Enhancement of AMOLED Display Performance and Lightweight-Thin Design Based on COE Technology

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Abstract

In the field of AMOLED display, COE (Color Filter on Encapsulation) technology achieves breakthroughs in lightweight design and low power consumption for AMOLED displays through the "polarizer (POL)-free" design. However, the traditional process relies on a PET two-in-one composite layer (PET substrate + OCA bonding layer), and its redundant manufacturing process and thickness limitations restrict the progress of industrialization. This study proposes a process scheme of "pre-positioning of Optically Clear Adhesive (OCA) attachment process + PET two-in-one Skip". In experiments, it realizes a thickness reduction of 73μm for COE AMOLED modules, a decrease in the single-piece material cost of the module, and an improvement in the overall yield. It provides an innovative path with both innovation and engineering value for the performance upgrade and lightweight development of AMOLED COE displays, and is of great value for promoting the implementation of high-end display scenarios such as flexible and automotive displays.

Author Keywords

COE Technology; Lightweight AMOLED; OCA Process Optimization

1. Introduction

Currently, AMOLED display technology is evolving towards the direction of "thinner, more flexible, and lower power consumption"[1]. Among them, COE (Color Filter on Encapsulation) technology, as a core revolutionary innovation in the AMOLED display field, achieves remarkable advantages in realizing display panel lightweight, improving light transmittance, and reducing power consumption by integrating color filters into the encapsulation layer [2].

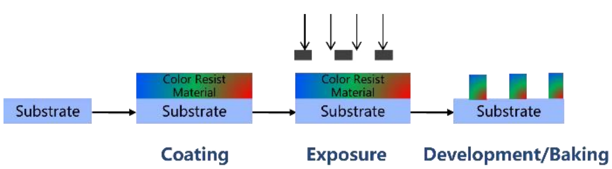

Figure 1. COE BPDL/BM/CF Single-Layer Color Resist Process

However, as shown in Figure 2, the multi-layer structure design relying on "PET two-in-one composite layer" material in the current mainstream process to realize temporary protection and optical lamination in panel manufacturing has pain points such as redundant manufacturing processes (multiple lamination procedures), limited thickness reduction, and high cost, which restrict the performance upgrade and market implementation of high-end AMOLED products:

- ***Thickness Redundancy:*** The total thickness of PET substrate + OCA layer is 73μm, accounting for 6.5% of the total screen thickness, failing to meet the ideal state of COE lightweight AMOLED design;
- ***Inefficient Manufacturing Process:*** It needs to go through processes such as "removal of screen protective film" → "PET two-in-one lamination" → "removal of PET two-in-one protective film" → "OCA lamination" → "removal of OCA heavy film" → "CG lamination", etc. Multiple film removal and lamination links are prone to generate static electricity, leading to foreign object adsorption defects;
- ***High Cost:*** The PET 2-in-1 composite material-a key component in display encapsulation stacks-constitutes 9% of the total bill of materials (BOM) cost for display modules, while the ±50μm-precision lamination equipment (critical for high-accuracy material integration) necessitates an initial investment exceeding 1,000,000 CNY per production line, thereby elevating the fixed cost threshold for establishing COE manufacturing infrastructure.

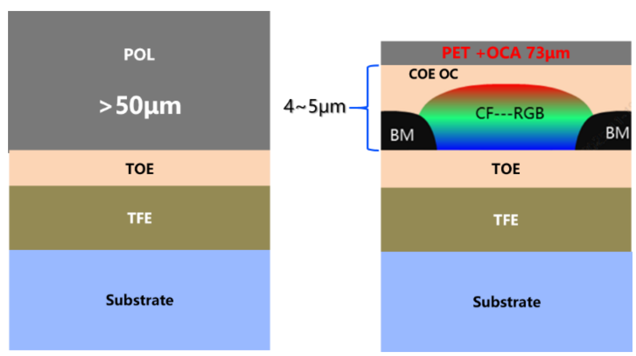

Figure 2. Comparison between COE and Traditional POL Technology

Aiming at the above pain points, this study takes "process sequence reconstruction + new material research and development" as the core idea, and proposes an innovative process optimization scheme of "pre-positioning of OCA lamination process". By replacing traditional PET two-in-one materials, it realizes triple breakthroughs in process simplification, structural lightweight, and cost optimization, providing key technical support for the industrial application of COE technology in the AMOLED display field, and having important academic value and engineering significance for promoting the development of the display industry towards "lightweight and high efficiency".

This technology provides an innovative path for the performance upgrade and cost optimization of COE technology in the AMOLED display field, and has important practical significance for promoting the lightweight development of high-end display products.

2. Methodology

2.1 Process Flow Optimization：

In the experimental scheme, as illustrated in Figure 3, the Optically Clear Adhesive (OCA) lamination process is pre-positioned at the offset lamination station to replace the traditional "PET two-in-one" material, thereby constructing a novel process linkage:

- ***Original Process (Control Group):*** PET two-in-one lamination → Other → OCA lamination (requiring removal of PET protective layer) → Cover Glass Lamination (requiring removal of OCA release film) → Other
- ***New Process (Experimental Group):*** OCA lamination → Other → OCA lamination → Cover Glass Lamination (requiring removal of OCA release film) → Other

