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Gas sensor based on tungsten trioxide (WO_3) nanoparticles

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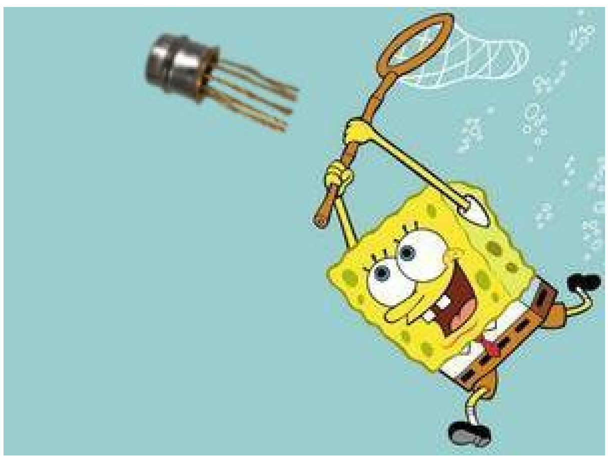

Features of the sensor :

- Detection of NH_3 (Ammonium hydroxide)
- Detection of CH_3CH_2OH (Ethanol)
- Quick response
- Heater resistor included (Polysilicon)
- High impedance
- Temperature sensor (Aluminium)

Description :

This gas sensor allows us to monitor the amount of gases (Ammonium hydroxide, Ethanol and air) . It was manufactured in the AIME local at INSA Toulouse. It is based on a nanoparticle: the tungsten (WO3), a doped polysilicon heater, and aluminium resistors where the tungsten is integrated. Consequently, depending on the amount of gas, the conductivity of the resistance variation enables the computation of the concentration of gas thanks to an external electronic circuit.

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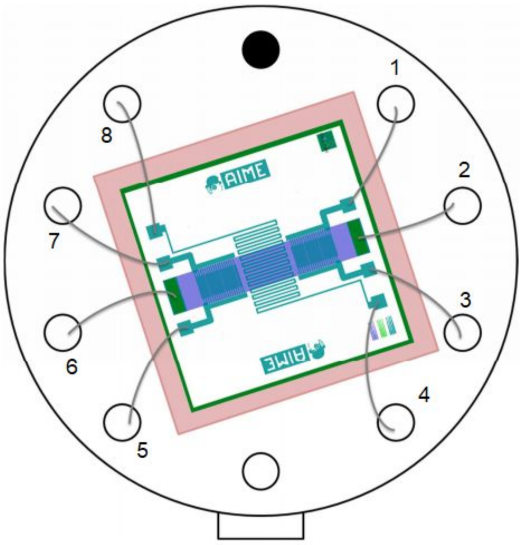
Pin Description and functions



Pin Number	Usage
1 - 3	Gas sensor (WO3 nanoparticles integrated on interdigital aluminium combs)
2 - 6	Heater (Doped Polysilicon)
5 - 7	Gas sensor (WO3 nanoparticles integrated on interdigital aluminium combs)
4 - 8	Temperature sensor (Aluminium resistor)

Specifications

Type	Nanoparticle based sensor
Materials	• Silicon • Doped polysilicon • Aluminium • Tungsten trioxide nanoparticle
Sensor type	Active sensor
Nature of output signal	Analog signal
Nature of measurand	Resistance mesure
Detectable gaz	• NH_3 (Ammonium hydroxide) • CH_3CH_2OH (Ethanol)
Mounting	Through hole fixed
Response time	< 30s
Recuperation time	> 100s
Nominale temperature	[423K - 573K]
Deterioration temperature	573K +

