

**Hideo Takezoe, Prof.**

**Department of Organic and Polymeric Materials**

## **1. Main Research Results**

### **1) Banana-shaped Liquid Crystals 7, 12, 14, 21**

The number of citation of the first banana LC paper (J. Mater. Chem. 1996) reported together with Prof. J. Watanabe's group became 618 (Feb. 16, 2009, ISI), and that of the review paper (Jpn. J. Appl. Phys., 2006) became 106 (Feb. 16, 2009, ISI). We continued to investigate this liquid crystal system.

Under collaboration with Prof. J. Watanabe, banana-shaped liquid crystals with asymmetric cores were synthesized and characterized, showing possible new structures [7]. Electroconvection effect so far conducted in rod-like liquid crystal was measured in bent-core nematic liquid crystals and observed chiral structure formation [12]. Kerr effect measurement was conducted in banana mesogens for the first time, although the Kerr constant was small [14]. One of the most interesting topic in banana mesogens is the emergence of biaxial nematic phase. So far many scientists have reported the discovery of biaxial nematic in many materials. We collaborate with Prof. A. Jakli in Kent state univ. to propose and demonstrate a new but simple optical method to examine the biaxiality. We proved that the molecule which was reported to show the uniaxial to biaxial nematic phase transition was actually the uniaxial nematic phase in entire temperature range [21].

### **2) Other Liquid Crystals 2, 16, 17**

Besides banana-shaped liquid crystals, we studied some other liquid crystal systems such as new discotic liquid crystals (synthesis and characterization) [2], paramagnetic ferroelectric liquid crystal (magnetic-field-induced molecular alignment) [16], discotic liquid crystals with a collanurene core which can be aligned by an electric field (synthesis and characterization) [17]. These are the consequence of collaboration works with Center for Liquid Crystal Research of India, Prof. R. Tamura of Kyoto Univ. and Prof. T. Aida of Tokyo Univ, respectively.

### **3) Photonic Devices 1, 4, 5, 6, 8, 9, 10, 11, 15, 18**

Most actively studied area in 2008. We studied optical devices with periodic structures such as cholesteric liquid crystals. We successfully achieved good results in OLED, laser device and optical reflection film and so on. Contrary to common knowledge, i.e., cholesteric liquid crystal reflects light corresponding to the helical pitch, we succeeded in getting films, which reflect RGB light, using cholesteric liquid crystal film and isotropic polymer film [1]. Further by making a dye-doped film sandwich by these hybrid films, we succeeded in RGB simultaneous lasing [5]. As for OLED devices using photonic structures, we succeeded in increasing external efficiency using imprinted one- and two-dimensional photonic crystal [4,8]. Polarization tunable OLED devices using electric-field-tunable nematic liquid crystal film was also realized [10]. Same function was also applied to lasing devices, i.e., polarization-tunable surface-emitting lasers using in-plane periodic structures was made [11,15]. The decrease of threshold energy was achieved using two dyes between which a energy transfer was possible [6]. Stabilization by polymerization was achieved in cholesteric liquid crystal lasers with pitch gradient showing lasing over full visible

wavelength [9]. Omnidirectional lasing device was made under the collaboration with Korean group [18].

#### 4) **Organic Transistors 3, 13, 20**

We collaborated with Prof. T. Mori in organic transistors to improve contact resistance [3], stability [13], and fabrication process [20].

#### 5) **Magneto-optic Materials 19**

Under the collaboration with Prof. T. Yamamoto, we measured Faraday rotation in  $\pi$ -conjugated polymer and obtained remarkably large Verdet constant [19]. The materials can be applied to magnetic field sensors.

