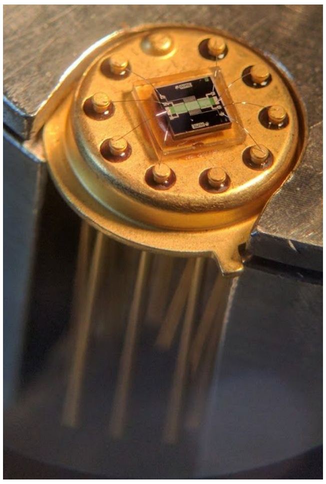
Gas sensor based on tungsten trioxide (WO_3) nanoparticles



Main features

- Reliable
- High sensitivity and selectivity
- Easy-to-use
- Low power consumption
- Low cost
- Small size
- Long lifetime
- Detection of several gases:
  - Nitrogen dioxide (NO_2)
  - Carbon monoxide (CO)
  - Hydrogen sulfide (SO_2)
  - Dihydrogen (H_2)
  - Methane (CH_4)
  - Alcohols (-OH)
  - ...
- Both different gas sensors
- Integrated temperature sensor
- Integrated heater

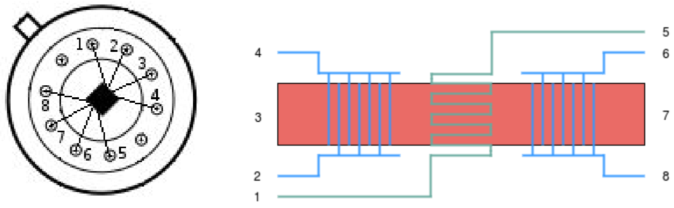
General description

This gas sensor based on tungsten trioxide nanoparticles is developed as part of INSA Toulouse *Innovative Smart System* curriculum. The sensing element is composed of a silicon substrate; an integrated heater formed on metal oxide semiconductor (doped polysilicon); and carved aluminium elements, especially a temperature sensitive resistor and both gas sensitive elements, where tungsten trioxide nanoparticles are integrated. When molecules of detectable gas are in contact with tungsten trioxide nanoparticles, the conductivity of sensitive elements are modified. The variation of conductivity is function of concentration and type of gas. An external electronic circuit can be used to detect and quantify variations in order to determine the nature and the concentration of a gas (or a blend of gases). Moreover, sensitivity and selectivity can be adjusted thanks to the integrated header; and the temperature of active zone can be monitor thanks to the integrated temperature sensor. Thanks to high resistivities, this sensor needs only several mA to work. This gas sensor is reliable, has high sensitivity to low concentrations (several ppm) and high selectivity (NO_2, CO, SO_2, H_2, CH_4,... (function of polarization)). It is integrated in a 10-Lead TO-5 standard package.

Specifications

Type	Chemical sensor
Sensing principle	MOS type
Materials	○Silicon ○Doped polysilicon ○Aluminium ○Tungsten trioxide nanoparticles
Power supply requirement	Active sensor
Nature of output signals	Analog
Nature of measurands	Resistance
Package	10-Lead TO-5 metal can
Head diameter	< 9.5 mm
Head height	< 4.7 mm
Package height	< 25 mm
Pin diameter	< 0.6 mm
Mounting	Through hole fixed
Detectable gases	○Nitrogen dioxide (NO_2) ○Carbon monoxide (CO) ○Hydrogen sulfide (SO_2) ○Dihydrogen (H_2) ○Methane (CH_4) ○Alcohols (-OH) (ethanol C_2H_6O) ○...
Typical detection range	> 1ppm
Typical response time	< 10 s
Typical recuperation time	> 60 s
Service temperature range	-30°C to 60°C
Typical applications	○Air quality monitoring ○Detections of toxic gases and contaminants ○...

Pins configuration



Pin number	Usage
1 / 5	Temperature sensor (Aluminium resistor)
2 / 4	Gas sensor n°1 (WO_3 nanoparticles integrated on aluminium interdigital combs)
6 / 8	Gas sensor n°2 (WO_3 nanoparticles integrated on aluminium interdigital combs)
3 / 7	Heater (Polysilicon resistor)

This sensor must not be used as a critical element because of injury risks in case of malfunctioning.
Calibration is needed before using this sensor because of a high disparity in product.