Physical Characteristics

Package	Package 10-Lead TO-5 metal can
Diameter	10mm
Height	25mm

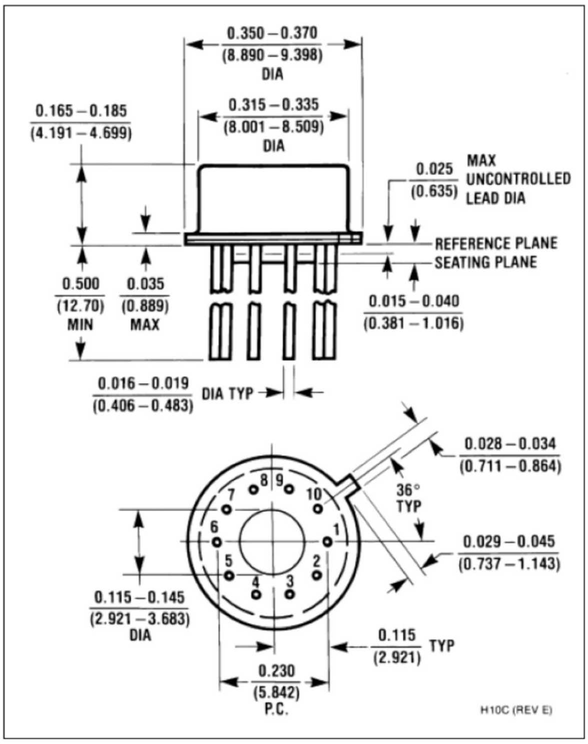
Recommended Operating Conditions

Temperature	25°C+-5°C
Pressure	101,325 Pa

Electrical Characteristics

	Aluminum	Polysilicon
Nominal Use	0 - 5V	0 - 11V
Non Deterioration Use	5V - 10V	11V - 15V

Dimensions



Characteristic graphs of resistances and currents in standard test conditions

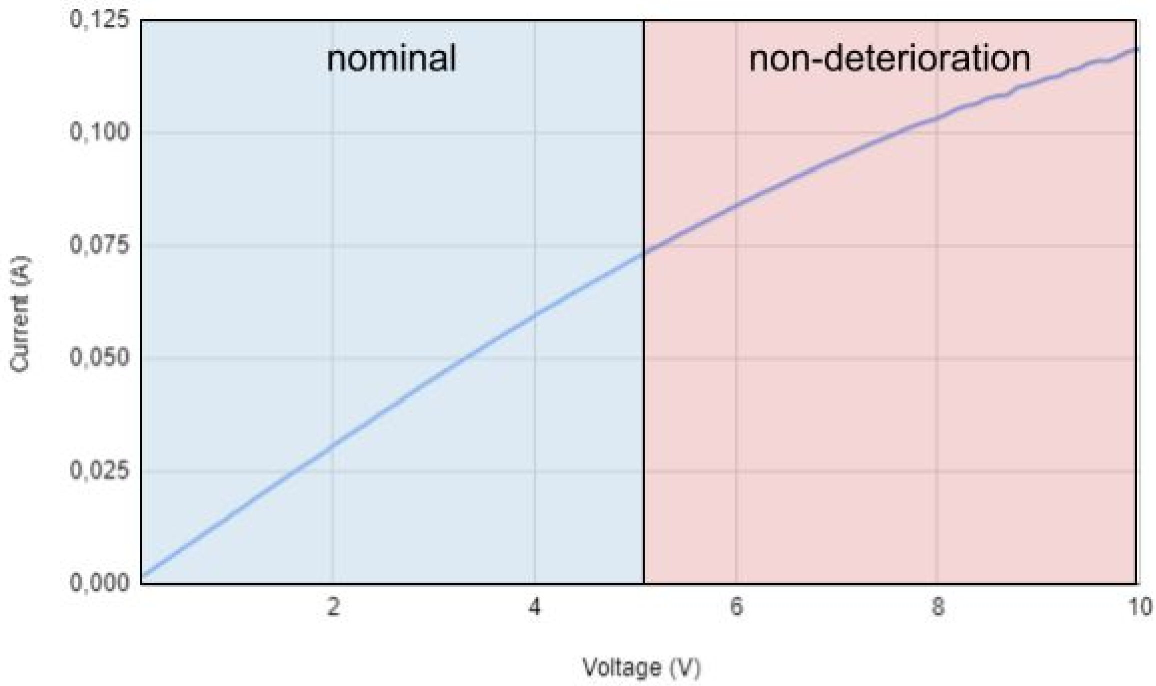


Figure1: Current and resistance response as a function of voltage (RESISTANCE ALU)