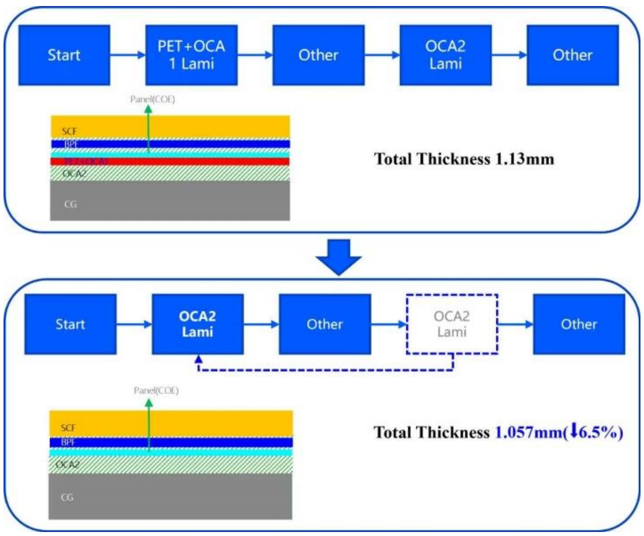

Figure 3. The New Process Route of COE

By comparing the process steps, structural thickness, yield, and cost of the two processes, the technical benefits of the optimized scheme are quantitatively analyzed, as shown in Table 1:

Table 1. Comparison of Process Schemes and Optimization Value

Process Stage	Normal	Optimized Technical Solution	Optimization Value
First Lamination	PET+ OCA1 Lamination	OCA2 Lamination	Eliminate PET, Thickness- 73μm
Second Lamination	OCA2 Lamination	Skip	Avoid Foreign Object Risk from Lamination& Film Tearing

2.2 Material Selection：

Aiming at the process characteristics of AMOLED displays, this study evaluates the adaptability of three types of OCA (Pressure-Sensitive Type, UV Type, Thermosetting Type) [2], with specific parameters as shown in Table 2 .

Table 2. Comparison of OCA Types for AMOLED Display

Parameter	Pressure-Sensitive OCA	UV-Curable OCA	Thermosetting OCA
Curing Mechanism	No secondary curing post lamination	UV-cured post lamination	Heat-cured post lamination
Advantages	Fast curing, simple process	High strength, good compatibility	Excellent thermal stability
Limitations	Moderate long-term stability	Susceptible to UV interference	Narrow applications
Applicable Scenarios	Foldable displays, automotive HMI	Mobile phones, etc.	Niche special displays

Pressure-sensitive and thermosetting OCA can be directly adapted to the "pre-positioning scheme for process sequence optimization" through process verification; for the UV interference issue of UV-type OCA, a solution path of "process sequence optimization + light shielding design" is proposed to expand its application feasibility.

After adopting the scheme of process sequence optimization and light-shielding design, the curing rate of UV-OCA during non-essential curing processes was significantly reduced to 17%. This improvement effectively suppresses the bubble rebound in the finished modules and significantly enhances the stability and reliability of the lamination process.

3. Experimental Results

3.1 Structural Lightweight

For users of portable electronic devices, the lightness and thinness of the device is one of the main concerns. In the current industry-standard COE technology process, a PET two-in-one layer is added to provide process protection barriers and reduce stress buffering, thereby improving impact resistance. Therefore, COE has not achieved the effect of removing the thickness of POL (Polarizer) to reach the ideal state. For the PET two-in-one Skip technology, by pre-positioning the existing OCA2 layer and using its heavy film as a process protective layer, the thickness of the module is reduced, which further reduces the thickness of COE products.

Through the new process design change, the overall thickness of the display module under the new process is reduced by approximately 127μm (compared with the traditional POL scheme). On the basis of the thickness reduction of the current mainstream COE technology, it is further reduced by 6.5%. Moreover, the uniformity and adhesion of OCA meet the industry reliability standards (no delamination under the double 85 (85℃, 85% RH) and 6090 reliability test environment for 480 hours, and no appearance defects such as bubbles on the cover plate).

Table 3. Thickness Reduction Ratio of Module (mobile phone panel)

Item	POL	Normal COE	New COE
Layer	CG 0.6mm OCA2 0.15mm POL 0.129mm Panel 0.042mm BPF 0.088mm SCF 0.175mm	CG 0.6mm OCA2 0.15mm PET+OCA1 0.073mm Panel (COE) 0.044mm BPF 0.088mm SCF 0.175mm	CG 0.6mm OCA2 0.15mm Panel (COE) 0.044mm BPF 0.088mm SCF 0.175mm
Total	1.184mm	1.13mm	1.057mm
Diff.	**Base**	**-0.054mm**	**-0.127mm**
Ratio	**Base**	**-4.6%**	**-10.7%**

3.2 Process and Cost Improvement

The novel process eliminates the "PET 2-in-1 lamination" step, yielding two pivotal cost advantages: it streamlines the manufacturing workflow by removing one production stage and reduces supporting lamination equipment investment by over 1,000,000 CNY, while eliminating PET material consumption to lower the per-panel processing cost-thus laying a robust foundation for the mature, stable advancement and large-scale commercialization of COE technology.

3.3 Yield and Reliability Improvement

In this study, the experimental group employed the OCA pre-positioning process. By eliminating one panel lamination step, defects induced by misalignment, dust, and foreign contamination during PET lamination were effectively suppressed, resulting in a higher yield relative to the control group.

4. Conclusion and Outlook

In summary, through "pre-positioning of OCA lamination process +material selection optimization", this study achieves a synergistic breakthrough of "lightweight, high yield, and low cost" in AMOLED COE. The thickness is reduced by 6.5%, meeting the "lightweight" design requirements of intelligent terminals. It reduces the production process on the production line, improves yield and production efficiency, lowers costs, and enhances the commercial competitiveness of COE technology, promoting the development of the display industry towards higher stability.

Future research will further overcome large-size adaptation to ensure the application of COE thickness reduction technology in medium and large-size automotive AMOLED. It will develop "UV-blocking OCA" that integrates the function of PI shielding layer to further simplify the process and reduce costs.

5. References

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