# The NDIR CO2 Sensor Implementation and Temperature Compensation

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**Abstract.** Recently, the CO2 sensor is used in various fields like industry, agriculture, firefighting, air quality system, and so on. The contact type CO2 sensors have been used extensively because of a very low energy consumption and small size. However, they have a negative side such as short lifetime and poor gas selectivity. On the other hand NDIR CO2 sensors have a long lifetime and good gas selectivity. In this paper, we study about NDIR CO2 sensor temperature compensation and comparison of reflector materials chrome and gold by practical implementation.

## Introduction

Recently, carbon dioxide (CO2) monitoring is very important issue of the society at large, because CO2 is affect global warming and air quality problem[1]. And it could be used for fire detection, cultivation under structure, and so on. Under these circumstances, CO2 monitoring has used NDIR(Non-dispersive Infrared) gas sensors and contact type gas sensors such as semiconductor and solid electrolyte. The contact type gas sensors have the merit of low power and small size, but their short lifetime, poor gas selectivity and temperature dependence are a serious impediment to keeping performance[2]. On the other hand, NDIR gas sensors have good gas selectivity and long lifetime, and therefore these are appropriate for real-time or longtime operating. So NDIR sensors are the only practical way to ensure the stable performance of the CO2 monitoring[3, 4].

The NDIR sensors use the physical sensing principle based on the infrared spectrum absorption method. Since the NDIR sensors exploit the large absorption of CO2 molecules in the infrared wavelength of $4.26\mu$ m, the gas selectivity is excellent[5, 6].

In this work, we implement the NDIR CO2 gas sensor and study the issues of practical application. An issue accompanied with the temperature dependence on practical application. So we research the effective temperature compensation method. The other issue is optical chamber, and therefore we compare and analyze the detecting performance in the conventional optical chambers covered with gold plating and chrome plating[7, 8].

## The NDIR CO2 Sensor Implementation

In this paper, we use IR emitter EMIR200 and IR detector LHI 807 with optical filter G2. Optical filter G2 have the wavelength of $4.26\mu$ m which is effective for CO2 detecting as shown as Fig 1. We design the low power driving voltage circuit for IR emitter and the noise filter for IR detector. NDIR sensor circuit has been designed using 32bit ARM Cortex and ZigBee module for wireless data transmission. The conventional optical chambers covered with gold plating and chrome have been designed and implemented like Fig. 2 (a) chrome plating and (b) gold plating.

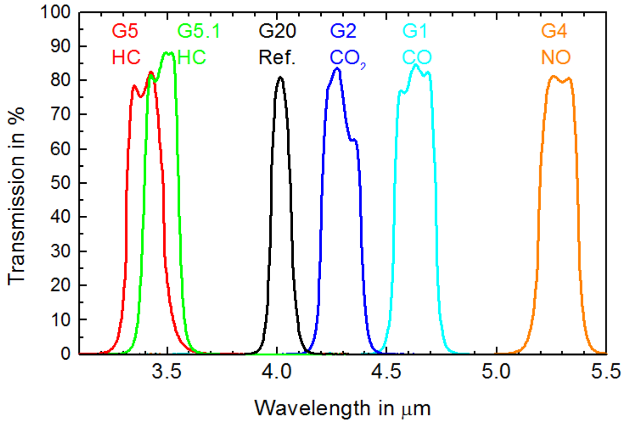
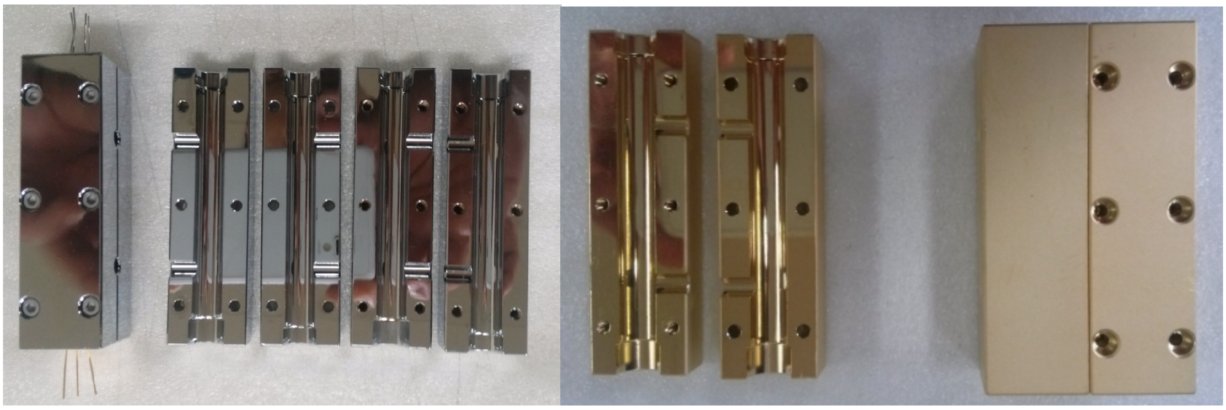


