

BOE Technology Source Open Research Program

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Advanced Display

High/Low Dielectric Materials Suitable for Liquid Crystal Display Array Substrates

Background

The successive iterations in transmittance and resolution of LCD products pose new requirements for TFT pixel design. The dielectric properties of the insulating layer directly affect the design of the pixels. For large-sized high-transmission products, low dielectric insulating materials are needed, while for ultra-high-resolution products, high dielectric insulating materials are required. Additionally, the current TFT-LCD production equipment mainly consists of low-density-thin-film deposition equipment such as PECVD and Sputter, and the insulating layer materials mainly include SiN, SiO, PFA, etc. These materials cannot simultaneously meet the requirements of dielectric properties, film thickness, and process performance.

Research Objectives

- Exploring high- and low-dielectric materials suitable for liquid crystal display array substrates.

Key Specifications

- **Low Permittivity Materials:**
Type 1: Slit Coating process, Permittivity ≤ 3.0 , dry film thickness 2000 ~ 6000Å, low leveling property;
Type 2: PECVD process with gaseous precursors, Permittivity ≤ 3.0 , film thickness 2000 ~ 6000Å;
- **High Permittivity Materials:**
Sputtering/PECVD process, Permittivity ≥ 15 , visible light transmittance $\geq 98\%$, film thickness 600-1000 Å, film thickness uniformity within 10%.

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Development of High- and Low-Refractive-Index Materials

Background

The display panel industry maintains a sustained demand for luminance enhancement. Conventional approaches to improving panel transmittance offer only limited gains. Consequently, the development of MLA technology can be employed to increase light extraction efficiency, which necessitates the use of high- and low-refractive-index materials to modulate the propagation direction of light. However, the materials currently compatible with existing production line processes are unable to satisfy the required refractive index specifications.

Research Objectives

- The development of novel high- and low-refractive-index materials is intended to enhance the light extraction efficiency of the MLA, while remaining compatible with existing production line processes.

Key Specifications

High refractive index material development targets:

- Refractive index $n > 1.7@550\text{nm}$;
- Resolution $< 20\mu\text{m}$;
- Transmittance $> 95\%@10\mu\text{m film thickness@visible light}$;
- Heat resistance temperature $> 230^\circ\text{C} * 1\text{H}$;
- Material viscosity $< 10\text{cp}$;

Low refractive index material development targets:

- Refractive index $n < 1.5 @550\text{nm}$;
- Transmittance $> 95\%@18\mu\text{m film thickness@visible light}$;
- Heat resistance temperature $> 230^\circ\text{C} * 1\text{H}$;
- Viscosity $< 10\text{cp}$;
- Solvent resistance to PGMEA and NMP.

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Improved Privacy Display Effect

Background

With the continuous evolution of privacy display technology, user requirements for privacy image quality such as viewing angle, brightness, and power consumption are becoming increasingly stringent. It is necessary to upgrade privacy technology from the dimensions of LCD device design, liquid crystal materials, optical film layers, circuit driving schemes, etc., to bring consumers a more satisfying experience.

At present, the privacy LCD mainly adopts a dual-panel structure. Among them, the privacy Panel only has the function of collecting light from one direction (6%→0.5%) or expanding light (0.4%→8%), showing limited functionalities.

Research Objectives

- Enhance the light collecting function of the liquid crystal layer, including but not limited to increasing the horizontal anti peeping angle, improving the sharing/anti-peeping ratio, four-way anti-peeping, and other functions;
- Option 1: The privacy Panel has a four-way light collection function. Option 2: The privacy Panel has a four-way light amplification function. Option 3: The privacy Panel has both the functions of receiving and expanding.

Key Specifications

- Option 1 and 2 achieve four-sided privacy and share switch ability, while Option 3 realizes two-sided switch ability;
- Four-sided privacy specifications (45°/ forward viewing Angle brightness): privacy state $\leq 0.4\%$, share state $\geq 8\%$ @L&R, 2-3%@U&D;
- Two-sided privacy specifications (45°/ forward viewing Angle brightness): privacy state $\leq 0.4\%$, share state $\geq 8\%$;
- From anti-peeping state to shared state, the brightness decrease is $\leq 40\%$.

