Fabrication and characterization of ZnO and TiO_2 nanostructured films for sensors

B. Ahmmad, K. Kanomata, S. Kubota, F. Hirose
Yamagata University, Japan

Abstract

In recent years, metal oxide nanoparticles have attracted substantial interest because of their unique optical, magnetic, and electronic properties, which are different from their bulk and highly dependent on their sizes, shape, orientation, and crystallinities. Among various transition metal oxide nanostructures, ZnO and TiO_2 are particularly important due to their positive qualities, such as low cost, good stability, nontoxicity, and their applications in electronic devices (such as, sensors, solar cell), catalysis, and adsorption. The one-dimensional and porous nanostructured films of metal oxides with very large internal surfaces offer a number of fascinating features that are advantageous in designing optoelectronic devices and sensors. In this work, we report the synthesis and characterization of self-aligned nanostructured thin films of ZnO and TiO_2 by chemical vapor deposition (CVD) and anodization methods, respectively. The as-prepared films were characterized by XRD, SEM, and XPS analysis. The results show that deposition temperature and time have drastic effects on the crystallinity and morphology of the nanostructured ZnO films. At 400~450°C, compact platelike structures of ZnO are obtained which are perpendicular to the substrate (Figure 1a). Keeping the deposition temperature constant at 400°C, change in deposition time shows that a minimum of 10 minutes is necessary for the formation of whisker-shaped nanostructures. After 120 min of deposition time, flower-like nanostructures are obtained. On the other hand, films of TiO_2 nanotube array (TNA) are markedly affected by the composition of electrolytes that are used during the anodization process. When an electrolyte solution of ethylene glycol and NH_4F was used, close-packed nanotube arrays were formed and when a solution of diethylene glycol and HF is used, individually separated nanotubes arrays (Figure 1b) are obtained. The as-prepared TNA films are amorphous but the highly crystallized anatase phase can be obtained by low-temperature hydrothermal treatment. These films are expected to show high performances in gas sensors or other electronic devices (such as solar cells, photoelectrochemical hydrogen production systems). Further research is underway in our lab.

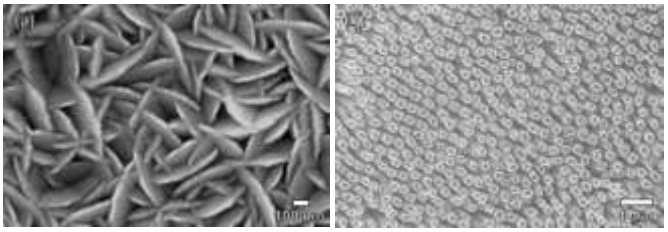


Figure 1 Nanostructured thin films of (a) ZnO (b) TiO_2

Recent Publications

1. Sogai K., Saito K., Yoshida K., Miura M., Kanomata K., Ahmmad B., Kubota S., Hirose F., (2021) Nanothick TiO_2 channel thin-film transistors for UV and gas sensing. ECS J. Solid State Sci. Technol. 10: 065006.
2. Yoshida K., Saito K., Miura M., Kanomata K., Ahmmad B., Kubota S., Hirose F., (2021) Room temperature atomic layer deposition of nanocrystalline ZnO and its application for flexible electronics. IEICE Trans. Electron. E104-C: in press.
3. Kubota S., Hiraga K., Kanomata K., Ahmma B., Mizuno J., Hirose F. (2020) Efficient light trapping structures for organic photovoltaics fabricated by nanoimprint lithography. J. Photopolym. Sci. Technol. 33:103-109.
4. Yoshida K., Tokoro K., Kanomata K., Miura M., Saito K., Ahmmad B., Kubota S., Hirose F. (2019) Room temperature atomic layer deposition of niobium oxide using plasma excited humidified argon and its application to anticorrosion to hydrochloric acid. J. Vac. Sci. Technol. A 37:060901.
5. Tokoro K., Saito S., Kanomata K., Miura M., Ahmmad B., Kubota S., Hirose F. (2018) Room-temperature atomic layer deposition of SnO_2 using tetramethyl tin and its application to TFT fabrication. IEICE Trans. Electron E101-C: 317-322.



Biography

Bashir Ahmmad has completed his Ph.D. from Kagoshima University, Japan. Currently, he is an associate professor at the Graduate School of Science and Engineering, Yamagata University, Japan. His research interests include nanomaterials, thin-film, solar-hydrogen, and solar cells. He has published more than 70 technical papers in reputed journals. He had been the guest editor of the International Journal of Photoenergy and Energies in 2014 and 2020, respectively. Presently, he is serving as an editorial board member of Energies, and a technical committee member of Component Parts and Materials (CPM) of the IEICE society in Japan.

Email: arima@yz.yamagata-u.ac.jp

Notes/Comments: