Design Elements and Prototypes of Metal Oxide Base Gas Sensors

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AIM

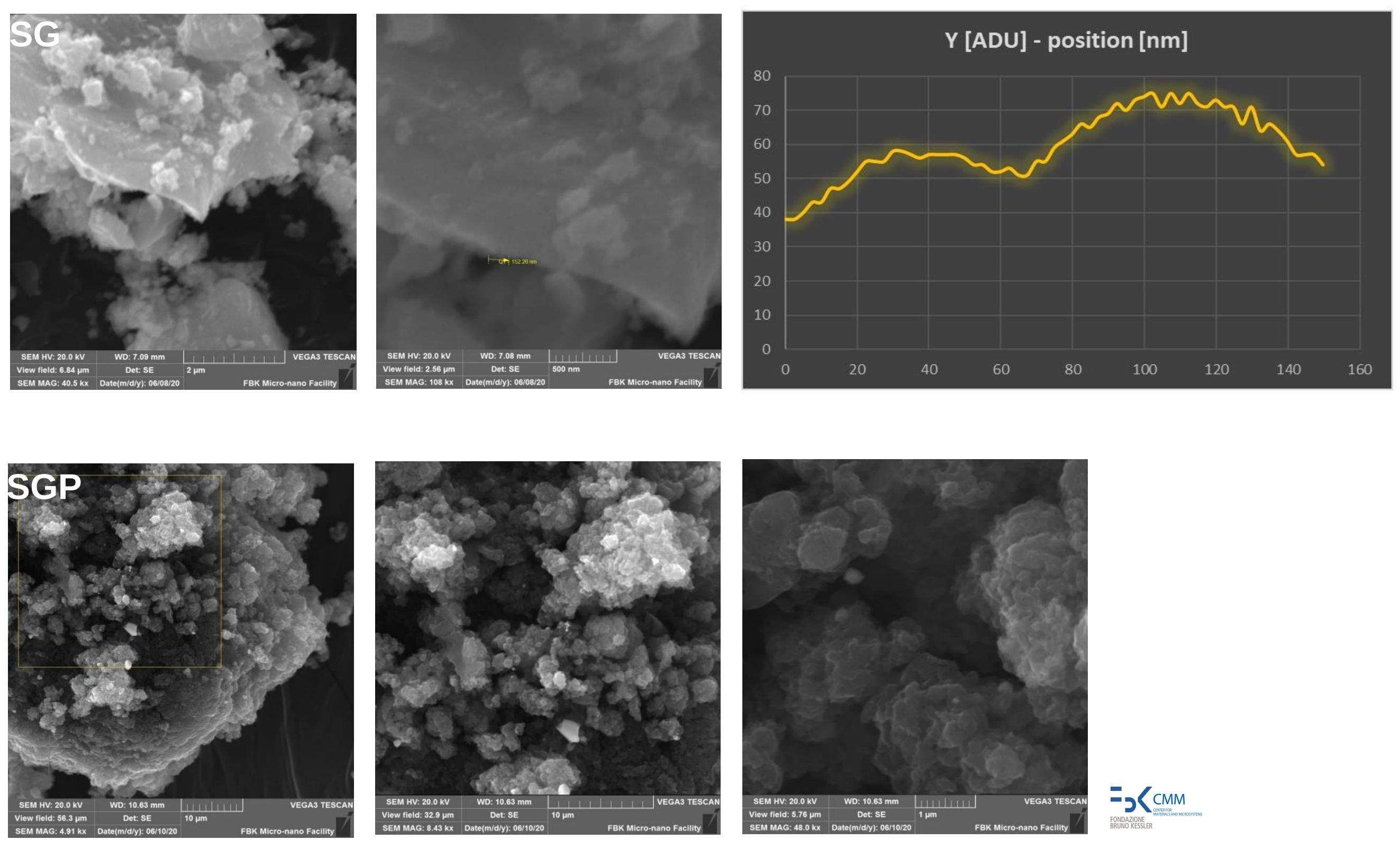
This work develops in the field of microelectronics applied to environmental real-time monitoring. The aim of the study was to realize a chemoresistive sensor that was based on thin film technology, at first finding packaging solutions and depositing the sensitive material via drop cast. The investigation then turns to the preliminary characterization of the selected hybrid powders and the gas sensing performance data gathering.

