Low-power & Inexpensive Carbon Dioxide Sensors

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Overview

- CO_2 applications
- Aims of the study
- Sensor fabrication
- Experimental results
- Conclusions
- Further Work

CO_2 application areas

- Automotive
- CO_2 capture & storage
- Boilers
- Indoor air quality monitoring
- Ventilation control
- Farming & greenhouse
- Medical Diagnostics

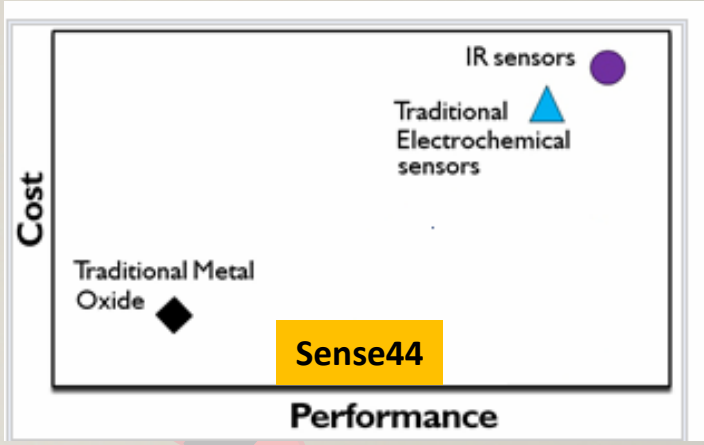
CO_2 sensor technology: State of the Art

Infra-Red (IR) sensors offer high performance but at relatively high cost.

Electrochemical (EC) sensors are moderately priced, offering reliable performance except for CO_2

Metal oxide (MOX) sensors are low cost, small footprint, broad service conditions, easily manufactured in high volume but

- have a high power consumption due to a high temperature of operation (~ 350–500°C)
- have typically poor selectivity to target gas



Approach

Develop MOX materials (in particular structural forms) which are sensitive & selective to CO_2 at low operating temperatures

Additional Benefit

A sufficiently low-operating temperature opens the door to **integration onto a silicon chip**, with the entire sensor drive and signal processing functions (and heater circuitry) embedded in the chip, i.e. a single component device.

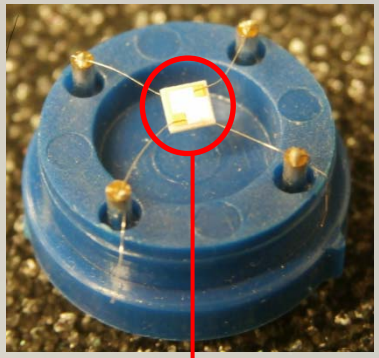
Aims of Study

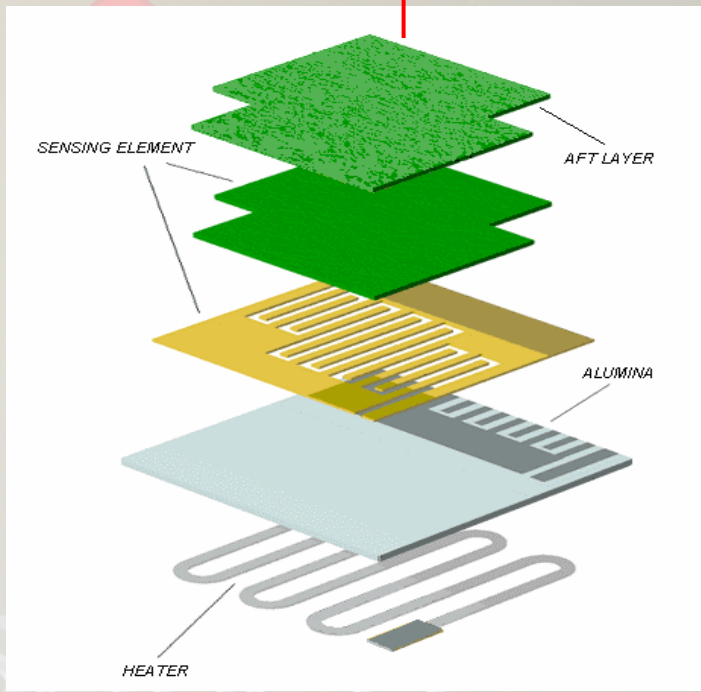
- Identify a class of gas sensitive materials for carbon dioxide sensing
- Demonstrate sensitivity and reliability
- Achieve low power operation (enabling compatibility with a silicon platform.

