Laboratory for Information and Functions of Materials (Usami Lab)
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1. Research topics

a. Control of molecular orientation of liquid crystal molecules by using photo-aligned polyimide films [1,3,5,6]

Photo-induced alignment of liquid crystal molecules is a promising alternative to the conventional rubbing technique, because photo-alignment is mechanical-contact-free and has high reproducibility and uniformity over a large-area substrate. Among various photo-alignment methods, we are focusing on a method using films of polyimide containing azobenzene in the backbone structure (Azo-PI). The Azo-PI films are thermally, chemically and optically stable. In addition, we demonstrated that the in-plane anisotropy much larger than that induced by rubbing can be optically induced, and also that the azimuthal anchoring energy coefficient is comparable to or larger than that of conventional rubbed polyimide alignment layers.

b. Liquid crystals alignment on perfluoropolymer films [4]

In liquid crystal displays (LCDs), weak anchoring of the liquid crystal (LC) molecules at the interface with the alignment layer can in principle lead to lower operating voltages and improved steepness of the electro-optic response [G. P. Bryan-Brown et al., Nature **399**, 338 (1999)]. It was reported that Langmuir-Blodgett films of perfluoropolyether had a weak surface anchoring for bend deformation, which was in the order of 10^{-5} J/m^2 for 4-n-pentyl-4'-cyanobiphenyl[J. M. Russell-Tanner et al., J. Chem. Phys. **126**, 244706 (2007)]. The perfluoropolyether film has high thermally and chemically resistant, high gas permeability, and low toxicity. Up to now, we succeeded in inducing a uniform LC alignment by using Fluorocur films exposed to linearly polarized ultraviolet light.

c. Optically isotropic chiral domains in bent-core liquid crystals [2]

Bent core liquid crystals are a class of materials that are interesting both for their fundamental theoretical study and for the applications that may be exhibited via their unique phases. Recently, the optically isotropic phases that have been observed in some bent-core materials have received

much attention, both with respect to fundamental structural studies and because of new modes of optical switching in devices. In both cases, chiral domains can be observed in the optically isotropic phase, with equal distributions of domains with opposite chirality. Recently, we found that large optically isotropic chiral domains can be generated in the optically isotropic phase of C5-Ph-ODBP-Ph-OC12 by applying an electric field.

2. Featured publications

1. K. Sakamoto, K. Usami, and K. Miki, "Photoalignment efficiency enhancement of polyimide alignment layers by alkyl-amine vapor treatment," Appl. Phys. Express **7**, 081701 (2014).

2. M. Nagaraj, K. Usami, Z. Zhang, V. Görtz, J. W. Goodby, and H. F. Gleeson, "Unusual electric-field-induced transformations in the dark conglomerate phase of a bent-core liquid crystal", Liq. Cryst. **41**, 800-811 (2014).

3. K. Usami and K. Sakamoto, "Photo-aligned blend films of azobenzene-containing polyimides with and without side-chains for inducing inclined alignment of liquid crystal molecules", J. Appl. Phys. **110**, 043522 (2011).

4. K. Usami, A. Sugimura, and E. T. Samulski, "Uniform alignment of liquid crystals induced by perfluoropolyether film exposed to linearly polarized ultraviolet light", Mol. Cryst. Liq. Cryst. **516**, 38-44 (2010).

5. K. Usami, K. Sakamoto, J. Yokota, Y. Uehara, and S. Ushioda, "Pretilt angle control of liquid crystal molecules by photoaligned films of azobenzene-containing polyimide with a different content of side-chain", J. Appl. Phys. **104**, 113528 (2008).

6. K. Usami, K. Sakamoto, Y. Uehara, and S. Ushioda, "Transfer of the in-plane molecular orientation of polyimide film surface to liquid crystal monolayer", Appl. Phys. Lett. **86** (21), 211906 (2005).

3. Corporate and other affiliates

a. National Institute for Materials Science (NIMS), Chisso Petrochemical Corporation

Joint research related to polyimide photoalignment films undertaken by NIMS principal researcher Kenji Sakamoto and Chisso Petrochemical Corporation