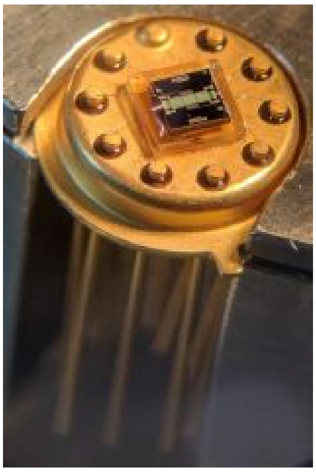
Gas Sensor based on WO_3 (Tungsten Trioxide) nanoparticles



Main Features

- High sensitivity and selectivity
- Low power consumption
- Detection of wide variety of gas (NH_3 , C_2H_5OH, CO, SO_2, ...)
- Easy-to-use
- Low cost
- Temperature sensor included
- Heater included
- Small size

Description

This gas sensor is developed at Atelier Interuniversitaire de Micro-nano Electronique (AIME) as part of the UF Smart Device module in the PTP Innovative Smart System curriculum. The gas sensor is based on a type of metal oxide semiconductor, which is tungsten trioxide (WO_3) nanoparticles. The sensing element used for gas measurement is composed of interdigitated combs of silicon substrate with a thin tungsten trioxide nanoparticles (WO_3) deposit. Each sensor consists of two such sensing elements. The gas sensor also has an aluminium resistor that acts as a temperature sensor and an integrated heater formed on a wide N-doped polysilicon layer which allows heating of the sensor up to 300°C. When molecules of detectable gas come into contact with the nanoparticles, the resistances vary according to the concentration and type of gas. Therefore, an external electronic measuring device may determine the nature and concentration of gas based on the variation of resistances. With the help of the integrated heater and the integrated temperature sensor, sensitivity and selectivity can be configured. Thanks to these, this gas sensor module is highly reliable with high sensitivity and selectivity.

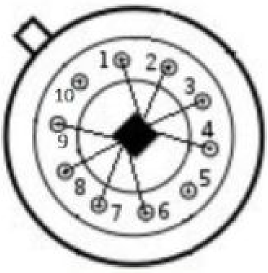
Specifications

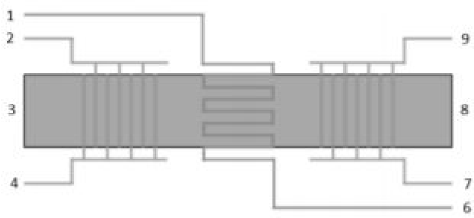
Type	Nanoparticle based sensor
Materials	• Silicon • N-doped poly-silicon (heater) • Aluminum (temperature measurement) • Nanoparticles of tungsten trioxide (WO3)
Power supply requirement	Active sensor
Gas measurement	Resistive measure
Temperature measurement	Resistive measure
Nature of output signals	Analog
Detectable gas	• Nitrogen dioxide (NO2) • Ammonia (NH3) • Carbon monoxide (CO) • Hydrogen sulfide (SO2) • Dihydrogen (H2) • Methane (CH4) • Alcohols (-OH)(ethanol C2H5OH)
Packaging	10-Lead TO-5 metal
Diameter	9.5mm
Mounting	Through hole fixed
Time response	• Ethanol <30s • Ammonia <15s

Standard use condition

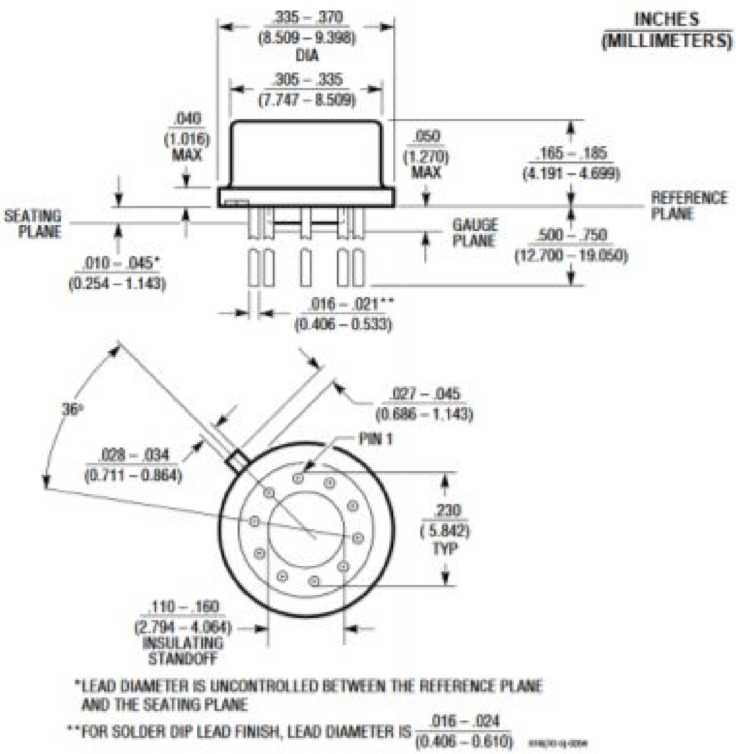
	Unit	**Typical value**
Diameter ?	°C	20±5
Mounting ?	%	60±5
Time response ?	%N2/O2	80/20

