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Nanofibrous metal oxide semiconductor for sensory face masks

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from Admas-Belta Ltd., China. Zinc nitrate hexahydrate (Zn (NO_3)$_2$·6 H_2O) and polyvinylpyrrolidone (PVP) (M_w □1300,000) were bought from Sigma-Aldrich LLC. n^{++}-silicon wafers with 300 nm SiO_2 were purchased from Suzhou Resemi Co., Ltd. To fabricate IGZO nanofibres using electrospinning, PVP was added as an additive to increase the viscosity of precursor solutions. Specifically, for IGZO/PVP precursor solution preparation, 320 mg of PVP powder was dissolved in 2 mL of DMF by stirring at RT. The requisite amount of metal salt(s) [172.50 mg of $In(NO_3)_3$, 72.27 mg of $Zn(NO_3)_2$ and 75.28 mg of Ga (NO_3)$_3$] at a molar ratio of 2:1:1 was added to the PVP solution, followed by stirring for about 12 h to obtain a clear and transparent solution.

2.2. IGZO fibrous thin film

recovers during a breath cycle, with a fast response and recovery time of approximately 0.7 seconds (Fig. 3b). For adults, a typical respiration cycle lasts 3–4 seconds, although breathing frequencies vary among individuals.

To demonstrate the sensor's effectiveness, we monitored the respiratory rates of five healthy volunteers using the same sensor. As shown in Fig. 3c, the results were 18.2, 13.5, 20.0, 16.4 and 14.7 breaths per minute (bpm) for the five volunteers. The IGZO nanofibre-based gas sensor was also used to record three distinct respiratory patterns: rapid, normal and deep breathing. Fig. 3d illustrates the clear differences in respiratory rates under these different breathing patterns. The respiration rate for normal breathing was approximately 14.6 bpm, while hurried breathing reached 50.2 bpm. During deep breathing, the peak width became wider, and the rate decreased to 7.4 bpm (Fig. 3e). These findings highlight the sensor's capability to accurately monitor various respiratory patterns.

Integrating sensors into conventional face masks for monitoring human respiration presents new opportunities in personalised healthcare and pandemic prevention. [15,16] Table 1 presents recent developments in smart masks, highlighting sensor materials, types, size and monitoring methods. Key sensors include triboelectric and resistive-based pressure sensors, as well as moisture-based humidity sensors, which are known for their sensitivity and stability in detecting various respiration patterns. Less common sensors, such as thermal-based resistive and luminescence-based CO_2 sensors, have seen limited adoption. Advanced features, such as remote monitoring and high integration levels, enhance long-term usability, wearer comfort and breathability. [17,18] The most reported smart

4. Conclusion and outlook

In this study, we successfully developed a highly sensitive and selective IGZO nanofibre-based TFT gas sensor integrated into a smart mask for real-time respiration monitoring. The amorphous IGZO nanofibres, with their enhanced surface area, demonstrated superior in-

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The flexible circuit system was designed and fabricated with the assistance of Chengdu WeSys Technology Co., Ltd.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.wees.2024.09.001.

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