Athermal Wavelength Lockers using Fiber Bragg Gratings

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Abstract: Two types of athermal wavelength locker, which use a Fiber Bragg Grating and a Fiber Bragg Grating Etalon were demonstrated. Each type operates stably without thermal control as a single wavelength locker and a multi-channel wavelength locker, respectively. Thermal wavelength drift of laser diode was less than 25pm for FBG type and 40pm for FBG Etalon type in the temperature rang from -5˚C to 70˚C.

l INTRODUCTION

Precise and stable wavelength control of a laser diode (LD) is required in Wavelength Division Multiplexing (WDM) systems. Conventionally, wavelength lockers using a dielectric filter were used. However, for this type wavelength locker, a series of filters must be designed for each channel. And the polarization dependent loss (PDL) should be considered at the precise wavelength control. Recently, corresponding to the multi-channel operation, etalon type wavelength lockers have been developed. However, for this type of wavelength locker, a very precise Etalon gap alignment should be required. Recently, we reported a wavelength locker using a Fiber Bragg Grating (FBG)[1] where the wavelength was easily adjusted by controlling the tension on FBG. This paper presents two types of athermal wavelength lockers using a FBG and a FBG Etalon which were compactly assembled in a small casing.

2 PRlNCIPLE AND CONFIGURATION

Fig.1 shows the configuration of a wavelength locker using a FBG. The monitor light tapped by a 5/95 coupler is divided into two paths (PortA and PortB) by a Planer Lightwave Circuit (PLO coupler. The power ratio was 33:67 respectively. The fiber, in which the FBG was inscribed, was joined with an adhesive to the 67% port of the PLC. And PDS (PD_A, PD_B) were aligned to each port. The voltage difference between two PDs' outputs was used as a collect signal. Operating wavelength point (λop) is at the wavelength where transmission of the FBG is 500/0, where the voltage difference is zero.

The configuration of a wavelength locker using a FBG Etalon is the same as Fig. 1. A FBG Etalon was used instead of a FBG in this case.

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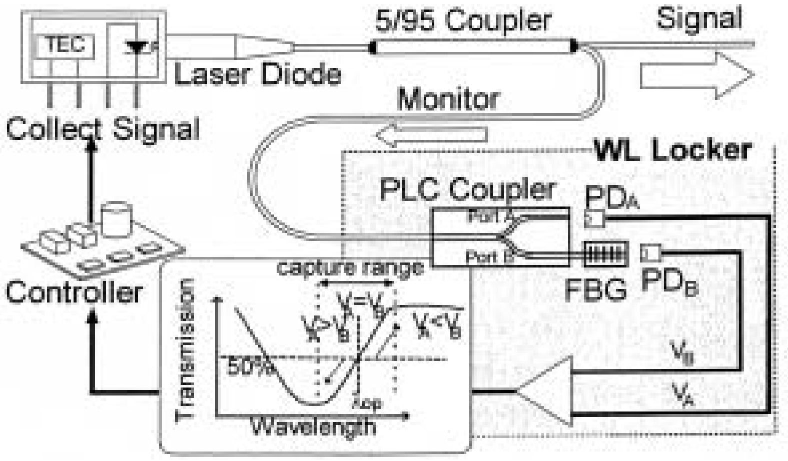

Figure1. Schematic diagram of a wavelength locker using a FBG

3 FABRICATION OF WAVELENGTH LOCKER

FBGs Were inscribed in H_2 Ioaded single mode fibers using a UV laser (Ar laser SHG at 244nm) by the phase mask method. The transmission slope ($\Delta T/\Delta\lambda$) , the capture range (showed in Fig. 1), and thermal wavelength deviations, and aging wavelength deviations of wavelength are important parameters. A transmission slope of 180 to 350 %/nm, and a capture range greater than 0.6nm(±0.3nm) are required for 100GHz WDM systems. And the thermal wavelength deviation less than 0.050nm is required in the operating temperature range from 0 to 70˚C for a 20-year life. The transmission slope and the capture range were controlled by the FBG Iength and chirp rate. Figure2 shows the rneasured transmission slope values as functions of the chirp rate of the phase mask and the FBG length.

