



Organic Electronics and Molecular Orientation

Takashi KOBAYASHI and Hiroyoshi NAITO

The control of molecular orientation is essential for the fabrication of liquid crystal displays. In recent years, this technique has also been used in the field of “molecular electronics” to induce anisotropic properties of organic molecules as well as to enhance quantum efficiency and field effect mobility of optoelectronic devices through the control of molecular arrangement in thin films. In this review, we focus on π -conjugated polymers that are considered as suitable materials for low-cost and flexible devices, and discuss fundamental properties and device applications of aligned π -conjugated polymers.

Keywords : π -Conjugated polymer, Molecular orientation, Self organization, Organic electroluminescence device, Field effect transistor

Development of Color Liquid Crystal Displays Driven by Organic TFTs

Masahiko ANDO

We have successfully developed color liquid-crystal displays driven by organic thin-film transistors (organic TFTs) and demonstrated for the first time (in August, 2004) moving images. That particular LCD panel has the following specifications : display size ; 1.4 inches diagonal, pixel number ; $80 \times 80 \times 3$ (RGB), 80 ppi (pixel per inch), which was the highest in the world at that time. This article reviews the key technologies that have been developed in this field and the present situation and future prospects of such a technology.

Keywords : Organic thin-film transistors, TFT, Pentacene, Display, Liquid crystal

Electro-luminescent Liquid Crystals

Masayoshi SUZUKI

This paper summarizes what is known about electro-luminescent liquid crystal (LC) materials to date and the electro-luminescent behavior for LCs with negative dielectric anisotropy. LCs, high molecular weight LCs,

and photo-polymerizable LCs are reported. Oligomer LCs having fluorene moieties showing the highest orientation order and give highly polarized light emission. Some nematic LCs with negative dielectric anisotropy are found to give light emission from the incorporated dye. It has been clarified that the energy matching among HOMO, LUMO levels and work function of electrodes is important for light emission. It has been also found that charge injection is a Schottky-type injection and charge recombination occurs mainly at dye molecules rather than LC molecules.

Keywords : Electro-luminescence, Photo-sensitive liquid crystal, Liquid crystalline polymer, Liquid crystal with negative dielectric anisotropy, Charge injection, Charge recombination

Present Status of Organic Solar Cells

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Photovoltaic applications are widespread. Next generation photovoltaic systems for low-cost and post silicon solar cells are developing, in which dye sensitized solar cells (DSCs) are excellent candidates for low-cost photovoltaic systems. DSCs consist of titanium dioxide (TiO_2), dye sensitizer, electrolyte, and transparent electrode. In this paper, the photovoltaic mechanism and fabricating processes are discussed.

Keywords : Photovoltaic system, Dye sensitized solar cell, Titanium dioxide

Electronic Carrier Transport in Liquid Crystalline Semiconductors

Masahiro FUNAHASHI

It is important to fabricate thin films of high quality with a low cost solution process in order to produce organic semiconductors for practical electronic purposes. Liquid crystalline semiconductors are more suitable to be used for thin film fabrication using a solution process due to their high carrier mobility compared to molecular crystals which have a crystal-like ordered structure. In this paper, the author reviews their molecular design, carrier transport mechanism, and potential

applications as electronic devices.

Keywords : Liquid crystalline semiconductor, Smectic phase, Discotic columnar phase, Carrier mobility, Carrier transport, Disorder model

Alignment Control for Discotic Liquid Crystals

Hirosato MONOBE and Yo SHIMIZU

Recently a new phenomenon was found that the change of liquid crystal alignment for columnar mesophases is realized under polarized infrared laser irradiation using an infrared laser in the vibrational mode of excitation of a chemical bond in the mesogen. This phenomenon could only be observed only with the relatively highly-ordered liquid crystals of higher viscosity such as columnar mesophases. It was not observed with discotic nematic, calamitic nematic or smectic A/C phases. Thus, liquid crystalline semiconductors could be used in the fabrication of organic devices.

Keywords : Discotic liquid crystal, Columnar phase, Alignment control, Infrared, Vibrational excitation

Single Crystal Growth of Pentacene Organic Semiconductor in Liquid Crystal Solvent

Hideo FUJIKAKE

We report that a large single crystal of pentacene organic semiconductor is obtained with molecular alignment by growing it in a nematic liquid crystal solvent. Pentacene with a stacked molecular structure of rigid π -electron conjugated skeleton shows high charge mobility like a-Si, and is suitable for organic transistor applications. However, as pentacene is mostly insoluble in conventional organic solvents, film-coating processes and liquid-phase crystal growth are generally difficult. Due to their considerable molecular movement and fluidity, liquid crystals with rigid and flexible skeletons could act as potential solvents for pentacene. Indeed, pentacene does dissolve in heated terphenyl liquid crystal materials. On cooling the solution down between glass substrates, lozenge pentacene single crystals up to 200 μm in length can be grown on alignment layers of rubbed polyimide. The molecular uniform alignment in single crystals was confirmed by polarizing microscopic studies of dichroic absorption and anisotropic Raman scattering of pentacene crystals.

Keywords : Pentacene organic semiconductor, Single crystal growth, Liquid crystal solvent, Molecular-alignment control, Dichroic absorption, Polarizing micros-

copy of Raman scattering

Superlattice Formation in Polymeric Thin Films Prepared by Vapor Deposition Polymerization

Atsushi KUBONO

A vapor deposition polymerization (VDP) method has been developed to prepare polymeric thin films, such as high performance polyimide films. Furthermore this method can afford the film specific structure, namely a polymeric superlattice. However, it is difficult to predict the appropriate condition for the regulation of the structure mainly because the formation mechanism has been almost unknown. This review presents several preparation techniques of polymeric thin films and experimental results for polymeric superlattice thin films. In addition, theoretical analyses for the film formation mechanism are discussed briefly.

Keywords : Polymer, Thin film, Vapor deposition, Vapor deposition polymerization, Orientation, superlattice, Quartz crystal microbalance

Fabrication of In-plane Oriented Organic Semiconductor Films on Rubbed Surfaces

Ken ISHIKAWA

Organic molecules are anisotropic in their shape. Reflecting anisotropy of molecules, molecular crystals also show anisotropy in their optical and electrical properties. This anisotropy sometimes causes a reduction of the device performance of organic electronic devices such as organic field-effect transistors (FET). Therefore, the orientational control of molecules is a significant challenge to realize high-performance organic electronic devices. In this article, fabrication of oriented Cu-phthalocyanine films and evaluation of the films by means of X-ray diffraction and AFM are described. As observed in the AFM images, the films are composed of needle-like oriented micro crystals. However, detailed analysis of X-ray diffraction patterns revealed that the needle-like micro crystals were not single crystals; they consist of fragmental crystals that have an average length of 10 nm. FET devices were fabricated using oriented Cu-phthalocyanine films. The mobility parallel to the rubbing direction is twice that in perpendicular direction.

Keywords : Organic field-effect transistors (FET), Cu-phthalocyanine, In-plane orientation