An Integrated Fiber-optic White-light interferometry System based on VT-DBR Laser

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Introduction

In this paper, a cost-effective and high-precision optical fiber sensing system based on VT-DBR laser for white light interferometry is proposed. A low-noise, low power, high modulation-bandwidth laser driver with excellent long-term stability is described. This system has a broad sweep range (1527-1567nm)with a wavelength interval of 8 pm, and a full-spectrum scanning rate of 100 Hz.. Contrast observation of spectrum experiment with commercial optical sensing interrogator sm125 and temperature sensing experiments of FP sensor cavity length demodulation using cross-correlation algorithm was carried out to investigate the performance of the system. Experimental results show that the system is reliable and has superior performance. Benefiting from the self-developed and integrated essential electrical circuits, the whole system has small size, cost-effective and potential application value.

System Design And Construction

Figure 1 shows the schematic of the laser drive circuit. The control circuit consists of two main components: a temperature controller and five constant current drivers to drive the five zones of the VT-DBR laser. The maximum output current of the current driver is up to 300 mA, which is suitable for driving high power laser diodes. The temperature controller chip ADN8831 can provide a maximum current of 1.5A for the thermoelectric cooler (TEC). This is sufficient to drive almost all TEC models designed for distributed feedback lasers (DFB) and can be used as a temperature control module for VT-DBR lasers.

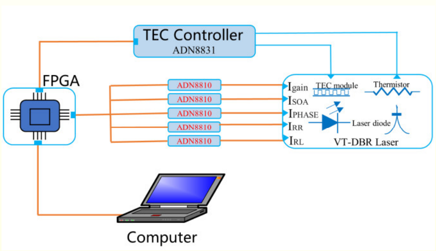

Fig. 1. Schematic of the VT-DBR laser control units

Experiment Setup

The optical fiber sensing system based on VT-DBR laser for FP sensors measurement system is described in Fig 2 below. The system consists of an self-developed interrogation system with a tunable laser. A fiber coupler, FP sensors, a temperature stove, and a personal computer. The self-developed interrogation system contains a monolithic VT-DBR laser diode, an Field Programmable Gate Array (FPGA) control system, constant current sources, a temperature controller based on the ADN8831, a photodiode (PD) and a analog data acquisition AD9226 modules, and a universal USB port. A look-up table (LUT) of the relationship between the laser wavelength and different current combinations is stored in an FPGA flash memory, which allows the wavelength to scan the entire spectrum from 1527 to 1568 nm with 8 nm spacing between each wavelength point. A coupler is passed from the VT-DBR and then split through the FP sensor 3-dB coupler from the FP sensor and preamplifier module. The analog-to-digital converter (ADC) converts the signal from the PD to a digital signal. The signal from the PD is converted into a digital signal and processed with a cross-correlation algorithmWhen the temperature of the heater changes, the cavity length of the FP sensor changes, the spectrum shifts, and the cross-correlation algorithm calculates the amount of cavity length change.

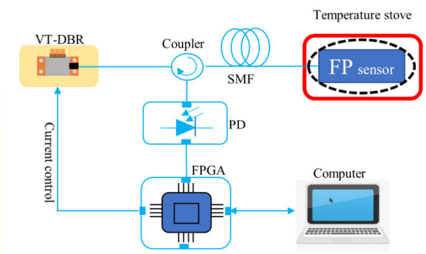

Fig. 2. Schematic diagram of EFPI sensing system

Results and Disscussion

In order to verify the self-developed white-light interferometry system, the FP sensor based on a section of a hollow capillary tube spliced between two pieces of a single mode fiber (SMF-28) with total cavity length of approximately 132μm was fabricated. and the interferometric spectra were collected using the sm125 optical sensing interrogator(provided by Micron Optics) and the self-developed WLI system.

Figure 3 shows the comparison of the interferometric spectra collected by the two systems with the external 132μm FP optical fiber sensor. From the fig, it can be seen that the spectrums collected by the two systems have an almost perfect overlap, which indicates that the self-developed WLI system has certain reliability and can collect the correct spectral information. Temperature sensing experiments were carried out using self-developed WLI system and a FP fiber-optic sensor. The temperature was slowly increased from 25℃ to 150℃ and then decreased throughout the experiments. The results of the FP sensor is shown in Figure 4, where the temperature was the abscissa, with the cavity length value regarded as the ordinate. The temperature sensitivity coefficient of the sensor is about 0.62 nm/℃.

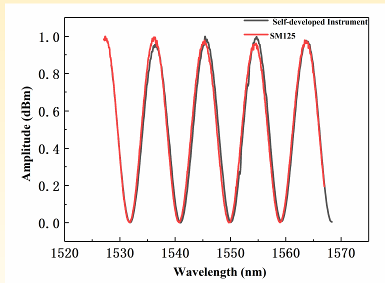

Fig. 3. The sensor interference spectrum collected by two systems.

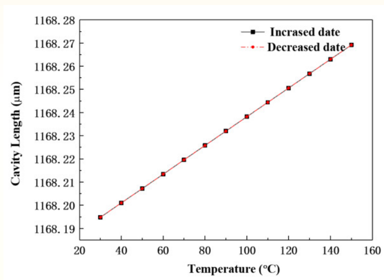

Fig. 4. Cavity length-temperature variation curve of EFPI sensor.

Conclusions

In conclusion, we have developed a low-cost optical fiber sensing system based on VT-DBR laser for WLI. The laser controller is designed as a combination of current driver and temperature controller. Contrast observation of spectrum, temperature sensing experiment show that the self-developed system has excellent performance in practical applications. In addition, the system is simple and very cost-effective.