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Novel Packaging Approach for Enhanced Performance Gas Sensor on multiple lines

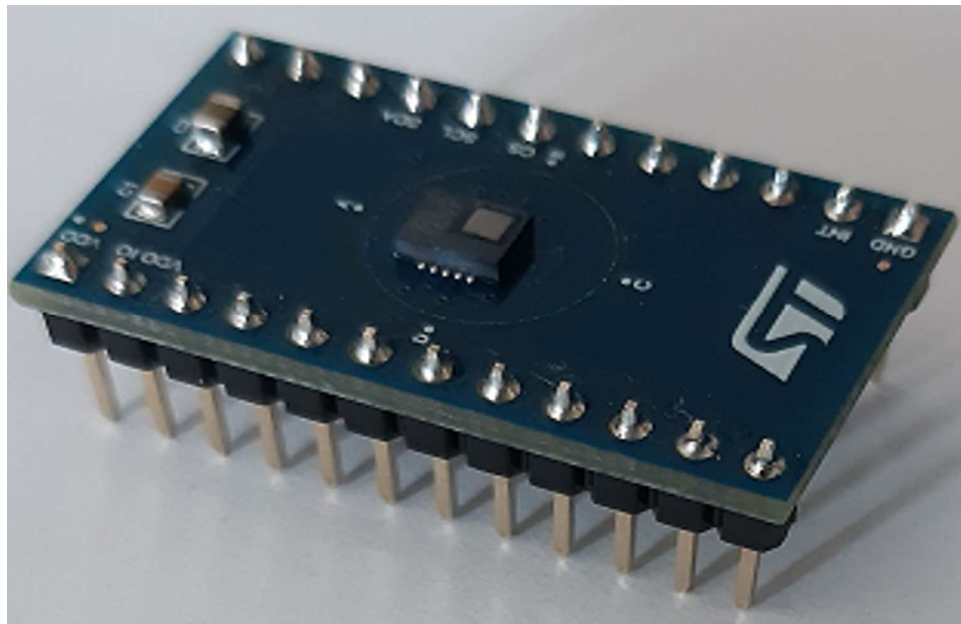
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STMicroelectronics, Italy

