Design of a Selective Gas Sensing Device
Using Platinum Electrode Interdigitated Substrates

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Abstract

Alumina substrates with interdigitated platinum (Pt) electrodes for resistive sensing applications and heating elements on its back have been successfully fabricated using photolithography method. Molybdenum oxygen (MoO$_3$) nanoparticles synthesized by alcoholic hydrolysis method have been deposited onto the substrates for nitrogen hydrogen (NH$_3$) gas detection. The synthesized resistive NH$_3$ sensors are used to integrate into a handheld device applied for breath analysis and disease detection.

Summary of Research

Semiconducting metal oxides have been used for decades in gas sensing applications. The basic principle behind the gas sensing mechanism by metal oxides is the change in their electrical resistance on exposure to a reducing or oxidizing gas, due to electronic change. On the other hand, NH$_3$ sensors are being used in diverse applications such as food technology, chemical plants, and medical diagnosis and for environmental protection.

Among many kinds of semiconducting metal oxides, MoO$_3$ is a promising material for NH$_3$ detection. MoO$_3$ has a weakly-bonded layered structure. In addition, it has been demonstrated by our group [1] that NH$_3$ tends to remove MoO$_3$ layer when it is exposed to MoO$_3$, replacing O with N. This reaction causes an ultra high sensitivity.

In this project, we successfully synthesized MoO$_3$ nanoparticles using alcoholic hydrolysis method. In this method, molybdenum isopropoxide mixed with butanol are ultrasonicated at room temperature to form MoO$_3$. The materials are then deposited onto the sensing substrate. Figure 1 shows the sensing response of a MoO$_3$ sensor when it is exposed to NH$_3$. The result indicates that our sensor can detect NH$_3$ with the concentration down to 100 ppb. The detecting signal is stable and the response time for each gas exposure is less than 100 s.

In order to make a hand-held NH$_3$ detection device, the substrate with measuring electrodes on which the MoO$_3$ nanoparticle sensing film is deposited should be small enough. Here, we use alumina substrates with the size of 3 mm x 3 mm x 0.1 mm. By using a photolithography method, a layer of Pt electrode used for resistive sensing applications has been deposited on one side of the substrate, as well as another Pt electrode layer on the other side for heating the substrate. Figure 2 and Figure 3 show the design of the sensing electrode and heating electrode, respectively. The deposition thickness is about 100 nm.

Finally, the fabricated MoO$_3$ sensing element is integrated into a hand held device. This device collects and analyzes human breath and is only sensitive to NH$_3$.

References

Figure 1: Sensing response of MoO$_3$ nanoparticle sensor to NH$_3$ gas.

Figure 2: Design of sensing electrode on the alumina substrate.

Figure 3: Design of heating electrode on the alumina substrate.