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Single-layer Photo-Controlled Cholesteric Liquid Crystal Full-Color Reflective Display Technology

Background

With the gradual deployment of low-power reflective display technology in scenarios such as electronic shelf labels, portable displays and outdoor signage, market demand for low-cost, thin-form-factor, full-color reflective display solutions keeps growing. Current mainstream cholesteric liquid crystal full-color solutions adopt multi-layer stacking structures, which are plagued by complicated manufacturing processes, high costs and low yields. Accordingly, it is necessary to develop single-layer photo-controlled cholesteric liquid crystal materials and full-color display technology to break through existing performance bottlenecks.

Research Objectives

- Develop cholesteric liquid crystal materials adapted for UV-light-tunable central reflection wavelength;
- Develop and verify the technical route of single-layer photo-controlled cholesteric liquid crystal full-color reflective display;
- Establish a photo-electric co-driving control scheme, and complete color gamut optimization and white-balance calibration.

Key Specifications

- Central reflection wavelengths of R/G/B: $R \approx 650 \pm 10 \text{nm}$, $G \approx 550 \pm 10 \text{nm}$, $B \approx 450 \pm 10 \text{nm}$;
- Single-wavelength reflectivity of R/G/B $> 50\%$, contrast ratio $> 30:1$.

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Development of Novel Photoresist and Stripper Materials

Background

The demand for high-resolution products is increasing, and the requirements for display manufacturing processes are becoming increasingly stringent. As core materials in the manufacturing process, photoresist and stripping solution, especially those with mass production lines, have become a strong demand that urgently needs to be addressed.

Research Objectives

- Novel photoresist materials and stripper materials.

Key Specifications

- Vacuum Evaporation-Type Photoresist: Film formation under vacuum; evaporation temperature $< 400^{\circ}\text{C}$; patterning under vacuum; etch resistance (etching rate $< 30\text{ nm/min}$); easy to strip; no residue;
- Wet-Type Photoresist and Etchant: Film formation under N_2 or vacuum; baking temperature $< 120^{\circ}\text{C}$; etch resistance under N_2 or vacuum; etching rate $< 30\text{ nm/min}$ (patterning conditions); and the required etchant must not affect other film layers..

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Metamerism Research for High-Color-Gamut Display Devices

Background

With the industrialization of new display technologies including Mini-LED, Quantum Dot, OLED and KSF-LED, the conventional CIE1931 color-matching functions can no longer fully satisfy evaluation requirements for state-of-the-art high-end displays. Even for displays with identical calibration parameters, significant chromatic differences can still be perceived by human eyes. Comprehensive in-depth evaluation shall be carried out on evaluation systems such as CIE1931, CIE1964 and CIE170-2. This project investigates CMF (Color-Matching-Function) evaluation logic adapted to new-generation high-end displays, systematically mitigates cross-device color deviation, and establishes unified measurement and calibration standards for smartphones, monitors, projectors and other equipment.

Research Objectives

- Bridge human vision and color science (covering human-eye physiology, fundamental CMF, standard observers), together with imaging technologies (display panels, scanning, photography, etc.). Special research on new-standard CMF to resolve the existing issue: good color accuracy measured by instruments yet unsatisfactory visual perception.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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OLED Image-Quality Enhancement under High-Ambient-Brightness Conditions

Background

When operated under bright outdoor conditions, electronic displays suffer from excessive reflectance and degraded image clarity. Existing anti-reflection solutions for OLED panels include AR coatings, anti-reflection films, anti-reflection polarizers and transmittance-boosting structures. Nevertheless, these approaches suffer from high cost and cannot guarantee clear visual performance under extreme harsh environments. Therefore, novel technical approaches are expected, such as active-control solutions represented by electrochromism with display-enhancing functions, to improve display image quality or enable additional display functions under high-brightness ambient light.

