Nanogap Electrode-based Oxygen Sensor using Ultrathin Solution-processed Ceria

ファン　チョン　トゥエ [1], 土佐　翼 [1], 真島　豊 [1]
[1] 東京工業大学フロンティア材料研究所
°Phan Trong Tue[1], (M2) Tsubasa Tosa[1], Yutaka Majima[1]
[1]Laboratory for Materials and Structures, Tokyo Institute of Technology
E-mail: phan.t.ac@m.titech.ac.jp

Measurement and control of oxygen content are critical in many areas such as the environment, transportation, and medicine [1]. However, the current solid-state electrolyte oxygen type sensors suffer from the high working temperature, poor sensitivity and slow response speed, which cannot meet demanding criteria. Thus, development of a simple, low-cost, and high-performance oxygen gas sensor is highly desired. In this regard, nanogap electrode-based gas sensor is a promising candidate to become the next-generation device because of its high sensitivity, fast, low power consumption, and portability. Previously, we have developed robust Pt-based nanogap electrodes with 10 nm scale which exhibits extremely high thermal stability [2]. In this study, we utilized the nanogap electrodes in combination with ultrathin ceria film to develop a new oxygen sensor platform for boosting up the sensor performance.

To fabricate the sensor, firstly the Pt-based nanogap electrodes with a thickness and gap separation of 13 nm and 25 nm, respectively, were fabricated on a thermally oxidized Si substrate by means of electron beam lithography [2]. After that, ultrathin cerium oxide film (~5 nm) was deposited on the electrode by spin-coating using cerium acetate as a raw material, followed by an annealing at 400 ºC. The film thickness and structure of the device were confirmed by scanning electron microscope (SEM) as shown in Fig. 1. Dependence of the sensor's responses on the temperature and oxygen partial pressure was investigated. Preliminary results showed that the working temperature could be lower than 300 ºC. Further, the sensing mechanism is associated with formation of oxygen vacancies upon the oxygen partial pressure.

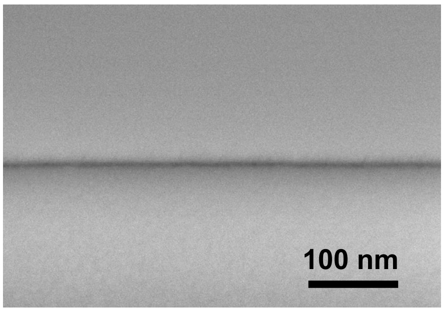

Fig. 1(a). SEM image of 5-nm-thick CeO_2 grown on SiO_2/Si substrate.

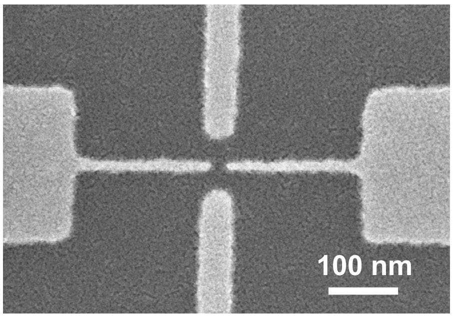

Fig. 1(b). SEM image of 5-nm-thick CeO_2 film deposited on the nanogap electrode.

[1] P. Li *et al.*, *Catalysis Today*, 2019, **327**, 90.

[2] Y. Y. Choi *et al.*, Appl. Phys. Exp. 2019, **12**, 025002.