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Near-room temperature NO_2 and H_2 gas sensors based on self-assembled 2D - $SnO_2/SnSe_2$ few-layered heterostructures

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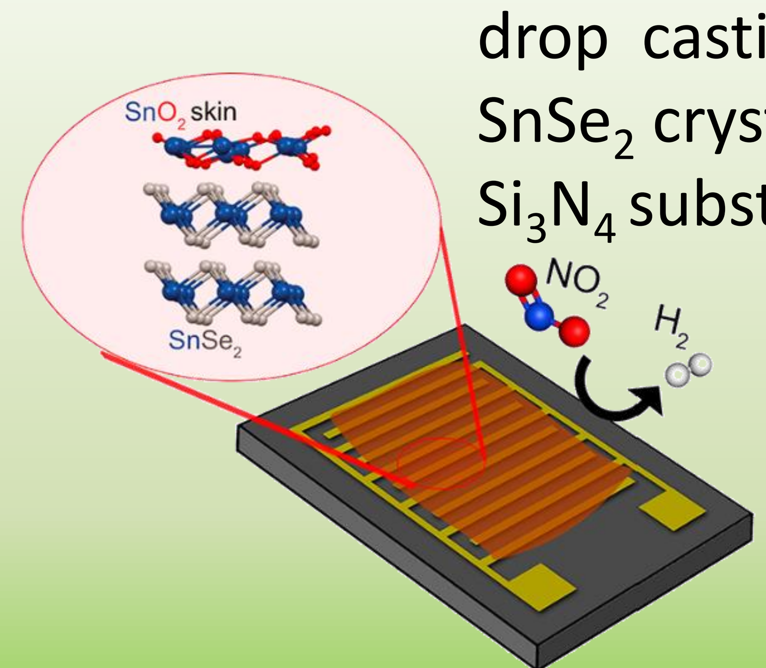
Introduction

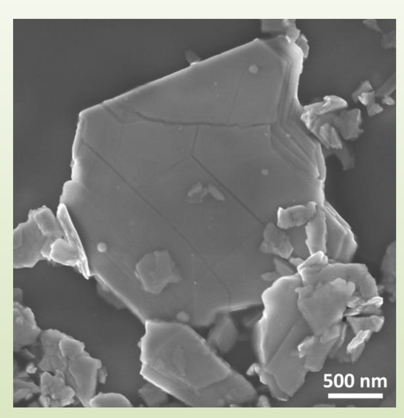
Long-term exposure to air pollutants in urban areas causes adverse health consequences and considerable environmental impacts. Various materials were proposed for gas sensing and in particular nanosheets of transition-metal dichalcogenides (TMDCs) have attracted great interest for low-temperature gas sensing applications. Recently, tin diselenide ($SnSe_2$) has emerged as a candidate material for gas sensing.

Here, we demonstrate that the non-stoichiometric sample ($SnSe_{2-x}$) once exposed to ambient atmosphere, assumes a sub-nanometric SnO_2 surface layer, which makes it particularly efficient in gas sensing.

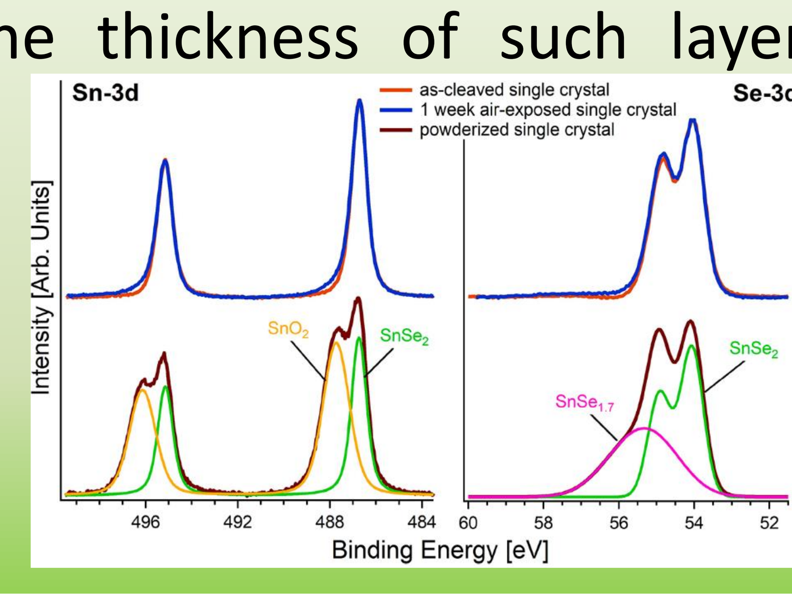
Results



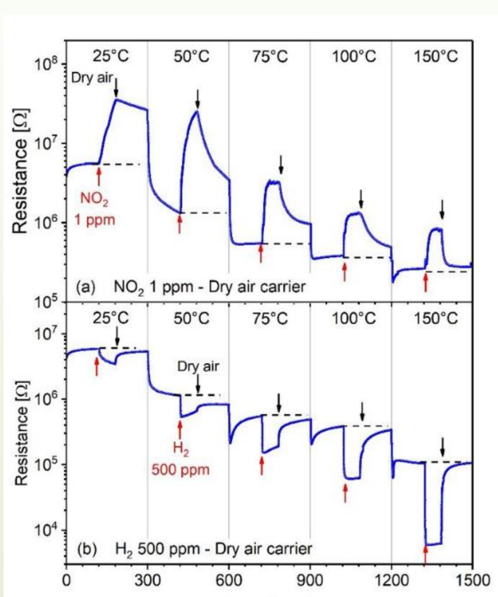
$SnSe_2$ thin films were prepared by drop casting 10 µL of finely ground $SnSe_2$ crystal suspended in ethanol on Si_3N_4 substrates provided with 30 µm spaced Pt interdigitated electrodes on the front side and a Pt resistor acting as a heater on the back side.

