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Multi-Wavelength Lasing with SOA and AWG for Linear-Cavity Fiber Sensor

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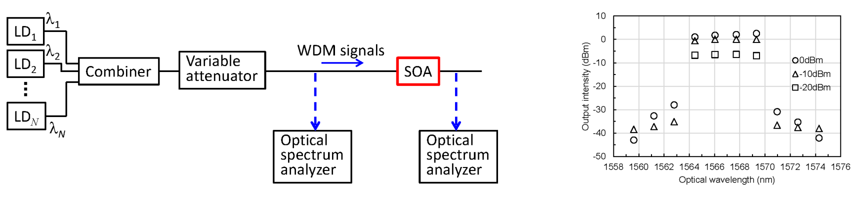
Optical fiber sensing has been extensively studied in various areas such as aging deterioration measurement of constructed building, seismic measurement, environmental measurement. Optical fiber sensing systems are classified into two configurations. One consists of an optical source, an optical fiber transmission line, and sensing elements. The other consists of a fiber lasing system including sensing element in the cavity [1-3]. Compared to the former, the latter systems have advantages such as higher resolution for wavelength-shift induced by sensing element, and higher signal-to-noise ratio (SNR). By employing a fiber Bragg grating (FBG) as the sensing element, reflecting center wavelength can be shifted due to environmental temperature or tension.

We propose multi-wavelength sensing system consisting of multiple FBG elements and an arrayed waveguide grating (AWG). In fiber lasing systems, erbium-doped fiber amplifier (EDFA), Raman amplifier, and semiconductor optical amplifier (SOA) have been employed as the gain component. We consider multi-wavelength simultaneous lasing to sense multiple points. When the EDFA is employed in the system, the homogeneous broadening of erbium ions limits the number of lasing wavelengths. On the contrary, the SOA shows the inhomogeneous broadening properties, which makes it possible to oscillate at multiple wavelengths.

The proposed fiber sensing system consists of multiple linear cavities lasing at different wavelengths as shown in Fig.1(a). The SOA placed in the linear-cavity amplifies multi-wavelength signals propagating in both directions. The AWG plays a role as multi-/demultiplexer. The passband filtering response of the AWG is schematically illustrated in (b). Since the FBG reflection frequency depends on the environment, an environmental change results in wavelength-shift of the lasing wavelength.



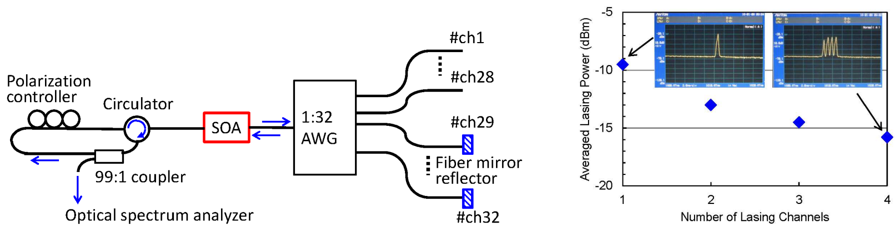
(a) **(b)**

Fig. 2 Multi-wavelength amplification;(a) the experimental set up and (b) a measured result.

Fig.1 (a) Linear-cavity multi-channel fiber sensing system and (b) lasing spectrum with AWG filtering characteristics.

We consider optical lasing at multiple wavelengths. The number of wavelength channels is limited by amplifiable wavelength range and by optical nonlinearity in the SOA. The nonlinearities in multi-channel amplification were experimentally verified with a SOA (Inphenix, IPSAD1502-214) using an experimental setup shown in Fig. 2(a). We demonstrated four-channel simultaneous amplification. The output intensities including four-wave-mixing (FWM) signals are shown in (b).

Next, we demonstrated multi-wavelength lasing with a linear cavity optical system shown in Fig.3(a). The cavity consists of the SOA, an AWG, fiber mirror reflectors at the end of the four demultiplexed channels (from channel #29 to #32), and a fiber loop mirror consisting of a circulator and a polarization controller. A 99:1 optical directional coupler is employed to measure the optical signal in the fiber loop mirror. The AWG has channel interval of 100 GHz with the insertion loss of 4.01 to 4.53 dB with 20 dB pass-bandwidth of 1.14 nm. The measured optical spectrum for the four-channel lasing is shown in (b). Although a pass-band wavelength of #30 is 1559.0 nm, the lasing was observed at 1609.8 nm due to cyclic nature of the AWG. By employing an optical band-pass filter in the linear-cavity, the lasing wavelength can be changed to 1559.0nm.



(a) **(b)**

Fig. 3. Multi-wavelength lasing; (a) the experimental set up and (b) a measured result.

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