

# Department of Metallurgy and Ceramic Science, Akira Nakajima

## 1. Research Activity of This Year

### 1. Study of Fluid Control on Solid Surface

Effects of surface composition and roughness on the water evaporation were revealed in detail on various hydrophobic silane coatings. Moreover, effect of droplet size on the line tension measurement was clarified using ionic liquids and nano-liter scale droplets. Furthermore, a new system to evaluate surface air-layer of superhydrophobic surface in water was developed.

### 2. High-performance Materials Development for Environmental Purification

Using phase separation of sol-gel method, a hybrid coating of  $\text{TiO}_2$  and  $\text{CS}_{2.5}\text{H}_{0.5}\text{PW}_{12}\text{O}_{40}$  was developed. Detailed evaluation of photocatalytic activity revealed that  $\text{CS}_{2.5}$  effectively adsorbed decomposition intermediate. We also prepared various heteropolyacids- $\text{TiO}_2$  hybrid thin films by layer-by-layer method, and clarified that  $\text{PW}_{12}$  and  $\text{H}_2\text{W}_{12}$  are effective for this combination. Moreover, effects of photocatalytic decomposition and subsequent water adsorption on the friction force variation were analyzed for  $\text{TiO}_2$  (anatase) polycrystalline thin films using a probe microscopy by changing atmospheres.

## 2. List of Papers

### 2-1. Original Papers

- 1) "Preparation and Properties of Titania- $\text{Cs}_{2.5}\text{H}_{0.5}\text{PW}_{12}\text{O}_{40}$  Hybrid Films"  
A. Nakajima, S. Matsui, S. Yanagida, Y. Kameshima, K. Okada  
*Surf. Coatings Tech.*, 203[9], 1133-1137 (2009).
- 2) "Low Temperature Preparation and Machinability of Porous Ceramics from Talc and Formed Glass Particles"  
K. Okada, F. Ikawa, T. Isobe, Y. Kameshima, A. Nakajima  
*J. Eur. Ceram. Soc.*, 29[6], 1047-1052 (2009).
- 3) "Preparation and Abrasion Resistance of Transparent Super-hydrophobic Coating by Combining Crater-like Silica Films with Acicular Boehmite Powder"  
T. Yanagisawa, A. Nakajima, Y. Kameshima, M. Sakai, K. Okada  
*Mater. Sci. Eng. B*, 161, 36-39 (2009).
- 4) "Effect of Surface Structure on the Sustainability of Air Layer on Superhydrophobic Coatings in Water-Ethanol Mixture"  
M. Sakai, T. Yanagisawa, A. Nakajima, Y. Kameshima, K. Okada  
*Langmuir*, 25[1], 13-16 (2009).
- 5) "Mass Dependence of Slipping/Rolling Ratio in Sliding Acceleration of Water Droplets on a Smooth Fluoroalkylsilane Coating"  
S. Suzuki, A. Nakajima, Y. Sakurada, M. Sakai, N. Yoshida, A. Hashimoto, Y. Kameshima, K. Okada  
*J. Jpn. Soc. Colour Mater.*, 82[1], 3-8 (2009).

