# A near-infrared gas sensor system based on tunable laser absorption spectroscopy and its application in $CH_4/C_2H_2$ detection

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RICE

## Introduction

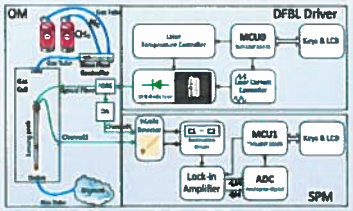
$CH_4$
- flammable in coal mines
- harmful to one's health

$C_2H_2$
- an inflammable and explosive gas

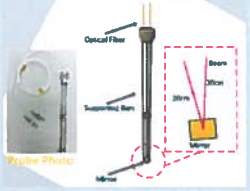
infrared absorption spectroscopy

high detection precision, good selectivity, fast response, non-contact measurement and long life

## Structure of detection system




Configuration of the near-infrared detection system, which includes three sections, DFBL driver, SPM and OM.



Structure and photo of the open reflective gas sensing probe

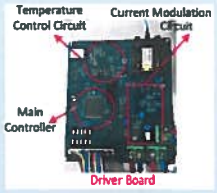



photo of the driver board

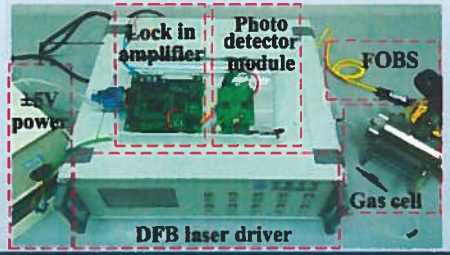
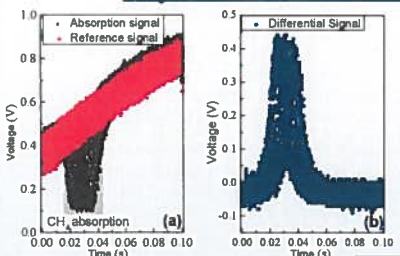
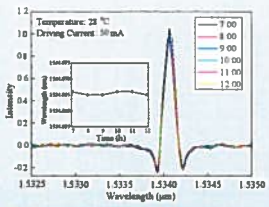



Photo of the detection system under measurement

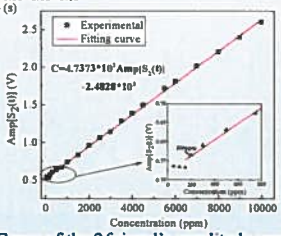
## Experiments and Rusults



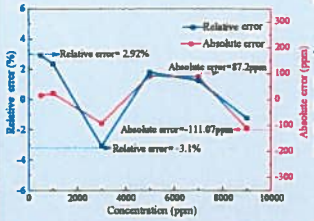

Measured waveforms of (a) absorption and reference signals and (b) differential signal, where the $CH_4$ concentration is $10^5$ ppm in experiment.



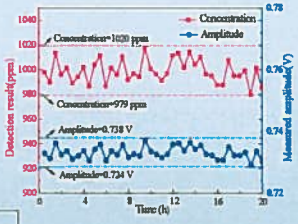

Stability of the emitting peak wavelength. The inset shows the emitting peak wavelength measured from 7:00 to 12:00.



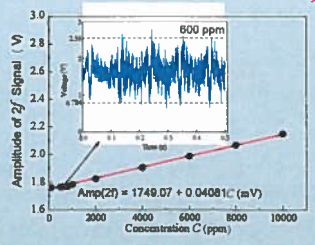

Curve of the 2*f* signal's amplitude versus $C_2H_2$ concentration. The inset shows the measured results of the amplitude of 2*f* signal versus $C_2H_2$ concentration within the range of 0 – 800 ppm.



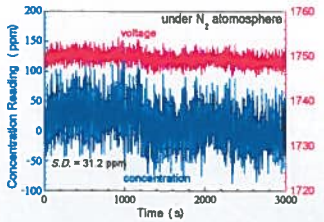

The absolute error and relative error of the detection system on six standard $C_2H_2$ samples with concentrations of 500, 1000, 3000, 5000, 7000 and 9000 ppm.



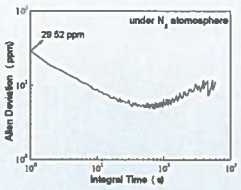

Long-term monitoring on the prepared standard 1000 ppm $C_2H_2$ sample. The red line represents the measured concentration, and the blue line represents the measured 2*f* signal's amplitude.



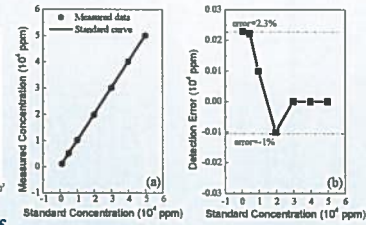

Within the low detection concentration range of 0~$10^4$ ppm, the measured amplitude of 2*f* signal. The inset shows the 2*f* harmonic signal under the $CH_4$ concentration of 600 ppm




The amplitude of the 2*f* signal and concentration variation under $N_2$ atomosphere for a period of 3000 s




The Allan deviation curve of the $CH_4$ detection system.




(a) Measured concentrations as well as standard concentrations and (b) relative detection errors on 8 prepared $CH_4$ samples.

## Summary

A near-infrared (NIR) dual-channel differential gas sensor system was experimentally demonstrated. As an application, a DFB laser with an emission wavelength of 1.65 μm and another one with an emission wavelength of 1.53 μm were used to detect CH4 and C2H2, respectively. The limit of detection on $CH_4$ was determined to be 29.52 ppm based on the Allan deviation with an averaging time of 1 s, and the relative detection error on $C_2H_2$ is < 5% within the concentration range of 200-10,000 ppm. The sensor system will be useful in industrial trace gas monitoring due to the use of low-loss optical fiber and the open-reflective gas-sensing probe.

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