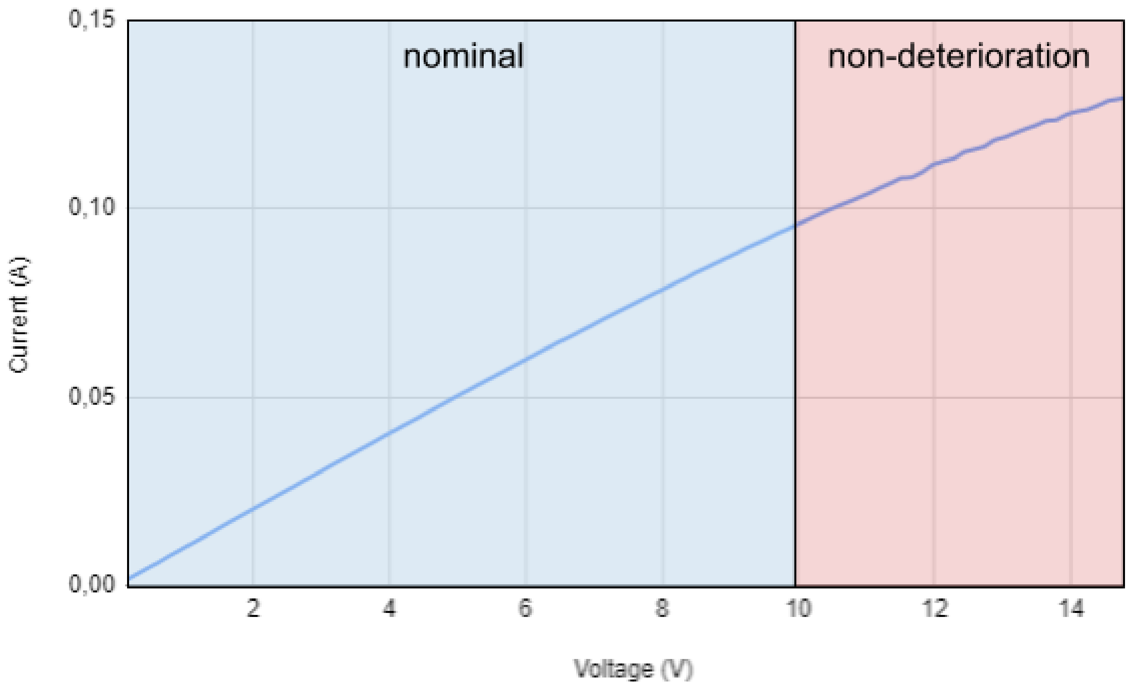


Figure2: Current and resistance response as a function of voltage (RESISTANCE POLYSILICON)

Procedure for the characterization of the sensor

15s	120s	120s	120s	120s	120s	120s	120s	120s	...
Ø	Dry air	Ethanol 1000ppm	Dry air	Ethanol 1000ppm	Dry air	NH_3 1000ppm	Dry air	NH_3 1000ppm	Dry air

