closed-form solution, the differential equations describing both the evolution and decay of the upper laser manifold population density can be solved exactly. An advantage of this model is the separation of the spectral and spatial portions of amplified spontaneous emission. Gain measurements, as a function of time and pump energy, are compared with the model and good agreement is found (Barnes, 2002).

2.1.4 Aluminium Rod

Pure aluminium is made up of silver-white metal. It is light, nontoxic (as a metal), nonmagnetic and also no sparking. Besides that, it is easily to form, easily to machine as well as casting. Aluminium is soft and lack of strength in properties, it contains a small amounts of copper, magnesium, silicon and other elements. The process to refine aluminium from bauxite called the Bayer process (Winter, 1993). Figure 2.3 shows the elements of chemical.

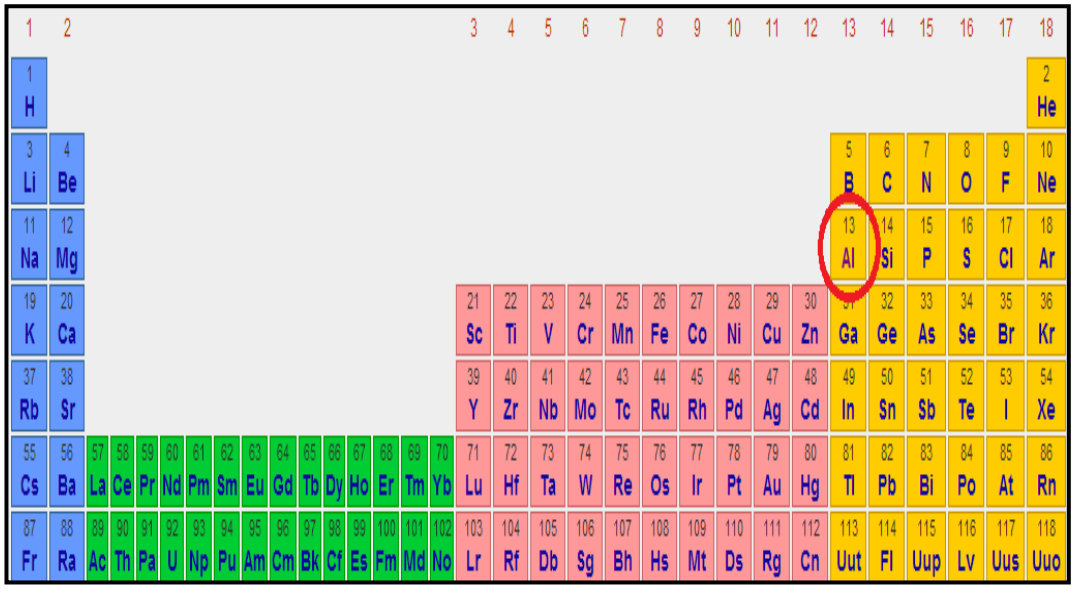

Figure 2.1: The elements of chemical, Aluminium (Al,13)

In additions, the aluminium is lighter with a specific weight of 2.7/gcm3. In automotive, the vehicles reduces dead-weight and energy consumption by increasing the load capacity. Besides that, aluminium is a good heat and electricity conductor

compared to copper as well as its height twice like a copper. Thus, it made aluminium being the most commonly material that have been used in a power transmission lines. Furthermore, the aluminium is a good reflector of visible light as well as heat, and together with its low weight; this have makes it an ideal material for reflectors. As example, it have been used for light fittings or rescue blankets (Azom, 2000).

Table 2.1: Properties of Aluminium (Azom, 2000)

Property	Minimum Value (Imp.)	Maximum Value (Imp.)	Units (Imp.)
Atomic Volume (average)	610.237	671.261	In^3/kmol
Density	160.44	184.163	Lb/ft^3
Elastic Limit	4.35113	40.6106	ksi
Hardness	35.5343	181.297	ksi
Loss Coefficient	0.0001	0.0025	NULL
Melting Point	841.73	1304.33	^oF
Thermal Conductivity	149.763	411.847	$BTU.ft/h.ft^2.F$

Based on the previous research, Aluminium have test for the environment. Resistance factors of these properties are 1(poor) until 5 (excellent).

Table 2.2: Environmental Properties (Azom, 2000)

Flammability	4
Fresh water	5
Organic Solvents	5
Sea Water	4
Strong Acid	5
Strong Alkalis	2
UV	5
Weak Acid	5
Weak Alkalis	4