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1. Main Research Results

Phase-segregated Nanostructured Polymer Template Film

Several structural transcription and hybridization processes by using normally oriented hexagonal cylinder nanostructured thin films of amphiphilic liquid crystalline block copolymer have been demonstrated: (1) Ge quantum dot array were fabricated by combining our block copolymer templating process and ultrahigh vacuum deposition technique through collaboration with Prof. Yoshiaki Nakamura and Mr. Murayama in the University of Tokyo. The Ge dots grew epitaxially through the ordered nanoholes of ultrathin oxide layer on silicon wafer substrate. The following nanostructural transcription processes have also been developed; (2) nanohole array on atomically flat gold substrate, (3) titanium dioxide nanowires, (4) conducting polymer nanowire array, and (5) Superconducting Pb nanorod array. Additionally, (6) conducting ruthenium oxide nanopillar array fabricated before in our laboratory was crystallized by calcinations to form crystalline RuO₂ rod array, which preliminarily emit electrons as cold cathode.

2. List of Publications

- 1) R. Watanabe, T. Iyoda, K. Ito
Nanostructured Titanium Oxide Fabricated via Block Copolymer Template
Electrochemistry, 77(3), 214-218 (2009).
- 2) M. Nakagawa, N. Kamata, T. Iyoda, S. Matsui
Thermal nanoimprint of a polystyrene and poly(4-vinylpyridine) double-layer thin film and visualization determination of its internal structure by transmission electron microscopy
Jpn. J. Appl. Phys., 48(6, Pt. 2), 06FH12/1-06FH12/6 (2009).
- 3) R. Watanabe, K. Ito, T. Iyoda, H. Sakaguchi
Nanohole arrays fabricated on gold surfaces by total wet nanopatterning through block copolymer masks
Jpn. J. Appl. Phys., 48(6, Pt. 2), 06FE08/1-06FE08/4 (2009).
- 4) M. Komura, K. Watanabe, T. Iyoda, T. Yamada, H. Yoshida, Y. Iwasaki
Laboratory-GISAXS measurements of block copolymer films with highly ordered and normally oriented nanocylinders
Chem. Lett., 38(5), 408-409 (2009).
- 5) H. Yu, Y. Naka, A. Shishido, T. Iyoda, T. Ikeda, Tomiki
Effect of recording time on grating formation and enhancement in an amphiphilic diblock

liquid-crystalline copolymer

Mol. Cryst. Liq. Cryst., 498, 29-39 (2009).

- 6) I. R. Laskar, S. Watanabe, M. Hada, H. Yoshida, J. Li, T. Iyoda
Tuning surface interactions to control shape and array behavior of diblock copolymer micelles on a silicon substrate
Surf. Sci., 603(4), 625-631 (2009).
- 7) L. Song, T. Iyoda
Supramolecular Framework Based on Pyridiniodiketone Ligand via Non-classic Hydrogen Bonding
J. Inorg. Organometal. Polym. Mater., 19(1), 124-132 (2009).
- 8) Y. Nakamura, A. Murayama, R. Watanabe, T. Iyoda, M. Ichikawa
Self-organized formation and self-repair of a two-dimensional nanoarray of Ge quantum dots epitaxially grown on ultrathin SiO₂-covered Si substrates
Nanotechnology, 21(9), 095305 (2010).

3. Books

None

4. International and domestic conferences

- 1) T. Iyoda (Invited)
Block Copolymer Templating Processes for Highly Ordered Nanostructured Materials
International Symposium on Joint Research Network for Advanced Material and Devices
“Chou”, March 25-26, Chitose 2010.
- 2) K. Ito, T. Iyoda (Invited)
Nanotemplate Processes through liquid Crystalline Block Copolymer Thin Films
The 58th SPSJ Annual Meeting, Kobe, May 26-28, (2009)
- 3) T. Iyoda (Award lecture)
Functionalization and Hybridization of Polymer Thin Films
The 58th Symposium on Macromolecules, Kumamoto, September 16-18, 2009.
- 4) T. Iyoda (Plenary lecture)
Ordered Nanostructure Control and Templating Materials Engineering based on
Macromolecular Microphase Separation
The 90th Annual Meeting of Chemical Society Japan, Advance Technology Program on Fine
Patterning Technology for Perspective with Materials, Osaka, March 27 (2010).
- 5) T. Iyoda (Invited)
Photochemical and electrochemical Perspectives of Microphase-separated Nanostructures of

Block Copolymer Thin Films

The 90th Annual Meeting of Chemical Society Japan, Special Program on Photochemistry of Low Dimensional Inorganic and Organic Hybrids. –Photofunctions of Organic Compounds in Inclusion Space-, Osaka, March 29 (2010).

5. Patent

- 1) Microcoils, Their Fabrication, and Application for Screening or Absorption of Electromagnetic Waves
JP2009-103681
- 2) Free-Standing Polymer Films
JP2009-126425

6. Award

- 1) T. Iyoda
The Award of the Society of Polymer Science, Japan in 2009
Structural Control, Functionalization, and Hybridization of Polymer Thin Films
- 2) R. Watanabe, K. Ito, T. Iyoda
ECSJ Award for the Outstanding Paper in Electrochemistry in 2009
Nanostructured Titanium Oxide Fabricated via Block Copolymer Template
Electrochemistry, **77**(3), 214-218 (2009).

7. International Collaboration

Prof. Yang Wantai and Prof. Wang Feng (Beijing University of Chemical Technology, China)

The following two collaborative researches have been started since two Ph.D. students in Beijing University of Chemical Technology stayed in 6 weeks in our laboratory. One is synthesis and nanostructure of new amphiphilic liquid crystalline block copolymer and the other is fabrication of conducting polymer wire array through block copolymer templating process.

8. News

- 1) “Copper plating on algae for metal microcoils by TIT and SMM”
Nihon Keizai Shimbun, July 27, 2009
- 2) “Ordered nanostructure fabricated by TIT”
Kagaku Kogyo Nippo, September, 17, 2009

9. Miscellaneous

The Third International Symposium on Integrated Macromolecular/Materials Engineering, ISIMME2009 in Sichuan University in Chengdu, China, was held with 140 participants including 46 Japanese scientists from 9 laboratories.