APXPS

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Operando AP-XPS study on chemical sensitivity and selectivity of Pt-Rh thin film gas sensor under working conditions

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Sensing of small gas molecules in human breath (e.g. H2, NH3, CH4) is expected to be a non-invasive and simple method for health diagnosis. Recently, a sensor using a Pt thin film of about 10 nm thickness has been developed to recognize ppm-order hydrogen gas from the change in its electrical resistance [1]. Previously, we have performed operando analysis using ambient-pressure X-ray photoelectron spectroscopy (AP-XPS) to elucidate the basic principle of the sensor response on the Pt thin film surface, and found a direct relationship between the surface chemical state and the sensor response [2]. Then, we have focused on an alloyed Pt-Rh thin-film sensor that is insensitive to ammonia and selective for hydrogen, and performed an operando AP-XPS analysis to clarify the principle of the sensor response and selectivity [3, 4]. All AP-XPS experiments were carried out at an undulator beamline BL-13B at the Photon Factory, Japan. The experiments were performed at room temperature (298 K). Two electric contacts were attached onto the sample surface, and the input voltage was about 100 mV. The background gases (H2, O2, and NH3) were introduced to the chamber up to 0.1 Torr. Evolutions of Rh 3d and Pt 4f core-levels were tracked in various gas atmospheres by AP-XPS, and the electrical resistance was measured simultaneously. It was found that the sensor response and the surface chemical state including elemental distribution changed depending on the background gas atmosphere. Initially, the surface is mainly covered by Rh oxide. When the hydrogen gas was exposed to the surface, Rh oxide was reduced to the metallic state, resulting in a decrease in resistance. Besides, it is found that Rh oxide inhibits the dissociative adsorption of ammonia, which acts as the key to chemical selectivity.

[1] Tanaka et al., Sens. Actuators B Chem., 258, 913, (2018).
[2] Toyoshima et al., Chem. Commun., 56, 10147 (2020).
[3] Tanaka et al., IEEE Trans. Electron Devices, 66, 5393, (2019).
[4] Toyoshima et al., J. Phys. Chem. Lett., 13, 8546 (2022).

if "Other", please specify:

I apply for a travel grant

No

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