テーパファイバを用いたファイバループリングダウンガス分光

Fiber Loop Ring-Down with Tapered Fiber for Gas Sensing

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Fiber loop ring down (FLRD) has the advantage of compact, stable, and economical properties [1]. With the help of interaction between the evanescent field and the materials, such as gas, liquid and small particles [2], we can use tapered fiber as the sensor, matching perfectly with the fiber loop system. In this paper, we demonstrated an FLRD system to successfully detect the absorption of acetylene (C_2H_2, 1010PPM, 1013.25 mbar, 293K) at the wavelength of 1558.7nm.

Figure 1 shows the experimental set-up of the system. Figure 2 shows an example of the photodiode detector output with an exponentially decaying signals caused by the absorption of the gas sample. To estimate the gas concentration, the time taken for the intensity to decay to 1/e of the initial light intensity (the ring-down time) is required. The gas concentration is estimated by calculating the change of ring-down time from without gas to with gas. The ring-down time would be shorter with the presence of the gas in the cavity, if the wavelength is matched to one of the absorption lines of the gas. Figure 3 plots the ring-down results with and without C_2H_2 in the system. The ring-down time is calculated to 41.53μs and 32.18 μs, respectively, which confirmed the system's feasibility for C_2H_2 detection. To study the accuracy of the sensing results, we investigated two curve fitting algorithms. In Fig. 4, show the comparison of two curve fitting algorithms: (1) weighted least square (WLS), (2) Levenberg-Marquardt (LW). It is clear that the LM algorithm has a better performance with a sensing accuracy of 84.7%, compared to an accuracy of 63.2% using the WLS. As a result, the sensing accuracy has been improved by 21.5%。

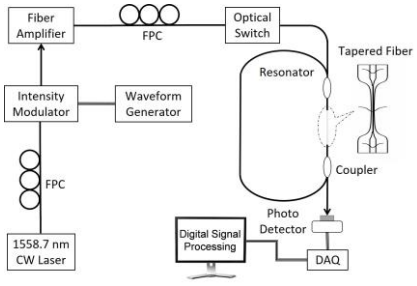

Fig. 1 Experimental diagram

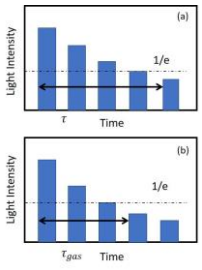

Fig. 2 Example output signal result
(a) without gas (b) with gas

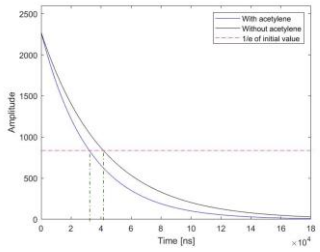

Fig. 3 Fitting curves of the sensing data without C_2H_2 and with C_2H_2

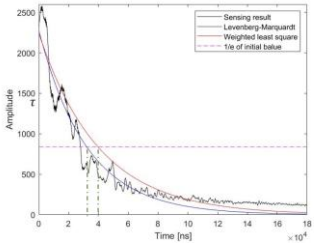

Fig. 4 Fitting curves of WLS method and LM

[1] Gagliardi, Gianluca, and Hans-Peter Loock, eds. Cavity-enhanced spectroscopy and sensing. Berlin, Germany Springer, 2014.

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