- 6) "Dependence of UV Intensity and Atmosphere on the Photoinduced Surface Friction Force Variation in Polycrystalline TiO<sub>2</sub> Thin Films"  
N. Arimitsu, A. Nakajima, T. Watanabe, Y. Kameshima, K. Okada  
*J. Photochem. Photobiol., A: Chem.*, 203[2-3], 155-160 (2009).
- 7) "Water Retention Properties of Porous Geopolymers for Use in Cooling Applications"  
K. Okada, A. Ooyama, T. Isobe, Y. Kameshima, A. Nakajima, K.J.D. MacKenzie  
*J. Eur. Ceram. Soc.*, 29, 1917-1923 (2009).
- 8) "Bioactivity and Mechanical Properties of CaSiO<sub>3</sub>/High-density Polyethylene (HDPE) Composites Prepared by A New Surface Loading Method of CaSiO<sub>3</sub> Powder"  
K. Okada, M. Tanuma, Y. Kameshima, A. Nakajima, S. Asai, M. Sumita  
*Mater. Res. Bull.*, 44[2], 298-305 (2009).
- 9) "Photocatalytic Destruction of 1,4-dioxane in Aqueous System by Surface-roughened TiO<sub>2</sub> Coating on Stainless Mesh"  
S. Yanagida, A. Nakajima, Y. Kameshima, K. Okada  
*Key Eng. Mater.*, 412, 137-141 (2009).
- 10) "Preparation of Alumina-Iron Oxide Compounds by Gel Evaporation Method and Its Simultaneous Uptake Properties for Ni<sup>2+</sup>, NH<sub>4</sub><sup>+</sup> and H<sub>2</sub>PO<sub>4</sub><sup>-</sup>"  
F. Gulshan, Y. Kameshima, A. Nakajima, K. Okada  
*J. Hazard. Mater.*, 169, 697-702 (2009).
- 11) "Preparation and Properties of TiO<sub>2</sub>/Montmorillonite Composites"  
Y. Kameshima, Y. Tamura, A. Nakajima, K. Okada  
*Appl. Clay Sci.*, 45, 20-23 (2009).
- 12) "Evaporation and Sliding of Water Droplets on Fluoroalkylsilane Coatings with Nanoscale Roughness"  
T. Furuta, A. Nakajima, M. Sakai, T. Isobe, Y. Kameshima, K. Okada  
*Langmuir* 25[10], 5417-5420 (2009).
- 13) "Droplet Size Dependence of Line Tension for an Ionic Liquid on a Smooth Silane Coating"  
T. Furuta, A. Nakajima, M. Sakai, T. Isobe, Y. Kameshima, K. Okada  
*Chem. Lett.*, 38[6], 580-581 (2009).
- 14) "Capillary Rise Properties of Porous Mullite Ceramics Prepared by Extrusion Method using Organic Fiber as the Pore Former"  
K. Okada, S. Uchiyama, T. Isobe, Y. Kameshima, A. Nakajima, T. Kurata  
*J. Eur. Ceram. Soc.*, 21, 2491-2497 (2009).
- 15) "Preparation and Properties of Cu-grafted Transparent TiO<sub>2</sub>-nanosheet Thin Films"  
A. Nakajima, Y. Akiyama, S. Yanagida, T. Koike, T. Isobe, Y. Kameshima, K. Okada  
*Mater. Lett.*, 63, 1699-1701 (2009).

- 16) "Preparation of Solid Acid Carbon Coating on the Surface of TiO<sub>2</sub> by Photo-CVD of Gaseous Aromatic Hydrocarbons"  
A. Nakajima, K. Horie, M. Hara, M. Kitano, T. Isobe, Y. Kameshima, K. Okada  
*Catal. Commun.*, 10, 1670-1673 (2009).
- 17) "Sliding of Water Droplets on the Superhydrophobic Surface with ZnO Nanorods"  
M. Sakai, H. Kono, A. Nakajima, X. Zhang, H. Sakai, M. Abe, A. Fujishima  
*Langmuir*, 25[24], 14182-14186 (2009).
- 18) "Measurement of Non-DLVO Force on a Silicon Substrate Coated with Ammonium Poly (Acrylic Acid) using Scanning Probe Microscopy"  
T. Isobe, Y. Nakano, Y. Kameshima, A. Nakajima, K. Okada  
*Appl. Surf. Sci.*, 255, 8710-8713 (2009).
- 19) "Nanostripe Patterning of Glass Surface by Nanoimprint using Self-organized Oxide Mold"  
Y. Akita, Y. Kato, M. Hosaka, Y. Ono, S. Suzuki, A. Nakajima, M. Yoshimoto  
*Mater. Sci. Eng. B*, 161, 151-154 (2009).
- 20) "Effect of the SiO<sub>2</sub>/TiO<sub>2</sub> Ratio on the Solid Acidity of SiO<sub>2</sub>-TiO<sub>2</sub>/montmorillonite Composites"  
Y. Kameshima, T. Koike, T. Isobe, A. Nakajima, K. Okada  
*Mater. Res. Bull.*, 44, 1906-1909 (2009).
- 21) "Preparation and Photocatalytic Activity of Keggin-ion Tungstate and TiO<sub>2</sub> Hybrid Layer-by-layer Film Composite"  
S. Yanagida, A. Nakajima, T. Sasaki, T. Isobe, Y. Kameshima, K. Okada  
*Appl. Catal. A General*, 366, 148-153 (2009).
- 22) "Preparation and Properties of Negative Thermal Expansion Zr<sub>2</sub>WP<sub>2</sub>O<sub>12</sub> Ceramics"  
T. Isobe, T. Umezome, Y. Kameshima, A. Nakajima, K. Okada,  
*Mater. Res. Bull.*, 44, 2045-2049 (2009).
- 23) "Nanosized silver - anionic clay matrix as nanostructured ensembles with antimicrobial activity"  
G. Carja, Y. Kameshima, A. Nakajima, C. Dranca, K. Okada  
*Int. J. Antimicrobial Agents.*, 34, 534-539 (2009).
- 24) "Intercalation Behavior of Various Fatty Acids into Mg-Al-Layered Double Hydroxide"  
Y. Kameshima, H. Sasaki, T. Isobe, A. Nakajima, K. Okada  
*Clay Sci.*, 14, 87-94 (2009).
- 25) "Evaporation Behavior of a Microliter and Sub-nanoliter Scale Water Droplets on Two Different Fluoroalkylsilane Coatings"  
T. Furuta, M. Sakai, T. Isobe, A. Nakajima  
*Langmuir* 25[20], 11998-12001 (2009).