Results at 523K

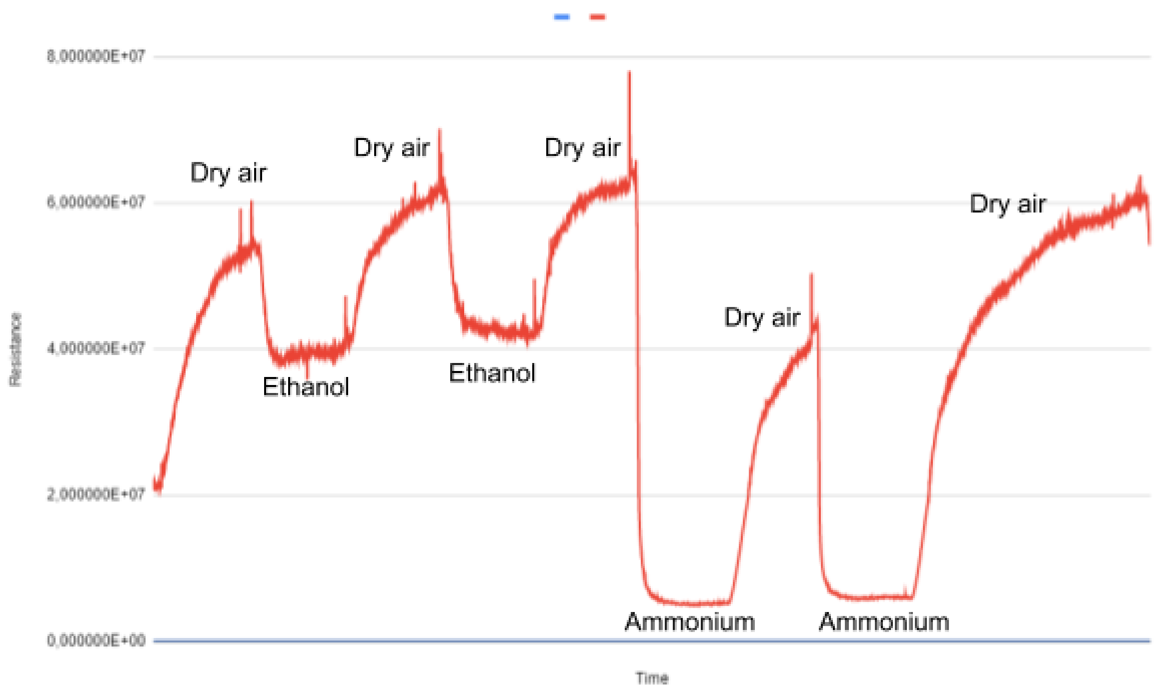


Figure3: Results at 523K, resistance response as a function of time

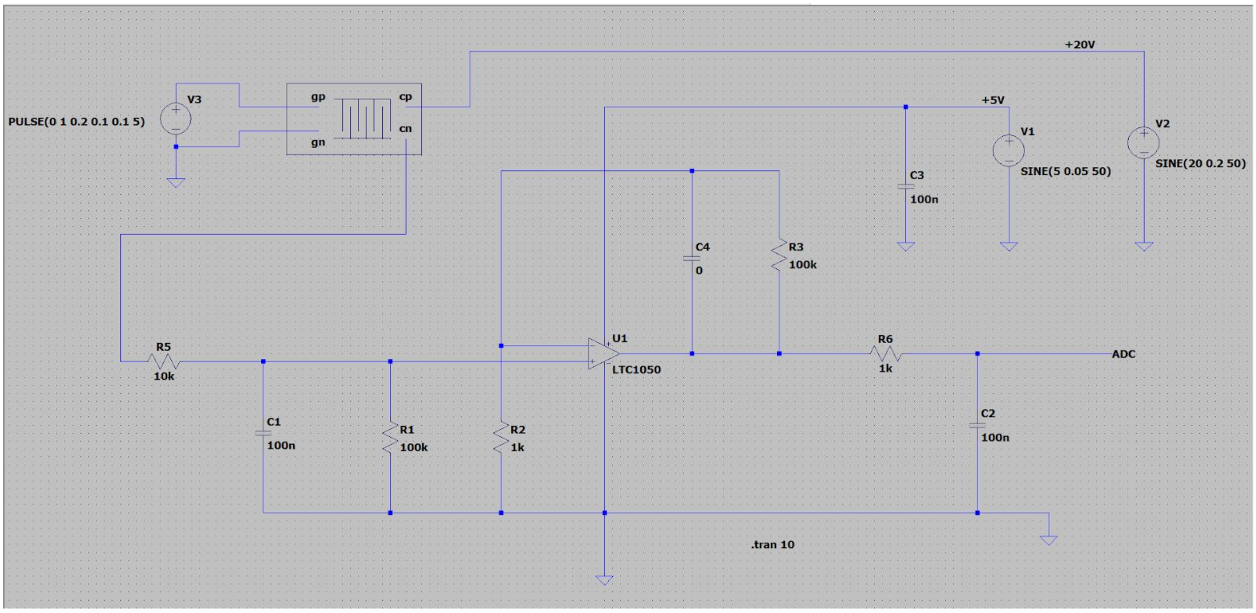
By measuring the resistance of the resistance, we outline the sensor characteristic. The first half of the test phase was the response under ethanol gas, while the last half was under ammonia. The drop in the resistance shows the gas sensor response to a given gas while the increase in resistance illustrates the process of rebuilding the sensor.