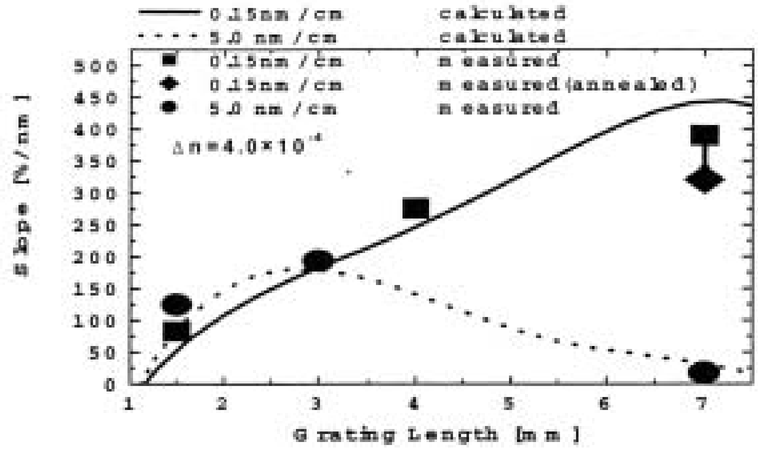

Figure2. Relation between the measured transmission slope and the chirp rate and the FBG length

FBGs were annealed at 150˚C for 10hours to avoid a wavelength shift induced by decay of the FBG (aging deviations). The residual shift after annealing was estimated less than 0.020nm for 20years[2]. The FBG was fixed on a negative expansion ceramic substrate (NECS, Nippon Electric Glass Co., Ltd. CTE=-82x10^{-7} [3]) using UV curable adhesive to adjust the wavelength and to avoid thermal drift. Fig.3- (a) shows the transmission spectrum of the FBG. Slope at λop was 320%/nm, and the capture range was 0.5nm.

The FBG Etalon in this work consisted of two chirped FBGs. Each FBG Length was 1mm and the gap between the FBGs was 1mm. The chirp rate of the phase mask was 10nm/cm. Fig. 3- (b) shows the transmission spectrum of the FBG Etalon. Wavelength spacing was 0.41nm. FBG Etalon fiber was stabilized and assembled by the same process as the single FBG fiber.

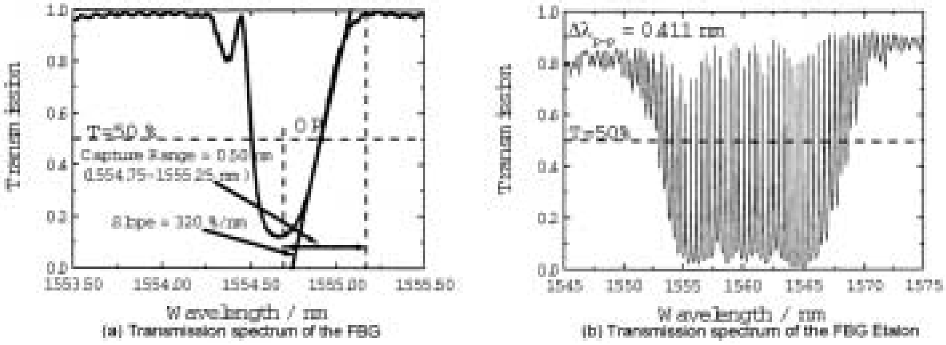

Figure3. Transmission spectrum of the wavelength locker [(a) FBG (b) FBG Etalon]

4 EVALUATION

The wavelength locker using a FBG was evaluated by connecting to a polarization controller and a programmable tunable LD. Fig.4 shows the deviation of λLD monitored with a wavelength meter while the temperature was changed between. -5˚C and 70˚C. Heating and cooling rate were 1.0˚C/min. Fig.4 shows that λLD Was well stabilized at the center wavelength of 1550.000nm within the range of 0.025nm(1554.989nm -1555.013nm). The thermal drift of λLD mainly results from that of the FBG fixed on NECS. Fig.4 shows hysteresis loops of about 0.010nm in wavelength. The hysteresis mainly induced by the hysteresis of thermal expansion of NECS. Fig. 5 shows a photograph of the casing of the compactly assembled wavelength locker. The size of the case was 60mm×20m×7.5mm.

