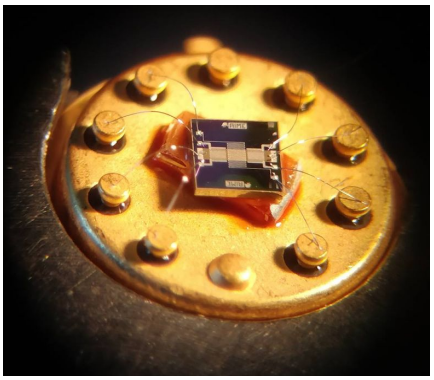


$W0_3$ nano-particles gas sensor

By Margot DELORME, Jean-Baptiste LAFFOSSE, Damaris MENDES FERREIRA, Dorian MOULINIÉ, Damien NICOLAS, Alex NOIZE, Mathieu RAYNAUD and Juan YU.

Introduction

As part of our training in Innovative Smart Systems at INSA Toulouse, we had a module about Smart Sensors. Our mission was to design an entire system including a gas sensor. We designed the PCB, we built and tested the circuit. Then we created a state of the art gas sensor at the AIME (Atelier Interuniversitaire de Micro-nano Électronique). This nanoparticle sensor was made in a clean-room. Its active ingredient is made of silicon and WO_3 nanoparticles. The sensor in itself is composed of 4 parts, 2 of them are gas sensible parts with varying conductivity depending on the gas it is in contact with. There are also an aluminium heating resistor and a polysilicon resistor.

Features

Thanks to his active part, the gas sensor is able to detect various gases. The heating resistor allows you to refresh quickly the sensing part of the sensor. Another resistor embedded in the sensor permit you to measure the temperature of the active part, and control the response time of the sensor. This low cost gas sensor is reliable, compact and low-power consumption, perfect for your IoT application. Then, all the manufacturing processes ensure a long lifetime and the sensor can be stored for a long time without using it.

Applications

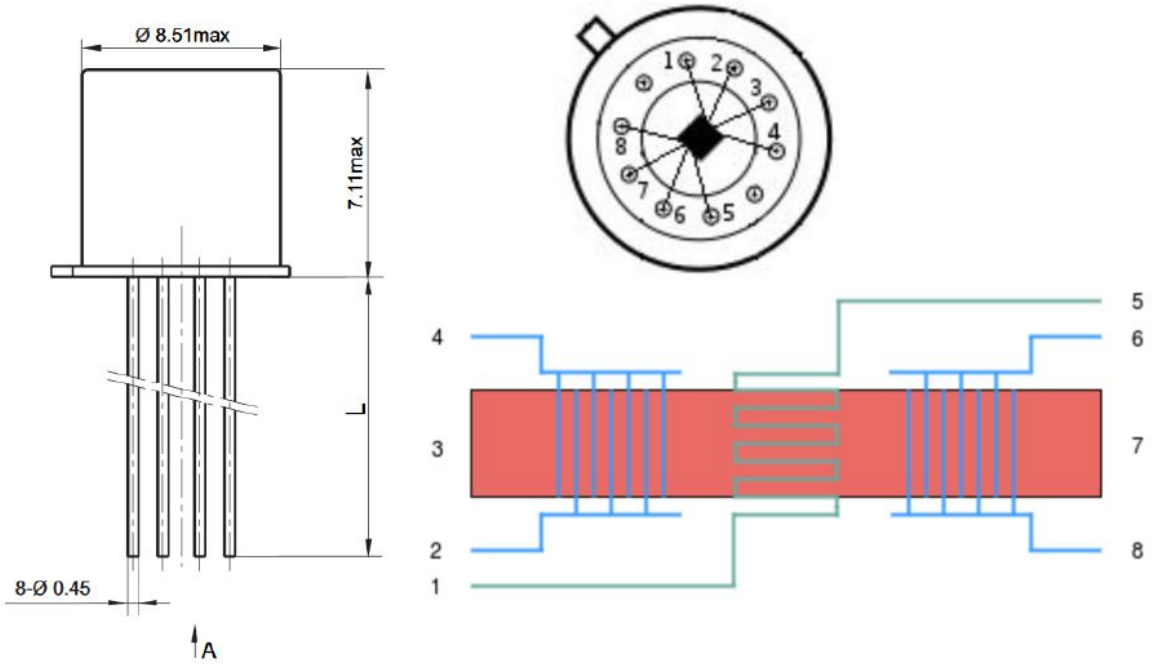
This gas sensor detects different gases:

- Carbon monoxide: CO
- Methane: CH_4
- Nitrogen dioxide: NO_2
- Dihydrogen: H_2

And others...