Research Objectives

- Propose technical solutions to achieve clear display under high-brightness ambient light (excluding the existing solutions mentioned in the background section).

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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Development of Hard Coating Materials

Background

Currently, the surface coating materials on foldable display covers are susceptible to damage, scratches, and indentation marks after prolonged use. To further improve the user experience and display quality, it is necessary to explore coating material solutions with higher hardness that also maintain flexibility.

Research Objectives

- High-hardness HC materials for foldable displays.

Key Specifications

- Pencil hardness $\geq 7H$;
- Compressive modulus: 5 GPa;
- Compressive hardness: 1 GPa;
- Other properties, including steel wool test, elongation at break, water contact angle, and folding test, shall be consistent with current industry levels.

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Ultra-High Mobility Backplane for Advanced Display Product

Background

Due to the the core issue of high power consumption in advanced display products, its market adoption is relatively slow. At present, the power consumption of the TFT driver backplane accounts for more than 40%. Therefore, developing a driver backplane with higher mobility can significantly reduce the power consumption.

Research Objectives

- Developing TFT backplanes with higher mobility for advanced display products.

Key Specifications

- PMOS Mobility: $> 200\text{cm}^2/(\text{V}\cdot\text{S})$;
- $I_{\text{off}} < 10^{-12}\text{A}$;
- NBTS 1H $|V_{\text{th}}| < 0.02\text{V}$;
- Adaptation to the process equipment of the display pilot line.

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Research on Direct Laser Mass Transfer Process for High-PPI Micro LED on G2.5-Generation Substrates

Background

Micro LED is widely regarded as the next-generation display technology; however, mass transfer remains a critical bottleneck impeding its industrialization. Direct laser transfer technology has attracted considerable attention due to its advantages of low cost, high pass yield, non-contact processing and high selectivity, enabling chip transfer onto large-area substrates such as the G2.5 generation (370mm × 470mm). As chip dimensions continue to scale down to < 20μm and pixel density exceeds 300 PPI, increasingly stringent demands are imposed on transfer precision, temporary adhesive materials, and process control. These challenges constitute key scientific and engineering issues that remain to be addressed in the field.

Research Objectives

- Establishment of a direct laser transfer process system on a G2.5-generation (or larger size) glass substrate platform to enable efficient transfer of Micro LED chips from sapphire substrates to driving backplanes;
- Optimization of the dynamic mechanical matching conditions between the chip and the substrate during transfer by tailoring the viscoelastic properties of the temporary adhesive material—including modulus and glass transition temperature—thereby achieving precise positioning and temporary fixation of high-density chips.

Key Specifications

- Substrate compatibility: ≥ G2.5 generation (370mm × 470mm), chip size: < 20μm, pixel density: > 300 PPI;
- Transfer placement accuracy: ≤ ±2μm, RGB transfer yield: > 99.9%, lighting yield: > 99%;
- Transfer throughput: ≥ 5 million chips/hour;
- Adhesive layer: bubble- and particle-free, with thickness uniformity ≤ ±10% across the effective area.

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Development of Long-Lifetime Blue QLED

Background

QLEDs (Quantum Dot Light-Emitting Diodes) have attracted widespread attention in both academia and industry due to their high color gamut, stability, and tunable emission spectra. Currently, the lifetime of blue QLEDs is one of the key challenges for the industrial application of AM-QLED displays. It is urgent to explore technical solutions to improve blue QLED lifetime from the perspectives of device degradation mechanisms, materials, and device structures.

Research Objectives

- Investigate the degradation mechanisms of blue QLED devices;
- Develop high-efficiency, stable blue quantum dots (QDs) and transport layer materials;
- Develop long-lifetime blue QLED device structures.

Key Specifications

- EQE $\geq 20\%$;
- LT95@1000nits $\geq 400\text{h}$;
- Wavelength: 450 ~ 470nm.

