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(Click on the topic name to jump to the corresponding content)

Displays

Fast Response Liquid Crystal Materials

Background

Vertigo is the major obstacle to the advancement of VR products, with screen motion blur being a primary contributing factor. Increasing the display refreshing rate can effectively reduce the motion blur. Therefore, there is a growing demand for the grey-to-grey response time (GTG) of liquid crystal (LC) materials.

Research Objectives

- The new LC materials need to meet GTG Max $\leqslant$ 3.5 milliseconds while maintaining high transmittance and high contrast ratio

Key Specifications

- GTG Max $\leqslant$ 3.5 ms @1.8μm Cell Gap

Back to Content

BOE

High PPI Optical Film

Background

High PPI displays can enhance the image quality of VR products and suppress the screen-door effect. Fast LCD is advancing towards a PPI (pixels per inch) of 2000+, which requires the development of more advanced optical films such as Black Matrix (BM), Red-Green-Blue Color Filters (RGB CF), Photo Spacer (PS), and Planarization Layers (PLN).

Research Objectives

- Development of high-resolution materials, including BM, RGB CF, PS, and PLN

Key Specifications

- RGB CF: RGB size ⩽ 4μm, RGB taper angle 60~80°, DCI-P3 coverage 90~95%
- PS: Top dimension 2.5μm, the bottom - top size ⩽ 1μm, recovery ratio > 80%
- PLN: Taper angle 60~80°, PLN flatness < 0.1μm

Back to Content

Development of Low Reflective Materials

Background

Low-reflection (LR) display technology can effectively reduce the ambient light reflection of display and greatly improve the image visibility and clarity. Reducing the reflectivity includes using low-reflective materials, in which the LR coating layer on the outermost side of the display plays a major role. Therefore, it is necessary to explore low-cost, high-performance LR technology solutions.

Research Objectives

- Low-cost wet-coating LR solutions
- Low-cost dry LR solutions

Key Specifications

- Achieve LR ⩽ 0.5 on non-antiglare-treated surface @SCI (specular component included)
- Achieve low-cost LR ⩽ 2.0 on AG-treated surface @SCI
- Achieve LR ~ 0.5 on AG-treated surface @SCI
- Meet display optical/reliability requirements, passing friction resistance and hardness requirements

Back to Content

Antibacterial and Antiviral Display

Background

The use of displays for information interaction is widespread and holds great importance in achieving antibacterial capabilities. Antibacterial technologies predominantly applied in the display sector often involve active antibacterial strategies such as metal ions (Ag, Cu, etc.), quaternary ammonium salts, or nano-materials. However, these strategies have limitations such as time-limited antibacterial efficiency, heavy metal toxicity, potential for antibiotic resistance, and nano-material toxicity, making it challenging to achieve antibacterial and antiviral properties simultaneously. Therefore, developing health-oriented displays that are long-lasting, antibacterial, antiviral, free from nano-toxicity, non-leaching, and biocompatible is essential for human health.

Research Objectives

- Antibacterial and antiviral optical films (polarizers, etc.) integrated with antibacterial and antiviral materials and anti-glare surface treatment without affecting the original film performance
- Antibacterial and antiviral cover glass with antibacterial and antiviral materials integrated with AF surface treatment without impacting the original coating performance
- Antibacterial and antiviral injection-molded components (back shells, back plates, etc.) made by mixing antibacterial and antiviral materials with injection molding materials for one-time molding

Key Specifications

- Antibacterial efficiency ⩾ 99.9% @ISO 22196, antiviral efficiency ⩾ 99.9%@ISO 21702
- For antibacterial and antiviral optical films: transmittance ⩾ 90%; hardness 3H; wear resistance against steel wool for 10 cycles; crosshatch test
- For antibacterial and antiviral cover plates: initial water contact angle > 110°; water contact angle > 100° after 2000 cycles of eraser abrasion; hardness 7H
- Antibacterial and antiviral materials mixed with injection molding materials for one-time molding

Back to Content

LCD Natural Polarization Conversion Technology

Background

The widespread use of electronic products in education has created a strong demand to prevent visual fatigue and decreased cognitive efficiency caused by linear polarized light. Circular polarization eye-protection technology, which is based on stretched phase retardation films, has been commercialized. However, the stability of circular polarization conversion rates across different wavelengths is poor. Additionally, circular polarized light is still with polarization, which is different from the natural light, and can only achieve a "quasi-natural" light.