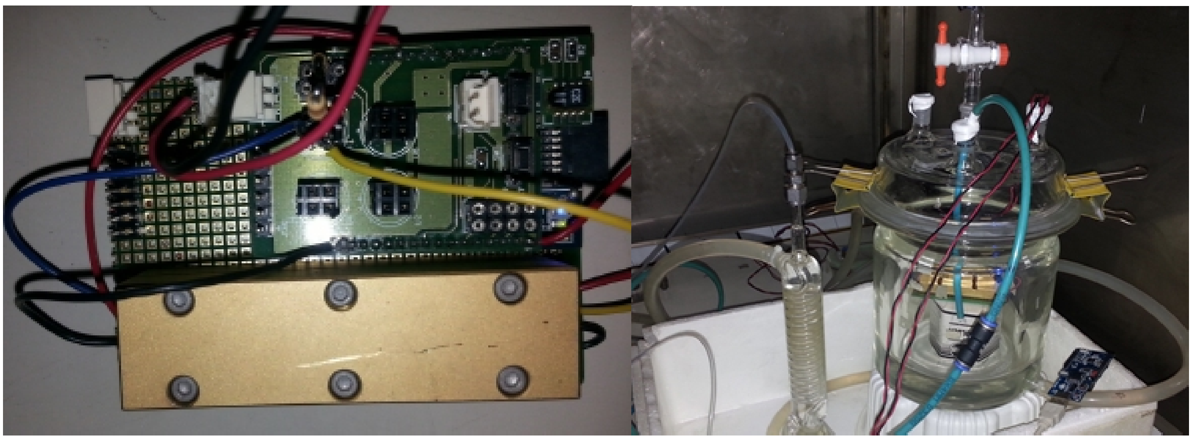

Fig. 1 The wavelength of optical filter used from Perkins Inc. database[9]



(a) (b)

Fig. 2 The implemented optical chamber (a) chrome plating (b) gold plating

The implemented NDIR CO2 sensor is shown as Fig. 3 (a), and test in glass chamber like Fig3 (b).



(a) (b)

Fig. 3 (a) The implemented NDIR CO2 sensor, (b) The experiment in glass chamber

**The temperature compensation**

The temperature compensation method has been used BP-MLP neural network with structure like Fig 4. The input layer consist of the sampling data $S_1$ from IR detector and the temperature $S_2$. The hidden layer is determined by heuristic method increasing the dimension of input pattern, and search the compensated CO2 concentration estimation result comparing the result of learning process.