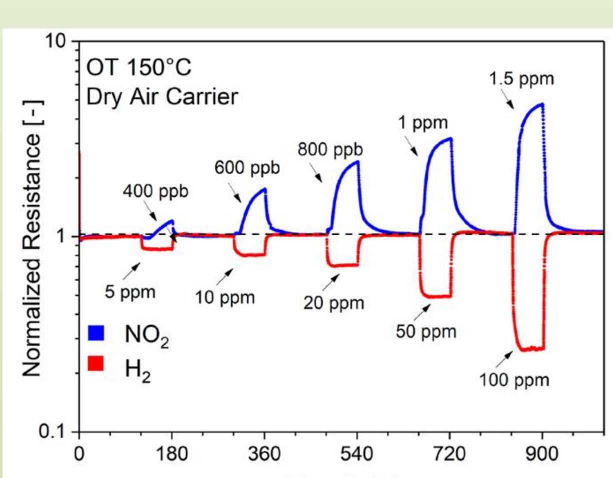


The formation of the SnO_2 surface oxide layer was demonstrated with several surface science techinques. In particular, the analysis of XPS spectra allowed to estimate the thickness of such layer which is calculated to be equal to 8 ± 1 Å, without noticeable changes after aging in air in a time scale of 1 week [1].



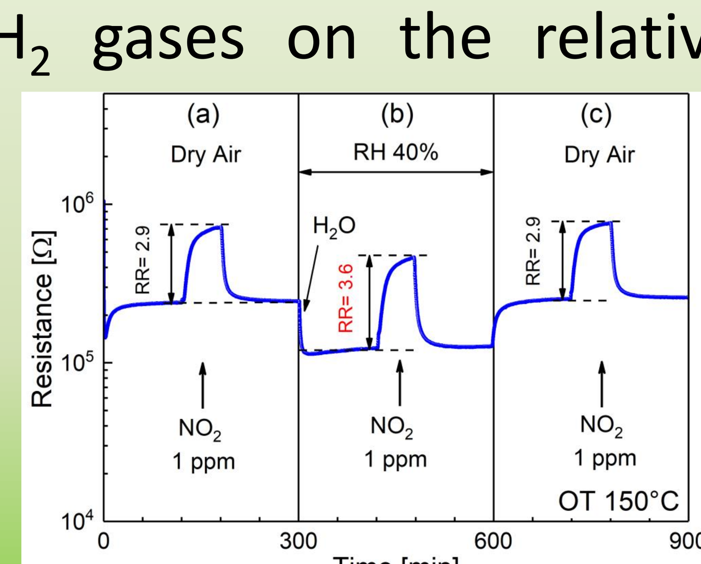
Gas sensing tests were performed by exposing the sensors to different of NO_2 and H_2 gas concentrations and different operating temperatures in dry air carrier.



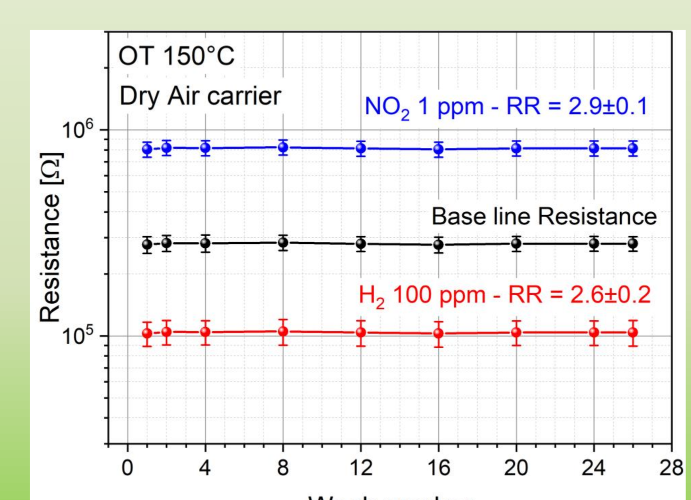


The SnO_2/ $SnSe_2$ heterostructure demonstrated comparable response as that of layered TMDs (resistance ratio =3.2 to 1ppm NO_2) and first experimental evidence ultrahigh response to H_2 at 150°C among the best measured to date for TMDCs based H_2 sensors.

Cross sensitivity tests in presence of NO_2, H_2 and 40% relative humidity revealed high selectivity to the target gas and the occurrence of a synergistic effect between water and NO_2 and H_2 gases on the relative response.



Reproducibility test over a period of six months of continuous operation at 150°C demonstrated remarkable long-term stability of the electrical properties including NO_2 and H_2 response.



Conclusions

We demonstrated the efficiency of the self-assembled $SnO_2/SnSe_{2-x}$ heterostructure in NO_2 and H_2 sensing at 150°C. In particular, the observed surface oxidation results into a self-assembled heterostructure which promotes ultra-sensitive gas sensing without the need of encapsulation.

These results are important because provide a new point of view also for other $SnSe_2$-based applications based on surface phenomena, including electrocatalysis and photocatalysis.

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For more info visit: https://www.goinnovation.it/

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