MATERIALS AND METHODS

- Characterizations are performed for many design types and sensing materials synthesized by Prof. Mattiello research team (LEOS, Lab of Electrochemistry and Organic Syntheses – Sapienza University). Gas sensing devices' response was performed in the MNF of FBK in Trento. SEM Images are graphically elaborated to evaluate 80 nm clusters' dimension.

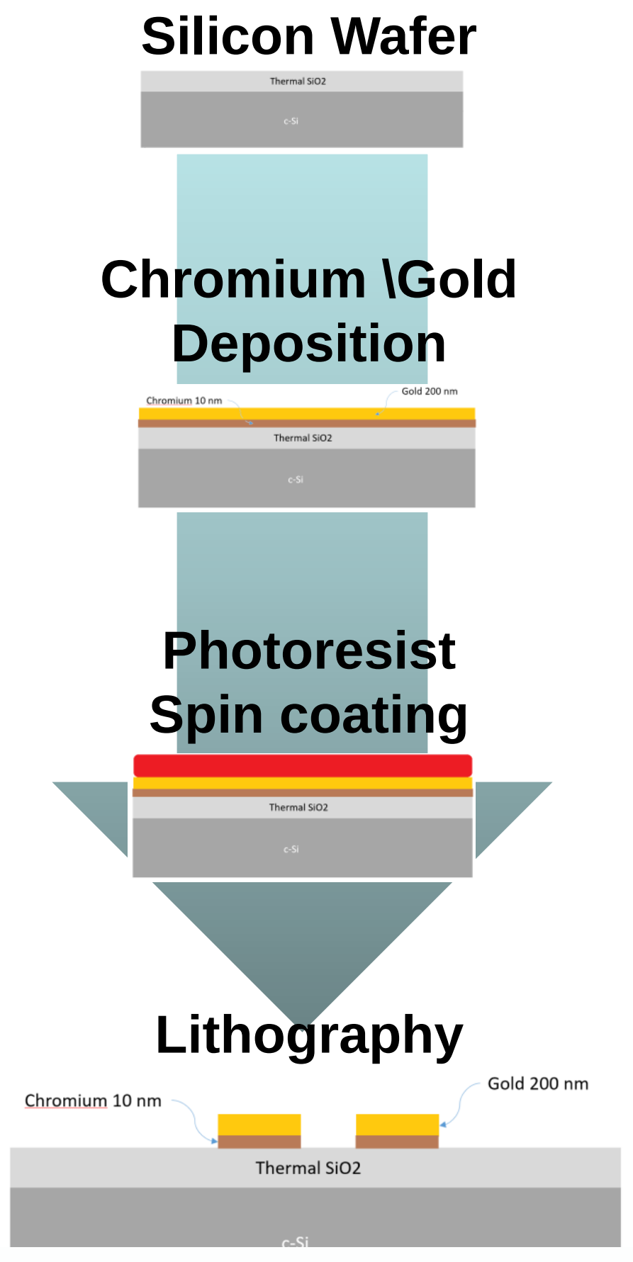
SnO2 /rGO
Hydro-thermal synthesis

SnO_2 /rGO/PANI
Chemical polymerization



Scanning Electron Microscope images are realized with VEGA3 TESCAN Everhart-Thornley SE relevator MNF FBK Trento 06/08/20.