This sensor can be used in many different areas (the health sector, industry, agribusinesses). It is important to bear in mind that the effect of WO_3 nanoparticles hasn't been studied enough: today, we do not know if they are dangerous for human or polluting for the environment. It is therefore important to be careful when using this sensor.

Configuration

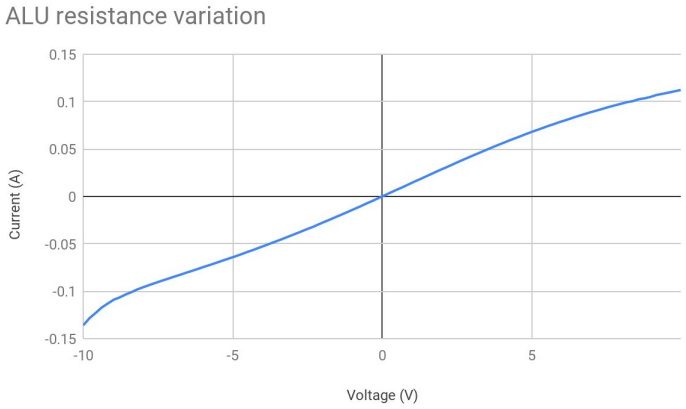


Pin Number	Purpose
1/5	Temperature Sensor made in aluminium
2/4	Gas sensor n°1 with the nanoparticles
6/8	Gas sensor n°2 with the nanoparticles
3/7	Heating resistor made in polysilicon

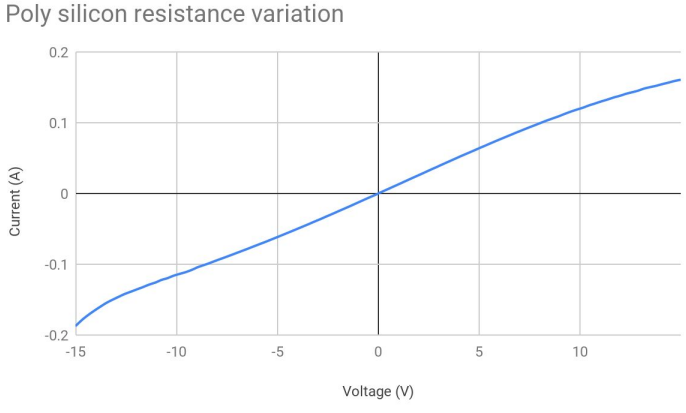
Technical specifications

Mounting type		Through-hole
Type		Semi-conductor
Materials		· Silicon · Doped polysilicon · Aluminium · Tungsten trioxide nanoparticles
Electronic box		TO-5 10 pins
Typical measure accuracy		> 1 ppm
Circuit maximal ratings	Gas sensor voltage	± 20V
	Temperature sensor voltage	± 15V
	Heating resistance voltage	± 10V
Characteristics	Sensible layer resistance	1 to 20 MΩ
	Temperature sensor resistance	N/A
	Heating resistance	130 Ω