Pin Mapping & Usage





Pin number	Usage
1/6	Temperature sensor (Aluminium resistor)
2/4	Gas sensor (WO3 nanoparticles integrated on aluminium interdigital combs)
3/8	Heater resistor (Polysilicon resistor)
7/9	Gas sensor (WO3 nanoparticles integrated on aluminium interdigital combs)
5/10	Not connected



Ambient Temperature Characteristics

Component	Material	Resistance (Ω)	Parallel Experiments Resistance (Ω)
Sensor Resistor	Aluminium	60	[63, 81]
Heating Resistor	polySilicium	71	[65, 100]

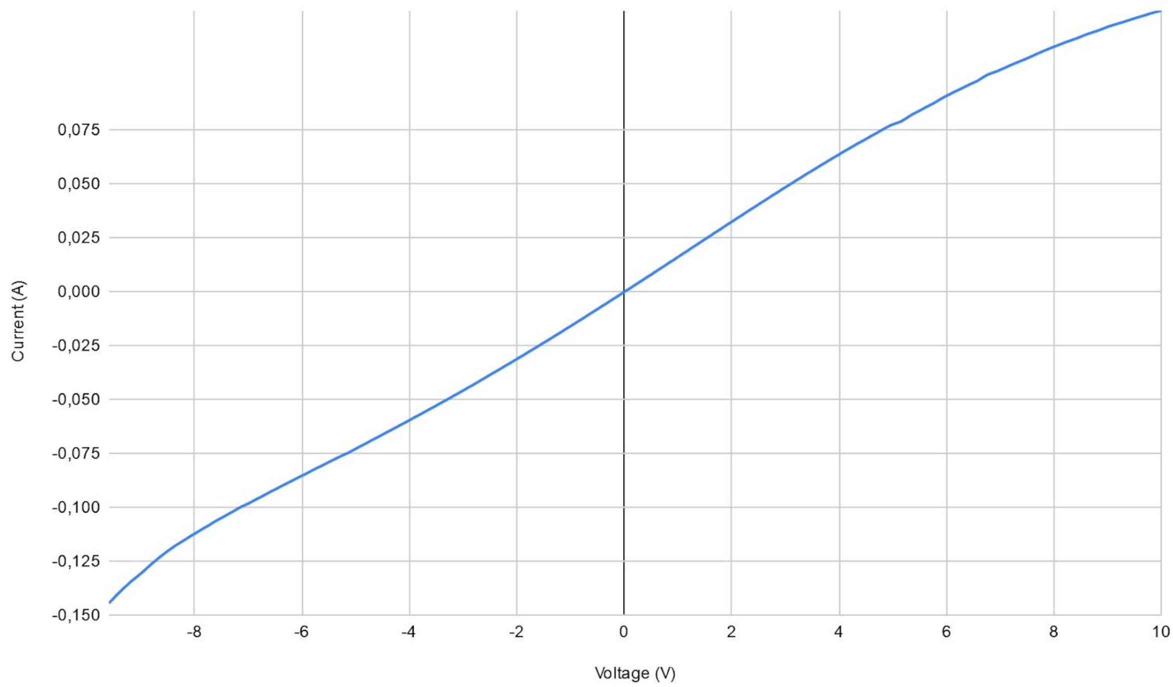


Figure 4: Aluminium Sensor Resistor Current/Voltage measurements

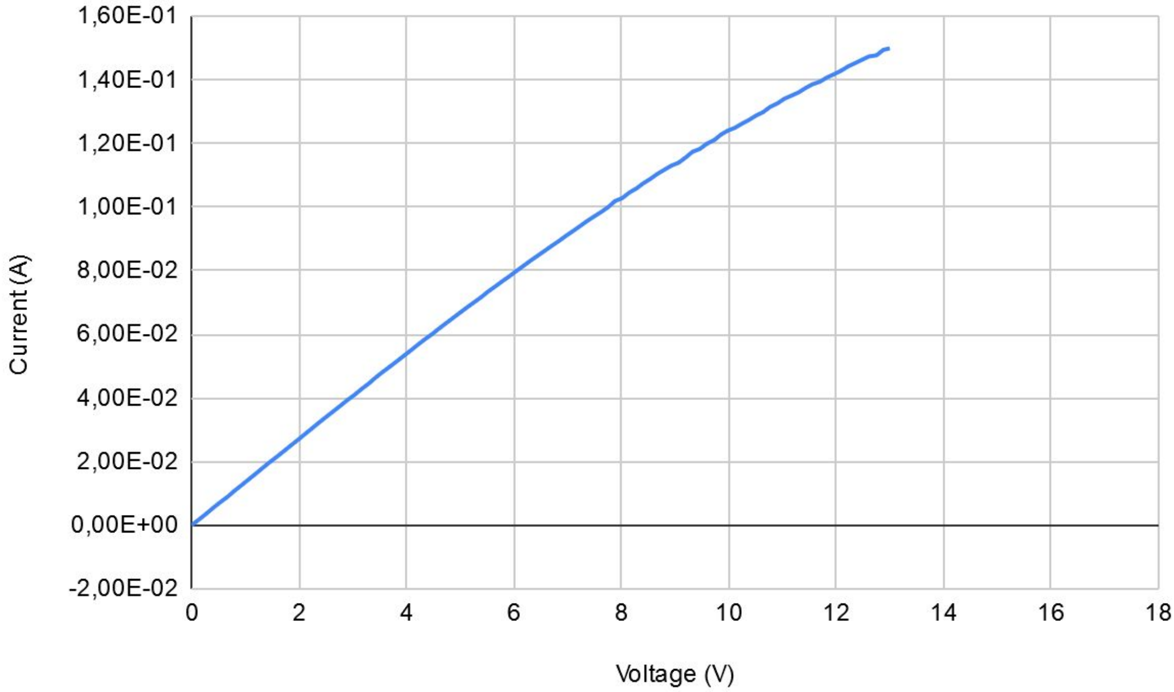


Figure 5: polySilicium Heating Resistor Current/Voltage measurements

Characteristics under gas exposure at certains temperatures

The characterization of the gas sensor has been performed around multiple temperatures, following a specific gas exposure procedure.

Dry Air - 2 mins
Ethanol - 2 mins
Dry Air - 2 mins
Ethanol - 2 mins
Dry Air - 2 mins
NH_3 - 2 mins
Dry Air - 2 mins
NH_3 - 2 mins
Dry Air - 2 mins

Temperature	ΔR/R0 N_2O_2	Variation time N_2O_2	ΔR/R0 CH_3CH_2OH (MΩ)	Variation time CH_3CH_2OH	ΔR/R0 NH_3 (MΩ)	Variation time NH_3
300°C	+66%	50,35 s	-38%	29,83 s	-44%	22,94 s