## 2. **List of publications (original article, comment/book)**

### 1) **Original Paper**

- (1) Fabrication of a simultaneous red-green-blue reflector using single-pitched cholesteric liquid crystals; N. Y. Ha, Y. Ohtsuka, S. M. Jeong, S. Nishimura, G. Suzuki, Y. Takanishi, K. Ishikawa and H. Takezoe: *Nature Mater.* **7** (2008) 43-47.
- (2) Discotic liquid crystals: synthesis and characterization of radial polyalkynylbenzene derivatives :S. K. Varshney, H. Takezoe and D. S. S. Rao *Bull. Chem. Soc. Jpn.* **81** (2008) 163-167.
- (3) Contact resistance of dibenzotetrathiafulvalene-based organic transistors with metal and organic electrodes; K. Shibata, K. Ishikawa, H. Takezoe, H. Wada and T. Mori: *Appl. Phys. Lett.* **92** (2008) 023305-1-3.
- (4) Enhancement of normally-directed light outcoupling from organic light-emitting diodes using nano-imprinted low-refractive-index layer; S. M. Jeong, F. Araoka, Y. Machida, K. Ishikawa, and H. Takezoe: *Appl. Phys. Lett.* **92** (2008) 083307-1-3.
- (5) Simultaneous red, green, and blue lasing emissions in a single-pitched cholesteric liquid crystal system; N. Y. Ha, S. M. Jeong, S. Nishimura, G. Suzuki, K. Ishikawa, and H. Takezoe: *Adv. Mater.* **20** (2008) 2503-2507
- (6) Lowering Threshold by Energy Transfer between Two Dyes in Cholesteric Liquid Crystal Distributed Feedback Lasers; K. Sonoyama, Y. Takanishi, K. Ishikawa, and H. Takezoe: *Appl. Phys. Exp.* **1** (2008) 032002-1-3.
- (7) Effect of Molecular Structure in Smectic Phases of Two Homologues Series of Bent-shaped Molecules with Asymmetric Central Naphthalene Core; S. K. Lee, M. Tokita, H. Takezoe, and J. Watanabe: *Ferroelectrics*, **365** (2008) 159-169.
- (8) Enhancement of Light Extraction from Organic Light-Emitting Diodes with Two-Dimensional Hexagonally Nano-Imprinted Periodic Structures Using Sequential Surface Relief Grating; S. M. Jeong, F. Araoka, Y. Machida, Y. Takanishi, K. Ishikawa, and H. Takezoe: *Jpn. J. Appl. Phys.* **47** (2008) 4566-4571.
- (9) Toward practical application of cholesteric liquid crystals to tunable lasers; T. Manabe, K. Sonoyama, Y. Takanishi, K. Ishikawa, and H. Takezoe: *J. Mater. Chem.* **18** (2008) 3040-3043.
- (10) Polarization-tunable electroluminescence using phase retardation based on photonic bandgap liquid