Research Objectives

- Commercializable technology for converting linearly polarized light into unpolarized light
- Systematically evaluate the influence on the subjective image quality and objective parameters of displays

Key Specifications

- The unpolarized light conversion rate (100%-Polarization efficiency (PE), PE is the degree of polarization) in the visible spectrum is more than 90 %
- The brightness loss of the module is less than 5 %, and the thickness is increased by less than 0.1 mm
- Without noticeable color deviation or graininess

Back to Content

BOE

Low-Frequency Materials for LCD LRR and Liquid Crystal Flexoelectricity Simulation Model

Background

Low-power display is a trend in LCD development. Conventional methods to reduce BLU (Backlight Unit) power consumption by increasing transmittance have reached a bottleneck. Low refresh rate (LRR) displays offer a solution by balancing normal display and low power consumption. However, the leakage time of the panel is prolonged when the driving frequency is 1Hz, and the flexoelectric effect of the liquid crystal leads to the deterioration of the flicker level. Therefore, it is necessary to explore low-frequency materials suitable for LRR and establish corresponding flexoelectric models to improve product performance.

Research Objectives

- Develop low-frequency liquid crystal materials
- Analyze and evaluate the factors affecting liquid crystal flexoelectric effects
- Develop high-resistance polyimide materials

Key Specifications

- -60dB max @L127 gray scale; high/low frequency switching (4 times/s)
  -60dB max @L127 gray scale (1~120Hz)
- Influencing factors and evaluation model of flexoelectric effect of liquid crystal

Back to Content

Development of Ultra-Low Dielectric Organic Materials

Background

As the demand for low-power consumption in display products continues to grow, innovative low-power technology solutions must be explored. The organic materials currently used in TFT-LCDs have a high dielectric constant, resulting in large parasitic capacitance. This leads to significant TFT loading and affects the panel's power consumption. Introducing ultra-low dielectric organic materials can significantly reduce the panel's charging rate, achieving lower power consumption.

Research Objectives

- Develop ultra-low dielectric organic materials with key indicators meeting or exceeding industry standards. These indicators include material sensitivity, film residue after development & Oven, CD stability, Mura performance, outgassing amount, and water absorption

Key Specifications

- Ultra-low dielectric organic material with a dielectric constant~2.8

Back to Content

Stability Improvement Mechanism of High Mobility Oxide TFT

Background

Oxide TFTs have advantages such as high mobility, low-temperature and large-area process, and low off-state current. However, as the mobility increases, the balance of mobility and stability becomes an issue. In-depth study of mechanism and solutions for improving stability under high mobility need to be explored.

Research Objectives

- Analyze the conduction mechanism and defect influence mechanism of high mobility oxide TFT
- Propose a solution for improving the stability of oxide TFT

Key Specifications

- Construct a theoretical model of high mobility devices and propose methods to improve the stability of devices

Back to Content

High and Low Refractive Index Optical Materials and Micro-Nano Processing Technology

Background

With the maturity of micro-nano processing technology, optoelectronic devices are developing towards miniaturization and integration. Optical micro-nano processing technology is conducive to improving the optical properties of display devices. Still, it is usually limited by large-area processing accuracy and uniformity and cannot be applied in display manufacturing. Through the optical design of the film layer, high refractive index or low refractive index materials are introduced to improve the light extraction, which can achieve the purpose of low power consumption. However, only a limited selection of materials can meet mass production requirements, and further exploration is needed.