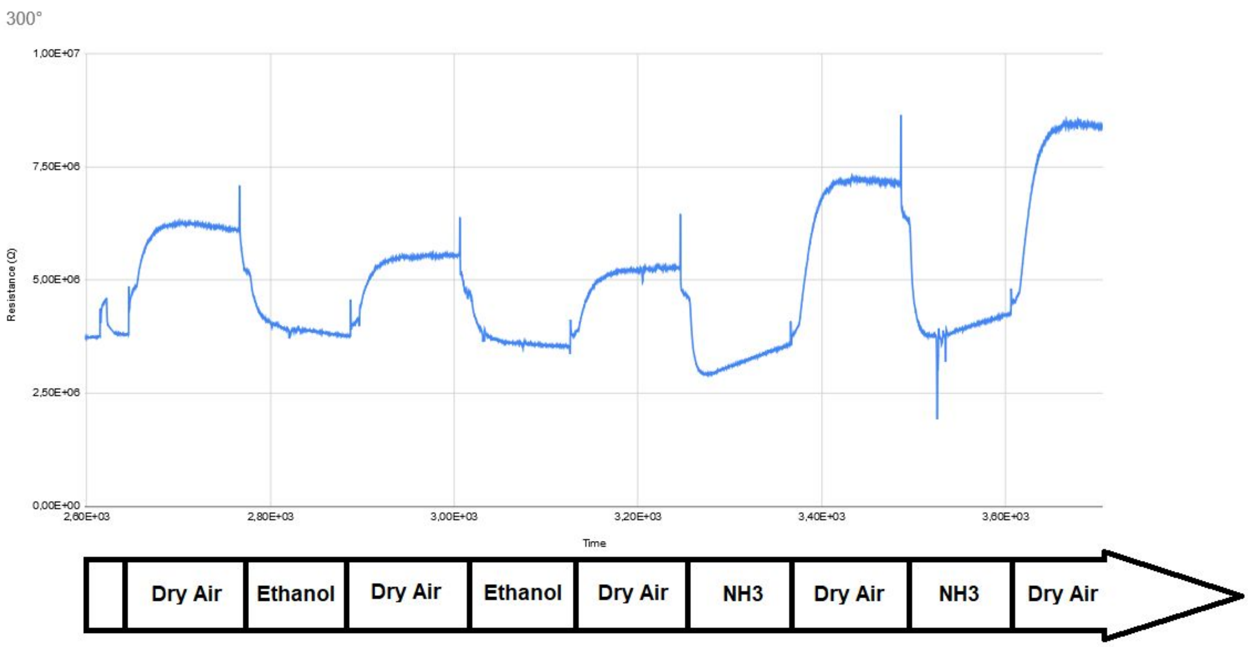


Figure 6: Resistor Variation over time under Gases exposures at 300°C

Parallel measurements

Temperature	ΔR/R0 N_2O_2	Variation time N_2O_2	ΔR/R0 CH_3CH_2OH (MΩ)	Variation time CH_3CH_2OH	ΔR/R0 NH_3 (MΩ)	Variation time NH_3
250°C	57%	100 s	-27%	25 s	-75%	6 s
227°C	203,7%	32 s	-	-	141,7%	25s
215°C	40,8%	39,3 s	-32,2%	80,4 s	-71,7%	99,5 s

Sensor Application

