

**INVESTIGATION ON THE STABILITY TO UV CURING AND
SURROUNDING TEMPERATURES OF POLYMER FILM FOR THE DESIGN
OF THERMO-OPTIC SWITCHES**

ZAIBUNNISHA BT MOHAMED KASSIM

**A project report submitted in partial fulfillment
of the requirements for the award of the degree of
Master of Engineering (Electrical)**

**Faculty of Electrical Engineering
Universiti Teknologi Malaysia**

OCTOBER, 2003

In the memory of my late father.....

To my beloved mother, my dearly loved fiancé & my caring family.....

ACKNOWLEDGEMENT

In the name of Allah, the Most Beneficent and Most Merciful.

First and foremost, I would like to extend my sincere great appreciation to my project supervisor, Associate Professor Dr. Norazan Mohd. Kassim for having confidence in me and for the endless patience and guidance that he has provided me throughout the completion of this project.

To my fiancé, Abdul Malek, your love and continuous encouragement have stirred my spirit in many ways. You made everything possible for me dear. To my dearest mother and family, thank you for the love and for being understanding and supportive at all times.

The thanks also go to all my friends for their constant kind help and moral support despite the hectic semester that we had to undergo. Special thanks to Mr. Asrul Izam and Mr. Rosli who have helped me technically with my project work. The thanks also go to everyone at Photonics Research Lab for providing me the assistance when I needed them.

To everyone else whom I have not mentioned but got acquainted during the course of this project, your help will always be appreciated, thank you.

ABSTRACT

Optical switches are the key component in all optical networks that selectively switch signal from one circuit to another. Many different technologies are available to realize an optical switch. Beyond all the technologies, thermo-optic switches has been exceptionally getting increasing attention due to the compensation of the polymer material in terms of performance and processing. For practical applications in optical systems all relevant polymer properties must satisfy strict demands. The outstanding polymer properties can then make the technology superior and the product a commercial success. For optical switch to maintain switching ability, the refractive index of the polymer at a specified temperature must remain stable. Thus, the aim of this work is to investigate the refractive index stability of polymer material HD-4000 by varying the UV cure time and exposing the samples at different temperature levels.

ABSTRAK

Suis optik adalah salah satu komponen penting di dalam rangkaian optik yang membenarkan isyarat disuis dari satu litar ke litar yang lain. Terdapat pelbagai teknologi yang membolehkan suis optik direkacipta. Daripada kesemua teknologi tersebut, suis optik-terma telah mendapat sambutan memberangsangkan yang mendadak kerana bahan polimer yang digunakan dalam suis ini mempunyai pelbagai kelebihan dari segi prestasi dan pembikinan. Untuk aplikasi yang praktikal di dalam rangkaian optik, kesemua ciri-ciri polimer mesti memenuhi syarat-syarat yang tertentu. Hanya dengan demikian kelebihan bahan polimer dapat menyerlah dan seterusnya menjadikan teknologi yang digunakan bermutu dan produk yang dihasilkan berjaya. Untuk membolehkan suis optik mengekalkan keupayaan mensuis, nilai *refractive index* bahan polimer perlulah stabil pada sebarang suhu. Oleh itu, tujuan projek ini ialah untuk menyiasat kestabilan nilai *refractive index* bahan polimer HD-4000 dengan mempelbagaikan masa sinaran UV dan mendedahkan sampel pada aras suhu yang berbeza-beza.

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LIST OF TERMINOLOGIES

AOTF	-	Acousto-Optical Tuneable Filters
BPM-CAD	-	Waveguide Optics Modelling Software System
CVD	-	Chemical Vapour Deposition
DR-A1	-	Refractometer
E/O	-	Electro-Optic
MEMS	-	Micro-Electro-Mechanical Systems
RH	-	Relative Humidity
RIE	-	Reactive Ion Etching
TE	-	Transverse Electric
TGA	-	Thermogravimetric Analysis
T/O	-	Thermo-Optic
UV	-	Ultraviolet
2D	-	Two Dimensions
3D	-	Three Dimensions

LIST OF SYMBOLS

cm	-	Centimeter
dB	-	Decibel
dn/dT	-	Thermo-Optic coefficient
e	-	Birefringence
Hz	-	Hertz
k	-	Kilo
mins	-	Minutes
mm	-	Milimeter
n	-	Refractive index
nm	-	Nanometer
rpm	-	Spin speed
μm	-	Micrometer
$^{\circ}\text{C}$	-	Degree Celcius
K^{-1}	-	Thermo-Optic coefficient

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CHAPTER I

INTRODUCTION

1.1 Introduction

The evolution of fiber optic systems into optical networks makes it essential to modify optical signals. At certain points in the system, certain functions need to be performed on the optical signals. These functions can include signal amplification, attenuation, modulation, multiplexing or de-multiplexing, and switching among others [1]. These functions are performed by discrete components, each of which typically performs a single function. Many of these components employ the use of integrated optical circuits, which take input signals from a fiber, perform a certain function on them, and then return the signal back to a fiber at the output.

One of the young optical devices that modify optical signal that has been getting increasing attention is an optical switch. An optical switch enables signals in optical fibers to be selectively switched from one circuit to another [1]. Several technologies can be used to realize an optical switch. Among them is thermo-optic, electro-optical, opto-mechanical, Micro-Electro-Mechanical Systems (MEMS), and many more are in development.

The use of polymers for thermo-optic switches applications, however, has taken on increased significance due to one or more of the outstanding polymer properties [2]. For optical switch to maintain switching ability, the refractive index of the polymer at a specified temperature must remain stable. Then only the outstanding polymer properties can make the technology superior and the product a commercial success.

Polymers for optical switches are typically made by spinning liquid monomer solutions onto substrates, followed by curing the films either thermally, or under UV exposure. If the film is not cured completely, the refractive index could change over time. The effects of environmental temperature exposure must also be considered as this effect too can cause changes to the refractive index.

The emphasis in the project is therefore on the material stability of the polymer towards UV curing time and environmental exposures. The polymer material that is used is commercially available photodefinable polyimides, under the trade name of Photodefinable HD-4000 Series Polyimide.

1.2 Objectives

The objectives of this project can be outlined as follows:

- i. To investigate the refractive index stability to the UV curing time.
- ii. To investigate the refractive index stability to the surrounding temperatures exposure.

1.3 Scope of work

The scope of work of the project comprises the following aspects:

- i. To fabricate polymer films.
- ii. To investigate the refractive index stability by varying the UV curing time.
- iii. To investigate the refractive index stability by exposing the samples at five various locations over a period of ten weeks.
- iv. To analyze the refractive index of the polymer film samples by using Refractometer.
- v. To display results in form of tables and graphs.

1.4 Outline Of Thesis

The thesis comprises of six chapters and the overview of all the chapters are given below.

- Chapter 1: This chapter gives the introduction to the project, objective and scope of work involved in accomplishing the project.
- Chapter 2: The literature review on various types of optical switches, the attractiveness of polymer and the polyimide based material are covered in this chapter. The product description of the material used in this project has also been fitted in this chapter.

- Chapter 3:** The fundamental processes required in the fabrication of the samples for the project are explained in this chapter.
- Chapter 4:** This chapter covers the experimental equipments utilized in the project with great importance of explanation given to the refractometer.
- Chapter 5:** All the measurement results obtained and the discussion for it are presented in this chapter.
- Chapter 6:** Conclusion of the project and suggestions for future work are presented in this final chapter.

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