# Sensor characterization and development for environmental monitoring

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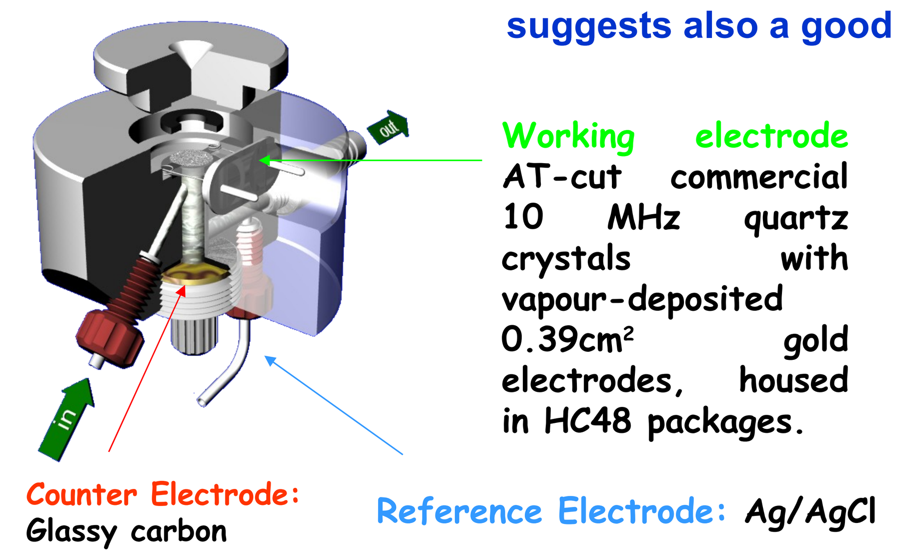
## $NO_2$ QCM gas sensor based on electrochemical deposition of PEDOT

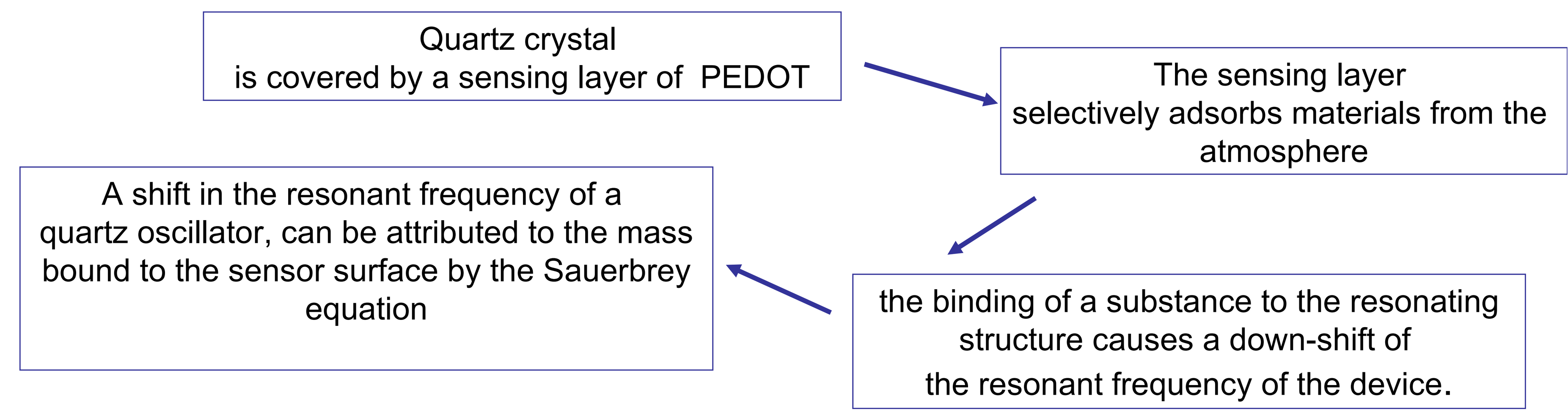
**In this work the development and the tests of a Quartz Crystal Microbalance (QCM) sensor for $NO_2$ detection with the sensitive layer made of a thin films of PEDOT, is described. A sensitivity to $NO_2$ of the order of 2.6 Hz/ppm was verified with an ad hoc developed measurement instrument, that grants a $NO_2$ resolution in the order of 1 ppm. Tests were also conducted to investigate the sensitivity to CO and $O_2$, and to evaluate the effects of environmental conditions such as gas flow variations and the results suggests also a good selectivity of the sensor to $NO_2$**

### Sensitive layer Preparation and Characterization

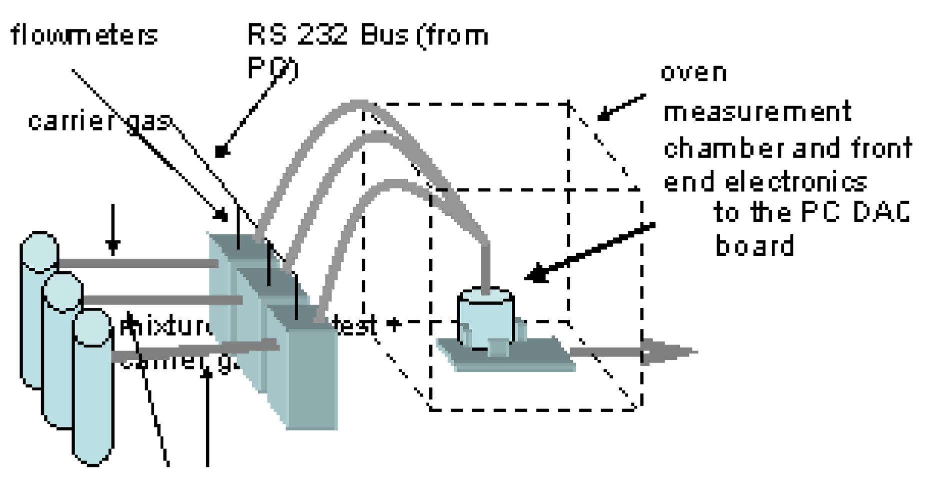



The electropolymerization processes were performed in 10 mM EDOT, 0.1 M $TEAPF_6$, $CH_3CN$ solution. In the potentiodynamic growth, the polymer-modified electrodes were prepared by repeatedly cycling the potential between - 0.5 V and +1.25 V.
A potential scan rate of 0.05 V/s was used in all depositions.