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3D Content Generation Technology

Background

The demand for 3D display terminals is expanding rapidly, yet the scarcity of native 3D content hinders its implementation in the industry. Leveraging lightweight real-time 2D-to-3D conversion, we can revitalize existing 2D resources, introduce new native stereoscopic materials, and achieve real-time stereoscopic image generation across all scenarios, fully adapting to various spatial stereoscopic devices such as glasses-free 3D and GPR (Glass Pattern Retarder).

Research Objectives

- A lightweight solution for real-time conversion of 2D content to 3D, compatible with Windows and Android platforms.

Key Specifications

- The targeted effect should be free of ghosting, streak artifacts, distortion, stutter, with accurate depth estimation, natural compensation and natural picture level;
- 2D-to-3D content conversion: Windows (dedicated/integrated GPU, NPU): > 4K/40fps; Android (Qualcomm, MediaTek): > 3K/30fps.

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Enhance GPR Field of View

Background

There is strong market demand for GPR (Glass Pattern Retarder) 3D displays, especially in applications like healthcare, gaming, and home entertainment. However, GPR technology does have a notable viewing angle limitation—the crosstalk at wider angles can significantly compromise both the visual performance and the overall user experience, and there is an urgent need to address the viewing angle problem.

Research Objectives

- Crosstalk&viewing angle compensation film: Compensates for the variation of GPR retardation across different viewing angles, ensuring that the spectroscopic retardation of the GPR combined with the compensation film remains comparable to that at 0° within a horizontal viewing angle range of -80° to 80° ;
- Development of light-uniforming/diffusion functional films: achieving viewing angle expansion above or below the GPR to significantly boost its vertical viewing angle from $\pm 8.5^\circ$ (Crosstalk $\leq 7\%$) to $\pm 70^\circ$ (Crosstalk $\leq 7\%$), without compromising the 2D display quality.

Key Specifications

- Horizontal 3D viewing angle $\geq \pm 80^\circ$ (Crosstalk $\leq 1\%$);
- Vertical 3D viewing angle $\geq \pm 30^\circ \sim \pm 70^\circ$ (Crosstalk $\leq 7\%$).

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Multi-Person Viewing of Wide-Angle High-Resolution Naked-Eye 3D Technology

Background

With the increasing popularity of naked-eye 3D technology in applications such as laptops and monitors, the market demand for multiple people to watch naked-eye 3D simultaneously is growing rapidly. Therefore, it is necessary to develop a high-resolution autostereoscopic 3D technology with a wide viewing angle ($\pm 70^\circ$) for multiple viewers to overcome existing performance bottlenecks.

Research Objectives

- Develop a high-resolution image interleaving algorithm for multi person viewing with a large viewing angle ($\pm 70^\circ$) that is compatible with switchable/non-switchable 3D optical lens array schemes;
- Explore an optical design scheme for wide-angle vision without eyes that is capable of mass production.

Key Specifications

Algorithm development indicators:

- With a movement within $\pm 70^\circ$, there is no sense of disconnection or ghosting;
- Display both 2D and 3D content simultaneously, with multiple viewpoints and high resolution;

Optical scheme indicators:

- Meet the specifications of a viewing angle of $\pm 70^\circ$ and 3D crosstalk of less than 1.8%, and specify the machining precision required for the optical design scheme.

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Healthy Display Technology

Background

Displays are now ubiquitous in daily life, and the resulting visual and non-visual health hazards have grown increasingly prominent, making healthy display a major research hotspot and a strong market demand. Humans have evolved over a long period of time to adapt to natural light, which has the following characteristics: 1. Randomly distributed vibration directions with uniform vibration intensity in all directions; 2. A continuous and evenly distributed spectrum with low blue light and rich red light, wide spectral coverage, high color rendering index, and dynamically changing spectra that conform to natural rhythms; 3. Exists in forms of diffusion, scattering and reflection, delivering uniform and soft light that avoids glare and intense light stimulation; 4. Continuously stable light intensity output with an extremely low fluctuation frequency (far beyond the perception range of the human eye), and adaptive brightness adjustment according to environment, seasons, day and night cycles. Based on years of deep cultivation in the field of eye protection technology, BOE has integrated multiple eye protection technologies including depolarization, low blue light, circadian rhythm, beneficial red light, infrared light, anti-glare, low reflection, flicker free, and light self-adaptive to develop the Beneficial Natural Light Technology (BNL), and further explores healthy display related technologies in multiple dimensions.