This gas sensor gives an output of around 100 nA. This is not acceptable for normal microcontrollers used nowadays. Therefore, to obtain the output of the gas sensor, the following circuit is needed as an intermediate between the gas sensor and the ADC of a microcontroller. This circuit will give a gain of 100 in nominal condition.

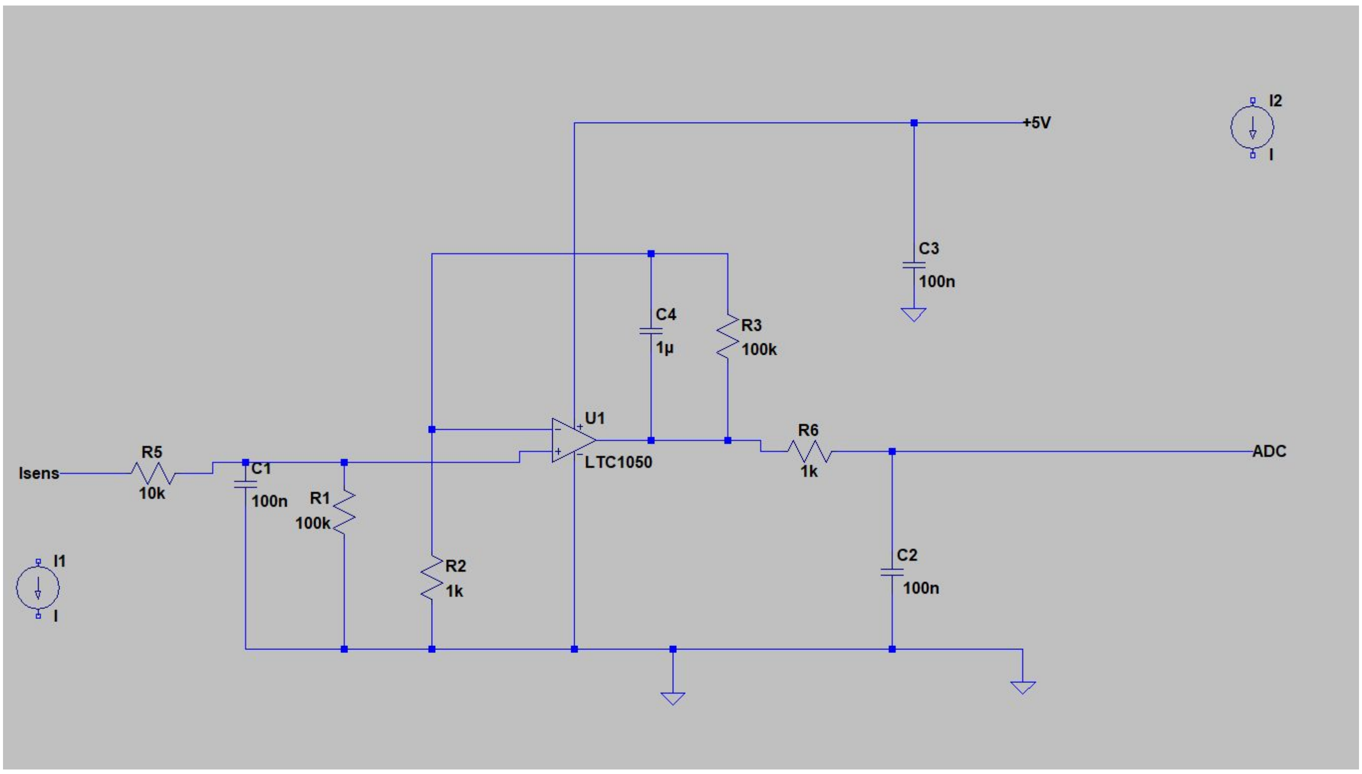


Figure 7: Electrical Diagram of a sensor application