ASEC 2024 Conference
The 5th International Electronic Conference on Applied Sciences
04–06 December 2024 | Online
MDPI

Synthesis and characterization of nanostructured α-MnO_2 and its composites with SnO_2 and TiO_2 for efficient gas sensing

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INTRODUCTION & AIM

- Clean air is extremely important for human survival.
- Owing to excessive industrialization and socio-economic developments, the air we breathe is contaminated.
- Gas sensors are highly serviceable devices, which detect the increasing concentration of any gas pollutant.
- Many solid state sensors show poor response, cross sensitivity, high working temperature.
- Hetero-nanocomposites have proved to be better gas sensors in contrast with pristine metal oxide based sensors.
- Hence, the aim is to build a quick responsive and highly sensitive gas sensors to detect any change in the natural concentration of the analyte in the surrounding.
- The present work reports the synthesis of heterostructures of MnO_2 (α-phase) with SnO_2 and TiO_2.
- The fabricated thin films using the hetero-nanocomposite powder can be applied as potential gas sensing devices.

METHOD

1.5M Manganese nitrate solution and 1M Potassium permanganate solution are separately prepared in distilled water

↓

The above solutions are mixed together and 2M solution of Sodium hydroxide is added under vigorous stirring

↓

Precipitate obtained is filtered and washed followed by drying at 80 ºC for 12 hours in oven and finally annealed at 400 ºC for 4 hours in muffle furnace

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Pristine manganese (IV) oxide (α-phase) nano-powder is obtained

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Manganese oxide is mixed with titanium dioxide and tin oxide separately in a 1:1 ratio by weight via a solid state method, followed by annealing at 400 ºC for 2 hours in muffle furnace