Research Objectives

- Developing high refractive index and low refractive index optical adhesive materials
- Developing mass-producible, large-area, high-precision micro-nano processing technology for fabricating microlens array

Key Specifications

- High refractive index lens: $n \geqslant 1.7$ with the lens diameter of 8~15μm and the height of 4~7μm
- Low refractive index lens: $n \leqslant 1.4$ with the thickness of 5~9μm
- The material can be patterned
- Average transmittance of visible light > 95 %
- Process temperature < 100 °C

Back to Content

High-Precision Cu Patterning

Background

As medium-to-large display products are being upgraded to achieve higher refreshing rates and resolution, more stringent requirements are imposed on metal wiring: low resistance and fine line width. Currently, Cu patterning generally employs wet etching processes, resulting in a large critical dimension (CD) bias, making it unsuitable for fine-line requirements. Therefore, finding a solution to achieve high-precision Cu patterning is necessary.

Research Objectives

- Exploring advanced Cu patterning solutions for display technology (including but not limited to etching)

Key Specifications

- Cu thickness=3000-9000 Å ,CD bias ⩽ ±0.4μm， CD Uniformity ⩽ 8%
- No undercut after barrier layer etching process， 25° ⩽ profile ⩽ 60°
- Line ⩽ 1.7μm±0.4μm， space ⩾ 2.5μm±0.4μm

Back to Content

BOE

Lightweight, High-Strength and High-Modulus Support Plates for Foldable Displays

Background

Current advancements in foldable display technology prioritize achieving a lighter and thinner design while ensuring screen flatness, impact resistance, and compression durability. Conventional support plates for foldable screens are typically stainless steel or titanium alloy. Emerging support materials must strive to reduce density while simultaneously enhancing thermal conductivity and dissipation without compromising structural strength.

Research Objectives

- Lightweight alloys (aluminum/magnesium/lithium alloy) with high-modulus powder composite materials
- Lightweight alloys reinforced with nano-carbon composite materials

Key Specifications

- Thickness: 0.1~0.15 mm
- Density: $\leqslant$ 3 g/cm^3
- Tensile modulus: $\geqslant$ 200 GPa
- Specific modulus (elastic modulus per unit density): $\geqslant$ 66.7×10^6 m^2/s^2
- Flexural modulus: $\geqslant$ 160 GPa
- Thermal conductivity: $\geqslant$ 190 W/m*K
- Electrical conductivity: $\geqslant$ 2000 S/m

Back to Content

High Hardness and Scratch-Resistant Coatings

Background

Surface coatings on foldable products can significantly enhance consumer experience by improving tactile sensation, visual appearance, and cleanliness. On the flexible cover of foldable screens, the coating is in direct contact with the environment, making it prone to abrasion. Current coating materials tend to suffer from damage and scratching after prolonged use, affecting user experience and display quality. To address these issues, coating materials with superior hardness and scratch resistance are needed.

Research Objectives

- Develop new coating materials for foldable devices
- Enhance pencil hardness
- Improve scratch resistance
- Increase elongation at break

Key Specifications

- Coating layer thickness: ⩾ 20µm
- Pencil hardness: ⩾ 7H
- Steel wool wear resistance: ⩾10,000 cycles
- Elongation at break: ⩾ 7%
- Eraser wear resistance: ⩾ 3,000 cycles
- Water contact angle: ⩾ 115°
- Substrate thickness: PET 50µm (with the coating layer on the substrate surface)

Back to Content

Wireless Screen Mirroring

Background

The trend of foldable products is growing in the display industry. However, the size of these products presents challenges in terms of weight and thickness. The module's structure includes a screen, motherboard, and battery, resulting in a thickness typically more than 6 mm and a weight exceeding 400g. This fails to meet the demands for a thin and portable design. The concept of wireless connectivity and wireless charging has been proposed, enabling display products to operate without a motherboard and battery, significantly improving their portability.