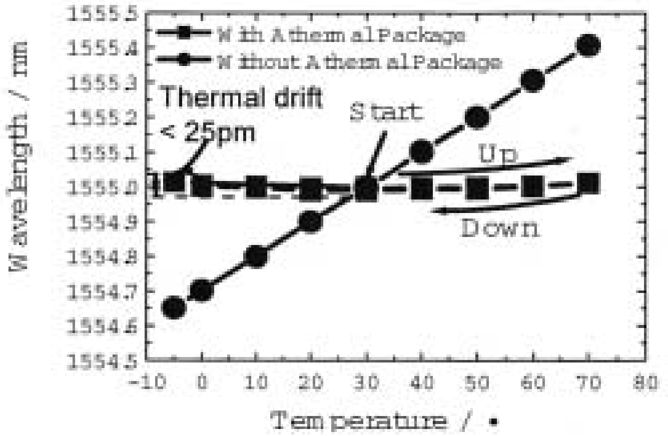

Figure4. Temperature dependency of the Wavelength locker using FBG

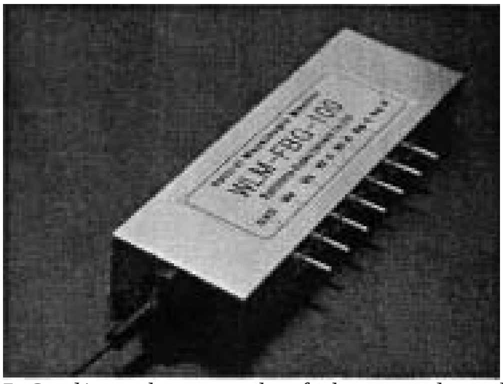

Figure. 5 Outline photograph of the wavelength locker

The wavelength locker using a FBG Etalon was evaluated by the same system. Fig.6- (a) shows one of the results of the temperature dependency. □$_{LD}$ Was well stabilized at the center wavelength of 1556.060nm within the range of 0.040nm(1556.022-1556.058nm). Fig.6- (b) shows the temperature dependency of the FBG Etalon for 4 channels. Each channel shows the same behavior. The maximum difference of the temperature dependency of the wavelength was 3pm. The wavelength locker using a FBG Etalon was also set up in the same casing as Fig.5.

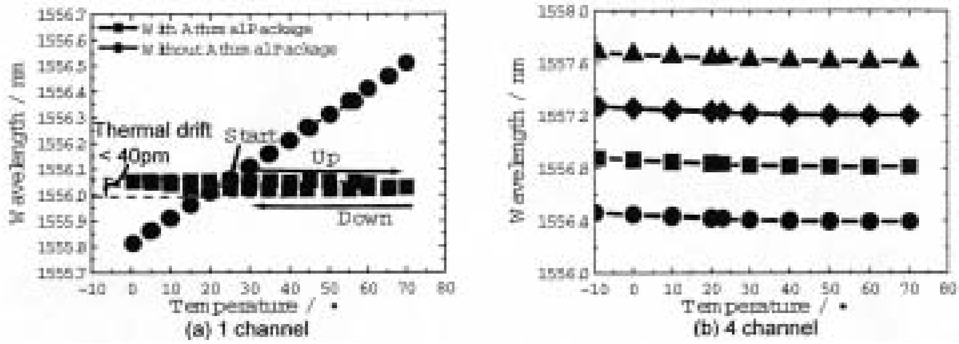

Figure. 6 Temperature dependency of the wavelength locker using FBG Etalon
[(a) 1 channel (b) 4 channel]

5 CONCLUS ION

Fabrication and evaluation of two types of athermal wavelength lockers using a FBG and a FBG Etalon were demonstrated. The thermal drift of the wavelength was small enough (0.025nm for FBG type, 0.040nm for FBG Etalon type) in the temperature range of -5 to 70°C. Each type operates stable without thermal control as a single wavelengih locker and a multi-charmel wavelength locker, respectively. Compared with the wavelength locker using a conventional dielectric filter or an etalon, these wavelength lockers using a FBG or a FBG Etalon have advantages of easy fabrication, and low assembling cost.

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