Carbon dioxide detection system based on TDLAS technology

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Introduction

With the rapid development of social industrialization, environmental problems are becoming increasingly serious. Reducing emission pollution and protecting the environment is the top priority. Among them, the greenhouse effect has a greater impact on the environment, which will lead to a variety of ecological and environmental problems and threaten the survival and development of human beings. Therefore, the effective monitoring of carbon dioxide (CO_2) in the environment is of great significance. In recent decades, due to the increase of issues in global environment, ecology and energy sources, laser-based gas detection technology has attracted more and more attention. Tunable semiconductor laser absorption spectroscopy (TDLAS) is the cutting-edge technology in recent decades. It is based on the principle of gas infrared absorption. The output wavelength of semiconductor laser is tuned by changing the current and temperature. A certain absorption line of the measured material is scanned, and the concentration of the measured material is obtained by detecting the absorption intensity of the absorption spectrum. This technology has the advantages of rapid response, high sensitivity, simple system and non-contact measurement.

Gas detection technology of TDLAS

1.principle

For TDLAS technology, when a laser beam passes through the gas to be measured, the beam will be partially absorbed by the gas and then result in the weakening of light intensity. Through the analysis of the gas spectral information obtained, the concentration value of the corresponding gas can be calculated, which is Lambert-Beer law. The equation is as follows:

$$I_t = I_0 exp[-S(T)CPL\varphi(v)]$$

2.rencent progress

Based on the high absorption rate of CO_2 at 4.26 μm, Hartmann·R. et al. developed a short-range (10-20 cm) sensor probe suitable for commercial respiratory tube in 2014. The minimum detection concentration resolution can be as low as 300 ppmv. The design is shown in Fig. 1.

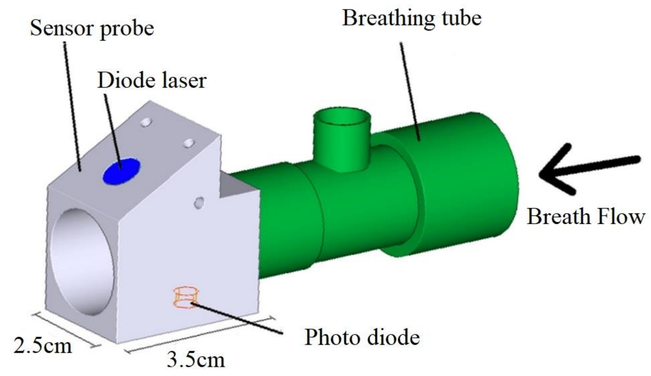

Figure 1: Simulated Fresnel Tail skews, then obliterates, the damage reflection at larger durations

In 2019, Lou Cunguang and others designed a spectroscopic detection system for the accurate monitoring of CO_2 in exhaled breath gas. The system adopts the TDLAS technology. The vertical-cavity surface-emitting laser (VCSEL) is combined with the multi-pass cell with effective optical path of 20 m. Experiments showed that exhaled CO_2 increased significantly with increasing exercise. The experimental schematic drawings and results are shown in Fig. 2 and Fig. 3.

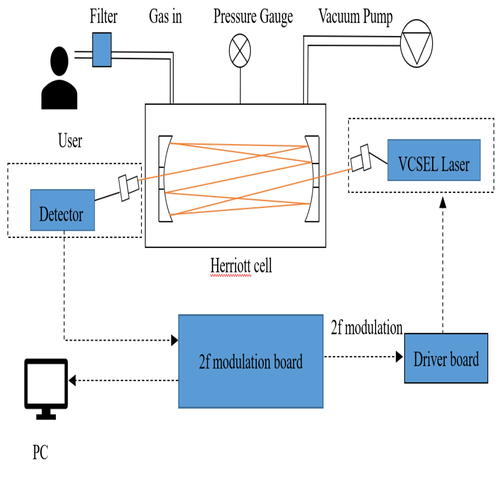

Figure 2: Experimental schematic drawings of Near Infrared Tunable Diode Laser Absorption Spectrometry for the Determination of Carbon Dioxide in Human Exhalation.

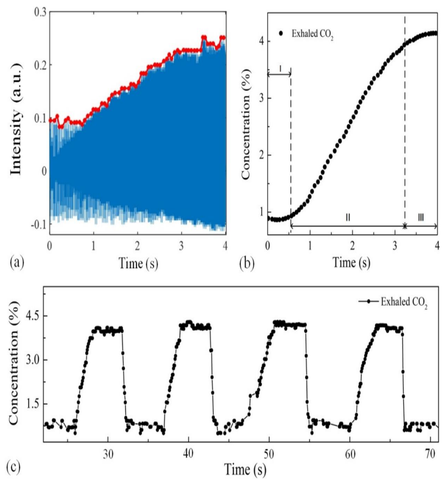

Figure 3: (a)-(c)Results of the experiment.

System of CO2 Gas Detection

According to the key technology of TDLAS detecting gas concentration described above, the schematic of detecting CO_2 concentration is shown in Fig. 4.

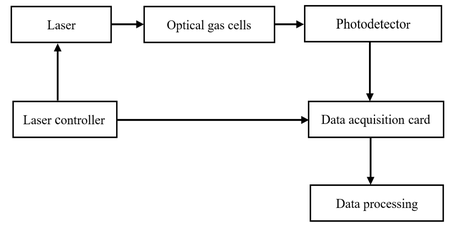

Figure 4: Schematic of detecting CO_2 concentration.

The whole system is mainly composed of light source system, optical gas cells, signal receiving and processing system. Light source system is mainly used to emit specific wavelength laser After the laser passes through the optical gas cells, the attenuated signal absorbed by the gas enters the signal receiving and processing system. Then the photodetector converts the attenuated optical signal into an electrical signal. Then the electrical signal is converted into digital signal by data acquisition card.

Conclusion

TDLAS technology has high sensitivity and reliability for gas detection. Moreover, it can realize real-time online detection. In the detection of trace gases, it has a good application prospect.

Reference

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