N_2O_2		CH_3CH_2OH		NH_3	
DR/R0 (%)	**kN_2O_2 - tN_2O_2**	**DR/R0 (%)**	**kEth - tEth**	**DR/R0 (%)**	**kNH_3 - tNH_3**
-50%	0,1 Hz - 10s	-27,00%	0.04 Hz - 25s	-150,00%	0.167 Hz - 6s

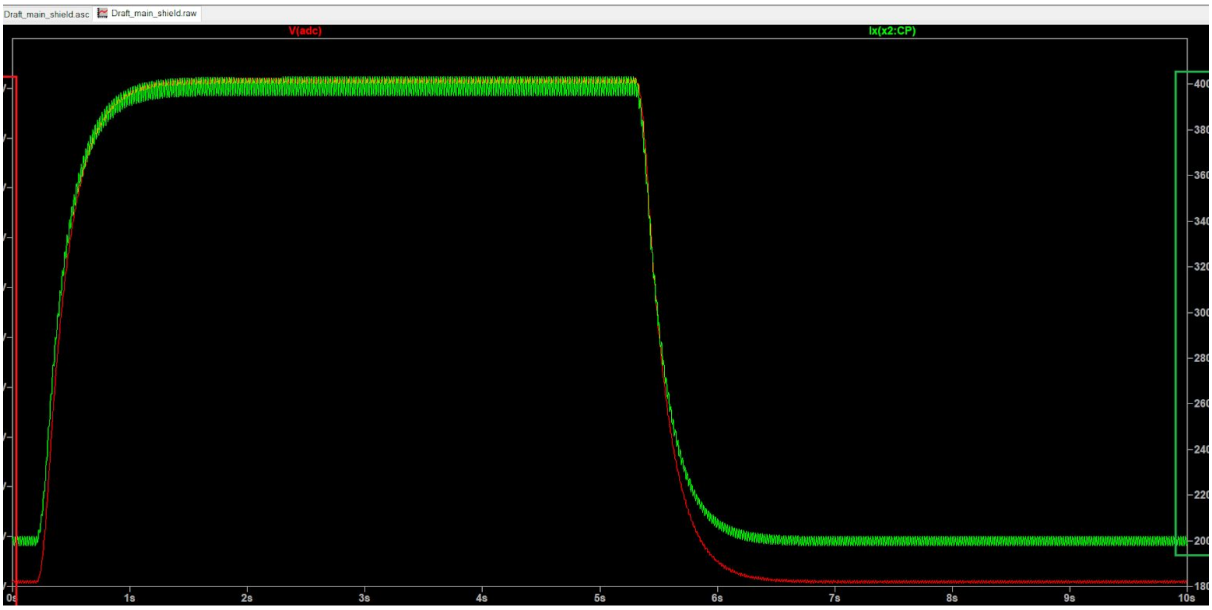
Note : The response at 453K provides a more sensitive response than at 523K. The detection of a gas causes a more significant reaction with a better response time. However, the resistor reconstitution time is much longer and is not suitable for high frequency use.