Standard test conditions	Air quality	/	Normal air
	Temperature	°C	20±2
	Humidity	%	60±5
Typical electrical characteristics under standard test conditions	Gas sensitive elements resistance	MΩ	1 - 20
	Temperature sensitive element resistance	Ω	40 - 70
	Heater resistance	Ω	120 - 150

Gas sensor voltage	V	-20 to 20
Temperature sensors voltage	V	-15 to 15
Heater voltage	V	-10 to 10

In a oxidant environment, the resistance of the gas sensor increase. Opposite, in a reducing environment, the resistance of the gas sensor decrease.

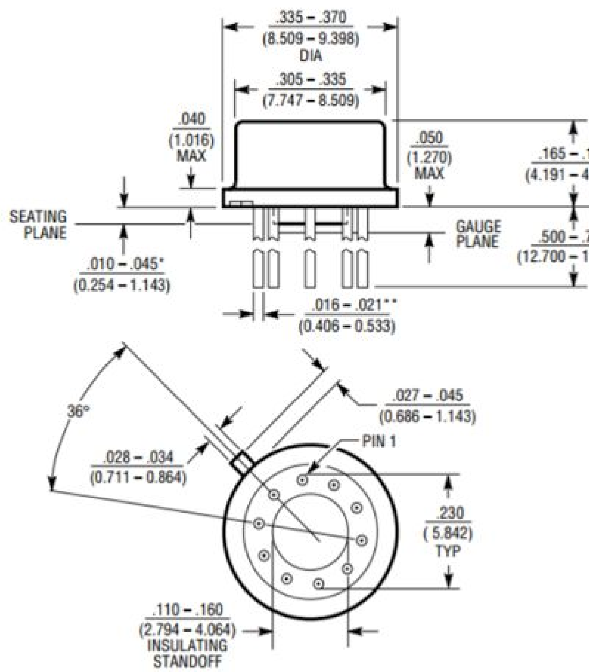
Higher is the gas sensor voltage, lower is the noise detection; lower is the initial resistance; lower is the resistance excursion; and higher is the power consumption.

Higher is the temperature sensor voltage; higher is the precision of measurement; and higher is the power consumption.

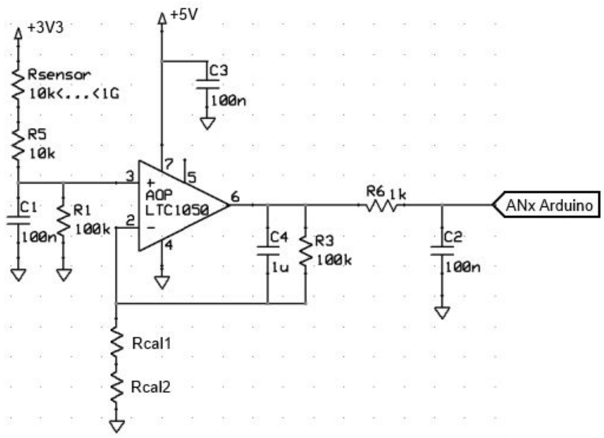
Higher is the heater voltage, higher is the temperature of sensitive areas; higher is the sensitivity; higher is the power consumption; and lower is the selectivity.

