Gas sensor using Tungsten trioxide (WO3) nanoparticles

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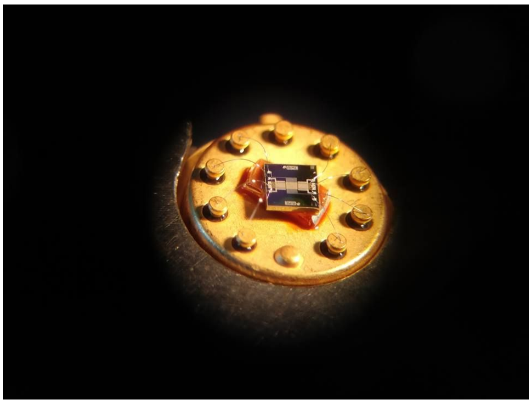
The internet of things field knows an exponential growth and the application are numerous, especially in public health-care. The development of high sensitivity and accuracy sensors are a huge interest for gas pollution detection. This sensor was developed using the INSA Toulouse AIME (Atelier Interuniversitaire de Micro-nano Electronique) facilities and based on the Jeremie Grisolia's work. It is composed of silicon rods and WO3 nanoparticles sensitive to gas and a heating resistor.



Features:

- High sensitivity to domestic and industrial gases
- Cheap
- Small and compact
- Excellent linearity and accuracy
- Low noise

Applications:

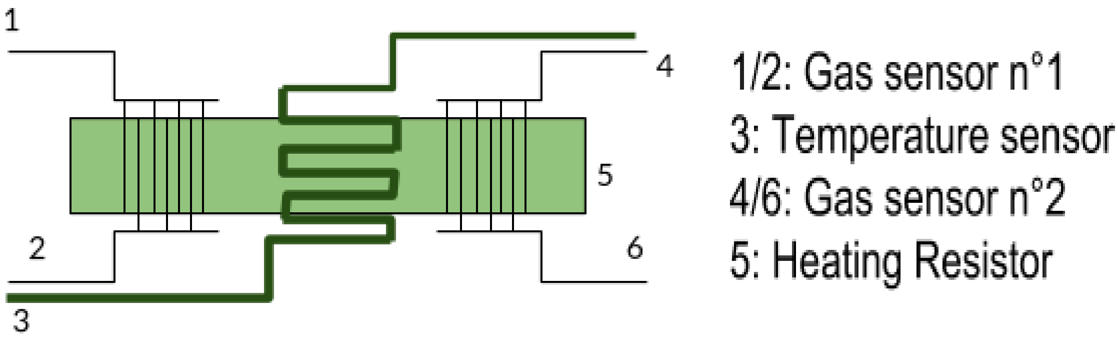
Integrated temperature sensor

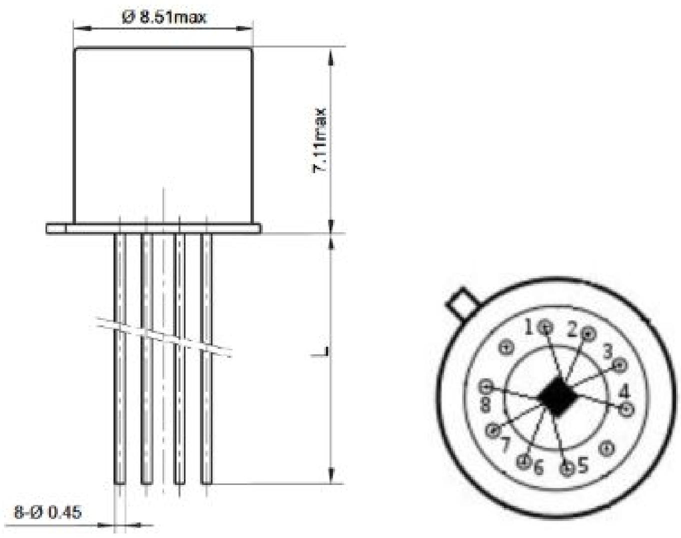
Integrated Heating resistor

Gas detection (non exhaustive list):

