Oxide Based Nanomaterials for Biomedical Applications

Mihai Brînză, Nicolai Ababii(✉), Maxim Chiriac, Cristian Lupan, Ion Pocaznoi, and Oleg Lupan

Centre for Nanotechnology and Nanosensors, Department of Microelectronics and Biomedical Engineering, Technical University of Moldova, 168 Stefan cel Mare Av., MD-2004 Chisinau, Republic of Moldova

nicolai.ababii@fcim.utm.md

Abstract. Although the gas sensor market is in constant development, proposing specific solutions for various niches might be challenging, as there are a lot of gases and markers, which require fast, sensitive and reliable solutions. In this paper, a metal-oxide based thin film of zinc oxide doped with silver particles is proposed as a potential solution for hydrogen, formaldehyde and even UV detection at specific ranges. Registered responses are shown as UV/gas to dark/air ratio. For gas detection, obtained results show relatively fast response and recovery for hydrogen, with a response value, up to ~2.5, at operating temperatures of 350–400 ° C. In case of formaldehyde, the response value has been registered at 250–300 ° C, up to ~1.7 and a better selectivity. UV photo-detection properties showed the best sensitivity towards the 280 nm wavelength, with the up to ~160. Formaldehyde is regarded as an inhalation hazard, which could provoke cancer if maintaining a certain concentration in lungs, thus it is important to have measurement tools for concentration in various work environment, especial medical one. On the other hand, hydrogen being studied as both energy carried and biomarker for certain diseases, offers a promising direction for gas sensing manufacturers. While UV sensors are necessary to monitor harmful outdoor radiation, they also play a vital role in controlled environments by supporting crop cultivation and improving semiconductor production.

Keywords: zinc oxide · gas sensor · nanosensor · UV · hydrogen · formaldehyde

H.-N. Costin et al. (Eds.): EHB 2025, IFMBE 144,pp. 138–144, 2026.
https://doi.org/10.1007/978-3-032-23952-5_15

References

1. Lupan, O. et al.: Sensors based on hybrid materials for environmental, industrial and biomedical applications. In: 2024 IEEE 14th International Conference Nanomaterials: Applications and Properties (NAP), pp. MTFC09-1–MTFC09-4. IEEE (2024). https://doi.org/10.1109/NAP62956.2024.10739678

2. Lupan, O. et al.: Hybrid nanomaterials for biomedical sensors. In: Sontea, V., Tiginyanu, I., Railean, S. (eds.) 7th International Conference on Nanotechnologies and Biomedical Engineering, ICNBME 2025, vol. 1, pp. 162–176. Springer Nature, Cham (2025). https://doi.org/10.1007/978-3-032-06494-3_18
3. Schröder, S. et al.: A new approach in detection of biomarker 2-propanol with PTFE-coated TiO_2 nanostructured films. In: Sontea, V., Tiginyanu, I., Railean, S. (eds.) 6th International Conference on Nanotechnologies and Biomedical Engineering, pp. 75–83. Springer Nature, Cham (2023). https://doi.org/10.1007/978-3-031-42782-4_9
4. Lupan, O. et al.: Influence of Silsesquioxane-containing ultra-thin polymer films on metal oxide gas sensor performance for the Tunable detection of biomarkers. Chemosensors. **12**, 76 (2024). https://doi.org/10.3390/chemosensors12050076
5. Brînză, M. et al.: Effect of PTFE thickness on gas sensing properties of TiO_2/Pd-doped ZnO nanostructures. In: Sontea, V., Tiginyanu, I., Railean, S. (eds.) 7th International Conference on Nanotechnologies and Biomedical Engineering, pp. 275–283. Springer Nature, Cham (2025). https://doi.org/10.1007/978-3-032-06494-3_28
6. Lupan, O. et al.: Polymer-coated cd-doped ZnO nanostructures for dual sensing of volatile organic compounds and battery vapours. In: Sontea, V., Tiginyanu, I., Railean, S. (eds.) 7th International Conference on Nanotechnologies and Biomedical Engineering, pp. 284–300. Springer Nature, Cham (2025). https://doi.org/10.1007/978-3-032-06494-3_29
7. Brinza, M. et al.: Influence of P(V3D3-co-TFE) copolymer coverage on hydrogen detection performance of a TiO_2 sensor at different relative humidity for industrial and biomedical applications. Chem. **13**, 150 (2025). https://doi.org/10.3390/chemosensors13040150
8. Schröder, S. et al.: Tuning the selectivity of metal oxide gas sensors with vapor phase deposited ultrathin polymer thin films. Polymers. **15**, 524 (2023). https://doi.org/10.3390/polym15030524
9. Brinza, M. et al.: Two-in-one sensor based on PV4D4-coated TiO_2 films for food spoilage detection and as a breath marker for several diseases. Biosensors. **13**, 538 (2023). https://doi.org/10.3390/bios13050538
10. Tsiapali, O.I., Ayfantopoulou, E., Tzourouni, A., Ofrydopoulou, A., Letsiou, S., Tsoupras, A.: Unveiling the utilization of grape and winery by-products in cosmetics with health promoting properties. Appl. Sci. **15**, 1007 (2025). https://doi.org/10.3390/app15031007
11. Le, Y. et al.: Characterizing the pulmonary toxicity and potential mutagenicity of formaldehyde fumes in a human bronchial epithelial tissue model. Environ. Mol. Mutagen. **66**, 6–21 (2025). https://doi.org/10.1002/em.70000
12. Chen, J. et al.: Dual effects of endogenous formaldehyde on the organism and drugs for its removal. J. Appl. Toxicol. **44**, 798–817 (2024). https://doi.org/10.1002/jat.4546
13. Zhang, T., Chen, Y., Shao, X., Wang, Z., Qiu, F.: Facile fabrication of transparent cellulose-based film with water and UV resistance properties for potential agriculture application. Fibers Polym. **25**, 765–774 (2024). https://doi.org/10.1007/s12221-023-00458-4
14. Gąstoł, M., Błaszczyk, U.: Effect of magnetic field and UV-C radiation on postharvest fruit properties. Agriculture. **14**, 1167 (2024). https://doi.org/10.3390/agriculture14071167
15. Al-Sadek, T., Yusuf, N.: Ultraviolet radiation biological and medical implications. Curr. Issues Mol. Biol. **46**, 1924–1942 (2024). https://doi.org/10.3390/cimb46030126
16. Chiriac, M. et al.: Performance of Ag_2S/ZnO nanostructures in radiation monitoring. In: 7th International Conference on Nanotechnologies and Biomedical Engineering, pp. 237–246 (2025). https://doi.org/10.1007/978-3-032-06494-3_25
17. Chiriac, M., Litra, D., Ababii, N., Sandu, I., Sereacov, A., Railean, S.: Semiconducting oxide nanostructures for wideband optical detectors. In: Electronics, Communications and Computing, pp. 82–83 (2024) https://ibn.idsi.md/vizualizare_articol/223198
18. Nagpal, R. et al.: Annealing effect on UV detection properties of ZnO:Al structures. J. Eng. Sci. **30**, 45–62 (2024). https://doi.org/10.52326/jes.utm.2023.30(4).04