- The device design development and fabrication stages of metal layer are developed in IMM-CNR clean room, in addition **packaging solutions** are found **: after cleaning wafer is cutted and diced. The electronic contact is made with wire bonding technique, drop casting method is used to deposit the powders with organic solvents.**



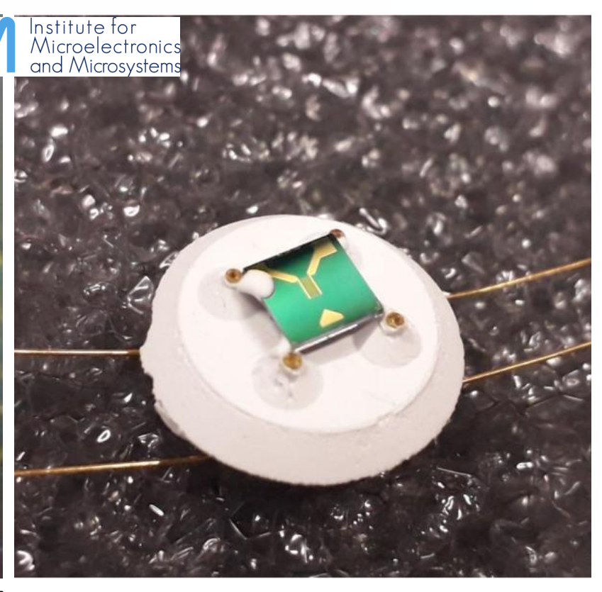
Silicon Wafer

Chromium \Gold Deposition

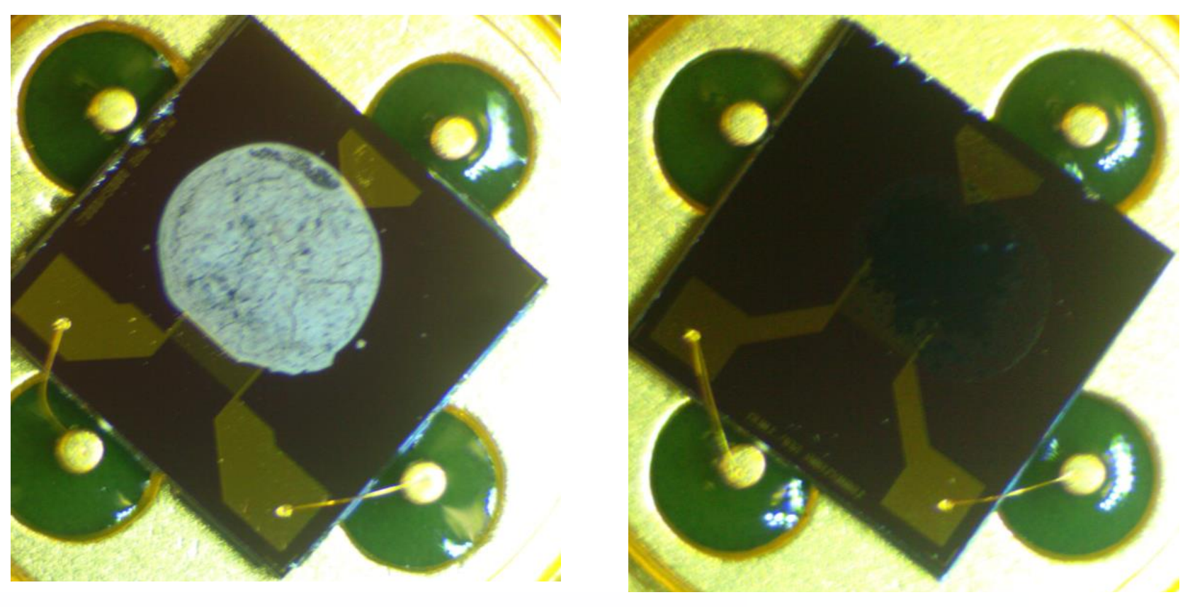
Photoresist Spin coating

Lithography

Gold-Silicon Wafer after cutting step