- 26) "Synthesis of Composite of Sodium Oleate/Mg-Al-Ascorbic Acid-Layered Double Hydroxides for Drug Delivery Applications"  
Y. Kameshima, H. Sakai, T. Isobe, A. Nakajima, K. Okada  
*Int. J. Pharma.*, 381, 34-39 (2009).
- 27) "Negative Line Tension for an Ionic Liquid on a Hydrophobic Fluoroalkylsilane Coating"  
T. Furuta, M. Sakai, T. Isobe, A. Nakajima  
*Chem. Lett.*, 38[11], 1092-1093 (2009).
- 28) "Solid Acidities of SiO<sub>2</sub>-TiO<sub>2</sub>/montmorillonite Composites Synthesized under Different pH Conditions"  
Y. Kameshima, Y. Yoshizawa, A. Nakajima, K. Okada  
*Appl. Clay Sci.*, 46[2], 181-184 (2009).
- 29) "Porous Properties of Mesoporous Silicas from Two Silica Sauces (Acid-leached Kaolinite and Si-Alkoxide)"  
K. Okada, H. Yoshizaki, Y. Kameshima, A. Nakajima, K.J.D.Mackenzie  
*J. Porous Mater.*, 17, 19-25 (2010).
- 30) "Characteristics of Microbubbles Generated by Porous Mullite Ceramics Prepared by an Extrusion Method using Organic Fibers as the Pore Former"  
K. Okada, M. Shimizu, T. Isobe, Y. Kameshima, M. Sakai, A. Nakajima, T. Kurata  
*J. Eur. Ceram. Soc.*, in press.
- 31) "Water Droplets' Internal Fluidity during Horizontal Motion on a Superhydrophobic Surface with an External Electric Field"  
M. Sakai, H. Kono, A. Nakajima, H. Sakai, M. Abe, A. Fujishima,  
*Langmuir*, in press.

## 2-2. Reviews and Books

- 1) A. Nakajima,  
"Science and Technology of Hydrophobic Solid Surface"  
*J. Surf. Finishing Soc. Jpn.*, 60 [1] 2-8 (2009) [in Japanese]
- 2) A. Nakajima,  
"Improvement of Photocatalytic Activity by Controlling Reaction Field of TiO<sub>2</sub> Coatings"  
*Shokubai(Catalysts)*, 51 [3] 222-227 (2009) [in Japanese]
- 3) A. Nakajima,  
"Design of Super-wettability"  
*J. Soc. Inorg. Mater. Jpn.*, 16, 407-413 (2009) [in Japanese]
- 4) A. Nakajima, A. Arimitsu

“Photoinduced Friction Force Variation on Anatase Polycrystalline Thin Films”  
*Hikarishokubai (Photocatalysts)*, 29, 88-91 (2009) [in Japanese]

5) A. Uematsu, A. Nakajima

“Preparation of Nb-doped Transparent Conductive TiO<sub>2</sub> Thin Films”  
Ceramic Data Book 2009/10, 37[91], 111-113 (2009) [in Japanese]

### **3. List of Invited Presentations**

#### **3-1. International Conference or Workshop**

- 1) A. Nakajima, N. Arimitsu, Y. Kameshima, K. Okada, T. Watanabe, “Photoinduced Surface Friction Force Variation of Polycrystalline TiO<sub>2</sub> Thin Films under Different UV Intensity and Atmosphere”, 2nd China-Japan Symposium on Advanced Photocatalytic Materials, Proceedings pp14-15, Nanjing University, Mar. 5-7 (2009) Nanjing, China.
- 2) A. Nakajima, S. Suzuki, M. Sakai, Y. Kameshima, K. Okada, "Direct Evaluation of the Sliding Motion of Water Droplets on Hydrophobic Silane Coatings" Proceedings of 2009 Tsinghua Univ.-Tokyo Tech.-Xiamen Univ. Joint Symposium on Advanced Materials, pp.20, November 22-24 (2009) Xiamen, China.

#### **3-2. Domestic Conferences**

1) A. Nakajima,

“Design of Super-wettability”

The 19<sup>th</sup> Symposium of the Society of Inorganic Materials Japan.

December 11, (2009)