CHAPTER 1

INTRODUCTION

1.1 Background

The increase in end-user bandwidth demand, along with the decrease in WDM component cost, implies that WDM-based devices are likely to offer performance enhancements in multiple-access networks. Wavelength division multiplexing (WDM) is considered as a promising solution to the demand for tremendous transmission capacity of the optical fiber communications network required in the near future.

Commercial interest in WDM components and systems is rapidly increasing. WDM provides a new dimension for solving capacity and flexibility problems in the telecommunication network. It offers a huge transmission capacity and allows for novel network architectures that offer much more flexibility than the current networks. No new fibre upgrade needed for adding new services (new capacities) to an existing fiber. Key components in WDM systems are the wavelength multiplexers and demultiplexers.

Wavelength splitting (demultiplexing) and combining (multiplexing) are important functions in optical applications. Wavelength Division Multiplexing (WDM) technology enable optical multiplexing and demultiplexing with the individual signals have different light wavelength can be separated or combined to transmit in single fibre optic.

There are two alternatives for WDM metro networks: dense WDM (DWDM) and coarse WDM (CWDM). In high capacity environments, DWDM is used. In DWDM, the channel separation can be as small as 0.8 or 0.4 nm, for up to 80 optical channels at line rates up to 10 Gbps. DWDM technologies is very expensive, so its application to access networks is difficult. Instead, CWDM is merging as a robust and economical solution. The advantage of CWDM technology lies in its low-cost optical components. CWDM offers solutions for 850, 1,300, and 1,500 nm applications at 10 and 40 Gbps on up to 15 optical channels spaced 20 nm apart. Both CWDM and DWDM technology have their place in current and emerging metro-network infrastructure.

Many technologies are used in optical multiplexing, such as thin film filters (TFFs), array waveguide gratings (AWGs), acousto optical tunable filters, mach-Zehnder interferometers and Fiber bragg gratings (FBGs) in order to overcome problems such as channel spacing, bandwidth, crosstalk and insertion loss. However, arrayed waveguide grating (AWG) multiplexer based on planar lightwave circuit (PLC) is the most likely used in wavelength division multiplexing (WDM) systems in optical telecommunication and it’s been focused to study in this project.

The key advantage of the AWG is that its cost is not dependent on wavelength count as is the dielectric filter solution. Therefore it suits metropolitan applications that require the cost-effective of large wavelength counts. Not only the approach is easily scalable, but the use of fiber-alignment methods depend on the whole wafer photoligraphy, rather than channel-by-channel alignment, further enhances the cost-effectiveness of this approach at higher channel counts. Other advantage of the AWG is the flexibility of selecting its channel number and channel spacing, as a result, various kinds of AWG's can be fabricated in a similar manner (Kien and Shaari 2000).

AWG multiplexers have already been developed using silica, semiconductors such as Si, GaAs, etc and polymers as the waveguide materials. Of the materials, polymers offer excellent potential for the realization of low-cost WDM components because they can be fabricated easily at low temperature on various kinds of substrates. (Kien and Shaari 2000)

AWG multiplexers based on polymeric waveguides have been gaining increasing attention because polymer devices are believed to be produce-able at lower cost than their conventional silica-based counterparts. Moreover, as polymer materials have a thermo-optic coefficient *(dn/dT)* roughly ten times larger than silica, polymeric AWG devices can be thermally tuned over a wider spectral range and may be integrated with polymer optical switches to form an add-drop multiplexer with much lower switching power consumption (Kein et al, 2001)

The first polymer AWG demonstrated by Hida et al 1994 applying deuterated fluoro-methacrylate (d-PFMA) on silicone substrate. However, this AWG only operated at 1300 nm window with some polarization dependence as small as 0.03 nm. Watanabe et al (1997) reported 16 channels polymeric AWG operated at 1550 nm realized using a silicone resin waveguide. This AWG multiplexer has an insertion loss in the range 9-13dB, a crosstalk less than -20dB, and a low polarization dependent wavelength shift.

In 1999, Beelen et al demonstrated 8 channels polymeric AWG with high index contrast of 0.01. By this technique, smaller bend radii can be achieved and it lead to smaller AWG dimension from 66x11 mm to 16x6 mm. Keil et al (2001) reported athermal polymer AWG consisting of polymer waveguide fabricated on a polymer substrate. On the other hand, Ahn et al (2004) proposed and fabricated an all-polymer based cost effective wavelength channel selector by using chip-to-chip bonding of a 16 channels to polymer switch array between two polymers AWG. However, the penalties are large insertion loss and low power of 0.1 dB at 10 Gb/s.

Huang Chang Lin et al (2005) designed a low loss, low crosstalk and low PDL SU-8 polymeric wavelength division multiplexer AWG with temperature variation in range of 0 – 70^{o}C. In year 2006 a compact wavelength division multiplexer based on AWG structures have been fabricated for CWDM using low-loss perfluorocyclobutane-containing polymers by Jiang et al. The device exhibit high thermal stability and low on chip losses.

