Visualization and Quantitative Analysis of Semiconductor Oxide Single Nanowire Array Based Electronic Nose

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Inspired by mammalian olfactory system, artificial olfactory (known as E-noses), have been developed based on cross-reactive sensor arrays that interact differentially with target molecules to generate a fingerprint pattern. There are more than 300 kinds of breath/skin gases in ppb order, some of them have been proved to have close relation with some clinical diseases, so the application of gas sensor in health monitoring and breath analysis is promising. Metal oxide semiconductor gas sensor is the most popular choice to assembly the gas sensor array-based E-nose device. However, the poor selectivity of oxide semiconductor to different target VOCs hinders the practical application prospect of oxide semiconductor E-nose.

In this study, we report on the fabrication and characterization of electron beam lithography patterned nanowire-based gas sensor array. The fabrication process involved the use of electron beam lithography to pattern single nanowires of tin oxide (SnO_2), indium oxide (In_2O_3), titanium oxide (Fe_3O_4), and nickel oxide (TiO_2). Each material have five different diameters from 100 nm to 250 nm to increase the diversity, which were then assembled into a 20-single nanowire sensor array based E-nose. The photo image of fabricated gas sensor array was shown in Fig. 1(a). The SEM image of single nanowire channel was shown in Fig. 1(b). In the process of data processing, we noticed that previous feature extraction methods only focused on limited features such as response intensity and response time of the response curve. We proposed to convert the response curve of the sensor array into a heatmap so that all features can be represented. The pattern of the heatmap is the feature of different gases (Fig. 1(d)). The fabricated E-nose was used to detect four kinds of volatile organic chemicals (VOCs) and the result of array was plotted into image to visualization . Also, the performance of individual sensor has been quantitatively study.

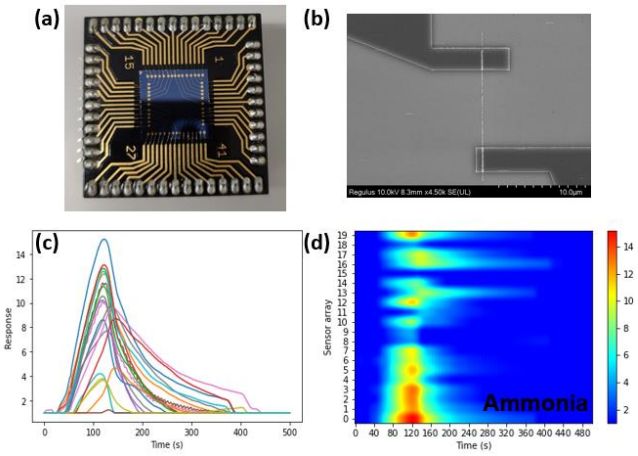

Figure 1. (a) Photo image of fabricated (b) SEM images of fabricated single nanowire gas sensor. (c) Time series response curve of 20 channel single nanowire gas sensor. (d) "Pattern (figerprint) of gas": plot the response curve to heat map to visualize the feature of gases

Reference:

Kang H, et al. Advanced Functional Materials, 2020, 30(27): 2002486.

Jeong, et al. Advanced Materials 32.51 (2020): 2002075.

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