Research Objectives

Explore technologies related to healthy displays covering mainstream display research directions, including but not limited to:

- Specification upgrades for BOE's BNL Technology;
- Proposal of new healthy display technologies that can be further integrated into the BNL Technology;
- Other healthy display technologies beyond natural light-based solutions.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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Low-Carbon Display Technology

Background

Low-carbon display has become a research hotspot and market demand, covering all aspects including low-carbon design, low-carbon materials, low-carbon manufacturing and low-carbon standards. BOE has been continuously cultivating the following carbon reduction pathways in the field of low-carbon display: 1. Environment-friendly (fluorine-free materials, bio-based materials, degradable materials); 2. Circular economy (recyclable materials, waste recycling, packaging recycling); 3. Energy conservation and emission reduction (low-power technology, low-volatile materials, low-temperature manufacturing processes, minimalist manufacturing processes). Based on years of in-depth exploration in the field of low-carbon technologies, BOE has established relevant product standards for low-carbon display devices, and further explored low-carbon display-related technologies across multiple dimensions.

Research Objectives

- Explore low-carbon display technologies, covering mainstream display technology directions.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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Optoelectronic Innovation

Development and Application of Micro LED Optical Interconnection Technology

Background

Driven by the rapid growth in computing demand, AI compute clusters impose higher requirements for data transmission rate, power consumption and bandwidth density. Traditional copper-cable solution faces severe challenges of the power wall and speed wall. Micro LED optical interconnects adopt a wide-and-slow technical approach to overcome the limitations of the power consumption wall and speed wall. While meeting the required transmission rate, this technology drastically cuts power consumption and boosts bandwidth density, emerging as a next-generation optical interconnect solution.

Research Objectives

- High-efficiency Micro LED optical interconnect system and link solution;
- High-sensitivity PD and high-speed high-gain circuit design solution;
- Innovative applications of Micro LED optical interconnects.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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Development of Optical Interconnection Technology Based on Glass Substrate

Background

The explosive growth in AI computing power demand has led to bandwidth and power consumption bottlenecks in traditional copper interconnects. Optical interconnection technology based on glass substrates, which co-packages photonic and electrical chips, can significantly shorten interconnection distances and reduce power consumption. However, glass-based optical interconnection technology still has some way to go before large-scale commercialization. The core bottleneck lies in the optical coupling from optical fiber to chip—the PIC waveguides and the optical fiber cores differ in size by tens of times, making alignment extremely difficult.

Research Objectives

- Low-loss glass substrate process solution;
- Optical interconnection system integration based on glass substrate;
- Multi-physics simulation of optical interconnection system based on glass substrate.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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Key Technology for High-Reliability Glass Packaging Substrates

Background

High-performance computing chips demand multilayer vertical stacked vias, high-density interconnects, and low-impedance transmission in packaging substrates. Conventional conformal plating cannot meet stacked via requirements, and no effective void-free filling process exists for 10:1 aspect-ratio through-glass vias (TGV). Meanwhile, glass substrates face warpage and stress concentration under multi-material assembly and thermal cycling, requiring systematic long-term service reliability evaluation.

Research Objectives

- Develop a board-level void-free plating process and produce fully filled substrates;
- Provide solid via filling solutions meeting void specifications;
- Reveal the mechanisms by which structural parameters affect overall warpage, stress redistribution, and interfacial failure risk;
- Evaluate structural reliability performance under typical thermal loads such as MR/TCT.

