Fabrication of mesoporous titania thin film on p-type semiconductor substrate toward efficient wastewater purification

*N. Suzuki[1)], A. Okazaki[2)], C. Terashima[1)], K. Nakata[1)3)], K. Katsumata[1)] and A. Fujisima[1)]
[1)] Photocatalysis International Research Center, Tokyo University of Science, Noda, Chiba, Japan,
[2)] ORC Manufacturing Co., Ltd., [3)] Graduate School of Science and Technology, Tokyo University of Science
*suzuki.norihiro@rs.tus.ac.jp
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Mesoporous material, which has pores with 2 – 50 nm in diameter, has unique properties such as uniform pore size, large pore volume, high surface area, and so on. Owing to these, mesoporous materials have a potential to show superior efficiency on surface related phenomena like catalytic reaction.

Titania (TiO_2) is a well-known metal oxide n-type semiconductor. Though its band gap differs depending on the crystal phase, it is about 3.2 eV (387 nm) in anatase phase. When UV light with wavelength shorter than 387 nm is irradiated, electrons in the valence band are excited to the conduction band, creating holes and electrons in the valence band and the conduction band, respectively. Because the photo-generated holes show strong oxidation ability, they can decompose organic pollutants. Thus, titania works as photocatalyst under UV light. Besides its high photocatalytic efficiency, titania has high stability and good biocompatibility. Furthermore, because titanium is an abundant metal, the production cost of titania is very low. Therefore, titania is one of the most widely-used photocatalyst.

To achieve an effective oxidation by photocatalysts, as many as photo-generated holes should react with organic pollutant. However, in the single titania, recombination of photo-carriers often occurs. This carrier recombination decreases the number of holes react with organic pollutants, leading the lowering photocatalytic properties. To suppress the carrier recombination, p-n heterojunction has been used. At hetero-interface, an energy gradient is created to match the energy level of both bulk, and this gradient is useful to promote photo-generated charge separation. Thus, we fabricated mesoporous titania thin film on the p-type semiconductor substrate, aiming to enhancing the photocatalytic activity.

Mesoporous titania thin film was fabricated by surfactant-assisted sol-gel method as described in the previous papers[1)]. The precursor solution containing amphipathic surfactant micelles and titania sol were spin-coated on the boron-doped Si or diamond substrate (p-type semiconductor). During the evaporation of solvent, surfactant micelles self-assembles and they act as organic template. After removal of the template by calcination, mesoporous titania thin film is obtained. Schematic image is shown in Fig. 1.

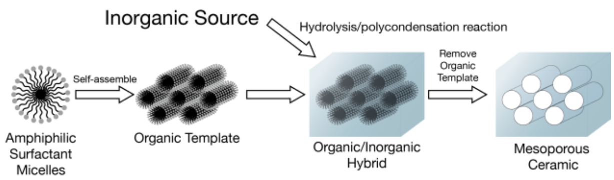

Fig. 1. Fabrication process of mesoporous ceramics by surfactant-assisted sol-gel method.

The morphology of synthesized film was examined with SEM image. As shown in Fig. 2, very well ordered porous structure was obtained. Mesopores with around 20 nm in diameter was hexagonally packed. The structural change depending on the substrate did not observed.

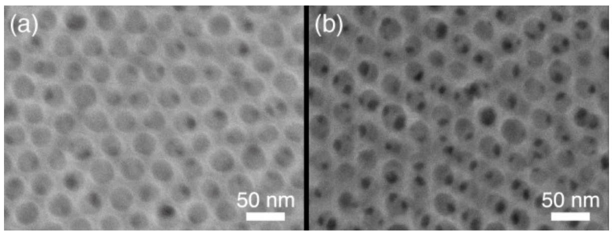

Fig. 2. Top-view SEM image of mesoporous titania thin film fabricated on boron-doped (a) silicon and (b) diamond substrate

In the presentation, we would like to show the photocatalytic activity of prepared films and their potential for wastewater purification.

References

1) X. Jiang, N. Suzuki *et al.*, *Eur. J. Inorg. Chem.*, 2013, 3286-3291 (2013); N. Suzuki *et al.*, *Chem. Lett.*, 44, 656-658 (2015).