### Sensing Principle



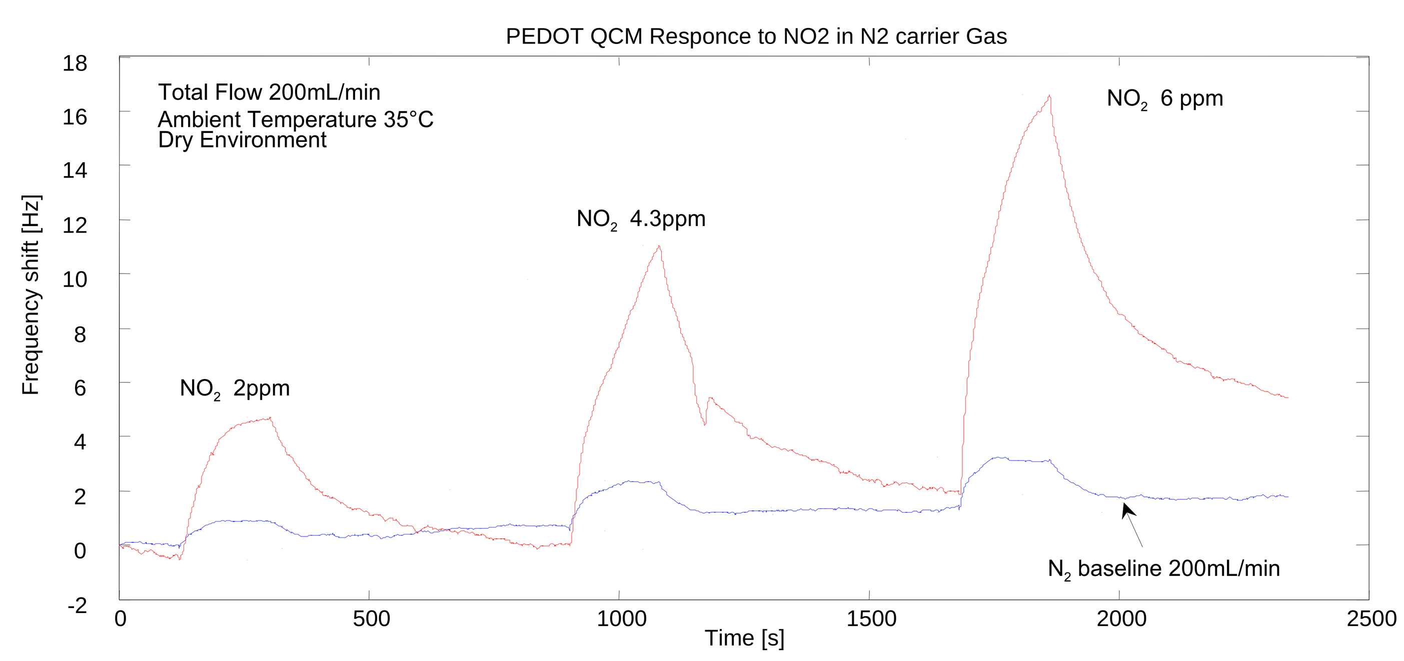

### Measurement Set-Up



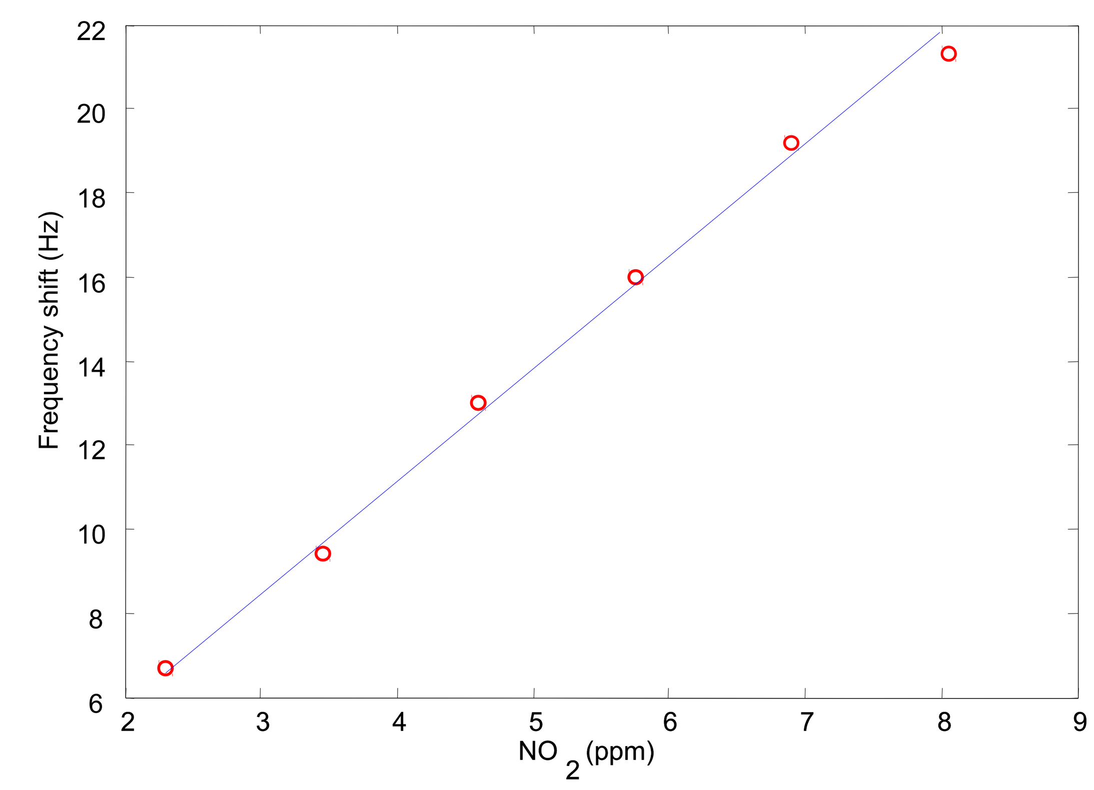

During measurements the chemical sampling and control system allows to maintain the sensors in known and predefined atmosphere and temperature. The measurement chamber allows performing measurements with 2 sensors and two reference quartzes, a humidity sensor and a temperature sensor.