TMOS technology for gas sensing

Realize a gas sensor module

- Minimal footprint
- High sensitivity
- Effective solution



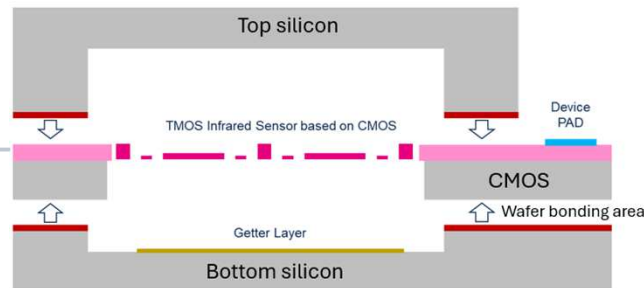


Thermal MOS (TMOS) technology

MEMS device with suspended structure

Hermetic bonding with top and bottom silicon cap

High vacuum

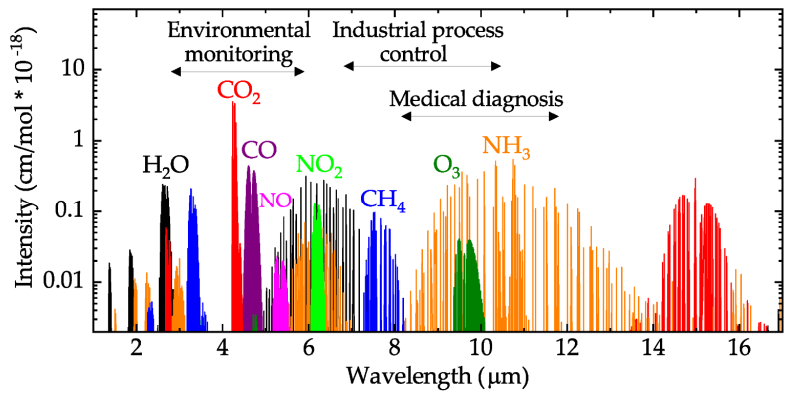


Sensible to IR radiation

Suitable for high volumes packaging



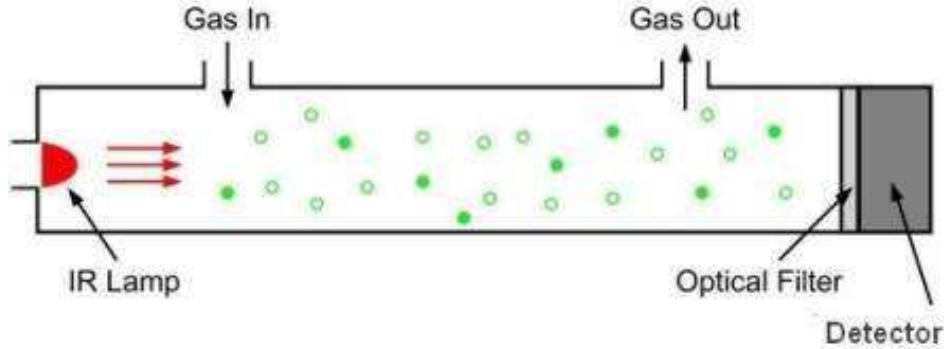
Absorption spectra



- 1 **Select the gas of interest**
CO2 case is presented
- 2 **Light emitter at proper wavelength**
Central wavelength equal to the absorption peak
- 3 **Insert filter at top of TMOS device**
Limiting the IR window
- 4 **Differential reading**
One TMOS for reading (4.2 – 4.4 μm), one TMOS for reference (3.79 – 3.99 μm)

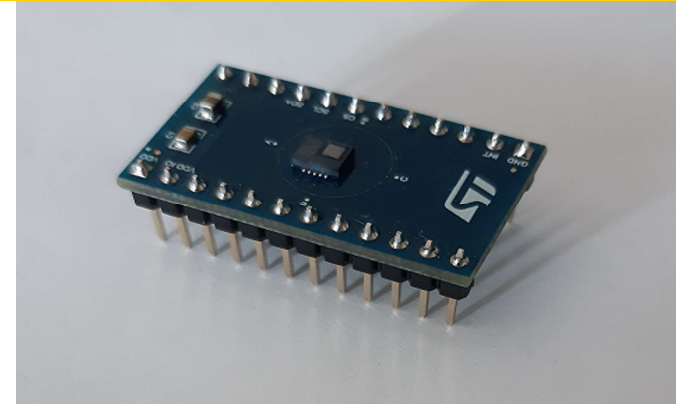
Requirements

High Sensitivity



- Beer – Lambert's law
- $I(\lambda) = I_0(\lambda)e^{-\alpha(\lambda)cl}$
- High sensitivity → long optical path

Reduced footprint



- Fit into DIL24 for characterization purpose
- Easy manufacturability
- Scalable solution
- Reduced size → short geometrical length



Change of perspective

Problem



- Long optical path vs Short geometrical length

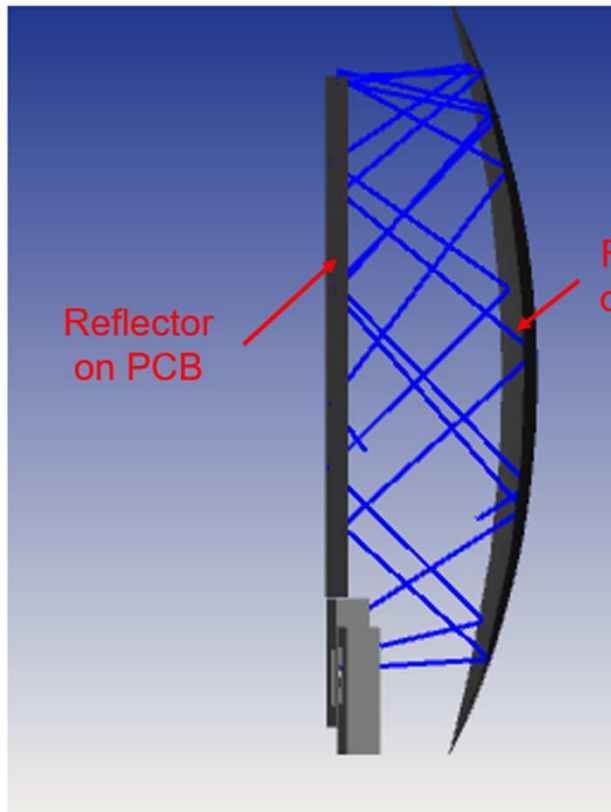


Solution



- Long optical path & short geometrical length

Solution



- 1

Reflector on PCB
Planar reflector integrated in the PCB
- ▼

2

Reflector on lid
Biconical shape
- ▼

3

Multiple reflections
Light source and detectors placed out of foci
- ▼

4

No need for accurate placement
Robustness vs assembly tolerances
- ▼

5

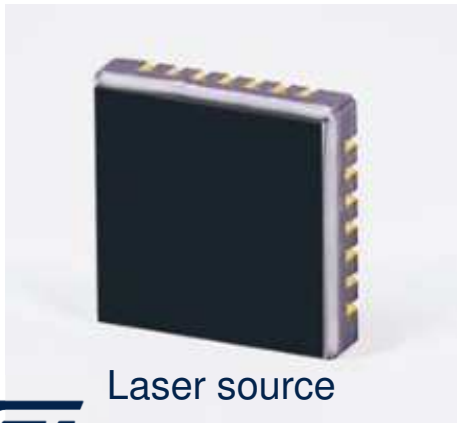
3D optical software
Surface optimization and performance verification



Assembly flow



TMOS Components



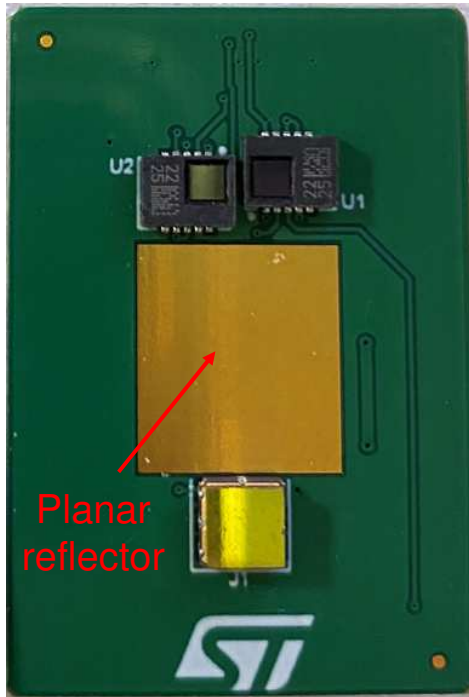
Laser source



- 1 TMOS component is LGA with optical filter on top
- 2 Laser source is provided in SMD package
- 3 Placement of the laser source and 2 TMOS close to planar reflection on PCB
- 4 Soldering of the laser source and 2 TMOS components on top of PCB
- 5 Glueing the metal lid with biconical reflector inside