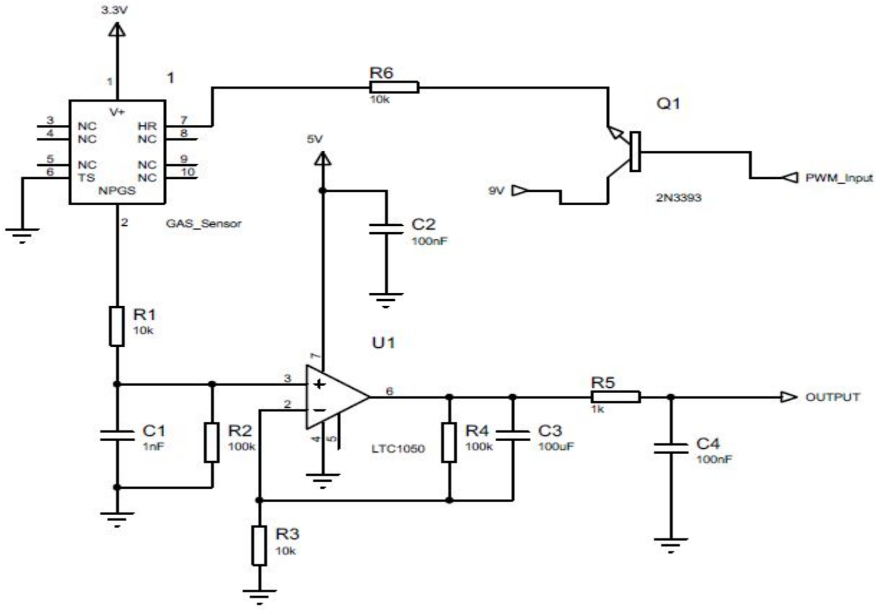
- Nitrogen dioxide (NO_2)
- Dihydrogene (H_2)
- Methane (CH_4)
- Carbon monoxide (CO)
- Ammoniac (NH_3)

❖ Configurations



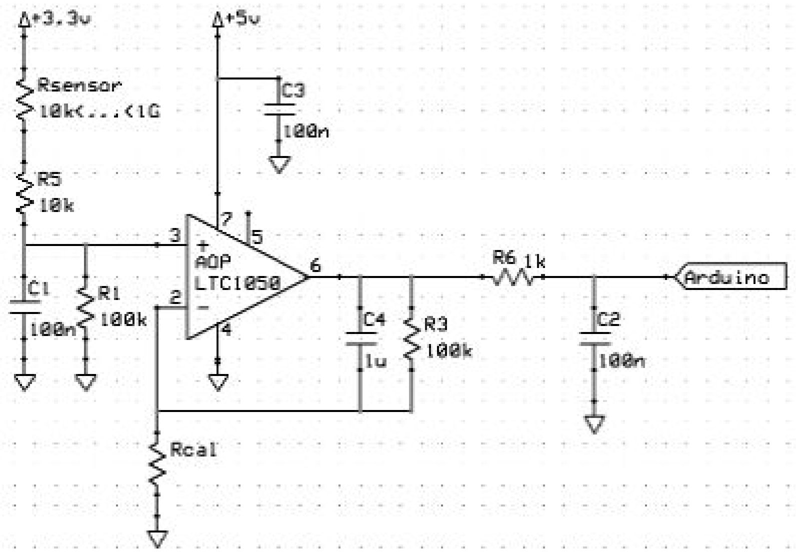


- The gas sensor is embedded on a TO5 connectic.



❖ Example of use

You can use this sensor in the following electronic circuit in order to get the value of the gas sensor on an Arduino board. The aim of the operational amplifier is to amplify and convert the current to a tension. This one is proportional to the sensitive layer of the gas sensor (here represented by *Rsensor*) and can be read the ADC of the Arduino.