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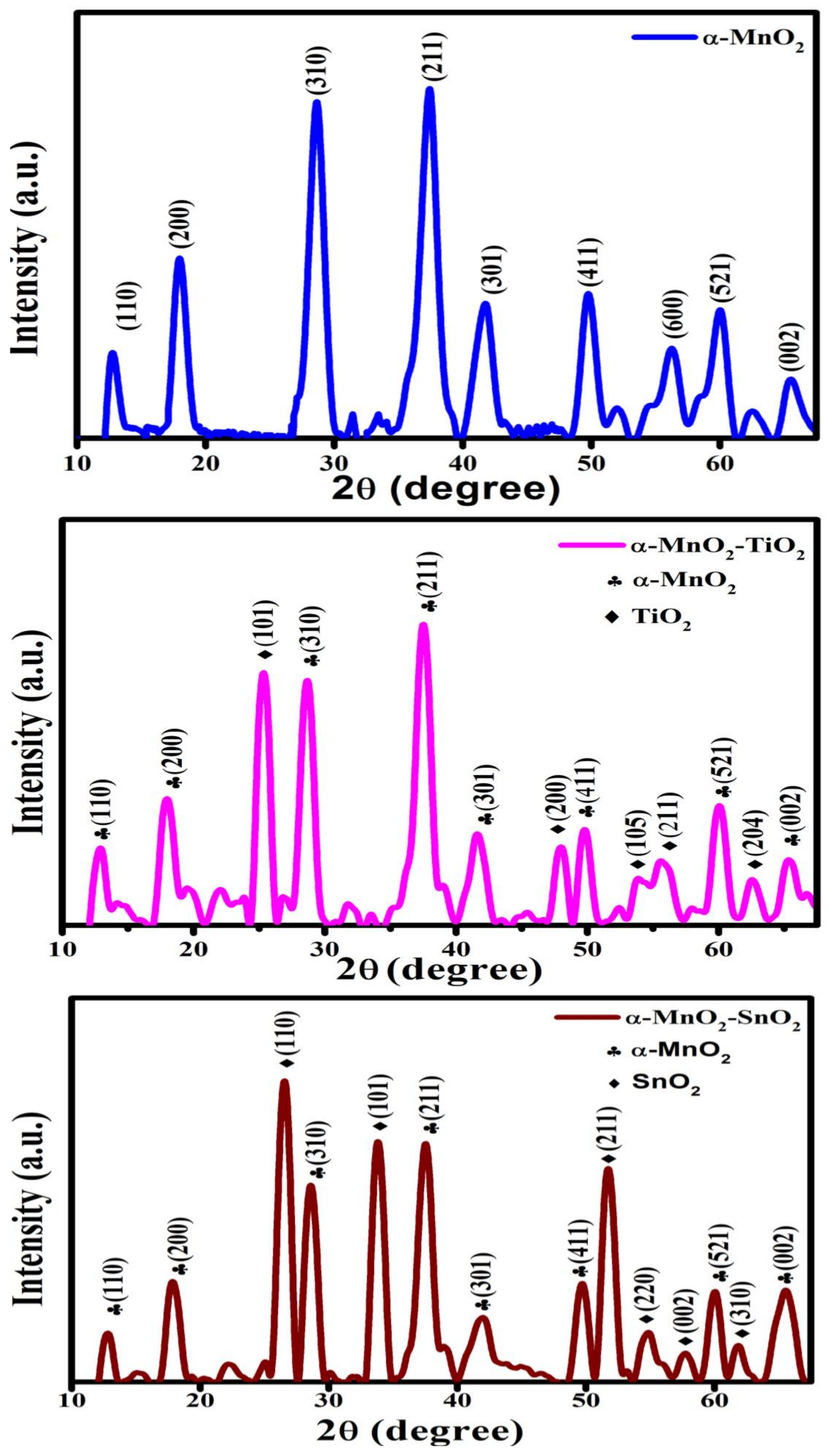
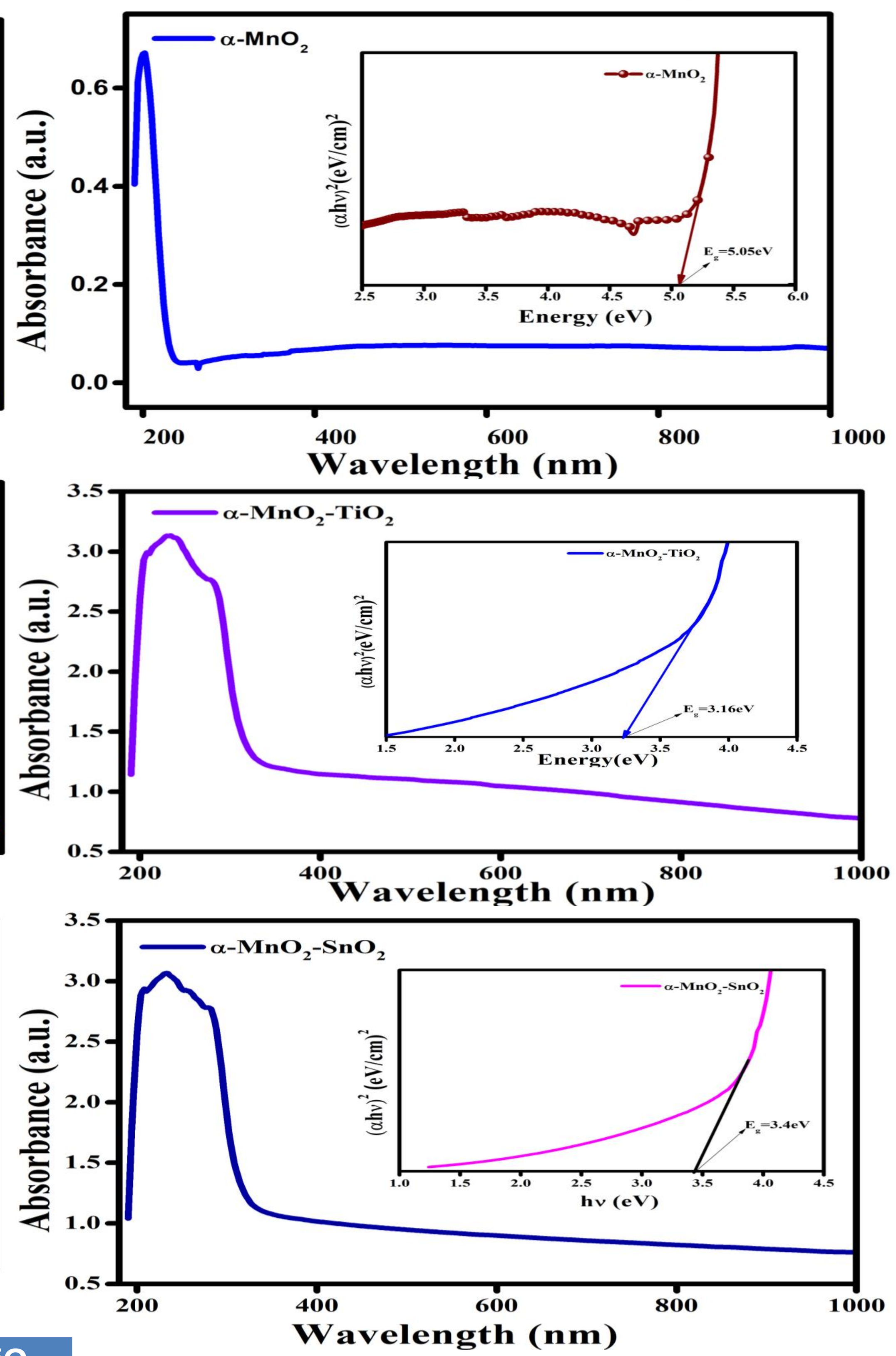
$\alpha-MnO_2$-TiO_2 and $\alpha-MnO_2$-SnO_2 nanocomposite is obtained