Research Objectives

- Develop a display demo with wireless connection and screen mirroring
- Develop integrated wireless charging functionality, achieving long-distance (> 5 m) wireless power supply
- Enable wireless transmission of video signals, utilizing only a receiving chip at the receiving end to achieve the lowest power consumption and the best portability

Key Specifications

- Enable wireless charging functionality (without battery), Power > 30W
- Achieve long-distance (> 5 m) wireless power supply with transmission power loss < 1 W
- Enable wireless screen mirroring functionality, connection rate > 10.4 Gbps
- Data transmission latency < 10 ms
- Distance between transmitter and receiver > 5 m
- Device thickness < 4 mm， weight < 300 g

Back to Content

In-Cell Camera Integration

Background

Mobile display products are developing towards multi-functional integration. To ensure better camera effects, the camera modules and telephoto lenses require better performance. However, the components become relatively thick, far exceeding the thickness of OLED display modules, which limits the development of OLED display products in terms of being thinner and lighter as well as having diverse forms to a certain extent. It is necessary to develop a display technology that can integrate camera functions into the screen, replacing the current structure and showcasing the advantages of OLED such as being flexible and thin.

Research Objectives

- Develop a solution for an in-cell camera and conduct feasibility assessments
- Develop an in-cell camera display prototype
- Implement the photo-taking function with the in-cell camera

Key Specifications

- Realize the in-cell integrated camera function
- Field of view up to 80°
- Thickness < 1 mm

Back to Content

Anti-Reflective Encapsulation Film for LED Screens

Background

LED screens have high requirements for black uniformity. High-consistency, low-reflectivity surface treatments can enhance black uniformity and achieve lower black levels. Currently, low-reflectivity AR (anti-reflective) surface treatments (reflectivity < 1%) in the industry exhibit noticeable color differences between different positions in transverse direction and machine direction. When applied to LED screens, this results in color differences between modules. Therefore, it is necessary to develop solutions to address the color inconsistency issues of AR film materials.

Research Objectives

- High haze AR surface treatment
- Low-reflectivity AR with surface reflectivity < 1%
- Control color differences between films at the same viewing angle and color differences at different angles on the same film
- Meet the reliability requirements of direct-view products, as well as high hardness, abrasion resistance, and anti-fingerprint properties

Key Specifications

- Surface treatment haze > 50%
- Low-reflectivity AR with surface reflectivity < 1%
- Color difference between films at the same viewing angle: $\Delta a < 0.3$, $\Delta b < 0.5$
- Color difference at different angles on the same film: $\Delta a < 4$, $\Delta b < 6$

Back to Content

IoT Innovation

High-Precision Spatial Positioning Technology for Remote Control Systems In Display Terminals

Background

Human-computer interaction have been continuously evolving. The traditional remote control has undergone a revolutionary upgrade with the introduction of precise pointing interaction. This approach accurately locates the remote's pointing position on the screen, enabling accurate and convenient control of on-screen menus, thereby enhancing the intelligence of the interaction process. Although some smart display terminals have adopted this technology, challenges remain in terms of positioning accuracy and latency. The user experience and objective performance specifications still fall short of the goals for natural and smooth interaction.

Research Objectives

Develop high-precision spatial positioning technology for remote control systems to achieve accurate control of the screen and smooth interaction. The main objectives include:

- UWB (Ultra Wide Band) ranging, angle measurement and positioning technology
- UWB + IMU (Inertial Measurement Unit) fusion algorithm for positioning and attitude calculation
- UWB antenna array miniaturization technology

Key Specifications

- UWB measurement: horizontal angle range: ±60°, vertical angle range: ±45°, with an angle error < 2°
- System latency ⩽ 50ms
- Operating distance ⩾ 10m

Back to Content

Sensors

Research on the Advantages of High-Density Interconnection Glass Substrate

Background

Compared to organic materials, glass has advantages in terms of thermal expansion coefficient, Young's modulus, surface flatness, via diameter, and density, which help improve the performance of glass substrates, such as reducing warpage, reducing packaging size, and increasing die area ratio. However, there is a lack of systematic quantitative performance analysis of glass substrates in the industry. This study aims to comprehensively analyze the structural, electrical, warpage, and thermal performance of glass substrates, comparing them with organic substrates and quantifying the differences to provide data support for optimizing glass substrate design.