Alumina Packaging solution

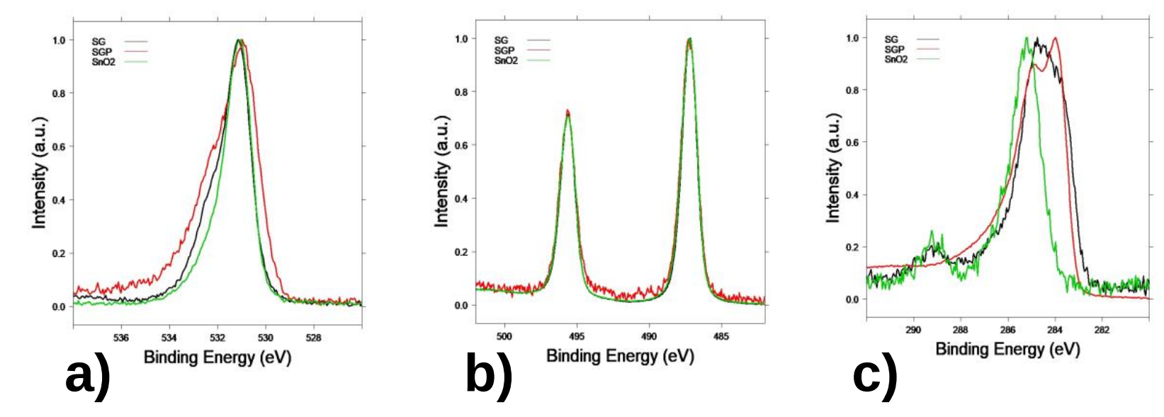


The FBK laboratory set up for gas sensing consists of seven independent gas injection lines and a mixing gas tank before several sealing chambers in series.
Nitrogen Dioxide and Carbon Oxide, as typical environmental pollutants, are chosen as gas targets and carried in dry air.
NO_2 detection is tested in the range from 0.2 to 4 ppm, CO injection is evaluated at 25 ppm fixed concentration.

RESULTS

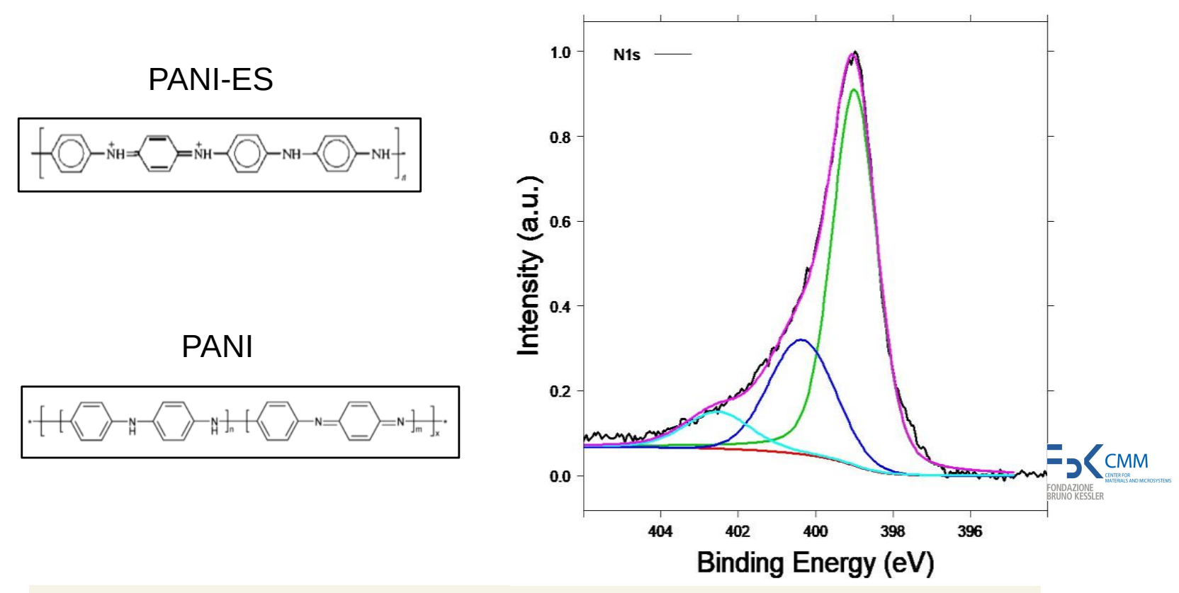
Physical Characterisation XPS and XRD : SG SGP

