Hydrophobic Filters Based on PDMS and Zeolite Hybrid Membrane for Pre-separation of Gas Detection

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Semiconductor metal oxides are widely used in gas detection due to their sensitivity, but their performance is often hindered by issues of selectivity and humidity endurance. Metal oxide gas sensors detect gases through redox reactions between adsorbed oxygen ions and target gases on the oxide surface. This mechanism, however, generally lacks significant selectivity among different gases and is highly susceptible to humidity due to the hydrophilic nature of most oxide semiconductor surfaces. Adsorbed water molecules can occupy oxygen vacancies and form hydroxyl groups, reducing the number of active sites and thereby decreasing sensor performance. Two primary solutions have been proposed to address these challenges,. The first involves doping the oxide semiconductors with high affinity for moisture like Rh, NiO, and CuO, which absorb moisture and prevent it from affecting sensor functionality. However this method usually has limitations. The second solution is to apply hydrophobic coatings to the sensors. Superhydrophobic polydimethylsiloxane (PDMS) coatings, applied via spin coating, significantly enhance the water resistance of the sensors. PDMS forms a protective layer that prevents humidity from impacting the sensor's performance.

In this study, the single nanowire gas sensor array was fabricated by electron beam lithography. Then, the PDMS and zeolites hybrid hydrophobic filter was spin-coating over the gas sensor array, as shown in Figure 1b. Due to their porous structure, the individual use of zeolites leads to easy adsorption of water vapor. On the other hand, PDMS coatings, while providing excellent moisture resistance, can impede the penetration of gases to the sensing material. Our experimental results indicate that mixed coatings of PDMS and zeolites effectively improve humidity resistance while allowing selective gas filtration through the zeolite pores. The PDMS layer also provides stability, enhancing the reliability of oxide gas sensors over prolonged use. The thickness effect of the hybrid membrane and pore size filter performance was studied quantitively. The simple combination of PDMS and porous materials as a coating method can be broadly applied to oxide gas sensors to improve their humidity resistance.

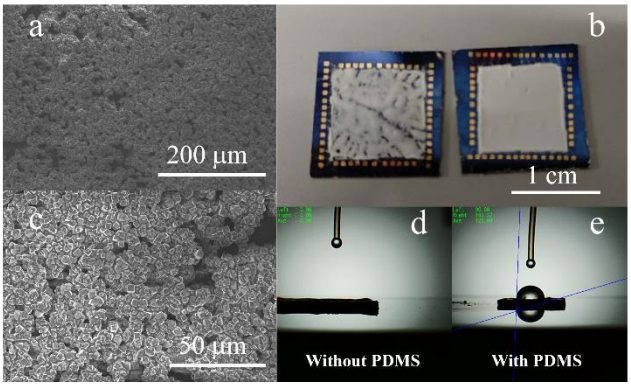

Figure 1. (a) (c) SEM images of PDMS and zeolite hybrid membrane (b) Photo image of fabricated gas sensor array and hybrid membrane. Contact angle for membrane without PDMS (c) with PDMS (d).

Reference: Zhang L T, et al. Angewandte Chemie, 2021, 133(28): 15320-15340.

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