Research Objectives

- Analysis of the performance advantages of glass substrates
- Development of new structures for glass substrates

Key Specifications

- Quantify the benefits in terms of size, layers, warpage, electrical, and thermal aspects of the substrate by designing and simulating glass substrates
- Develop a design scheme for a glass hybrid substrate with a 20% reduction in layers and a difference < 10% in electrical performance compared to the existing scheme

Back to Content

Thermal and Mechanical Modeling and Analysis of Glass Package Substrate

Background

Compared to silicon, glass has good insulation properties and is suitable for large-area fabrication, making it a promising choice for future advanced packaging technologies at the panel level. During the TGV (Through-Glass Via) and subsequent RDL (Redistribution Layer) fabricating process, issues such as radial and circumferential cracks in TGV, panel warpage, and poor adhesion between Cu and glass due to the mismatch of CTE (Coefficient of Thermal Expansion) can significantly affect device performance and reliability. The improvement mechanism for the aforementioned issues still remains unclear. Additionally, the low surface roughness of glass materials leads to weak adhesion to the seed layer, resulting in peeling. This research topic aims to develop a simulation model compatible with the characteristics of glass substrates to enhance the accuracy and efficiency of simulation

Research Objectives

- Study of TGV cracking mechanisms
- Simulation study of glass substrate warping
- Simulation study of interfacial adhesion strength

Key Specifications

- Identify the main stress risk points in the TGV structure and provide a crack elimination solution for TGVs under high temperatures
- Provide a warping (height difference between the center and edges) control scheme that matches the process, with panel-level warpage < 3 mm
- Provide a solution to enhance adhesion strength, meeting the requirement of adhesion strength > 5 N/cm
- Model and verification difference < 10%

Back to Content

Panel-Level High Aspect Ratio Through-Glass Via (TGV) Process

Background

In glass-substrate package technology, the adhesion strength of PVD (Physical Vapor Deposition) or chemical plating seed layers on the glass surface is relatively weak. Although increasing the substrate roughness can enhance the adhesion strength, it reduces the substrate strength. During the electroplating process, Filled electroplating is prone to bulging at high temperatures, leading to lap joint failure, while conformal electroplating cannot meet the requirement of vertically stacked holes above the TGV. Meanwhile, the bonding strength between glass and organic materials is also weak, which can easily lead to delamination and damage during the cutting process. This topic aims to explore the enhancement of interfacial bonding strength, conformal electroplating hole-filling technology, and glass substrate-cutting technology to achieve performance improvement in glass packaging substrates.

Research Objectives

- Development of glass-metal adhesion layer materials
- Development of conformal electroplating hole-filling and grinding technology
- Development of TGV substrate cutting technology

Key Specifications

- Verification of glass + organic material cutting solution completed, with a cutting thickness ⩾ 1.1 mm, and no peeling of the film layer and no damage to the glass after cutting
- Development of panel-level conformal electroplating resin hole-filling technology completed, meeting the requirement of hole diameter < 30 μm and stacked hole layers ⩾ 3 layers
- Completion of metal-glass adhesion strength enhancement development, with an interfacial bonding strength ⩾ 5 N/cm

Back to Content

Establishment and Development of Mechanical Waveform Library

Background

On rigid substrates, the achievable mechanical wave vibration modes need to be continuously enriched, and the driving signals and vibration modes can be designed.

Research Objectives

Based on rigid substrates, the following content should be developed:

- Design and development of a mechanical waveform library
- Construction of a closed-loop feedback control system

Key Specifications

- Number of mechanical waveforms: ⩾ 30
- Distinguishable waveforms types: ⩾ 15
- Frequency range: 150Hz~250kHz
- Half wavelength of some high-frequency modes: 2~5 mm

Back to Content