A Study on The VOC Detection Mechanism of ZnO Nanorods

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VOCs such as acetone contained in exhaled breath are promising as biomarkers, and it will be possible to detect specific diseases if ultra-low concentrations of VOCs can be detected. However, since it is difficult to detect ppb-level VOCs in exhaled breath with a gas sensor, further improvement the gas sensor is required. The semiconductor gas sensor detects the gas by using the change in resistance value that occurs when the test gas reacts with the adsorbed oxygen species on the surface of the material. Therefore, it is necessary to design a material that maximizes the reactivity between the adsorbed oxygen and the test gas and the gas diffusivity. In this study, we focused on the ZnO nanorods typical n-type semiconductor material which were vertically grown on the substrate.

ZnO nanorods were synthesized under hydrothermal conditions using ZnO nanocrystals, which were synthesized by a hot soap method, as seed crystals. The sensor signals (S = R_a/R_g R_a: the resistance in the air, R_g: the resistance in the gas) to acetone and ethanol of the synthesized ZnO nanorods showed about 100 under dry condition, which means the resistance value was changed about 100 times under these gases. And also still high even under humidity condition (Fig.1). The SEM image is showing the synthesized ZnO nanorods with very smooth surface, not rough such like the surface with grain boundaries which is considered to be the most important factor for improving the gas sensing properties. Even though, it showed very unique gas sensing properties. It may be due to the high reactivity and high surface area of m-plane (10-10) which is main gas response interface. For investigating the mechanism of this unique properties, ZnO single crystal was synthesized on a m-plane sapphire substrate by mist-CVD method[1]. Then the electric resistance measurement was conducted using the membrane. The response behavior of the m-plane ZnO single crystal was similar to that of ZnO nanorod, which implies that the gas sensing properties of ZnO nanorods attributed to high responsibility of the m-plane. The DRIFTS (Diffuse Reflectance Infrared Fourier Transform Spectroscopy) measurement was also conducted for seeing what is happening on the ZnO nanorods surface when exposed to ethanol at 300 °C.

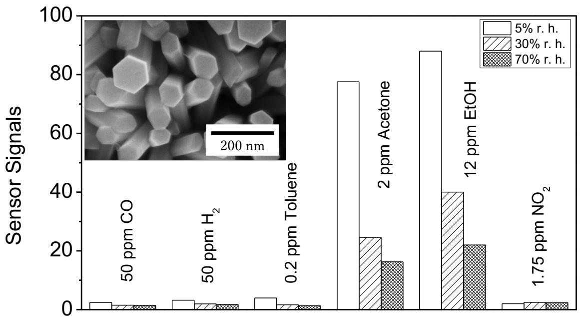

Fig.1 The sensor signals and SEM image of ZnO nanorods.

[1] H. Tanoue et al., Applied Physics Express **8**, 125502 (2015).