19. Salminen, A., Kaarniranta, K., Kauppinen, A.: Photoaging: UV radiation-induced inflammation and immunosuppression accelerate the aging process in the skin. Inflamm. Res. **71**, 817–831 (2022). https://doi.org/10.1007/s00011-022-01598-8
20. Litra, D., Chiriac, M., Ababii, N., Lupan, O.: Acetone sensors based on Al-coated and Ni-doped copper oxide nanocrystalline thin films. Sensors. **24**, 6550 (2024). https://doi.org/10.3390/s24206550
21. Nazpal, R. et al.: Sensory properties of CuO/Cu_2O nanostructures coated with zeolitic imidazolate frameworks. In: 2024 E-Health and Bioengineering Conference (EHB), pp. 1–4. IEEE (2024). https://doi.org/10.1109/EHB64556.2024.10805729
22. Mishra, Y.K. et al.: Direct growth of freestanding ZnO tetrapod networks for multifunctional applications in photocatalysis, UV photodetection, and gas sensing. ACS Appl. Mater. Interfaces. **7**, 14303–14316 (2015). https://doi.org/10.1021/acsami.5b02816
23. Lupan, O., Postica, V., Labat, F., Ciofini, I., Pauporté, T., Adelung, R.: Ultra-sensitive and selective hydrogen nanosensor with fast response at room temperature based on a single Pd/ZnO nanowire. Sens. Actuators B Chem. **254**, 1259–1270 (2018). https://doi.org/10.1016/j.snb.2017.07.200
24. Zhu, Q., Xie, C., Li, H., Yang, Q.: Comparative study of ZnO nanorod array and nanoparticle film in photoelectric response and charge storage. J. Alloys Compd. **585**, 267–276 (2014). https://doi.org/10.1016/j.jallcom.2013.09.157
25. Ahn, M.-W. et al.: Gas sensing properties of defect-controlled ZnO-nanowire gas sensor. Appl. Phys. Lett. **93**, 263103 (2008). https://doi.org/10.1063/1.3046726
26. Yu, A. et al.: Micro-lotus constructed by Fe-doped ZnO hierarchically porous nanosheets: preparation, characterization and gas sensing property. Sens. Actuators B Chem. **158**, 9–16 (2011). https://doi.org/10.1016/j.snb.2011.03.052
27. Liu, D. et al.: Defect-related photoluminescence and photocatalytic properties of porous ZnO nanosheets. J. Mater. Chem. A. **2**, 15377 (2014). https://doi.org/10.1039/C4TA02678K
28. Lupan, O., Chow, L., Pauporté, T., Ono, L.K., Roldan Cuenya, B., Chai, G.: Highly sensitive and selective hydrogen single-nanowire nanosensor. Sens. Actuators B Chem. **173**, 772–780 (2012). https://doi.org/10.1016/j.snb.2012.07.111
29. Yamazoe, N.: New approaches for improving semiconductor gas sensors. Sens. Actuators B Chem. **5**, 7–19 (1991). https://doi.org/10.1016/0925-4005(91)80213-4
30. Zhang, Z., Shao, C., Li, X., Wang, C., Zhang, M., Liu, Y.: Electrospun nanofibers of p -type NiO/ n -type ZnO heterojunctions with enhanced photocatalytic activity. ACS Appl. Mater. Interfaces. **2**, 2915–2923 (2010). https://doi.org/10.1021/am100618h
31. Kim, H.-R., Choi, K.-I., Kim, K.-M., Kim, I.-D., Cao, G., Lee, J.-H.: Ultra-fast responding and recovering C_2H_5OH sensors using SnO_2 hollow spheres prepared and activated by Ni templates. Chem. Commun. **46**, 5061 (2010). https://doi.org/10.1039/c0cc00213e