Fig. 1 Core electrons O 1s (a), Sn 3d (b) and C 1s (c)



Sample	O %	Sn %	C %	Sn/O	N %	S %
SGP	8.2	0.6	77.6	0.07	12.3	1.4
SG	55.9	27.6	16.2	0.49	-	-

Fig. 2 (left) molecular aspect of PANI species; (right) Fitting of ore electron spectra of N1s



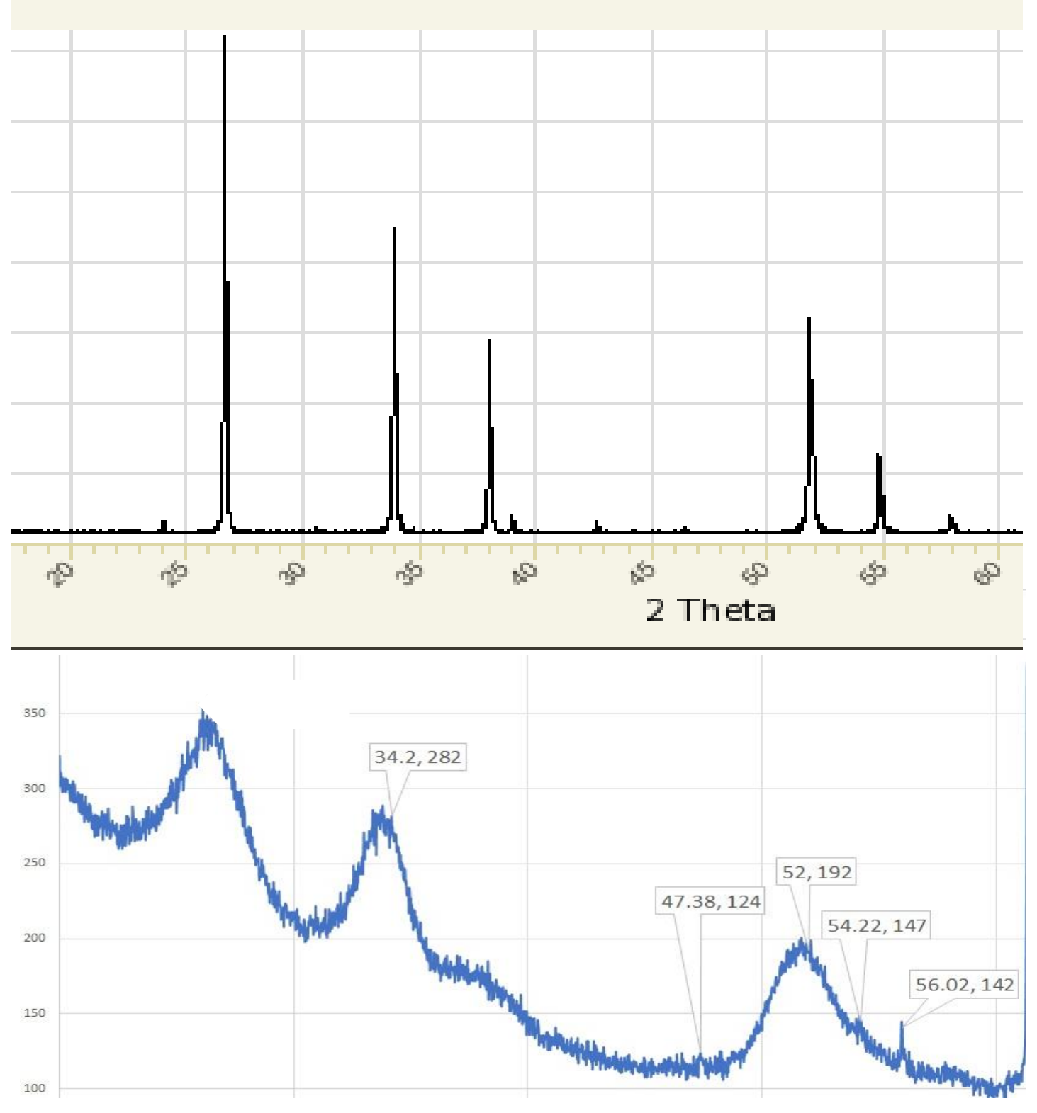


Fig. 3 x-ray spectra of cassiterite https://rruff.info/Cassiterite/R040017 above compared to x-ray peaks of SnO_2\rGO powder below