Warning!
We advice to not induce high voltage variations to

Structure and dimensions



Examples of integration

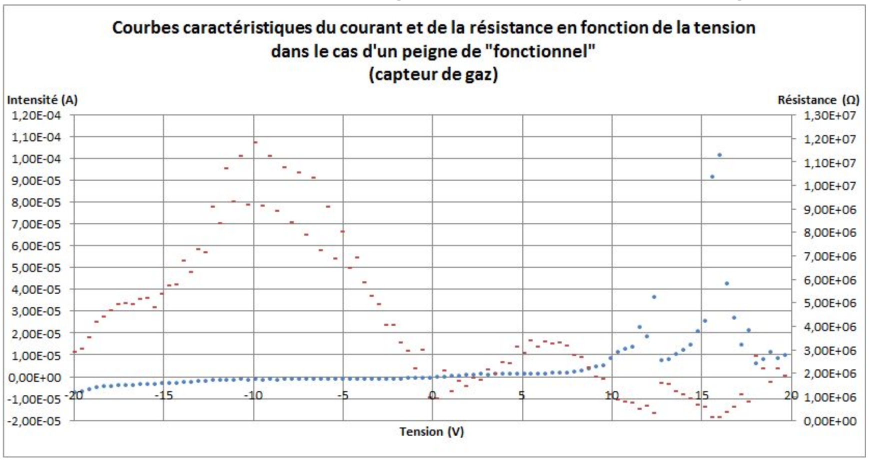


Above is an example of an integration circuit used to interface the gas sensor with an Arduino.
The operational amplifier will convert and amplify a current proportional to the resistance of the gas sensitive element (here Rsensor) to a voltage signal, which will be read by the Arduino.

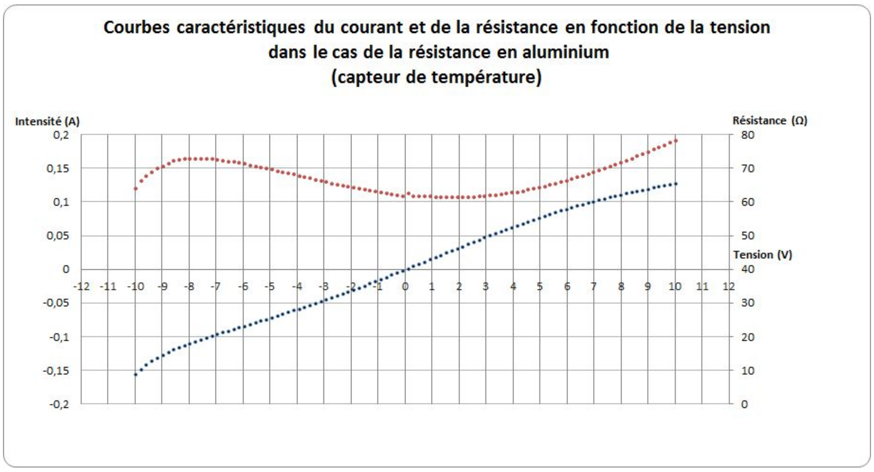
protect the integrity of the sensor (in case a thermal shock, aluminium area could take off).

Characteristic graphs of resistances and currents in standard test conditions

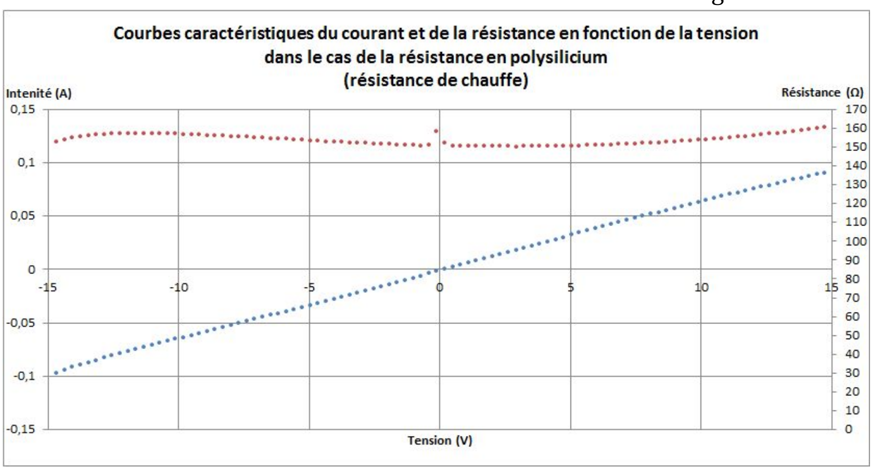
Current and resistance of gas sensors in function of voltage