Key Specifications

Board-level TGV Void-free Filling:

- Substrate dimension: 510mm × 515mm, glass thickness: 0.7 ~ 1.1mm;
- Void-free filling at aspect ratio (AR) 10:1, void volume fraction < 5%;

System-level Reliability Simulation:

- Establish TCT failure-evolution analysis model; keep the cyclic-life deviation between simulation and experimental results within a reasonable range;
- Output simulation-guided documents covering overall structure warpage, stress distribution and failure-risk analysis;
- Deliver failure-mechanism analysis report together and provide optimization suggestions.

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Development of High-Performance Light-Control Technology

Background

Smart windows achieve electrically controlled light-dark switching via dichroic dye-doped liquid crystals and have been deployed in automotive windows and architectural daylighting roofs. Currently, architectural applications and certain passenger-vehicle windows call for a high bright-state transmittance ($>70\%$), while the dark-state transmittance can only reach roughly $40\% \sim 50\%$, leading to a narrow optical dimming range between bright and dark modes. For rear side windows of passenger vehicles that prioritize privacy and high contrast, further lowering dark-state transmittance while preserving bright-state transmittance unchanged remains a long-standing technical challenge. Furthermore, both automotive and architectural applications involve long-term solar exposure, requiring the materials to be insensitive to ultraviolet, visible-light and infrared spectral bands.

Research Objectives

- Liquid crystal materials: development of high-dichroic-ratio dyes;
- Non-liquid-crystal materials: development of highly durable materials with a wide light-modulation range.

Key Specifications

- Dimming range: wide dimming range of $10\% \sim 75\%$ or high-contrast performance of $0.3\% \sim 16\%$ (the bright-state transmittance should be as high as possible);
- Solar-resistant performance requirement: xenon-lamp aging test for 4500h, with $\Delta E_{ab} < 2$;
- Driving voltage: $\leq 12V$.

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Thermal Management Solutions for Smart Dimming Technology

Background

BOE smart windows employing dichroic dye-doped liquid crystals (DDLCs) for electrically controlled light modulation have been widely applied in automotive windows, architectural daylighting, and other fields. Currently, DDLCs demonstrate excellent modulation capabilities for visible light; however, their effectiveness in infrared modulation and thermal management remains limited. Therefore, it is necessary to explore relevant thermal management solutions.

Research Objectives

- Develop thermal-management solutions compatible with dye-doped liquid-crystal dimming technology, which impose little impact on the visible-light modulation performance of dye-doped liquid crystals or deliver favorable neutral-color modulation for visible light. Technical approaches include high near-infrared reflectivity or effective infrared regulation, high emissivity in the atmospheric transparency window, or other wavelength-selective modulation strategies.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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Development of Smart Controller for 4T Perovskite-Crystalline Silicon Tandem Photovoltaic Modules

Background

At present, there are two major engineering challenges in the application of 4T perovskite-crystalline silicon tandem modules: First, the operating voltages and currents of the top perovskite cell and the bottom crystalline silicon cell are significantly different, and direct parallel/series connection cause severe power loss; the maximum power point dynamic shift caused by the discrete differences between the modules and temperature inhomogeneity will also significantly reduce the power generation of the modules. The smart controller for the 4T tandem module is the best scalable DC-side solution for 4T tandem currently.

Research Objectives

- This project conducts a full-chain research around voltage regulation MPPT + direct parallel type smart controller. It aims to solve the problem of severe power loss caused by direct parallel/series connection due to the large voltage/current difference between perovskite and crystalline silicon solar cells, as well as the reduction in power generation caused by the dynamic shift of the maximum power point due to discrete differences between components and uneven temperature.

