Amplifier Assisted CRDS (Cavity Ring-down Spectroscopy) toward Compact Breath Sensing

I-EggS (Interdisciplinary Graduate School of Engineering Sciences), Kyushu Univ.,
Wenying Li ○, Yu Han, Zanhui Chen, Haisong Jiang, and Kiichi Hamamoto
Email: ri.uenin.271@s.kyushu-u.ac.jp

1. Introduction

Breath sensing using cavity ring-down spectroscopy (CRDS) method is attractive due to its real time sensing in addition to the capability of high sensitivity [1]. Using waveguide for sensing realizes several meters' optical path integration that needs for measuring ppm-order components in human breath into a compact area [2]. One issue is the propagation loss of the waveguide as it may prevent ppm-order gas detection. To compensate this loss, we have already proposed optical amplifier assisted gas sensing system [3] scheme. The amplifier in CRDS system, however, may result in self-lasing at specific wavelength in case of high pumping condition. Once self-lasing happens, signal light loose the gain from amplifier. In this work, we propose the scheme of polarization direction control so as to prevent the self-lasing. As a result, the gain improvement of 24 dB has been successfully confirmed.

2. Self-lasing issue in amplifier assisted CRDS system

The amplifier assisted CRDS system we use is shown in Fig. 1 (a). Two couplers and sensing-waveguide [4] form sensing "cavity". Couplers work like mirrors to reflect signal light back into the cavity except 10% monitor-light leak out via the 90: 10 coupler. In this system, we used an EDFA (Erbium-doped fiber amplifier) as an optical amplifier to compensate the propagation loss of the waveguide. An EDFA inside a closed ring loop, however, may form the structure of fiber ring laser, self-lasing happens at a specific wavelength in case of high pumping condition. Figure 1 (b) shows an example of this self-lasing. 1572 nm wavelength (Absorption wavelength of CO_2) light is introduced into the CRDS system, however, another wavelength of 1564 nm starts lasing. Once self-lasing happens, signal light lose its gain while most of the gain is consumed at self-lasing wavelength.

To suspend this self-lasing, we propose the scheme of polarization direction control. The configuration is shown in Fig. 2 (b). 1/2 wave plate is used to rotate the polarization direction of the lasing light 90° from the polarizer direction. The lasing light is suspended by polarizer when it loops back, because its polarization direction has 90° difference from the initial polarization.

3. Results and Discussion

A three stage polarization controller with a polarizer, a 1/4 wave plate and a 1/2 wave plate was used in the experiment, and all the fibers that used in experiment were polarization maintaining fiber. The lasing light generated by EDFA propagates through the polarizer, and only one polarization direction is left. Then we adjusted the fast axis of 1/2 wave plate to make it turn 45° from the polarizer direction. When ASE propagate through the half wave plate, its polarization direction changes 90°. Figure 2 (b) shows the spectrum after polarization direction control. It illustrates that the self-lasing power is suppressed to be below -50 dBm. We estimate that a gain of 24 dB is improved. Figure 3 shows the cavity ring-down waveform after the polarization direction control. As is shown in the figure, more than 200 pulses is achieved, which corresponds to the possibility of 10 ppm-order CH_4 detection.

4. Conclusions

We introduced the scheme of polarization direction control to suspend self-lasing in amplifier assisted CRDS system. As a result, we confirmed the light intensity of self-lasing wavelength was suppressed down below -50 dBm and the gain improved 24 dB at signal.

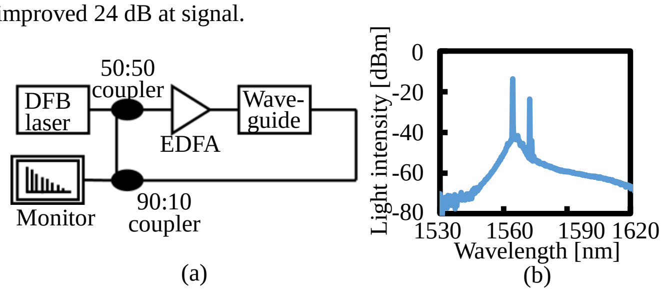

Fig. 1 (a) Amplifier assisted CRDS system configuration. (b) Spectrum of amplifier assisted CRDS system.

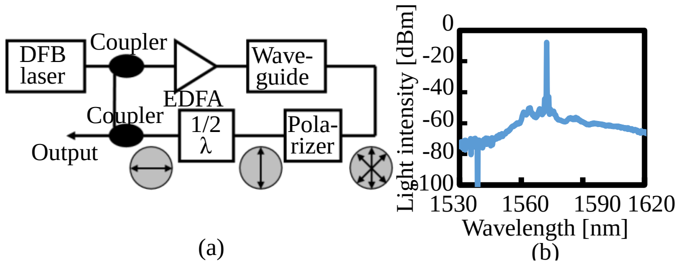

Fig. 2 (a) Configuration of polarization direction control in amplifier assisted CRDS system. (b) Spectrum of polarization direction controlled CRDS system.

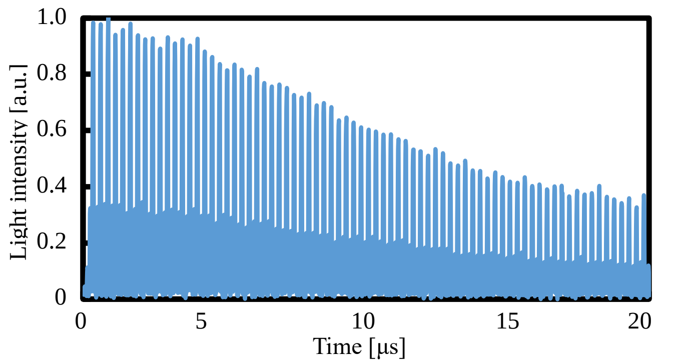

Fig. 3. Cavity ring-down waveform after polarization direction control.

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