RESULTS & DISCUSSION

XRD Analysis

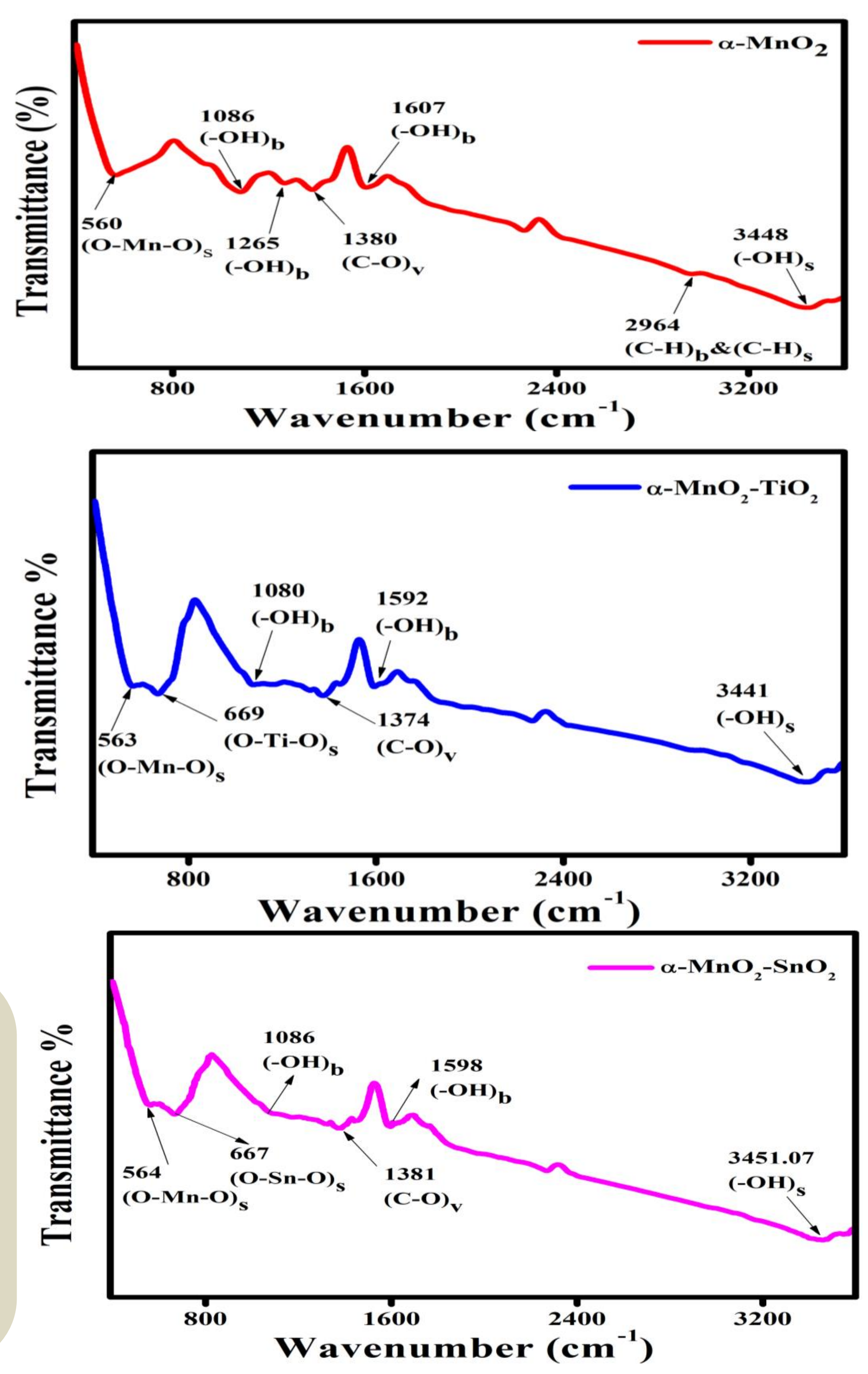


UV-Visible Analysis

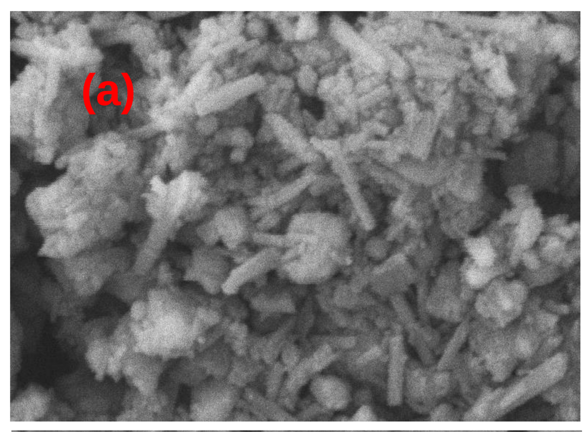


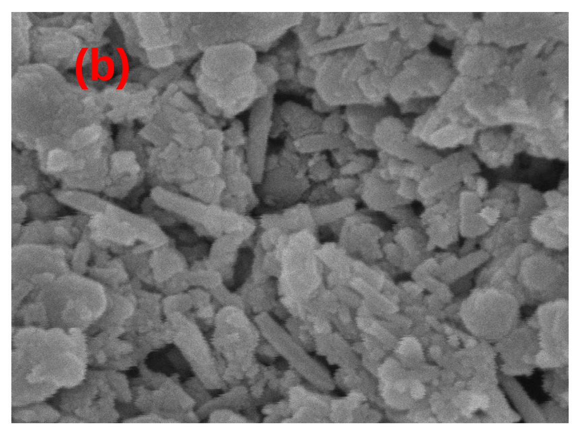
Parameters	α-MnO_2	α-MnO_2-SnO_2	α-MnO_2-TiO_2
Crystallite size D (nm)	15.04	19.33	24.25
Dislocation density(δ) × 10^{-3}(nm)$^{-2}$	4.42	2.67	1.70
% Crystallinity	81	94.75	92.98
Lattice strain (ε)	2.97 × 10^{-3}	2.18 × 10^{-5}	7.47× 10^{-4}

FT-IR Analysis



SEM Analysis





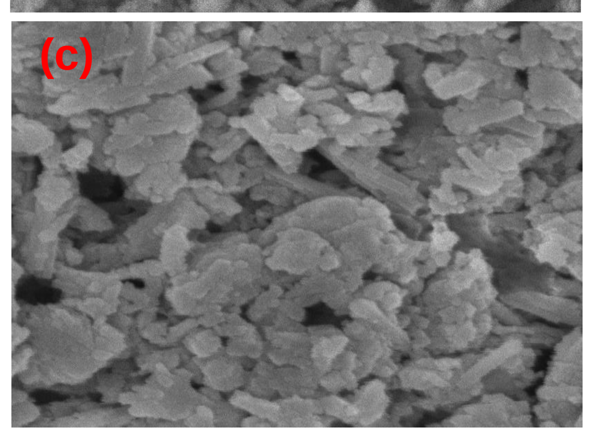


Fig a shows nanorods of pristine manganese oxide. Fig b shows nanorods of manganese oxide and granules of titanium oxide. Fig c shows nanorods of manganese oxide and granules of tin oxide.

REFERENCES

[1] Structural and Optical Properties of α-MnO2 Nanowires and β-MnO2 Nanorods N. Rajamanickam et al. Solid-State Physics AIP Conf. Proc. 1591, 267-269 (2014); doi: 10.1063/1.4872568
[2] MnO2-SnO2 Based Liquefied Petroleum Gas Sensing Device for Lowest Explosion Limit Gas Concentration Ajeet Singh et al. ECS Sensors Plus, 2022, 1 025201, doi: 10.1149/ 2754-2726/ac8437

CONCLUSION

- The crystallinity and the crystallite size increased in the nanocomposite. The lattice strain and dislocation density decreased in the nanocomposite [1].
- The optical energy band gap decreased for both nanocomposite.
- From the SEM images, it can be seen that the porosity increased and the granules were randomly distributed between the nanorods.
- Such characteristics could improve the gas sensing response of the thin films fabricated using these synthesis nanocomposite [2].