COMPUTER CONTROLLED TUNEABLE OPTICAL FILTER BASED ON A FIBRE BRAGG GRATING

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ABSTRACT

This paper describes the theory, design and implementation of an optical tuneable filter, controlled by LabView through an USB connection. The tuneable filter system is based on a piezoelectric actuator which works by compressing a fiber Bragg grating. A high-voltage amplifier was also developed for driving the actuator. The optical filter is suitable for channel demultiplexing within WDM systems.

1. Introduction

The center wavelength, $\lambda_B = 2\Lambda \cdot n_{eff}$, of a fiber Bragg grating (FBG), may be tuned through temperature variation (refractive index change) or mechanical strain (period change). With the later, broader tuning ranges are generally achieved. Taking into account the good stress and strain properties of silica fibers, and since silica is 23 times stronger under compression than under tension [1], compressive stresses have been preferentially selected to achieve large tuning ranges. The shift of the Bragg central wavelength peak, $\Delta\lambda_B$ as a result of stress application is described by $\Delta\lambda_B/\lambda_B = (1-p_e)\cdot\varepsilon_Z$,, where $\varepsilon_Z = \Delta L_Z/L_Z$ is the axial strain and p_e=0.22 is the photoelastic coefficient, which implies a negative contribution to the wavelength shift due to a change in the refraction index. In this paper a Bragg grating compressed by a piezoelectric transducer (PZT) with a response time in the order of milliseconds is described.

2. Device description

A special steel frame has been designed and realized to hold the FBG. The piezoelectric actuator is screwed within this frame and connected to a system of ceramic FC ferrules to accurately compress the fiber along its axis and prevent it from buckling. The FBG was glued between the ferrules with a total distance of approximately 2 cm.

A high voltage amplifier to drive the PZT was also developed. Since the PZT behaves like a pure capacitance (about 130 nF) to the driving amplifier, high currents are

necessary to charge and discharge it quickly. On the other hand they require high voltages (1000 V) in order to attain effective displacements. The amplifier has a single-ended topology and uses an operational amplifier connected in a negative feedback configuration. The USB communication is established between the PIC microprocessor and the computer running LabView. A unique and specific communication protocol was developed, integrating code error correction capabilities. The device also supports stand-alone operation, featuring an encoder, two press buttons and a LCD panel in the front panel. A diagram of the system is shown in Figure 1.

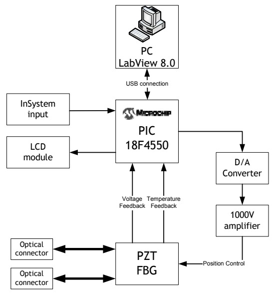

Fig 1 – General functioning diagram

3. Experiment

Before compression, the central Bragg wavelength was 1554.2 nm and the grating was 10 mm long. Figure 2 shows that the maximum negative shift was 3.3 nm. Minor spectral changes were observed during compression, with changes in the peak of reflectivity within 0.6 dB. Figure 2 shows the wavelength change with the applied PZT voltage.

The calibration procedure consists in spanning the full wavelength range before trying to reach the required value. This method gives very good repeatability (within 100 pm). LabView integrates the inverse function of the polynom depicted in figure 2, to allow the selection of the required channel (wavelength) in the computer.

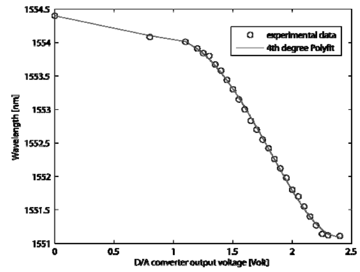

Fig 2 - Bragg grating wavelength shift versus control voltage, with calibration

4. Conclusions

An optical tuneable filter was proposed and demonstrated. The spectral characteristics of the architecture were presented. The operation of the device has been experimentally tested. The tuning range may be further improved by compressing a reduced length of the fiber through the use of ferrules with a smaller length.

REFERENCES

[1] G. A. Ball and W. W. Morey, "Compression-tuned single-frequency Bragg grating fiber laser" (1994) Opt. Lett., vol. 19, pp. 1979–1981, 1994.