Core electrons state spectra are seen in Fig. 2

- The results get in evidence the sp^2 majority with respect to the sp^3 in C Fig. 1(c)
- Nitrogen's 1s core electron fitting curve reveals the prevalence of ***-N=*** form (at 399.3) over the others, **N^+** (>400 eV) and **-N-** (at 398.2) Fig. 2

XRD Brag Brentano (Theta/2Theta scan 20-60, step 0,02) powders profiles are in Fig. 3 \4

- Cassiterite white mineral as SnO_2 typical peaks and broadening effect are detected in Fig. 3
- PANI in salt form and random copolymers distribution are highlighted by the big signal at low angles in Fig. 4

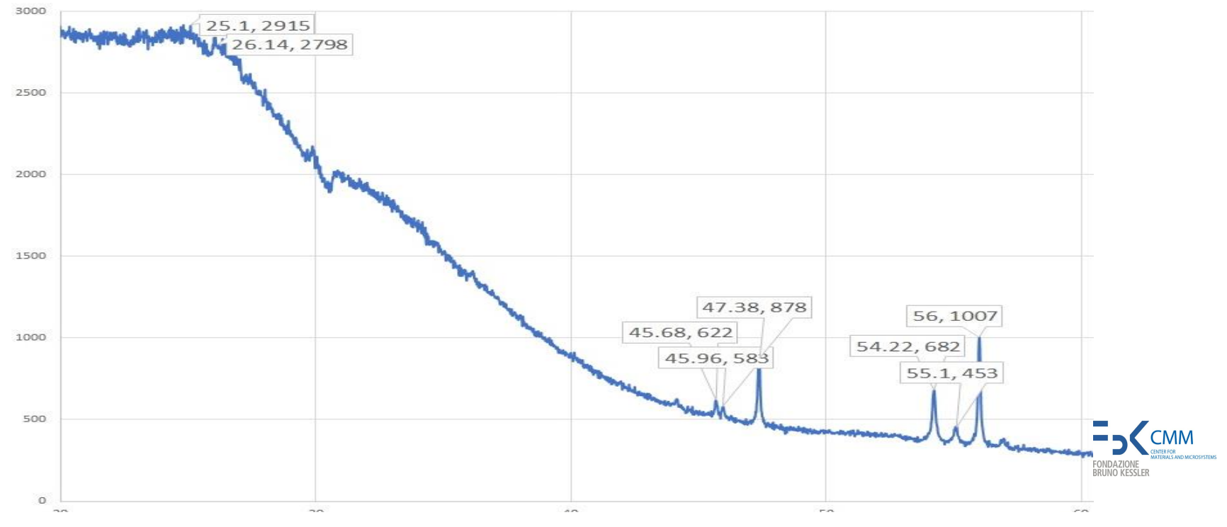
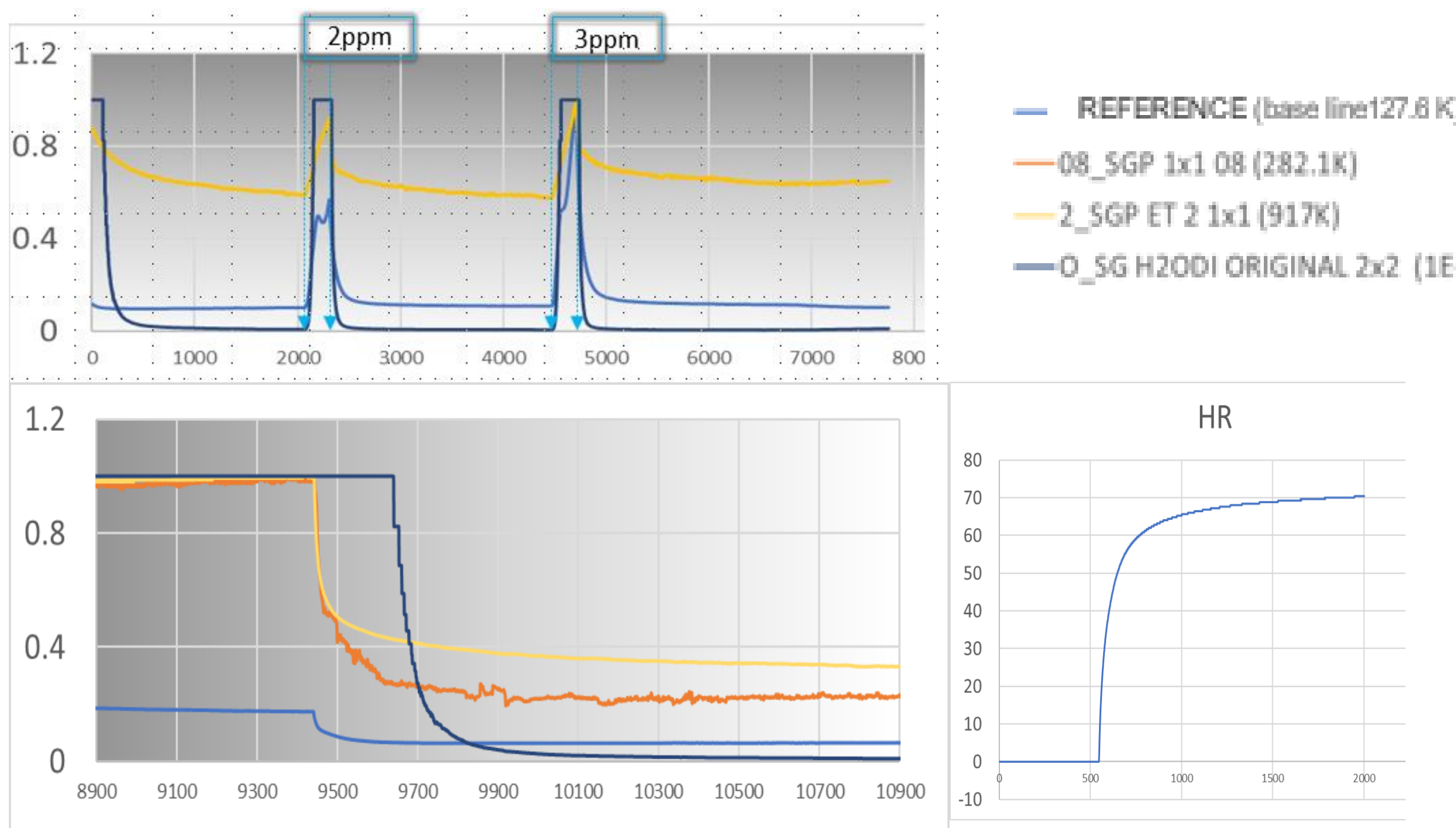