Key Specifications

- Power generation efficiency index: Compared with the scheme of directly connecting inverters without smart controller components in series, the annual power generation of the system is increased by $\geq 3\%$ (when the power difference between stacked modules is $\geq 5\%$);
- Eliminating interlayer circulation and reverse bias losses, first-year outdoor degradation-rate of perovskite cells is improved by $\geq 10\%$;
- MPPT tracking efficiency $\geq 99.5\%$, full operating condition conversion efficiency of boost/buck circuit $\geq 96\%$;
- Study the improvement effect of smart controllers on the power generation of tandem modules under different shading conditions;
- Reliability and safety: 1) Operating temperature of the controller: $-40^{\circ}\text{C} \sim +85^{\circ}\text{C}$, IP68 outdoor protection, meeting a design life of 25 years; 2) Equipped with five levels of protection including overvoltage, overcurrent, short circuit, reverse connection, and over temperature; 3) Single branch fault only reduces power in this branch, and the whole machine fault can be bypassed; 4) Passing a full photovoltaic reliability tests including damp heat, thermal shock, UV aging, and salt spray.

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Electrochemical Behavior of Perovskite Photovoltaics Under Photo-Thermal Aging

Background

Perovskite solar cells have achieved remarkable advances in power conversion efficiency; however, long-term operational stability remains a critical impediment to their commercialization process. Consequently, conducting systematic aging and accelerated-aging studies under 85 °C MPPT conditions is of paramount importance for advancing perovskite photovoltaics toward industrial scale-up.

The current challenge is that, under the coupled thermal, optical, and electrical stresses encountered during operation, ion migration drives progressive device degradation. There is an urgent need to elucidate the failure mechanisms arising from ion-migration behavior across these multifactorial stress conditions and to establish the corresponding characterization methodologies, thereby forming an integrated closed-loop framework that bridges the visualization of failure mechanisms with targeted improvement strategies.

Research Objectives

- Series aging tests at 85°C MPPT → Electric field analysis → Ion migration behavior → Multi-dimensional characterization framework → Targeted improvement strategies;
- Targeted improvement strategies: building upon the above mechanistic insights, concrete improvement strategies will be proposed from the perspectives of material engineering and interface engineering, among others.

Key Specifications

Normal 85°C MPPT:

- Glovebox-processed cells: 10mm x 10mm→27%, T95 ≥ 2000h;
- Pilot line modules: 300mm x 300mm→25%, T95 ≥ 1000h.

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Forward-Looking Exploration

Stretchable Display Materials and Design Solutions

Background

Stretchable displays possess free-form deformation capability, enabling conformal attachment to arbitrary shapes while delivering true 3D physical display effects. This represents a key direction in the evolution of next-generation human-machine interfaces. Current stretchable display technology has achieved 200 PPI resolution and 30% stretch ratio, yet its limited mechanical robustness results in insufficient stretch cycle life, necessitating further improvement for practical applications.

Research Objectives

- Propose new stretchable materials or design schemes with mechanical robustness for stretchable displays with PPI ≥ 200 and stretch ratio $\geq 30\%$.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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Exploration of Metasurface Applications

Background

The metasurface is a two-dimensional artificial electromagnetic functional surface with a thickness smaller than the operating wavelength. It can modulate the phase, amplitude, and polarization state of incident light, enabling effects such as beam convergence/divergence, collimation, polarization conversion, and amplitude modulation. Its operating spectral range covers ultraviolet, visible light, infrared, terahertz, and microwave bands.

Compared with conventional optical components, such as lenses, prisms, and polarizers, metasurfaces offer advantages including ultrathin and lightweight form factors, planar integrability, and dynamically reconfigurable optical functions.

Research Objectives

- Exploration of material selection, structural design, and manufacturing processes for high-performance metasurface devices;
- Metasurface solutions for performance improvement and compact integration targeting visible, infrared, and microwave bands.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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Exploration of Innovative TFT Applications

Background

Glass/PI-based TFTs possess advantages such as low cost, low-temperature large-area fabrication, flexible fabrication, and high-density integration, and have been widely applied in fields including display, high-precision sensing, X-ray detection, and microfluidics. Meanwhile, TFTs are continuously expanding into new application directions such as neural network computing and sensing-computing convergence. In the future, with the development and technological transformation in various fields (memory, artificial intelligence, communications, robotics, quantum computing, healthcare, ...), TFTs are expected to enable a growing range of innovative applications.