Metal Oxide Sensors

- Fabricate sensors using these materials as the gas sensitive layer
- Used a traditional thick film platform for these studies
- Thermal analysis is used to guide conditioning and operation

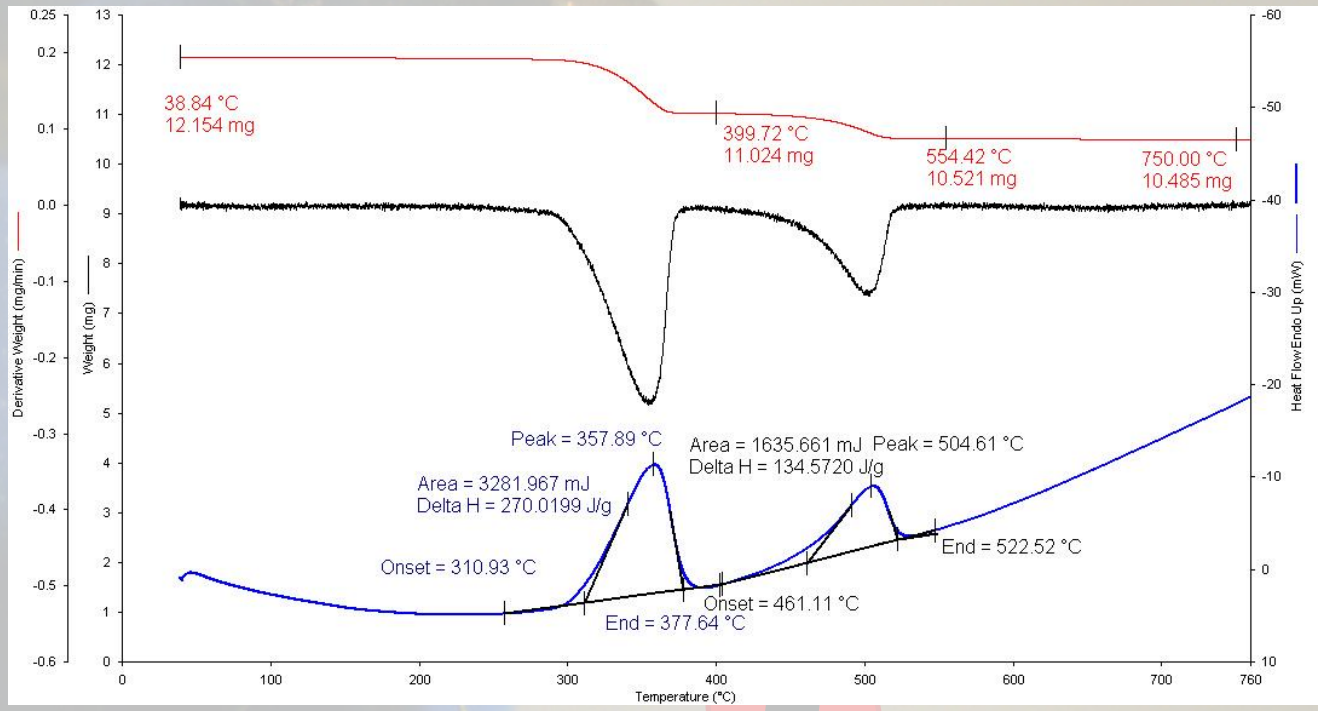
Sense44 gas sensor





Layout of sensor chip

Thermal analysis



- Thermal analysis is an important tool in study
- The desired material structure forms in a narrow temperature range