Possible Conditioning Circuit for measurement with Arduino Uno

The entry impedance of the Arduino is much lower than the impedance of the Sensor.
We must therefore put in place a conditioning circuit. This conditioning circuit is an amplifier that allows us to shape the sensor response to obtain an exploitable signal that our Arduino will take care of.
Here is below a possible circuit:



For input, we apply a PULSE signal with 5 seconds at HIGH LEVEL (1 digital) and we observe in output the VADC which is also the input voltage of our Arduino board.



We observe that when I_x change its state from LOW to HIGH or HIGH to LOW, V_{ADC} also changes its state with a very small delay. For I_x varies from 200nA to 400nA, we obtain V_{ADC} varies from 2V to 4V, so the gain of our amplifier circuit equals to: 10^7 (V/nA)

The V_{ADC} signal (red) “follows” very well the evolution of our input signal (I_x).

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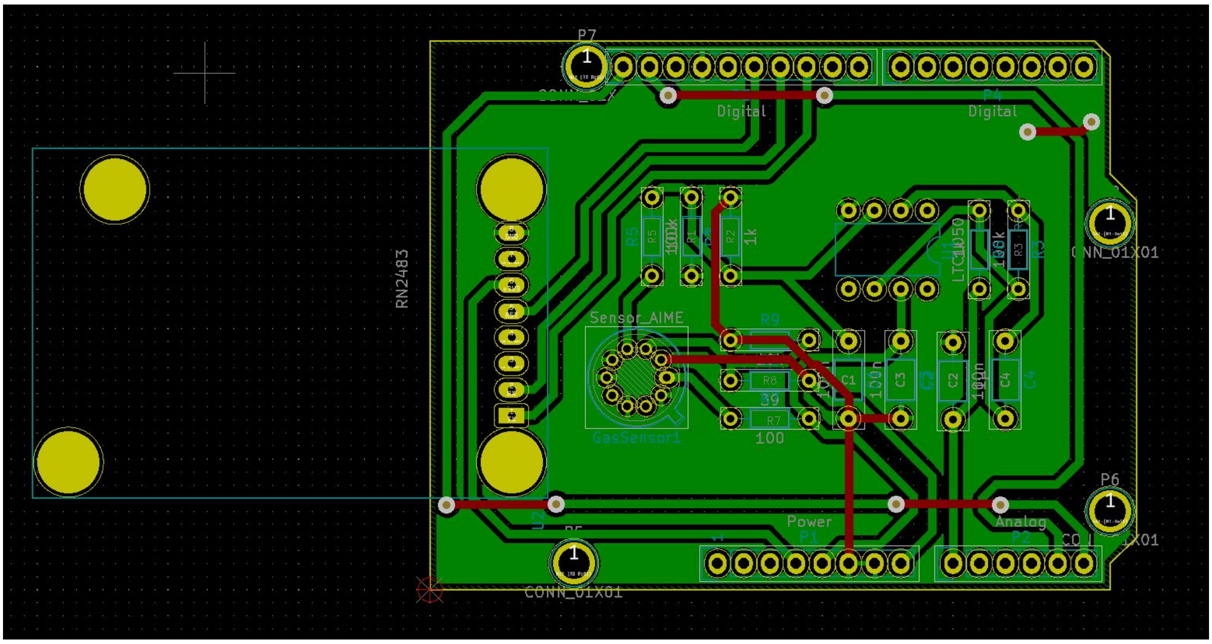
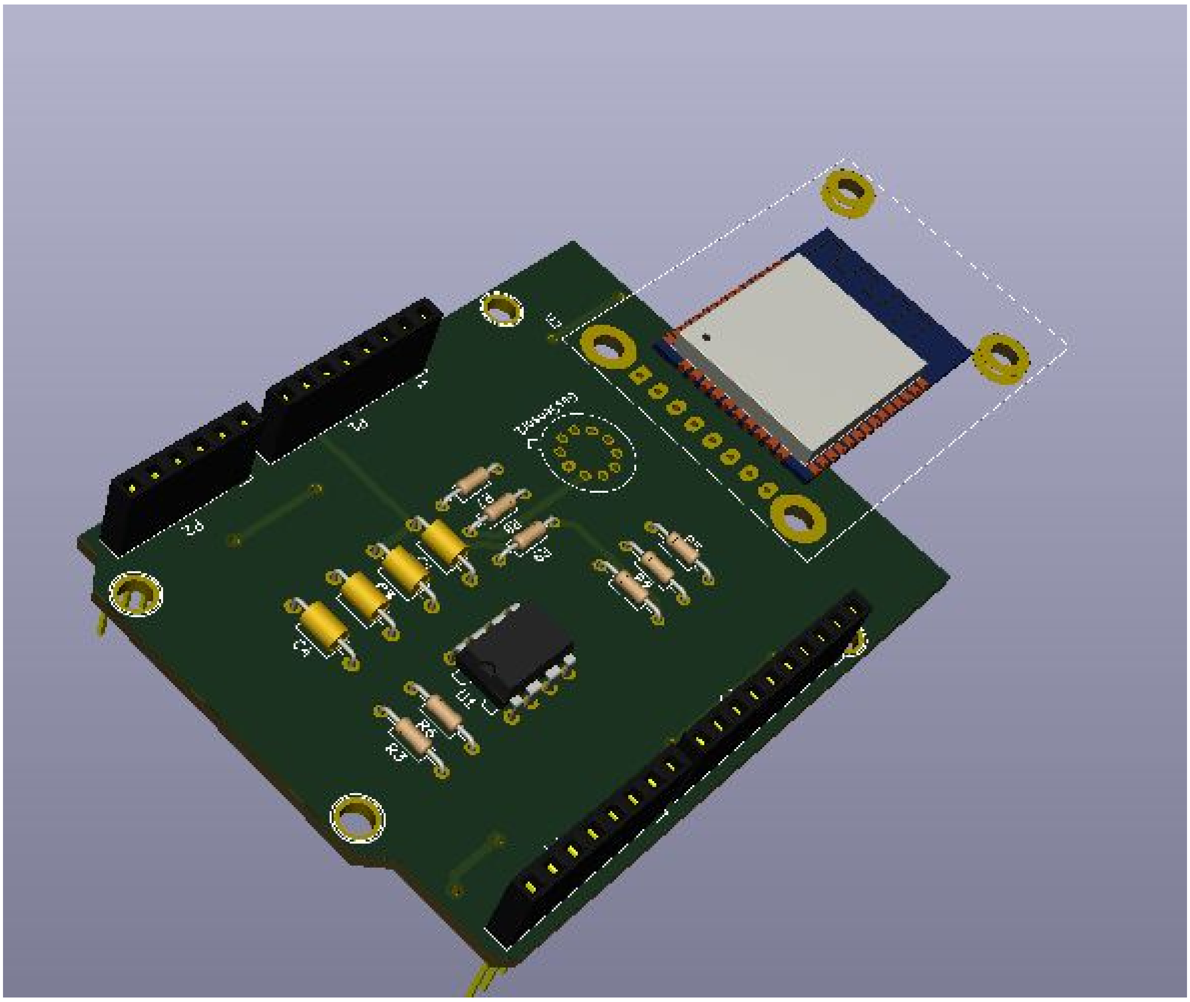
AiME Micro-Nano Pôle CNFM de Toulouse

KiCad shield for sensor integration





Possible arduino code for usage

Arduino code for sensor reading, optimizing the energy consumption by puting on sleep the gas sensor when we don't need it.

```
#define debugSerial Serial

void setup(){
  debugSerial.begin(9600);
  pinMode(9,OUTPUT); //Sensor alim PIN
  pinMode(A0,INPUT); //Sensor output PIN
  while (!debugSerial && millis() < 10000)
    ;
}

void loop(){
  debugSerial.println("-- LOOP");
  digitalWrite(9,HIGH);
  delay(200);
  uint32_t tension = analogRead(A0); //Reading the gas level
  digitalWrite(9,LOW);
  delay(200);
  debugSerial.println("Mesure: " + String(tension));
  delay(1000);
}
```