Research Objectives

- Exploration of TFT in-memory computing technologies including multi-modal signal sensing, array architecture design, and in-memory computing modeling, targeting application scenarios, such as robotic tactile sensing and analog in-memory computing chips.

Key Specifications

- This project is an innovative idea call, and the key specifications shall be established according to discussions on the submitted proposals.

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LC-Based Non-Display Dimming Applications

Background

Liquid crystal (LC) technology is rapidly expanding from display applications into the non-display dimming applications.

The eND filter has achieved the pioneering application of dye-doped liquid crystal technology in UAV sector. However, UAV applications impose extremely stringent optical requirements—including color shift, vignetting, and glare—requiring upgrades across multiple dimensions such as liquid crystal materials, display modes, optical films, and device design.

In the wearable dimming market, smart glasses equipped with dimming functionality offer enhanced fashionability and practicality—a demand that has been expressed by multiple customers. However, current challenges include warpage of the CPI material and an excessively large R_{th} value.

Research Objectives

- **eND Filter:** Develop novel dye-doped liquid crystal and display-mode optical metrics (color shift and vignetting);
- **Flexible CPI materials:** Complete the development and resolve major defects, including warpage, excessive R_{th} , and IC bonding cracks.

Key Specifications

- **eND Filter:** Color shift: $\Delta E_{ab} < 8$ (or color temperature shift between the highest and lowest settings $< 200K$). Vignetting: For Θ (0–45°) and Φ (0–360°), the ratio of illuminance EV at $\Theta = 45^\circ$ to that at $\Theta = 0^\circ$ shall be ≤ 3 , with no significant luminance or color difference at wide viewing angles;
- **Flexible CPI materials:** Trans $\geq 90\%$, $T_g \geq 400^\circ C$, $YI \leq 2$, CTE $\leq 10\text{ppm}/^\circ C$, $R_{th} < 10\text{nm}$, Young's modulus $\geq 8\text{GPa}$.

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Broadband Noise Analysis and Suppression for High-Speed Jets

Background

Jet devices have demonstrated broad application prospects in the field of high-efficiency thermal management, owing to their advantages such as fast response, compact size, and immunity to electromagnetic interference. However, the directional jet formed within confined spaces generates significant broadband noise during operation. This noise arises from two primary sources: on one hand, the high-frequency vibration that drives the gas produces radiated broadband noise; on the other hand, structural vibrations transmitted outward through the housing couple and superimpose with the jet noise in the frequency spectrum. Such noise severely constrains the engineering application of jet devices in scenarios with stringent acoustic environment requirements.

Research Objectives

- Analysis of the causes of broadband noise generation in miniaturized high-speed jet devices;
- Proposal of noise mitigation solutions for miniaturized high-speed jet devices.

Key Specifications

- The noise level of the high-speed jet device during operation is below 30dBA within the frequency range of 20Hz to 20kHz;
- Sharpness below 2.5acum.

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Efficient Editing Technology for Hematopoietic Stem Cell Gene

Background

Gene editing of hematopoietic stem cells holds great potential in the treatment of hereditary hematological diseases and immune enhancement therapies. The CRISPR system is a common tool for current gene editing applications. Nevertheless, CRISPR-mediated gene knockout triggers DNA damage responses, which exert adverse effects on the survival of hematopoietic stem cells. In addition, it may lead to insufficient knockout efficiency, chromosomal translocations and other issues during gene knockout. Accordingly, it is necessary to construct and optimize an efficient CRISPR-based gene knockout system to achieve highly efficient gene knockout in hematopoietic stem cells.

Research Objectives

- Construct and optimize an efficient CRISPR-based gene knockout system for hematopoietic stem cells;
- Evaluate the stemness maintenance, functionality and safety of hematopoietic stem cells after gene knockout.

Key Specifications

- On-target editing efficiency (indel frequency): $\geq 90\%$;
- Colony-forming capacity (total CFU): $\geq 80\%$ of mock-edited control, Off-target editing rate: $< 0.1\%$.

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