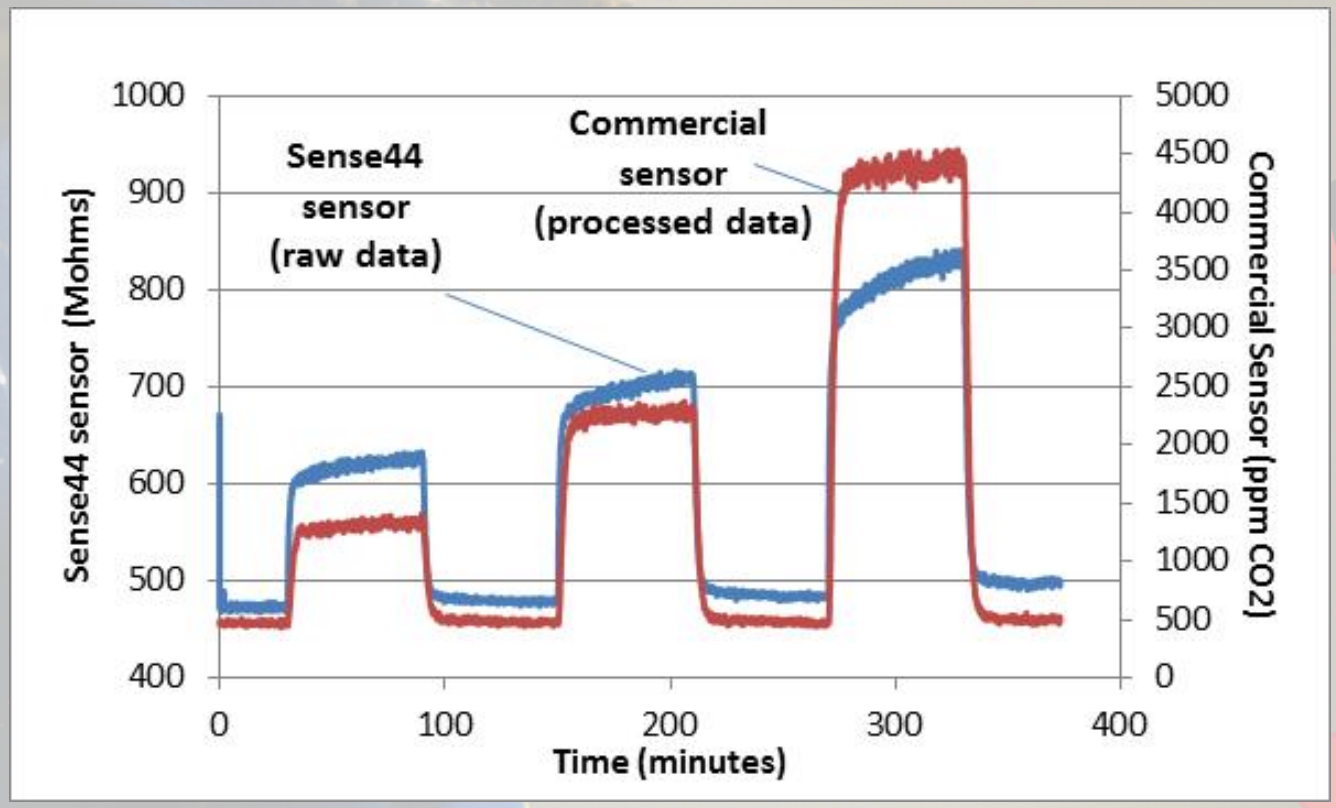
Testing to CO_2

Two concentration ranges

1. Ambient to 2000ppm (low range)
2. 1% to 5% (high range)

Long term testing in **low range** with operating temperature at 400oC, to test the structure and stability of the material.

