# Tin dioxide-graphene based chemiresistive device for $NO_2$ detection in the sub-ppm range

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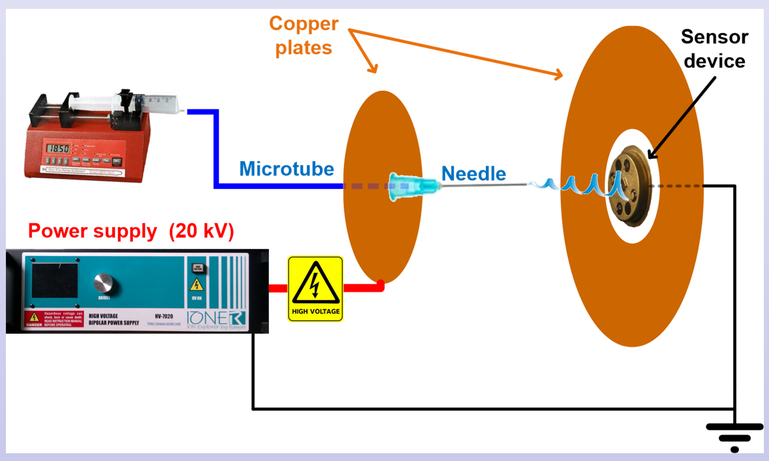
## ABSTRACT

Chemical devices based on active films of electrospun nanofibers of pure tin dioxide and graphene-doped tin oxide were developed and characterized for $NO_2$ detection at sub-ppm level. The film morphology was investigated by scanning electron microscopy (SEM). The response of the devices to sub-ppm $NO_2$ concentrations was measured from room temperature up to 300 ºC. An improvement in sensing performance in terms of sensitivity and response time, together with higher response at room temperature, were obtained when nanofibers of tin oxide-graphene was used. A comparison with state of the art commercial sensors was performed.

## EXPERIMENTAL

### Sample preparation Electrospinning



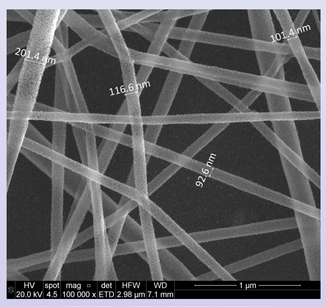

| Solution | D (cm) | q (μl/min) | t(min) |
|---|---|---|---|
| $SnCl_4$-PVA | 8 | 4 | 25 |
| Gr1- $SnCl_4$-PVA 100 ppm (Gr/Sn) | 5 | 1 | 20 |
| Gr2- $SnCl_4$-PVA 1000 ppm(Gr/Sn) | 5 | 1 | 20 |

Table 1. Electrospinning deposition conditions: D, distance between the tip and the substrate; q, solution flowrate; t, deposition time. Deposition voltage of 19 kV for all samples

$SnO_2$

$SnO_2$-Gr

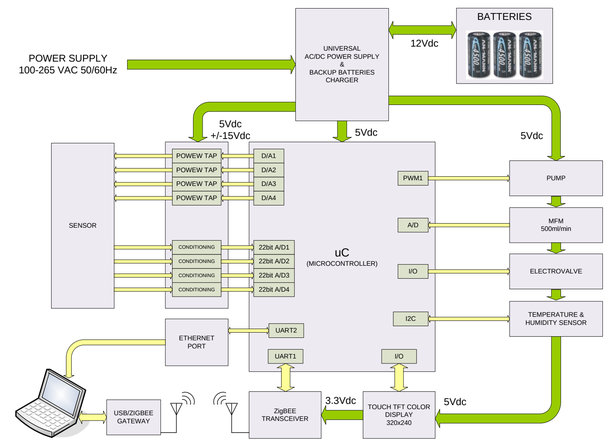
CCS 801 803





AMS
CCS 801 and 803

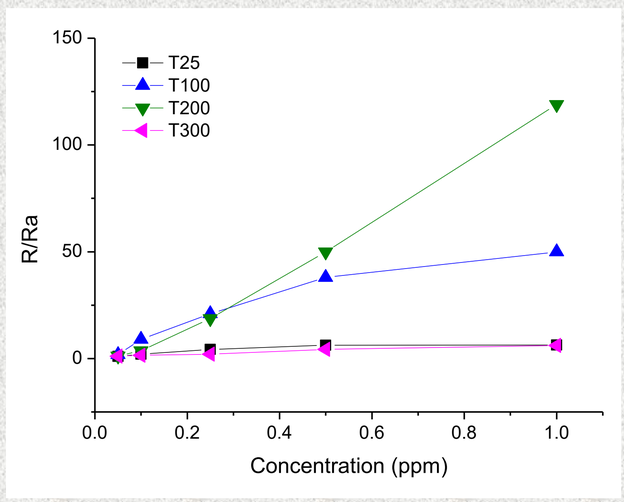
### Measurement system

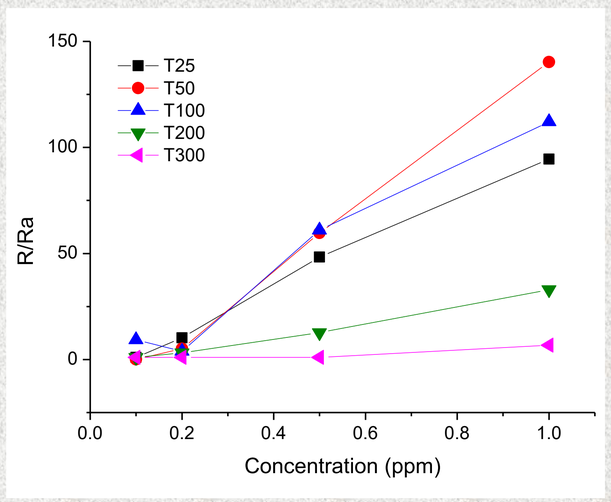

## RESULTS

The curves represent the relative resistance change for the $SnO_2$ nanofiber-based devices and for the state of the art ultralow power commercial microsensors (CCS 801 and 803, AMS AG Austria) towards low $NO_2$ concentrations in air for the whole temperature range. Main difference between Gr2 device and Gr1 device was the better response at room temperature of the former although for the rest of the temperature range its response was lower. An overall improvement in response for the entire temperature range for the doped device is clearly observed, with a more remarkable difference at lower temperatures (<100ºC). Optimal operation temperature was 200 ºC for the undoped $SnO_2$ based chemi-device and between 50 ºC and 100 ºC for the doped one. Commercial sensors exhibited no response at room temperature.

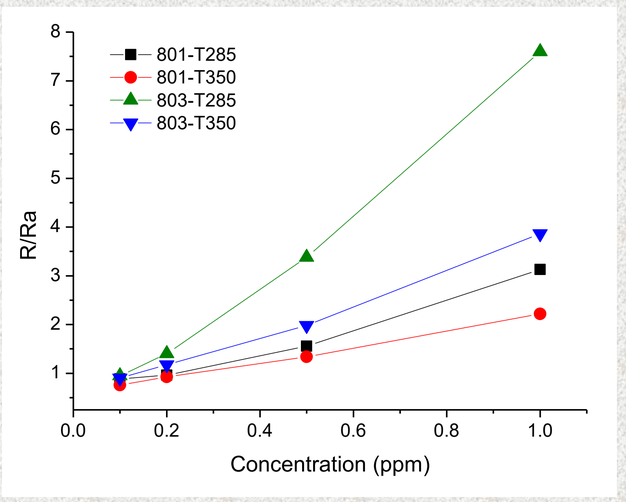
### Undoped $SnO_2$




### Gr-doped $SnO_2$ (Gr2)




### Commercial sensors




Calibration curves to $NO_2$ in air

## CONCLUSIONS

Doping tin dioxide nanofibers chemi-devices with pristine graphene improved its sensing performance to nitrogen oxide. The most remarkable effect were the increase of the response at any temperature and the decrease of the optimal detection temperature. Also both tin dioxide nanofiber chemi-devices showed overall better performance than the state of the art commercial sensors particularly at room temperature.



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