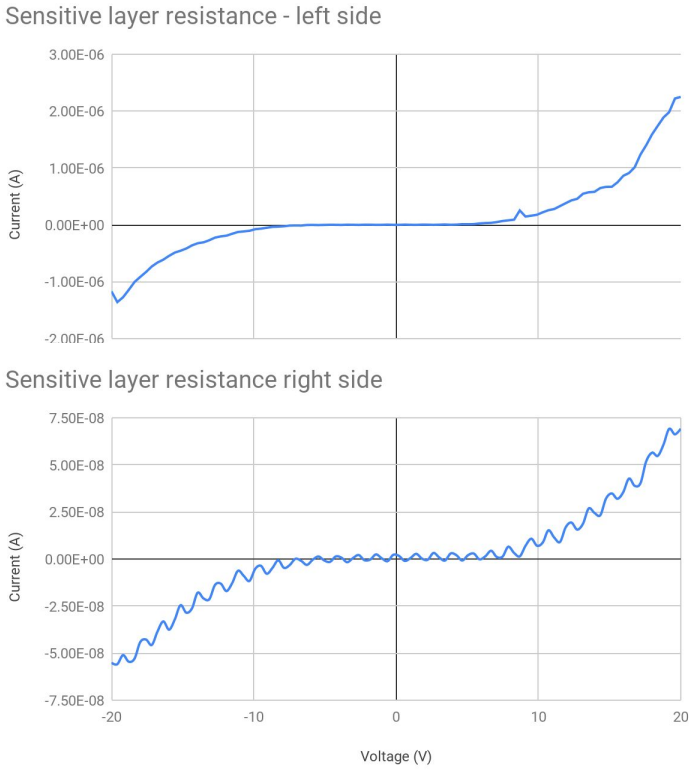
Technical Data



When we apply a voltage on the aluminium resistor, we can draw the current curve and we can find a linear relation between the voltage and the current. This means the aluminium behaves like a pur resistor. We can use the aluminium as a heater or a temperature sensor. We know the resistance of the aluminium change according to the temperature, so it makes a good temperature sensor.



Same for the polysilicon resistor.



The sensitive layer has a diode characteristic.

Example of use

The gases can be detected by this gaz sensor are: CO, CH_4, NO_2,H_2. This sensor can be used in many different areas (the health sector, industry, agribusinesses).

For the health sector, some gases are poison for animals. The detection of CO can be used to monitor if there is a CO leak. Because CO is a colorless and odorless gas that is toxic to animals. To prevent carbon monoxide poisoning, it is recommended to install a gas detector in the house using this gas sensor. Since it is small, it won't take large space in the house.

For the pollution of the environment, this sensor can be used to build a air pollution detector. With the concerns raised by air quality, people nowadays want to have knowledge of the air quality around them. This kind of detector can also help the scientists to study the cause of air pollution.

Sensitivity Characteristics

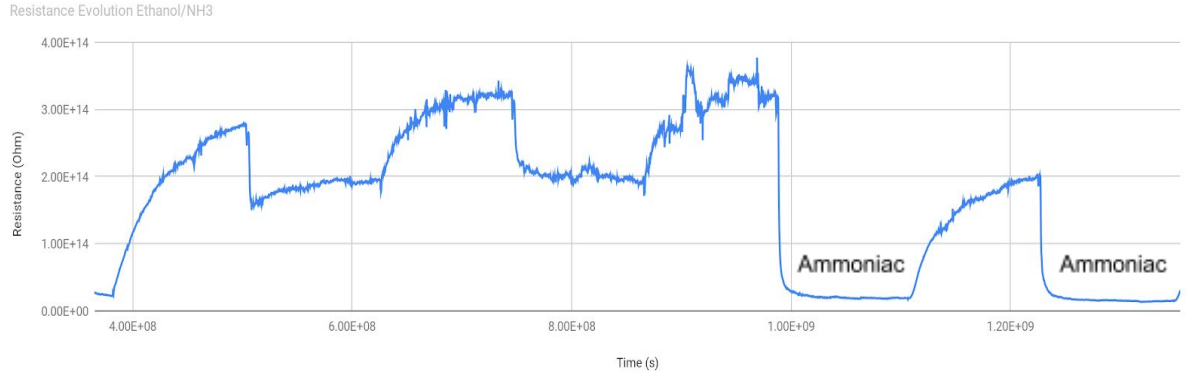
The gas sensor was tested under gas presence.

The working temperature of the sensor is 180°C (453,15 K). This is the temperature at which we did the following tests. This choice was made to avoid presence of water on the sensor, and to maintain an acceptable power consumption.

In the following chart, you may find the behaviour of the gas sensor in presence of Ethanol (C_2H_5OH) and then of Ammoniac (NH_3). The tests were done in presence of dry air and gazes following this sequence:

- 15 seconds air
- 2 minutes dry air
- 2 minutes ethanol
- 2 minutes dry air
- 2 minutes ethanol
- 2 minutes dry air
- 2 minutes ammoniac
- 2 minutes dry air
- 2 minutes ammoniac

These are the results obtained:



During the heating phase, the resistance of the sensor increases logarithmically.

In presence of Ethanol, we observe a fall of 50% of the resistance. This is the characteristic behaviour of the sensor for Ethanol.

In presence of NH_3, we observe a fall of 90% of the resistance of the sensor. This is the characteristic behaviour of the sensor in presence of Ammoniac.