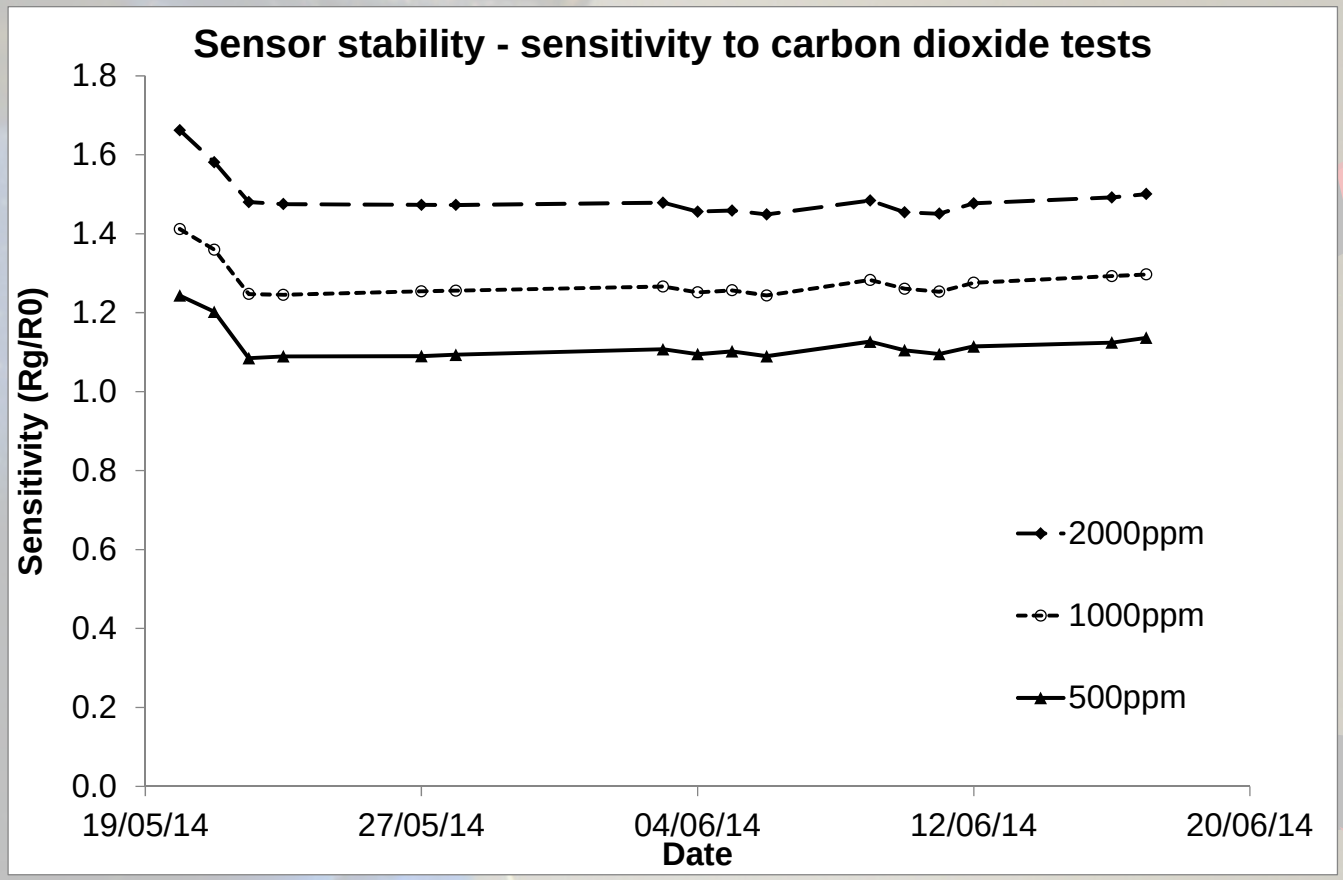
Response to CO_2 (low range)



Performance of Sense44 sensor vs high-cost commercial sensor

- 4 sensors plus an IR sensor included in the test rig for comparison.

Sensitivity & Stability



- Stable sensors running for ~1month
- No evidence of cross-sensitivity to humidity

Higher range CO_2

- Initial tests at 400°C
- Tested the sensors to 1, 3 and 5% CO_2

CO_2	1%	3%
Sensitivity	1.85	2.02

Reduced operating temperature

- Characterization done at 400°C
- Lowering operating temperature increases sensitivity
- At 275°C, sensitivity is 2.7x higher than at 400°C:

CO_2 (ppm)	2000
Sensitivity	3.98

- But lowering operating temperature increases resisitivity

Conclusions

- Demonstrated that a class of material with a particular microstructure is sensitive and selective to CO_2
- Stable sensitivities are observed for over a month at 400°C – testing ongoing
- Low-operating temperatures of 275°C demonstrated

Future work

- A number of customers lined up for more extensive factory trials
- More stress testing will be carried
- Other materials within this class of materials will be characterized
- Materials will be tested on silicon micro-hotplate platforms to reduce power consumption to < 10mW.


Thank you for your kind attention
Sense44