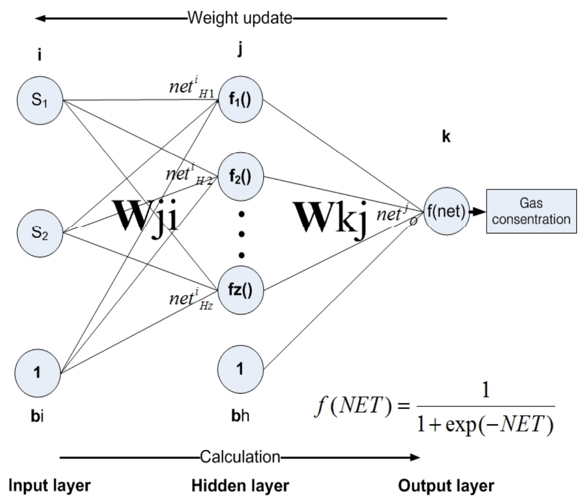



Fig. 4 The structure of BP-MLP neural network

## Experiment and discussion

We acquire the detecting data from the experiment process in Fig. 6 and the experiment is iterated 10 times. One of the detecting data has the deviation in same concentration level as shown in Fig. 6.

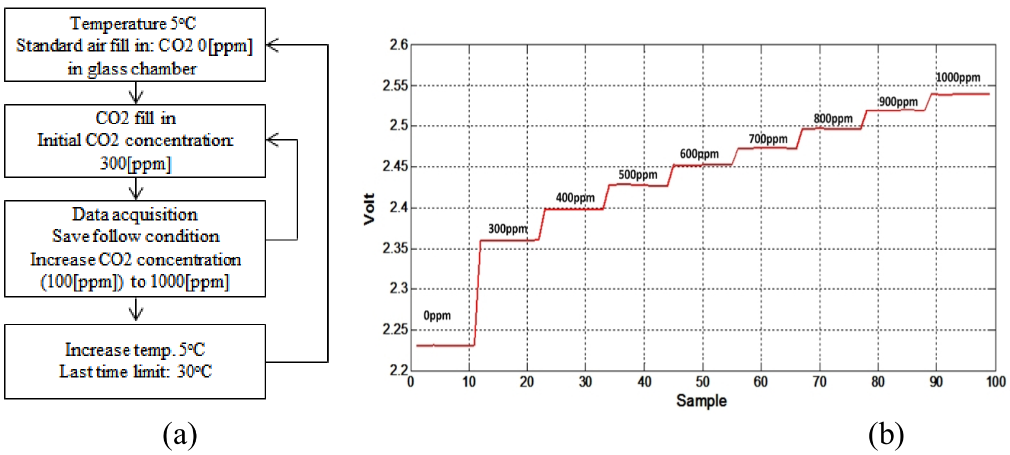



Fig. 6 (a) The experiment process, (b) The output sample data of IR detector (Gold plating chamber, temperature 20°)

Table 1 The comparison of results

| CO2 concentration [ppm] | Gold plating | | Chrome plating | |
|---|---|---|---|---|
| | Sensor output deviation | Compensation deviation | Sensor output deviation | Compensation deviation |
| 300 | 19.1 | 8.2 | 20.1 | 8.9 |
| 400 | 19.8 | 8.1 | 21.8 | 8.8 |
| 500 | 20.1 | 9.1 | 24.1 | 8.9 |
| 600 | 21.9 | 8.9 | 27.9 | 9.2 |
| 700 | 21.8 | 8.7 | 29.1 | 9.3 |
| 800 | 22.6 | 8.7 | 32.1 | 9.8 |
| 900 | 29.8 | 9.1 | 38.7 | 10.1. |
| 1000 | 30.1 | 9.0 | 39.1 | 10.8 |

To analyze the performance, we compare the deviation of estimated concentration values among four cases using two types of optical chambers and temperature compensation or not. The sensor output data is based on Beer-Lambert theory, and the temperature compensation concentration estimation is applied BP-MLP neural network algorithm[10]. The temperature compensation improves the performance decreasing the deviation 50%~70% in Table 1. The gold plating optical chamber and temperature compensation results are better than the others.

## Conclusions

In this paper, we implemented NDIR CO2 sensor and suggested temperature compensation method using BP-MLP neural network. The performance of proposed system was evaluated by the comparison of reflector materials chrome and gold by practical implementation, and the comparison of the temperature compensation before and after. We evaluated that the gold plating optical chamber and temperature compensation results were better than the others.

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