●Basic Stage

(Fiscal Year 2006-2008)

Onoda and Shimonoseki Area

Development of Enhanced Digital Materials with New Hybrid Nanoparticles and Their Application to Energy-Saving Liquid Crystal Displays

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Life Sciences
IT
Environment
Nanotech Materials
Others

Framework for Project Promotion

Project Director……Yuichi Miura (Chairman, Yamaguchi Industrial Promotion Foundation)
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Core Research Organization

Tokyo University of Science, Yamaguchi

Major Participating Research Organizations

Industry…UBE INDUSTRIES, LTD., Ube Material Industries, Ltd., HDT INC., OKAYA Electric Industries Co., Ltd., SHINTEC, INC., SEIKO EPSON CORPORATION, DIC Corporation, Tokuyama Corporation, NanoOpto Laboratories, Inc., CHOSHU INDUSTRY CO., LTD., NISSAN CHEMICAL INDUSTRIES, LTD., Victor Company of Japan, Limited
Academia…Tokyo University of Science, Yamaguchi
Government…Yamaguchi Prefectural Industrial Technology Institute

Aims of Project

This research project is aimed at activating revitalizing and newly initiating regional industries in Yamaguchi prefecture using new technologies developed for creating energy-saving liquid crystal displays and related materials by adopting nanoparticles synthesized in this research project. For this purpose, we are synthesizing “hybrid nanoparticles” that have a stable spatial dispersion in liquid crystals and in their peripheral materials, such as liquid crystal alignment layers, by developing useful ligand molecules that cover each nanoparticle. Through such research using these nanoparticles, LCDs with reduced operating voltage and/or response time, particularly at the low temperature of -20°C, are expected to be realized. These technologies will be applied to the fabrication of the prototypes of field sequential color LCDs and other LCDs with low power consumption.

Contents of Project

1. Syntheses of New Hybrid Nanoparticles and Development of Technology to Disperse Them into Liquid Crystal Media

After observing the properties of the present liquid crystals doped with hybrid nanoparticles, stably dispersed hybrid nanoparticles will be developed by selecting organic protective agents, and then their solubility in practical liquid crystals will be examined.

- Electrooptic properties of liquid crystals doped with metal nanoparticles, which have been judged to be soluble in practical liquid crystals through cooperative research with industries, will be measured.
- Semiconductor nanoparticles including metal oxides, which are soluble in liquid crystals, will be synthesized.
- Organic protective agents that stabilize the dispersion of nanoparticles in practical liquid crystals will be synthesized.
- The operating voltage of ferroelectric liquid crystal devices (FLCDs) will be reduced by constructing polymeric nanostructures in liquid crystals by adding the corresponding monomers.
- The alignment structures of liquid crystal molecules bound with metal nanoparticles will be analyzed.

2. Syntheses of Various Oxide Nanoparticles and Development of Hybridization Technologies to Disperse the Particles into Liquid Crystal Media and Polymer Alignment Films

The hybridization of various oxide nanoparticles, the syntheses of oxide nanoparticles and composite oxide nanoparticles, and the surface modification of the nanoparticles will be examined.

- Various oxide nanoparticles to be dispersed into liquid crystal media will be hybridized and the electrooptic properties of liquid crystal devices doped with these nanoparticles will be evaluated.
- Oxide nanoparticles will be synthesized by the solid phase reaction, the surface properties of nanoparticles will be improved by hydrophobic treatment, and the surface behavior against organic solvents of oxide nanoparticles, prepared by the gas phase reaction, will be analyzed.
- Techniques for improving the surface properties will be developed by evaluating various surface treatment methods of hybridizing oxide nanoparticles and techniques of synthesizing oxide nanoparticles containing TiO_2 of over 40%.

3. Assembly and Evaluation of Nanoparticle-Doped Energy-Saving Liquid Crystal Displays (LCDs)

Enhancement of the performance of LCDs, such as low-voltage operation and fast response, is aimed at through the doping of nanoparticles into host liquid crystal media, and the fabrication and evaluation of prototype LCDs doped with nanoparticles are conducted.

- The conditions necessary for obtaining a stable spatial dispersion of nanoparticles in liquid crystal media and a scientific explanation of the effect of nanoparticles on the performance of LCDs, particularly at a low temperature, will be investigated.
- The mechanisms of the reduction of the response time and/ or operating voltage of various LCDs modes, such as TN, ECB, IPS/FFS, VA and PS-VF-LCDs, will be clarified.

The following prototype LCDs will be fabricated and evaluated and their practical applications examined:
1) 4-inch-diagonal field sequential full-color SVGA (800×600) PSV-FLCD,
2) field sequential full-color narrow gap TN-LCD of 10 cm×10 cm size, and
3) projector displays using VA-LCD and PSV-FLCD.

4. Research on Production Processes for Developing and Realizing Energy-Saving Liquid Crystal Displays (LCDs) Using Nanoparticle Technology

We aim at developing the production processes for energy-saving LCDs by doping nanoparticles into liquid crystal alignment films and by adopting new peripheral material and new printing technology.

- The contrast ratio of LCDs will be enhanced by doping ferroelectric nanoparticles into liquid crystal alignment layers.
- The effect of doping alignment layers with ferroelectric nanoparticles invented in this project at Tokyo University of Science, Yamaguchi, will be clarified.
- Special sealing material for ODF use will be developed.
- Printing technology that is useful for assembling LCDs with nanoparticle-doped alignment layers will be developed.

Main Results

1. Syntheses of New Hybrid Nanoparticles and Development of Their Dispersion Techniques in Liquid Crystal Media

Nanoparticles soluble in practical liquid crystals were successfully synthesized and dispersed into practical liquid crystal media using various organic protective reagents. Liquid crystal cells with a twisted nematic (TN) mode were fabricated with the nanoparticle-doped liquid crystals.The liquid crystal cells thus fabricated have been found to have faster response at low temperature and lower driving voltage than those without dopants.

2. Syntheses of Various Oxide Nanoparticles and Development of Their Hybridization Techniques with Liquid Crystals and Polymeric Membranes

Various oxide nanoparticles were synthesized by a sol-gel method and a gas phase synthesis method. The oxide nanoparticles were hybridized and dispersed in practical liquid crystals. Liquid crystal cells fabricated with the doped liquid crystals were observed to be driven at a lower applied voltage than those without dopant.

3. Assembly and Evaluation of Energy-Saving Liquid Crystal Displays Embedded with Nanoparticles

Metal-nanoparticle-doped nematic liquid crystal displays are shown to have three times faster response speed at –20°C than those without dopant. Oxide-nanoparticle-doped nematic liquid crystal displays (LCDs) exhibit low-voltage operation and fast response speed. Furthermore, the luminance level was increased twofold in the field sequential LCDs with a novel polymer-stabilized V-shaped ferroelectric (PSV-F) liquid crystal.

4. Fabrication Process of Energy-Saving Liquid Crystal Displays Utilizing Nanoparticles

By doping nanoparticles into liquid crystal alignment layers, the increase of the contrast ratio of LCDs and the control of anchoring energy became possible. Furthermore, we developed novel peripheral components to satisfy the needs of the production of LCDs.

Ultrahigh-speed and ultrahigh-resolution liquid crystal display