Chapter 1

Introduction

The basic theory of Fabry-Pérot resonator is utilizing the gain medium and two reflex materials. In general, the structure of cavity is using two mirrors as reflex material to form a resonator. However, wave bounces back and forth between the two mirrors and amplified by the gain medium. The gain medium must conform to the character of two-way amplifier in this experimental structure. If cavity want to the laser oscillation occurred, the cavity must correspond with the threshold condition for oscillation. However, the threshold condition is the gain per unit of length must exceed loss in this resonator. When the oscillatory phenomenon occurred express in this cavity should produce a cavity laser. However, basis of the Fabry-pérot resonator the cavity laser produced in this resonator must be the multimode laser. The free spectral range (FSR) of those multimode lasers is relation with the length of resonator, the reflectance of reflex material and so on.

Nowadays, multi-wavelength fiber lasers [1-4] are cost-effective sources in wavelength-division-multiplexed (WDM) fiber communication system, fiber sensor and so on. Therefore, the technique of however to stable resonator and select the specific wavelength is becomes more important. Various techniques to reduce the wavelength competition caused by the homogeneous gain broadening of EDF [5] have been used to achieve stable multi-wavelength oscillations. In these designs, the cavity losses corresponding to the different wavelengths have to be balanced with the cavity gains simultaneously. As a result, all oscillation lines have the same pump threshold, and the properties of a specific wavelength are difficult to be adjusted or controlled. However, fiber Bragg gratings are ideal wavelength selection components for fiber lasers. Cascaded FBGs have been used in actively mode-locked multi-wavelength fiber lasers [6-8] and applied on the temperature sensor. Mostly recently, continuous-locked (CW) multi-wavelength fiber lasers have also been reported by utilizing a tree and inline topology FBGs to select the oscillation wavelength [9]. Therefore, may experiments utilize this character of fiber Bragg grating to generate multi-wavelength laser [10-12]. Multi-wavelength fiber lasers have applications in sensing, instrument testing, optical signal processing, and in optical communications. Besides, the

Multi-wavelength oscillations have been demonstrated by using a comb filter [13-15], a fiber grating sagnac loop [16], an overlap fiber Bragg grating [17], a multiple quantum-well waveguide [18], a high birefringence fiber loop mirror [19], an acoustooptic frequency shifter [20], a twin core fiber [21], a spatial mode filter [22] and a polarization-maintaining fiber in a ring cavity. Meanwhile, dual wavelength operation has been achieved using a fiber ring laser with two cavities that share one erbium-doped fiber amplifier [23], a fiber laser with a twin peak reflection grating or two cavities formed by four fiber gratings [24], a coupled dual-cavity fiber laser incorporating four fiber gratings [25], and a fiber ring laser with two grating Fabry-Perot etalon.

In our experimental we also use FBG to form an asymmetric cavity. We know that fiber Bragg grating (FBG) has been used in many different ways in combination with semiconductor laser to improve their emission properties [26-29]. One motivation for using FBGs is their good wavelength stability in comparison with simple Fabry-Perot cavities or even with DFB or DBR diode lasers. However, if we wish to use the transmission wavelength window effectively, it is important to stabilize the laser source oscillation wavelength for wavelength-division-multiplexing (WDM) applications. An external fiber grating employ a FBG or a UV written waveguide grating is promising for this purpose because the lasing wavelength is stabilized by the Bragg wavelength of the grating and is less dependent on temperature than that of conventional distributed-feedback laser diodes (DFB-LDs) [30-34]

Then, we use this asymmetric cavity laser to accomplish the polarization shift keying (PolSk) transmission. In the transmission system, we must overcome the factors influence the transmission ratio such as: vibration, temperature and stress by external force all influence the polarization state. Those variations of external environment cause the error of transmission results. Therefore, we must observe and control the polarization state, degree of polarization (DOP), ellipticity and polarization mode dispersion (PMD), because they influence the transmission ratio. Therefore, various technologies of PMD compensation are investigated, nowadays.

Polarization mode dispersion is the major limiting factor for high-speed optical communication system [35-43]. PMD can be subdivided into two classes: those that occur intrinsically and those that result from extrinsic factors. Intrinsic effects result from processes during the fiber's manufacture. For example, sometimes a fiber's core is slightly elliptical. Other times, the fiber may have some built-in asymmetric stress. These stresses cause the index of one polarized state to differ slightly from the other, resulting in PMD. Older fibers tend to have more PMD than newer fibers because modern process controls eliminate virtually all the stress and asymmetry in the fiber during manufacture, resulting in very low levels of PMD in the un-cabled raw fiber. Extrinsic factors all result from stress. Stress may result from twisting [44] or bending the fiber [45-48], or from environmental effects like changes in temperature or thermal gradients [49-53]. Twisting and bending occur in fibers resting against each other in fiber bundles, when they are organized in splicing trays. To summarize thus far, PMD is a dispersive phenomenon that causes pulse spreading in optical telecommunications networks [54-60] and influence on state of polarization (SOP).

Recently, some methods to mitigate PMD in WDM systems were proposed and demonstrated [61-63]. Sȃrkimukka et al. [61] proposed to use channel switching to mitigate PMD in WDM system. The overall system performance is improved at the expense of total capacity (or spectral efficiency). In [62] and [63], a method of using one PMDC to compensate for several channels before wavelength demultiplexing was proposed. Several different electrical and optical methods for mitigation of polarization-mode dispersion (PMD) induced intersymbol interference (ISI) have been demonstrated on a signal channel basis. Roughly speaking, electrical equalizers offer less system performance improvement than optical PMD compensator (PMDC). However, optical PMDCs are much more expensive than integrated electrical equalizers. However, due to statistical nature of PMD, it cannot be compensated or mitigated with fixed compensators. Therefore, all PMD compensation techniques must rely on feedback systems.

Therefore, in our compensation system, we use simple circuit and 8051 program to form a feedback control system. In order to reduce the impairments of the variational state of polarization in the optical fiber system. We use the instruments of dynamic polarization controller with the microcomputer to reduce the impairments in the optical fiber system. The compensator that we design not only can adjust the variational state of the polarization in the fiber, but also can do other applications with it example for PMD mitigation, PDL compensation, PDG effect reduction and so on. In our instruments, the technological novelty of the instrument is acquiring from the PolaRite**II** PCS-4X device with four squeezers made by the General Photonics Corporation. We have to design some circuits and write program codes to control the component. The homemade compensator can de applied on the transmission system. We can utilize it to compensate the

DOP, Ellipticity and improve the transmission quality. The compensator can eliminate the unstable factors of external environment, the compensation results are shown in chapter3. However, our compensator structure and characteristic measured is described in chapter4.

In this thesis,we design the compensator and apply it to the WDM transmission system. First, we utilize the theory of cavity to produce the unsymmetrical resonator laser. This laser system can be use on different purpose. The asymmetrical resonator laser is very stable and has the range of SMSR is very large, the detailed describe is in chapter1. We apply the asymmetrical resonator laser to the WDM transmission system, and we design the compensator in order to compensate the polarization state after long-distance transmission. It can control and compensate the polarization state influenced by the external environment, such as temperature and stress. In the chapter3, we apply the homemade compensator to the transmission experimentation. In this chapter, we analyze and compare the degree of polarization (DOP), ellipticity and direction states with/without using our homemade compensator. In chapter4, we detailed analyze the structure of our compensator. From the experimental result of chapter3, we find that the compensate results are limited by the transmission delay. Therefore, we utilize the basic measurement to find the key point that cause the serious transmission delay and improve it. In the last, we will test the improved result of our homemade compensator.