❖ Technical Specifications

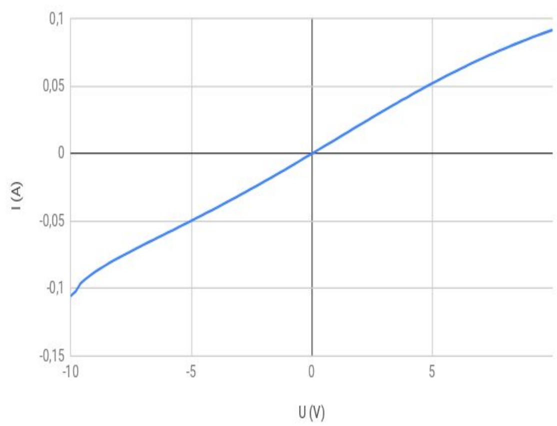
Type	Semi-conductor
Materials	• Silicon • Doped polysilion • Aluminium • Tungsten trioxide nanoparticles

Packaging	10 Pins TO-5
Typical measure precision	Above 1 ppm
Mounting Type	Crossing
Gas Sensor supply voltage	from -20 V to 20 V
Resistance supply voltage	from -10 V to 10 V
Temperature sensor supply voltage	from -10 V to 10 V
Resistance's sensitive layer characteristics	Typical : from 1 to 20 MΩ
Heater's sensitive layer characteristics	Typical: 130 Ω
Air quality test condition	Ambient air
Temperature test condition	19° C ±2
Humidity test condition	60±5 %

❖ Conditions of use

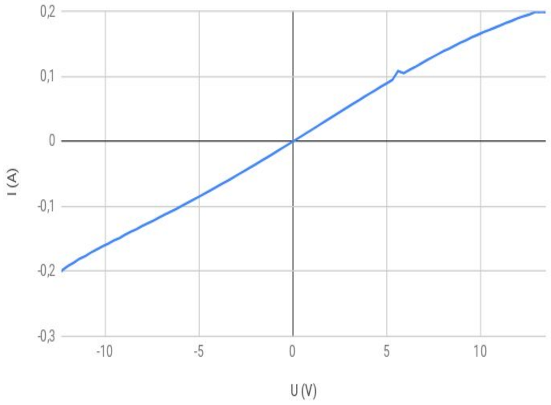
For optimal use, it is required to always stay above 100°C. If your main objective is low energy consumption, while the sensor is in standby the temperature can stay slightly above 100°C. When a threshold of reaction detection is crossed, the temperature needs to be raised, for instance up to 400°C to enable a more precise detection.
The lower the temperature, the longest the regeneration cycles of exposition to dry air needs to be.

❖ Technical characteristics



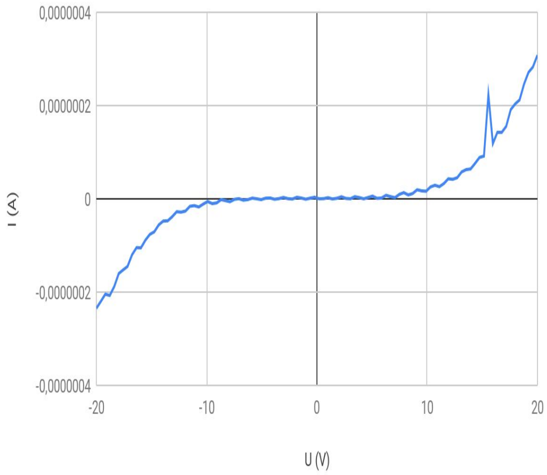
Aluminium - I(V) characteristic

This graph shows the I(V) characteristic of the aluminium layer of the sensor. We can see that the current is proportional to the voltage. Thus the aluminium act as a resistor.
Therefore, it can be used as a heater for the gas sensor. Moreover, because the resistivity of the aluminium varies with the temperature, we can also use it as a temperature sensor.
We recommend to use it between -10V and 10V.



Polysilicon - I(V) characteristic

This graph shows the I(V) characteristic of the polysilicon layer of the sensor. We can see that the current is proportional to the voltage. Thus the polysilicon act as a resistor. This is due to the fact that it is n-doped, but with such a high level of doping that it is degenerated.
Therefore, the polysilicon can be used as a heater for the gas sensor.
We recommend to use it between -10V and 10V.



