1. Research Activity of This Year

1) Study of Fluid Control on Solid Surface

It was demonstrated using ultrasmooth hydrophobic silane coatings and photolithography technique that the effects of chemical heterogeneity on the static and dynamic wettability depend on the size and distribution of the defects, and were different even if the area fraction of the defects was constant in the surface. Moreover, a correlation was identified between the roughness criteria (the average roughness distance ($R_{nm}$) and the average roughness height ($R_c$)) and droplet radius at the wetting mode transition (WMT) on the highly hydrophobic surface with the random roughness, which is important from the practical viewpoint. The WMT was inhibited when the moiety of the fluoroalkyl silane was long. These results provide a guideline for designing highly hydrophobic surface with excellent water-shedding performance (namely, sustainability of the Cassie’s mode). Moreover, the effect of the external conditions such as electric field on the surface wettability was theoretically rationalized.

2) High-performance Materials Development for Environmental Purification

Various heteropolyacids (PW$_{12}$, PMo$_{12}$)-TiO$_2$ hybrid thin films were prepared by layer-by-layer method, and the effect of layer-order on entire photocatalytic activity was clarified. Moreover, porous spherical CeO$_2$ particles were successfully prepared by impregnation of a cerium precursor solution into organic monolith sphere particles, with subsequent firing in air. Photodeposition with UV illumination loaded Au onto the CeO$_2$ particle surface, which changed from yellowish to purple because of localized surface plasmon resonance (LSPR). The Au-loading increased photocatalytic decomposition activity of the CeO$_2$ powder for gaseous 2-propanol (IPA) under visible light. Thermal desorption of IPA, which was adsorbed to all porous spheres, provided flux to the photocatalytic reaction field of the sphere outer surface. Furthermore, wettability variation under UV irradiation was evaluated by friction force microscopy on polycrystalline rutile ceramics. The relation between micro-structural change of photo-induced rutile surface and its wettability was discussed.

2. List of Papers

2-1. Original Papers

1) “Stability of Sc$_2$O$_3$ and CeO$_2$ co-doped ZrO$_2$ Electrolyte during the Operation of Solid Oxide Fuel Cells”

2) “Processing and Photocatalytic Properties of Cu-grafted TiO$_2$ Powder from Acid Treated BaTiO$_3$”
   L. Liu, T. Isobe, H. Lin, K. Okada, A. Nakajima


15) “Preparation and Visible-light Photocatalytic Activity of Au-supported Porous CeO₂ Spherical Particles Using Templating”
A. Nakajima, T. Kobayashi, T. Isobe, S. Matsushita

16) “Preparation of TiO₂ Thin Films Using Water-soluble Titanium Complexes and Their Photoinduced Properties”
K. Katsumata, Y. Ohno, K. Tomita, M. Sakai, A. Nakajima, M. Kakihana, A. Fujishima, N. Matsushita, K. Okada

17) “Photocatalytic Activity and Related Surface Properties of Transparent ZnO Films Prepared by a Low-temperature Aqueous Route”
H. Wagata, K. Katsumata, N. Ohashi, M. Sakai, A. Nakajima, A. Fujishima, K. Okada, N. Matsushita

18) “Comparison of the Photocatalytic and Related Surface Properties of Transparent ZnO Films Prepared by a Low-temperature Aqueous Route”
K. Katsumata, Y. Ohno, K. Tomita, M. Sakai, A. Nakajima, M. Kakihana, A. Fujishima, N. Matsushita

19) “Preparation of Porous Spherical ZrO₂-SiO₂ Composite Particles using Templating and Its Solid Acidity by H₂SO₄ Treatment”
S. Uchiyama, T. Isobe, S. Matsushita, K. Nakajima, M. Hara, A. Nakajima
*J. Mater. Sci.*, in press.

20) “Instrument for Ceramic Particle Dispersion II: Computational Fluid Dynamics Analysis”
T. Isobe, N. Yamamoto, A. Nakajima
*Powder Technol.*, in press.

21) “Pore size control of Al₂O₃ Ceramics using Two-Step Sintering”
T. Isobe, A. Ooyama, M. Shimizu, A. Nakajima
*Ceram. Int.*, in press.

22) “Wetting Mode Transition of Nanoliter Scale Water Droplets during Evaporation on Superhydrophobic Surfaces with Random Roughness Structure”
T. Furuta, T. Isobe, M. Sakai, S. Matsushita, A. Nakajima

23) “Wetting Mode Transition of Water Droplets by Electrowetting on Highly Hydrophobic Surfaces Coated with Two Different Silanes”
T. Furuta, M. Sakai, T. Isobe, S. Matsushita, A. Nakajima

24) “Kinetics Study for Photodegradation of Methylene Blue Dye by Titanium Dioxide Powder”
Y. Ono, T. Rachi, T. Okuda, M. Yokouchi, Y. Kamimoto, A. Nakajima, K. Okada

2-2. Reviews and Books

1) A. Nakajima
“Design of Hydrophobic Surfaces for Liquid Droplet Control”
2) A. Nakajima
“Control of Static and Dynamic Hydrophobicity of Solid Surface and its Application”

“Porous Ceramics Mimicking Nature---Preparation and Properties of Microstructures with
Unidirectionally Oriented Pores”

4) A. Nakajima, L. Liu, N. Yamamoto
“Processing and photocatalytic activity of TiO₂ powders by acid-leaching of BaTiO₃”
Photocatalyst 35, 26-27 (2011)

5) T. Furuta, A. Nakajima
“Static and Dynamic Hydrophobicity of Solid Surface”

3. List of Invited Presentations

3-1. International Conference or Workshop

1) A. Nakajima “Reduction of Friction Drag on the Surface coated with Photocatalyst under
UV illumination”, 4th China-Japan Symposium on Advanced Photocatalytic Materials,

2) A. Nakajima “Processing and photocatalytic properties of Cu-grafted TiO₂ powder from
acid treated BaTiO₃”, PacRim 9 "The 9th International Meeting of Pacific Rim Ceramic
Societies” 10 - 14 July 2011 Cairns Convention Centre, Queensland Australia

3-2. Domestic Conferences

1) A. Nakajima,
“Processing and properties of TiO₂ particles from BaTiO₃”
The 11th Symposium of Photocatalyst Research, The University of Tokyo, July 21, (2011)