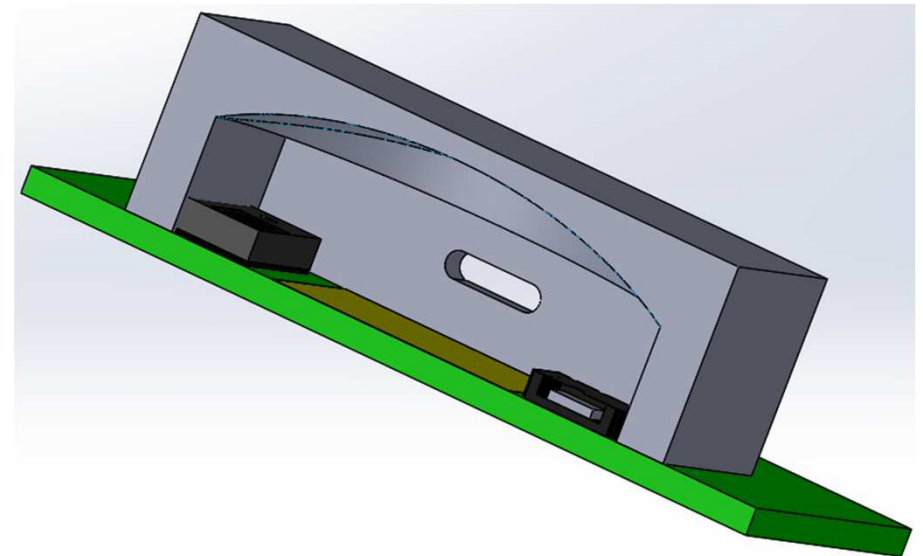
Realization



DIL PCB



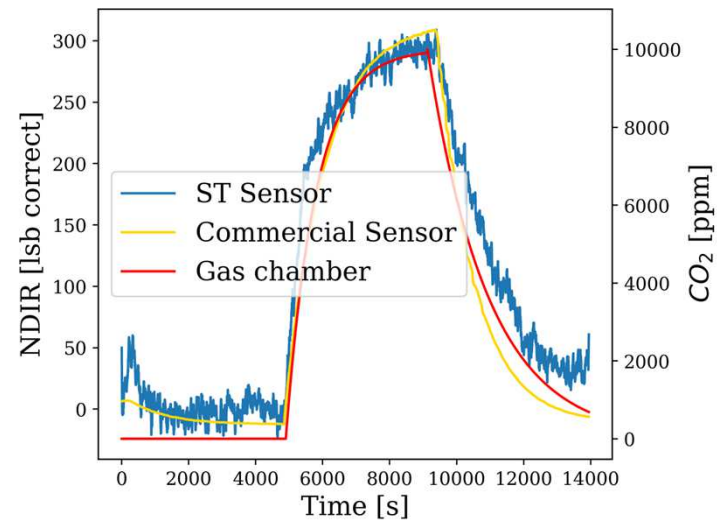
Lid with biconical reflector



Cross section of gas sensor module

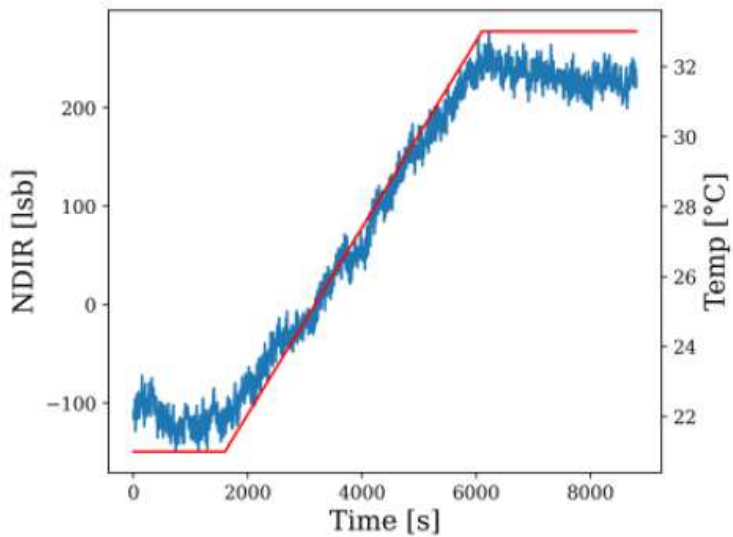


Sensor response



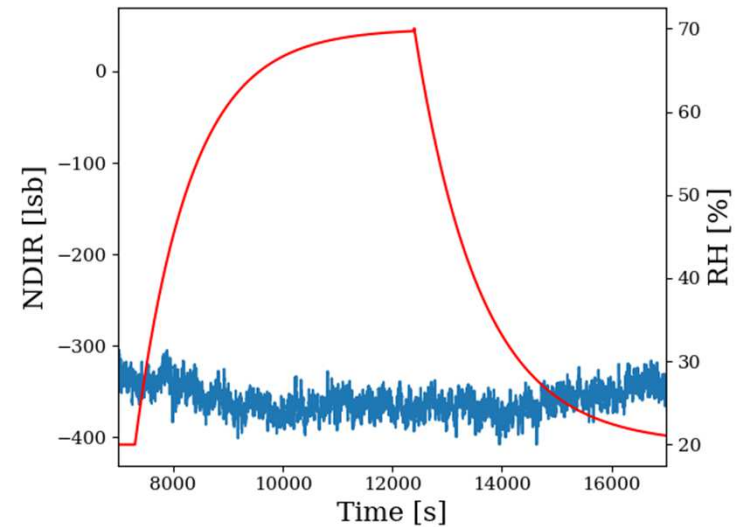
- Noise rejection to be improved by working on the hardware components and power supply

Temperature variation



- Temperature of the chamber varied from 21 °C to 33 °C
- Small drift in sensor reading
- To be fixed by a firmware recalibration procedure

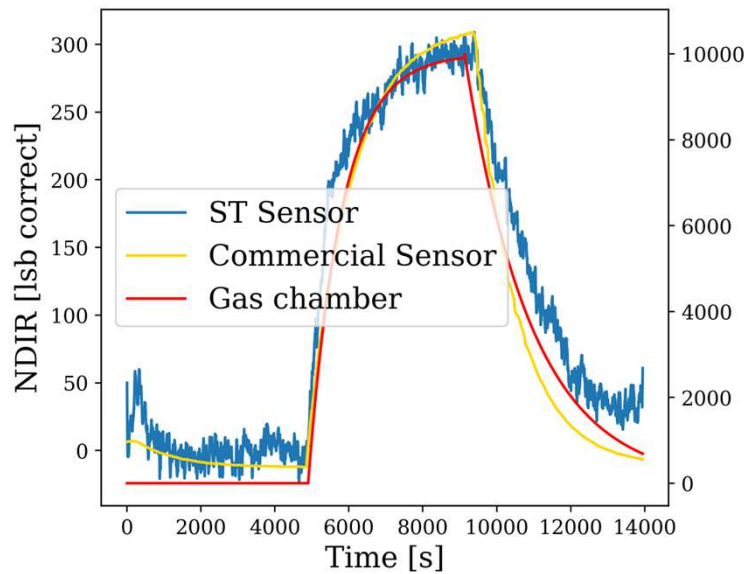
Humidity variation



- Relative humidity varied from 20 % to 70 %
- No drift in sensor reading



Takeaways



- 1 **Multiple reflections for combining long optical path & short geometrical length**
- 2 **Planar reflector integrated on top of PCB + biconical surface on the lid**
- 3 **Out of foci placement, robustness vs assembly tolerances**
- 4 **Performances aligned with benchmark**
From 0 to 10000 ppm (commercial sensor are usually limited to 5000 ppm)
- 5 **Performances enhancement**
Improved hardware and firmware to be implemented





Acknowledgement

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Our technology starts with You



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