Fig. 4 x-ray peaks of SnO_2\rGO\PANI powder

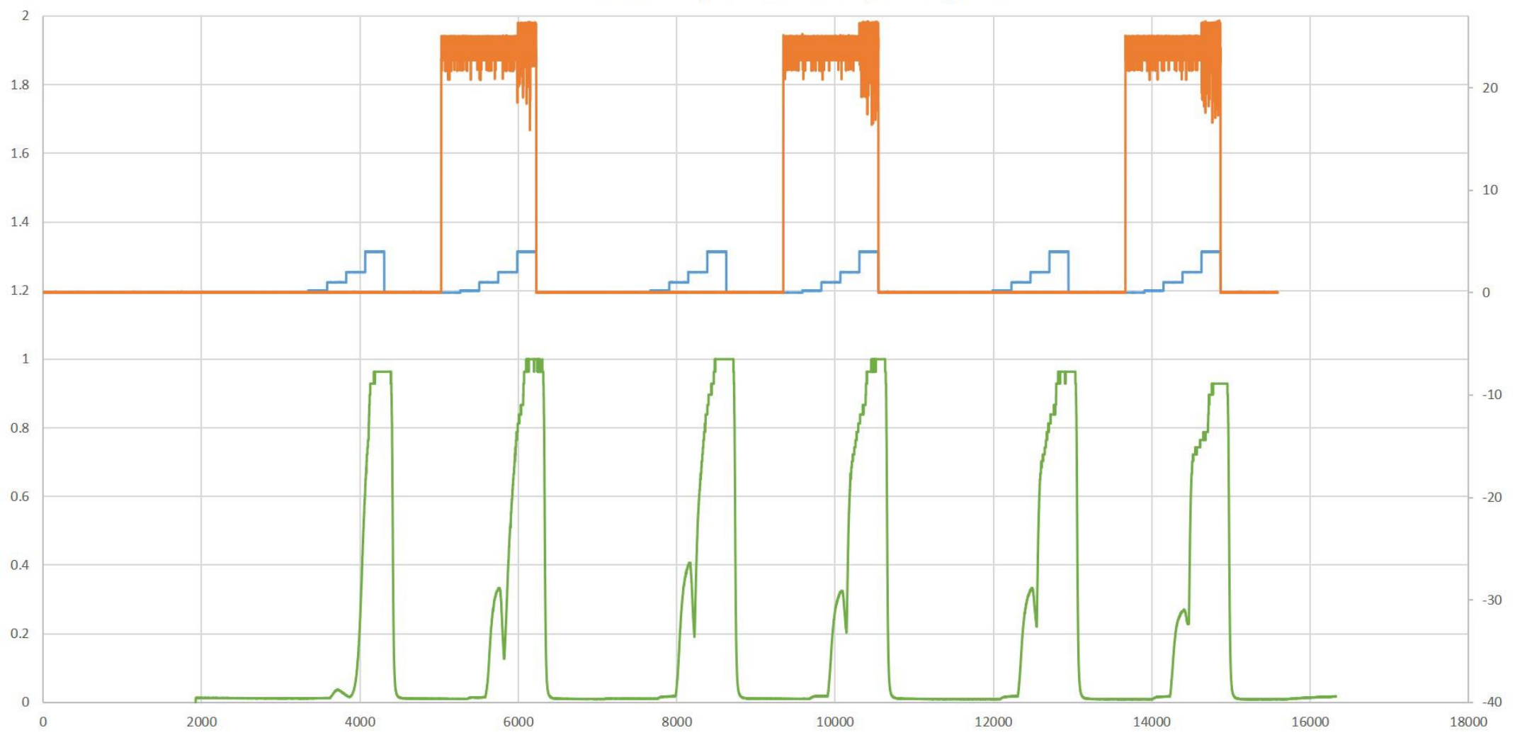
Functional Characterisation : Gas Sensing

- Better recovery for SGP in wet environment
- Better response for wet environment
- Cross selectivity for NO_2 in multiple targets injection
- Low detection limit found for our application is 0.2 ppm NO_2
- No relevant result is found for CO injection at 25 ppm concentration

Gas NO_2 injection 1200 sec in 70% wet air above
Humidity effect: dry air to 70% wet air (on the bottom)



Fluxed CO 25 ppm + NO2 ramp 0.2, 1, 2, 4 ppm (on the top)
Sensor in SG (on the bottom)



CONCLUSIONS

- Protocol of chemical and morphological characterization was effective for the determination of the chemical-physical composition set as the research goal.
- The method of synthesis is proved to be valid to obtain the desired composition, confirming the evidences available in the literature source
- The design developed has proved effective for our application purposes and a larger application field of environmental monitoring needs for further considerations

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