### RESULTS

**Measurement conditions:**
**Dry environment.**
**Total flow: 200 mL/min.**
**Meauremet protocol:**
**Phase 0: exposure to reference gas (N2, duration 120 s);**
**phase 1: exposure to the mixture under test (180 s);**
**phase 2: recovery in N2 (480 s);**




A reference baseline is obtained performing preliminary measurements in Nitrogen at 200 mL/min.




**A set of 6 nominally equal sensors was tested for $NO_2$ sensitivity in the range 2 ppm-10 ppm in the same enviromental conditions.**

## YCoO3 perovskite as possible candidate for CO-sensors: synthesis and sensing properties

**Perovskite structure ($ABO_3$) is an eccelent catalyst to CO oxidation. In this work the preparation of ittrium cobaltite ($YCoO_3$) is presented : due to thereaction of adsorbed oxygen species on the surface and the p-type semiconducting behavior of this material, the resistance increased with the introducing of CO to the flow. The sensing properties towards the CO were analyzed by following the resistivity response when changing the gas composition from air to air with CO. Measurements have show a good response starting from a very low temperature.**

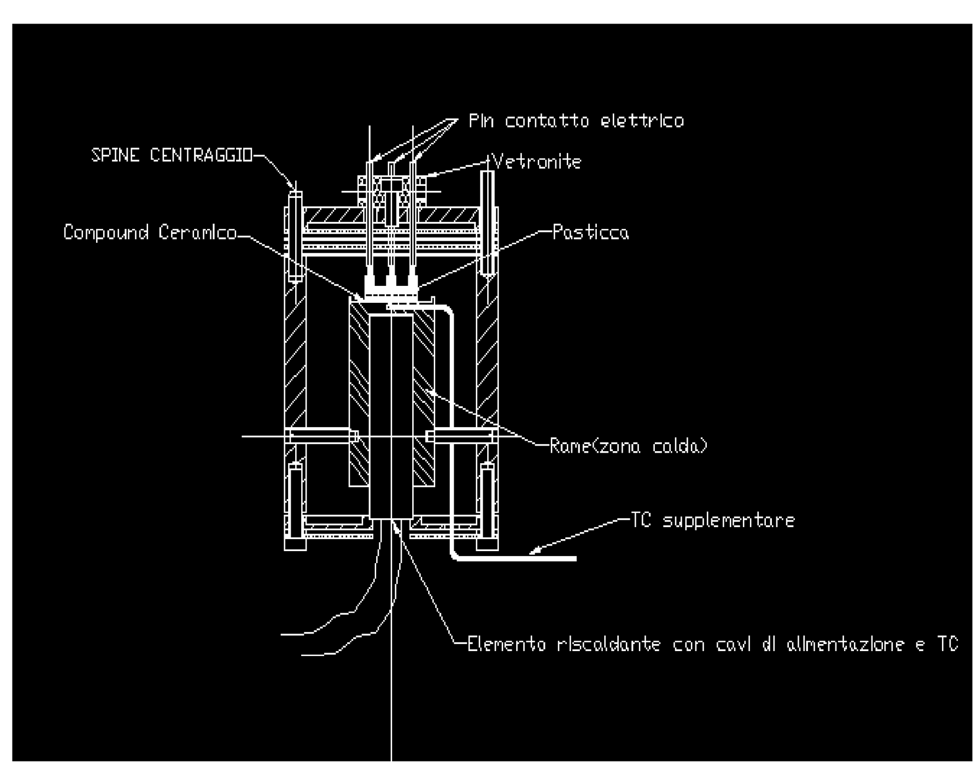
### Preparation and characterization of sensitive material

$YCoO_3$ was prepared by means of sol-gel technique. An aqueous solution of $Y(NO_3)3{\cdot}6H_2O$,$Co(NO_3)2{\cdot}6H_2O$ and citrate acid was prepared and heated with continuous stirring. The as-obtained gel is thermally decomposed at 150°C and the final sintering was performed from 300°C to 900°C for more then 24 hours.

This material was characterized by power X-ray diffraction technique to check the development of crystal phase.

### Measurement Set-Up

Oxide powder thus obtained were pressed into disks ( 12 mm diameter and 2 mm thickness) and than was put in the measurement chamber .

