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Sensing Mechanism and Behavior of Sputtered ZnCdO Ozone Sensors Enhanced by Photons for Room-Temperature Operation

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ZnCdO oxide thin films have been deposited by using the radiofrequency cosputtering method to prepare ozone sensors for room-temperature operation. The sensors were fabricated in the order: electrode/sensor/glass/illuminant. The mechanisms of photo-assisted oxidation and reduction on the surface of the ZnCdO ozone sensors were investigated. Free electrons and holes were generated by exposure of the surface of the ZnCdO ozone sensor to ultraviolet light, tending to enhance surface absorption of dissociated O_2 molecules and dissociation of adsorbed oxygen ions, respectively. Thereby, the sensitivity of the ZnCdO ozone sensor was increased. This photon exposure method can replace the conventional heating mode used in ozone sensors. Moreover, 405-nm light from a light-emitting diode, corresponding to photon energy of 3.061 eV, was found to assist the processes of oxidation and reduction due to the chemical reaction of the ozone gas. We present a possible route for fabrication of portable ZnCdO ozone sensors for room-temperature operation.

Key words: ZnCdO, sputtering, ozone sensor, photo-assisted oxidation process

INTRODUCTION

Ozone, an allotrope of oxygen, has both positive and negative aspects. The former is as a species beneficial to human life, where it has been widely used for deodorization, purification, and sterilization. The latter is as a toxic gas that is very harmful to health. Prolonged exposure to ozone at high concentration can produce pulmonary edema, which can then give rise to hemorrhage. Ozone in the air is generated from NO_2 from traffic pollution under excessive illumination by sunlight, and can also occur indoors as air pollution caused by office machinery such as photocopiers and laser printers. In the natural environment, the ozone concentration is about 30 parts per billion (ppb).[1] Ozone concentrations over 151 ppb are considered unhealthy.[2] Therefore, it is important to monitor ozone gas for human health purposes.

Ozone, which is by nature a very powerful oxidizing agent, is highly unstable and reactive. Thus, the oxidation power of ozone is much greater than that of oxygen. However, this means that the reversibility of monitoring is poor owing to its strong oxidation action.[3] The conventional method for reversible ozone sensing is through heating. Therefore, widely used ozone sensors, such as those based on In_2O_3, WO_3, and indium tin oxide, require temperatures above 200°C to operate.[4] This feature limits the fabrication of ozone sensors that are low cost, simple to fabricate, and small size (portable). Nevertheless, room-temperature operation with ultraviolet (UV) light has been achieved in In_2O_3 and ZnO materials.[5,6] To reduce the enhanced surface oxidation after ozone sensing, light of 400 nm from a light-emitting diode (LED) was shone on the In_2O_3 sensor.[7] However, it is a common point that

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