- crystal; S. M. Jeong, N. Y. Ha, H. Takezoe, S. Nishimura, G. Suzuki: *J. Appl. Phys.* **103** (2008) 113101-1-4.
- (11) Electro-tunable polarization of surface-emitting distributed feedback laser with nematic liquid crystals; S. M. Jeong, N. Y. Ha, F. Araoka, K. Ishikawa, and H. Takezoe: *Appl. Phys. Lett.* **92** (2008) 171105-1-3.
- (12) Alternating twist structures formed by electroconvection in the nematic phase of an achiral bent-core molecule; S. Tanaka, S. Dhara, B. K. Sadashiva, Y. Shimbo, Y. Takanishi, F. Araoka, K. Ishikawa and H. Takezoe: *Phys. Rev. E*, **77** (2008) 041708-1-5.
- (13) (Tetrathiafulvalene)tetracyanoquinodimethane as a contact material for n-channel and ambipolar organic transistors; K. Shibata, Y. Watakabe, K. Ishikawa, H. Takezoe, H. Wada, and T. Mori: *Appl. Phys. Exp.* **1** (2008) 051801-1-3.
- (14) Kerr constant and third-order nonlinear optic susceptibility measurements in a liquid crystal composed of bent-shaped molecules; S. Dhara, F. Araoka, M. Lee, K. V. Le, L. Guo, B. K. Sadashiva, K. Song, K. Ishikawa and H. Takezoe: *Phys. Rev. E* **78** (2008) 050701(R) 1-4.
- (15) Enhanced linearly-polarized lasing emission from nano-imprinted surface-emitting distributed feedback laser based on polymeric liquid crystals; S. M. Jeong, N. Y. Ha, M. G. Chee, F. Araoka, K. Ishikawa, and H. Takezoe: *Appl. Phys. Lett.* **93** (2008) 221101.
- (16) Magnetic-field-induced molecular alignment in the achiral liquid crystal spin-labeled by a nitroxyl group in the mesogen core; Y. Uchida, R. Tamura, N. Ikuma, S. Shimonono, J. Yamauchi, Y. Shimbo, H. Takezoe, Y. Aoki, and H. Nohira: *J. Mater. Chem.* **19** (2009) 415-418
- (17) Liquid crystalline corannulene responsive to electric field; D. Miyajima, K. Tashiro, F. Araoka, H. Takezoe, J. Kim, K. Kato, M. Takata, and T. Aida: *J. Am. Chem. Soc.* **131** (2009) 44-45.
- (18) Electro-controllable omni-directional laser emissions from a helical polymeric network composite film; B. Park, M. Kim, S. W. Kim, W. Jang, H. Takezoe, Y. Kim, E. H. Choi, Y. H. Seo, G. S. Cho and S. O. Kang: *Adv. Mater.* **21** (2009) 771-775.
- (19) Large Faraday Rotation in a  $\pi$ -conjugated Poly(aryleneethynylene) Thin Film; F. Araoka, M. Abe, T. Yamamoto, and H. Takezoe: *Appl. Phys. Ex.* **2** (2009) 011501-1-3.
- (20) Organic field-effect transistors based on solution-processible debenzotetrathiafulvalene derivatives; T. Yoshino, K. Shibata, H. Wada, Y. Bando, K. Ishikawa, H. Takezoe, and T. Mori: *Chem. Lett.* **38** (2009) 200-201.
- (21) New method to study biaxiality of liquid crystals with positive dielectric anisotropy –the case of a bent-core material; K. V. Le, M. Mathew, M. Chambers, J. Harden, Q. Li, H. Takezoe, and A. Jakli: *Phys. Rev. E*, **79** (2009) in press.

## 2) Review & Book

- (1) Story of Liquid Crystals –Exploring their mysterious behavior-; Hideo Takezoe: Nihon Kikaku Kyokai (2008, March)

### **3. Invited/Plenary Talks in Conference**

#### **1) International Conference or Workshop**

- (1) “Polymer Cholesteric Liquid Crystals for Photonic Devices”; Korea-Japan International Symposium on Polymer Nanomaterials; Jan. 28 to Jan. 31, 2008 (Daejeon, Korea)  
Invited
- (2) “Tunable Lasers over Wide Wavelength Range”; International Symposium of Photonics and Electronics, from Fundamental to Device; April, 2, 2008 (Tokyo) Invited
- (3) “Cholesteric Liquid Crystals for Photonic Devices”; International Liquid Crystal Conference: June, 29~July 4, 2008 (Jeju, Korea) Invited
- (4) “Chirality in Liquid Crystals – Ester group, this unique chiral property!”; The 4<sup>th</sup> Japanese-Italian Workshop on Liquid Crystals: July 7-10, 2008 (Nara, Japan) Invited
- (5) “Chirality in Liquid Crystals – Ester group, this unique chiral property!”; The National Conference on Liquid Crystals: Oct. 13-15, 2008 (Bangalore, India) Invited
- (6) “Vibrational Circular Dichroism in Spontaneously Chiral Segregated Domains of Ester Molecules”; International School of Liquid Crystals –Liquid Crystal Phases and Nano-Structures: Oct. 27 – Nov. 1, 2008 (Erice, Italy)
- (7) “Induced Optical Activity of Achiral Rod-Like Molecules Nano-Segregated in the B4 Structure of Achiral Bent-Core Molecules”; International Workshop on Mesomorphic Advanced Materials and Nanotechnology (MAMN 2009): March 9-10, 2009 (Tokyo)  
Invited

### **4. Others**

#### **1) Award**

- (1) “Research on Banana-shaped Liquid Crystals”; The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology: April 15, 2008
- (2) “Introduction to Liquid Crystal and Polymer” (Shokabo, 2004); Japan Liquid Crystal Award: Sep. 4, 2009

#### **2) International Collaboration**

- (1) Jpn-Hungary collaboration research (JSPS)