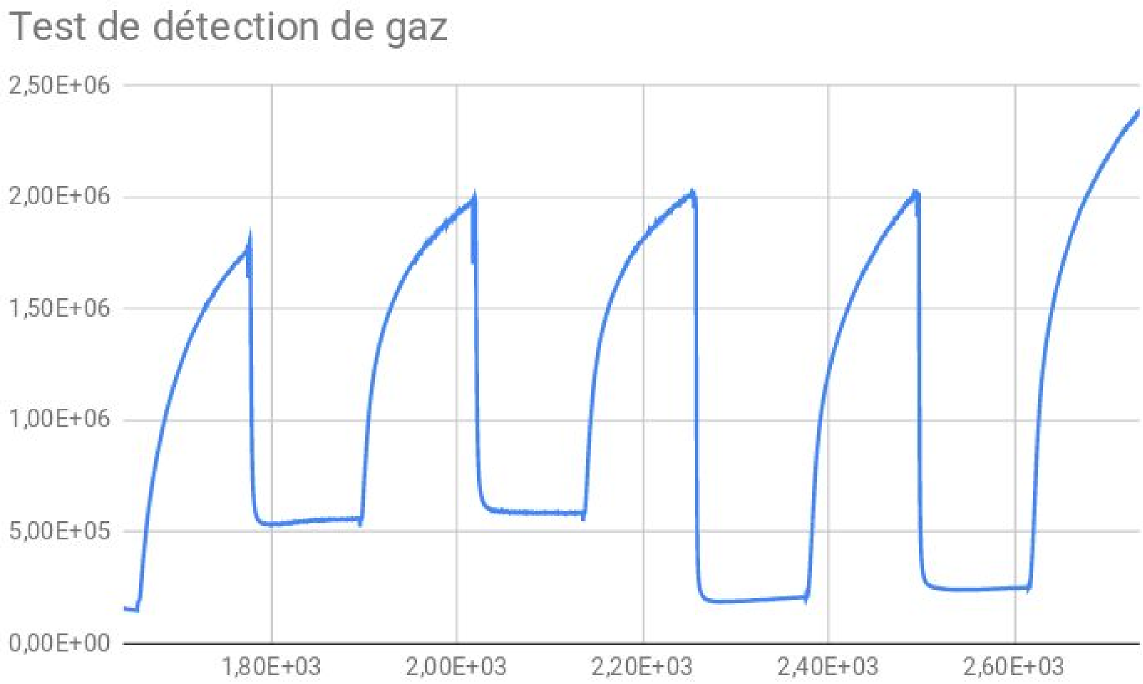
Sensitive layer - I(V) characteristic

This graph shows the I(V) characteristic of the sensitive layer of the sensor. We can see that it is the same characteristic as a semiconductor, that is to say a nul current for V < |Vth| and an exponential increasement of the current for V > |Vth|. Here, we have Vth = 10V.
Note that the pic in the positive part of the curve is an artefact of measurement.

❖ Test under controlled atmosphere

This sensor was tested under controlled atmosphere with the following gases: ethanol (C_2H_6O) and ammonia (NH_3). To perform the sensor characterization, the following protocol was implemented at 120°C:

Duration	15 s	2 min	2 min	2 min	2 min	2 min	2 min	2 min	2 min	...
Condition	No gas	dry air	C_2H_6O	dry air	C_2H_6O	dry air	NH_3	dry air	NH_3	dry air



This curve shows the evolution of the resistance over the time for the two gases. In average, the drop of the resistance for ethanol is 30% of the maximal peak against 10% for ammonia. Thus, the variation of the resistance depends on the gas surrounding the sensor reacting with nanoparticles.

Warning!

Nanoparticles are small enough to go into human body through pores. It is important to be careful with nanoparticles in ambient air when they are dry, they can be blown away. Moreover, for ecological reasons, do not throw away nanoparticles into sink: they had to be safely put into dedicated container when they are no longer used.