New insight into the gas-sensing properties of β-Ga_2O_2 nanowires by near-ambient pressure XPS

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Gas sensors play an essential role in environmental monitoring, medical diagnosis, chemical processing control, energy efficiency, and emission control in combustion processes. Traditionally, various metal oxides have been used as active sensing materials. The key advantages of metal-oxide sensors are their high sensitivity, rapid recovery and response times, low cost, compact size, easy production, and simple measuring electronics.

Among the various metal oxides, Ga_2O_3, which is an ultrawide-bandgap n-type semiconductor [1-3], is an excellent material for the detection of both oxidizing (O_2, NO_x, CO_2) and reducing (H_2, CO, NH_3, ethanol, acetone, and CH_4) gases over a wide temperature range [4]. It has been demonstrated that at high temperatures (T>800°C), the formation of oxygen vacancies and complex lattice defects are responsible for their sensitivity. In contrast, at lower temperatures, the sensing mechanism remains unclear, and it is assumed that surface reduction-oxidation reactions play an essential role in sensing .

The objective of this study [5] was to evaluate the potential of β-Ga_2O_3 nanorods as gas sensors and to elucidate their sensing mechanism at low temperatures. Using near-ambient pressure X-ray photoelectron spectroscopy, we demonstrated that adsorbed oxygen species play a crucial role in the gas-sensing properties of β-Ga_2O_3 nanorods. Our results confirmed that the interaction of oxidizing/reducing analytes with adsorbed oxygen species changes the resistivity of the β-Ga_2O_3 nanorods and that redox reactions govern the sensing mechanism at low temperatures. Furthermore, we provided new insights into the ethanol-sensing mechanisms at different temperatures. Our findings revealed that at 400°C ethanol reacts with chemisorbed oxygen on the surface of β-Ga_2O_3 via the acetaldehyde pathway, whereas at 100°C, the gas-sensing mechanism includes the adsorption of ethanol molecules, which are partially oxidized to ethoxy due to the dissociative chemisorption of ethanol.

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