1.2 Problem Statement

There is demand for high capacity and cost effective for the long and short haul application optical transmission. WDM offers a new dimension for solving capacity and flexibility problems in the telecommunication network. Key motivation for this study is the importance of optical multiplexing and demultiplexing component in optical telecommunication network which are crucial elements in WDM technology, namely the Dense WDM and Coarse WDM. There are also claims for these technologies and the needs of precise design with low cost fabrication process. The polymer waveguide technology is chosen because of low material cost and easy fabrication process. Motivated from the advantages of polymer material, the development of polymer based AWG is initiated in this project.

1.3 Objective

The main objective of this project is to design and simulate conventional four channel AWGs structure based on the BenzoCyclobutene (BCB 4024-40) polymer for DWDM and CWDM application. To employ this objective, thorough studies and researches are to be conducted in order to get relevant informations and also to gain the required knowledge.

1.4 Scope of study

This project is intended for the design and simulation of four channels AWGs structure based on BCB 4024-40 polymer for Wavelength Division Demultiplexing application.

To make this project successful, several scopes are listed to ensure the project is conducted within its intended time frame. The first scope for this project is to understand the concept of DWDM/CWDM and AWG, and also the characteristics of the BenzoCyclobutene (BCB 4024-40) polymer, which is currently being used in the Photonics Research Lab. Literature review was done to find out the related theory.

The second scope of work is to specify the parameters of the design based on mathematical equation of basic design rules for AWG. Suitable numbers of waveguide channel have been studied to figure out the best structure to be implemented in this study. Then, conventional AWGs with 4x4 channels structure based on polymer with varies spacing between the channels for DWDM and CWDM environment will be designed at centre wavelength of 1550nm. Modelling and simulation will be carried out by using WDM_Phasar software, from Optiwave Corporation. With this software, AWG performance such as bandwidth, insertion loss, output power and crosstalk will be analysed.

1.5 Research Methodology

Figure 1 shows the overall project activities. The project begins with literature review on fundamental of DWDM/CWDM and AWG characteristics. After the design parameter is determined, the project is followed by proceeding with the design. Following this, the designs will be analysed and its performances will be evaluated.

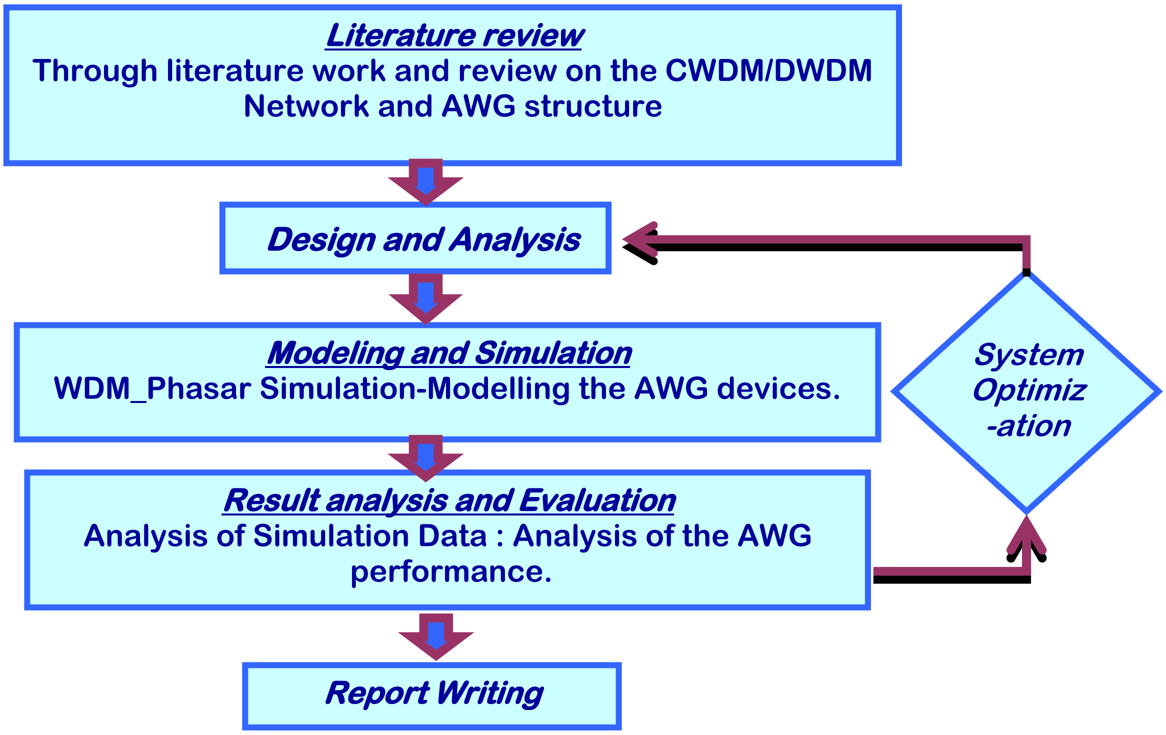

Figure 1 Project Flow Chart

1.6 Thesis Outline

In this thesis the design and simulation AWGs multiplexer/demultiplexer are presented. The background, objectives, scopes and research methodology are discussed in Chapter 1. The literature review of wavelength division multiplexer (WDM) technology, array waveguide grating (AWG) characteristic and polymer material are presented in Chapter 2. The design procedure and AWG simulation are discussed in Chapter 3. The results, analysis and discussion of the simulated results and comparison of the designed devices are presented in Chapter 4. Finally, the conclusion and recommendations for future works are given in Chapter 5.