Articoli references notes

# A Miniaturised, Fully Integrated NDIR CO2 Sensor On-Chip

* CO2 long term exposure by humans can affect the organism: cognitive abilities, bones demineralization and kidney calcification
* Ventilation air quality dictated by sensors
* Also a low cost sensor can sometimes make the effect (electromechanical sensors and NDIR ones)
* ELECTROMECHANICAL SENSORS: measurement of gas concentration by measuring the change in electrical properties
  + Resistance
  + Capacitance
  + Electric potential

Induced by the absorption of a gas.

* ELECTROMECHANICAL SENSORS:
  + advantageous because of easy of fabrication
  + low cost
  + high sensitivity to wide range of compounds
* ELECTROMECHANICAL SENSORS: poor long-term stability and cross-sensitivity to other gases = less attractive in the CO2 sensor market
* NDIR CO2: superior long-term stability and high gas specificity: significant absorption strength of CO2 in mid-IR region.
* NDIR CO2: very high absorption coefficient of CO2 in mid-infrared: a path length of few centimeters is sufficient to detect small changes in CO2 concentration
* NDIR CO2: the 83% of the total advanced CO2 sensors are based on the NDIR technique
* NDIR CO2: are also bulky: long (several cm) interaction length is required for achieving ppm detection
* NDIR CO2: the cost is high because they are typically based on discrete co-assembled optical elements… in last years price and dimension changed giving them more interest in industry and academia
* NDIR CO2: decreasing the cost depending on the design of miniaturized ones, which can use a multi-pass cell or an optical cavity with various shapes.
* NDIR CO2: pre-concentrator coatings can be employed to effectively amplify the gas concentration in the vicinity of the optical field 🡪 the optical path length can be reduced
* NDIR CO2: broadband infrared source + reflective gas tube + 2 optical detectors that are sensing and reference … the overall mechanism allows for autocalibration
* NDIR CO2: mid-IR led has a relatively narrow emission spectrum such that the need for optical filters can be eliminated without introducing notable cross-sensitivity by other gases
* NDIR CO2: why integrating cylinder? Multiple reflections can be experienced by the sensor before reaching the detector and thus a long effective path length on a small sensor footprint
* NDIR CO2: the response time of the sensor usually depends on the level to measure in ambient (usually few hundreds of ppm), usually it could be long but there’s not a big problem for applications such as air quality monitoring
* NDIR sensor accuracy: can vary depending on the presence of water molecules (it depends on relative humidity RH in the air): the water vapor has a broad absorption in the infrared wavelength range that can be significant for some specific wavelength depending on the spectral overlap between the absorption band of the target gas and the water molecules
  + Different water interference characteristics
  + It is negligible in common ranges
* All sensors: characteristics curves used for determine some points of concentrations dependent on T and RH (that are made variable during the measurement)
* Stability of a sensor: deals with the degree to which the sensor’s characteristics remain constant over time. The drift can be attributed to factors such as temperature fluctuations and component aging.
* Sometimes it could happen that the reference signal and the sensing signal change in opposite directions during this drift (led photodiode characteristics): strong correlation between the ambient temperature and the sensing signal whilst the worse correlation of the reference channel is not yet fully understood

# Quartz-Enhanced Photoacoustic Spectroscopy: A Review

* Quantitative and qualitative gas sensors categorization: analytical sensors (gas-chromatography and spectrometry), electrochemical, semiconductor and laser optical absorption sensors 🡪 they are mainly classified based on the physical mechanism used
* Analytical techniques: no real time response, costly, invasive and with a large spatial footprint
* Electromechanical: relatively specific to individual gases, with usable resolution of less than one part per million of gas concentration and operate with a very small amount of current
  + Suited for portable, battery powered instruments
  + But there’s the influence of hysteresis and water humidity
  + Slow time response: fluctuations of gas and power up can make minutes for the sensor to reach 90% of tis final output value
* Laser absorption spectroscopy (LAS): response is < 1s and they are faster and part per quadrillion detection sensitivity (small traces detection)
  + Molecular absorption principle: transitions that an electromagnetic wave cause in a chemical species
  + If a molecule is irradiated by infrared light, it is excited to a rotational vibrational energy level manifold.
* Semiconductor lasers as light source for sensors: limited by the available optical power
* Mid-IR and previous analyzed NDIR are the common choice
  + Quantum cascade lasers (QCLs)
  + Interband cascade lasers (ICLs)

High output power