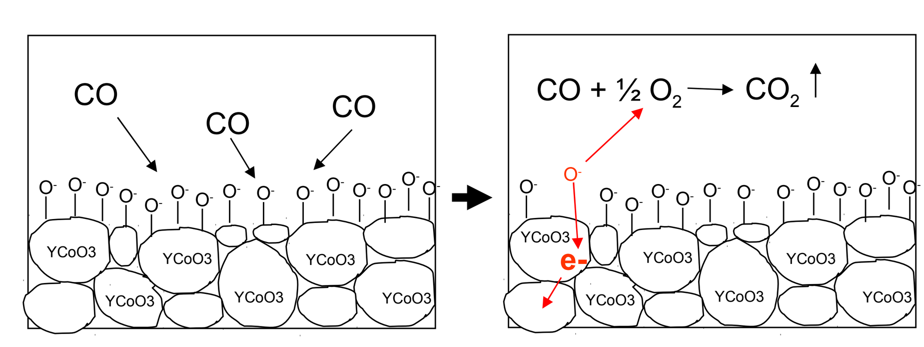



### Sensing Principle

In the test response properties to CO, when CO was introduced to air flow, the resistance of the film increased , thus the behavior of the $YCoO_3$ film is like a p-type semiconductor.
The sensitivity is defined as:

$$Sensitivity = \frac{(Rco - Rair)}{Rair} \times 100$$

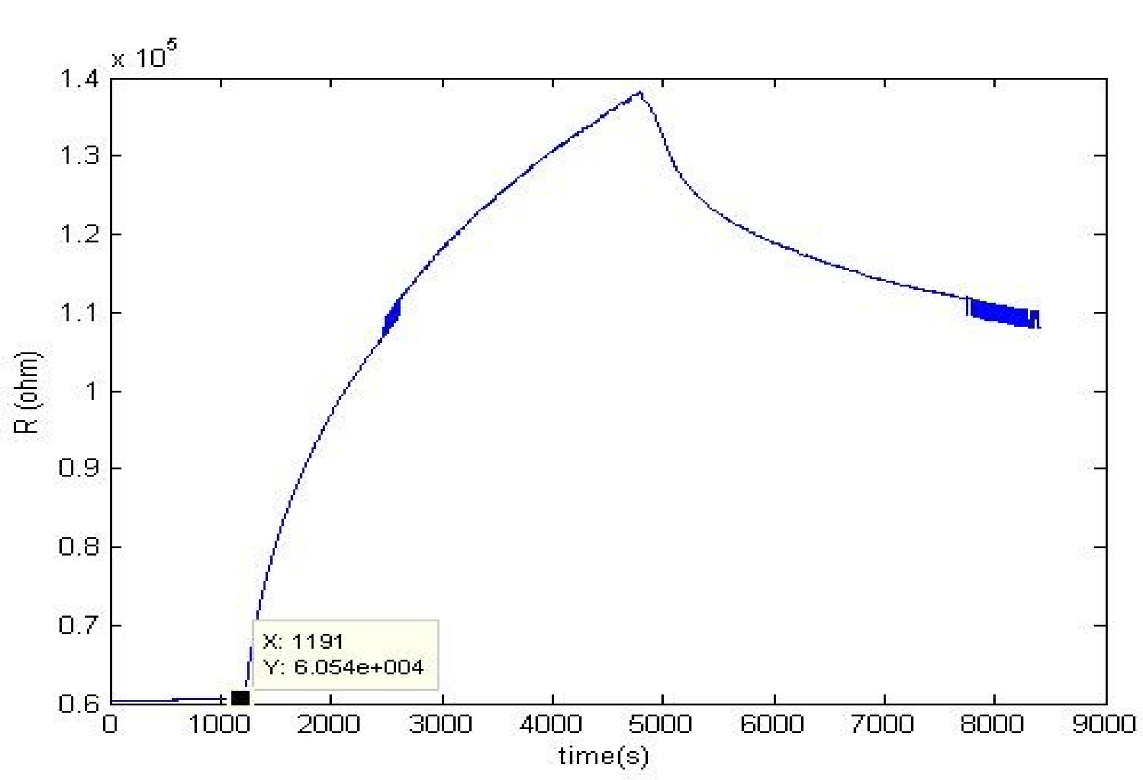
Where Rair is the resistance before CO was introduced and Rco is the final resistence after CO was introduced in the air flow.