Current and resistance of temperature sensor in function of voltage



Current and resistance of header in function of voltage



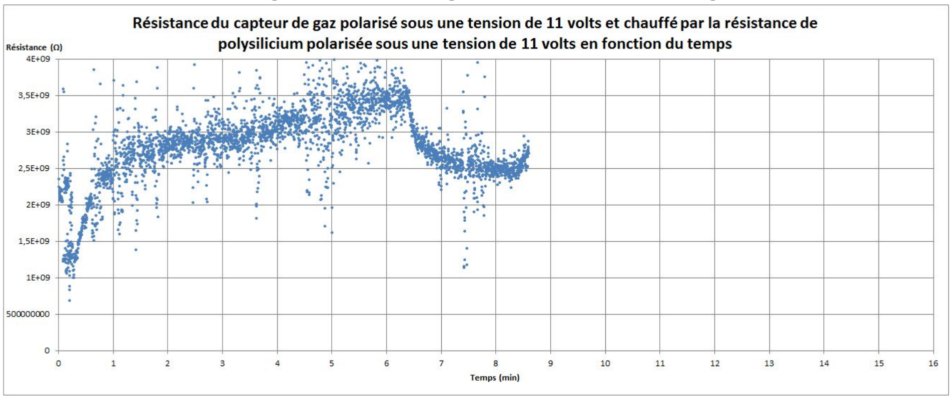
Test graphs for different heater and gas sensor voltages

Protocol:

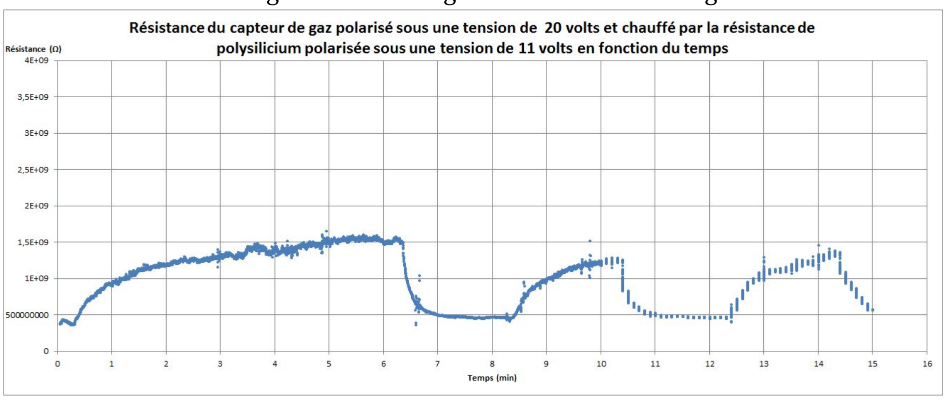
The sensor is exposed alternatively and for two minutes to three different types of air.

1. ethanol enriched air
2. natural air without flow
3. ethanol enriched air
4. dry air
5. ethanol enriched air
6. natural air without flow or dry air
7. ethanol enriched air

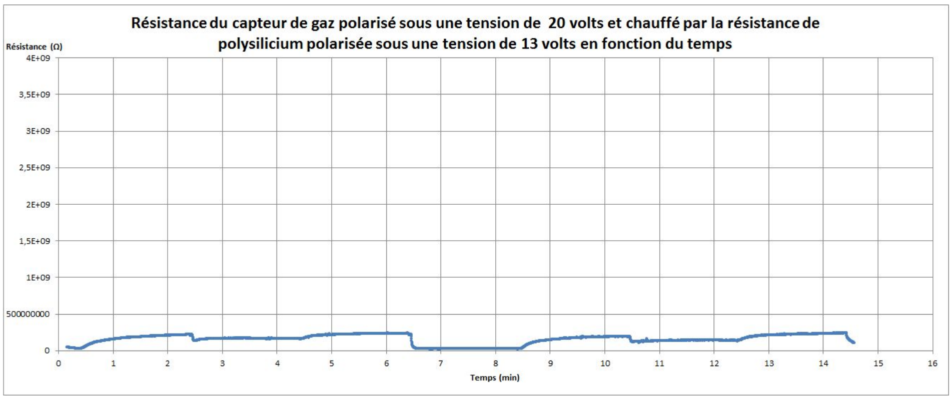
11V gas sensor voltage and 11V heater voltage



20V gas sensor voltage and 11V heater voltage



20V gas sensor voltage and 13V heater voltage


Résistance du capteur de gaz polarisé sous une tension de 20 volts et chauffé par la résistance de polysilicium polarisée sous une tension de 13 volts en fonction du temps
Résistance (Ω)
4E+09
3,5E+09
3E+09
2,5E+09
2E+09
1,5E+09
1E+09
500000000
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Temps (min)