### RESULTS

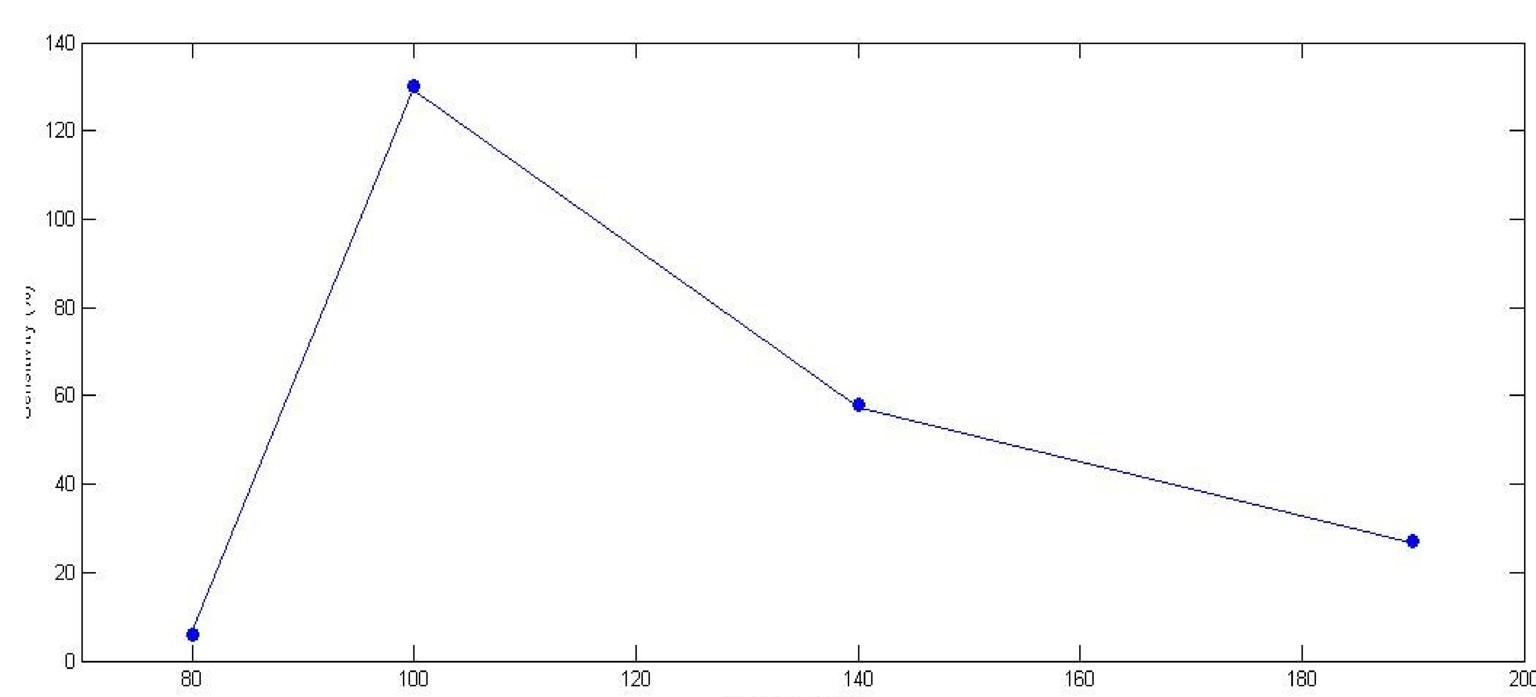
**Measurement conditions:**

**Dry environment.**
**Total flow: 200 mL/min.**
**Meauremet protocol:**
**phase 0: exposure to synthetic air ;**
**phase 1: exposure to the mixture under test (air + CO**




Response of $YCoO_3$ with 0,4% Pd to 5000 ppm CO

According to the figure below the maximum sensivity was obtain at about 100°C.




The sensitivity as a function of temperature for 10000 ppm CO in air of $YCoO_3$

References:
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