Ultra Thin Profile RGB LED Module
for LCD Monitors and TV Backlighting

White Paper

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Abstract

The use of Red, Green and Blue (RGB) Light Emitting Diodes (LEDs) to backlight liquid crystal display (LCD) panels is a must to achieving a superior color gamut in monitors and TVs. The tradeoffs in using RGB LED backlighting include the efficiency and cost of the LED assemblies. A new package is needed to properly address this LED backlight market. Avago developed a chip-on-board (COB) package which combines a compact and low profile package outline with good color mixing and efficient thermal management. This package demonstrates that COB technology can still be an attractive option for LED package designers because of its cost effectiveness and its ability to incorporate simple electrical connections.

Introduction

Hundreds of millions of LCD panels are being produced every year. Today, less than 1% of them are backlit with RGB LEDs. Many RGB LED solutions have been proposed to address this market, but none of them are able to meet the requirements of thin profile, good color mixing, simple thermal management, plug & play and cost effectiveness. Cold cathode fluorescent lamps (CCFL) are still the industry standard for LCD monitors and TVs. Discrete LED packaging cannot replace the CCFL solutions in price because the size is larger and more effort is required in color mixing and thermal management. To accelerate the adoption of RGB LED backlight in LCD monitors, Avago developed the chip-on-board package RGB LED light source as shown in Figure 1.

Figure 1. The COB package outline for ADJD-MJ00, ADJD-MJ10

Chip-On-Board Packaging

The conventional packaging approach is to mount the LED chip on the substrate to create a discrete LED component. Then arrange the LED components on the printed circuit board (PCB) to achieve a combination of RGB LED light source. The new approach is to mount the LED chips directly onto the printed circuit board.

This approach enables the light to be very compact compared to existing solutions (refer to Figure 2). The pitch between LED chips is reduced significantly. Normally, the minimum pitch for LED components is 5mm. The COB approach is able to adjust the pitch to 2mm. In addition, the height of the light source is reduced because the substrate is eliminated. By doing this, the thin profile outline is achievable.

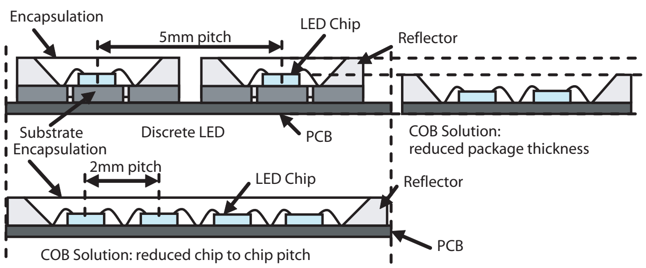

Figure 2. Size comparison between the discrete component solution and the COB solution

Once the pitch of the LED is reduced, the color mixing area needed is also reduced (refer to Figure 3). To achieve high light coupling efficiency from the light source to the light guide plate (LGP), the reflector is incorporated in the COB package to produce an oval radiation pattern. The radiation pattern measurement is shown in Figure 4. Narrow viewing on the X-axis allows more light to enter the LGP. The wide viewing angle on the Y-axis enhances color mixing. With this enhancement, the color mixing zone needed in the backlight unit is minimized.

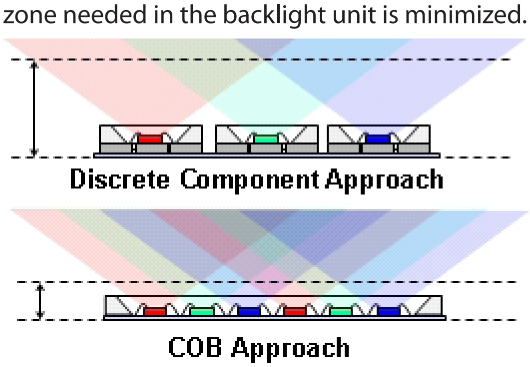

Figure 3. The COB Approach reduces the color mixing area needed

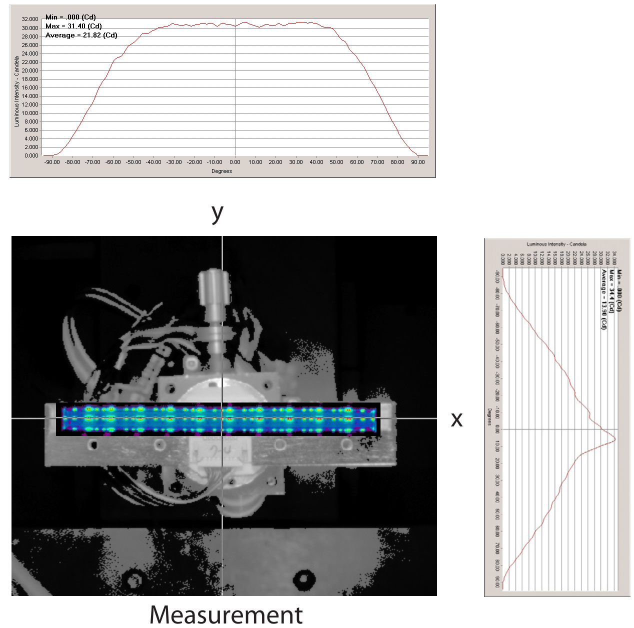

Figure 4. Radiation pattern measurement for the COB unit

A Metal Core PCB is used in the package to enable the lowest thermal resistance. The heat generated by the operating LED chip can be efficiently transferred to the heat sink through the metal core PCB because the thermal path is shorter (Refer to Figure 5).

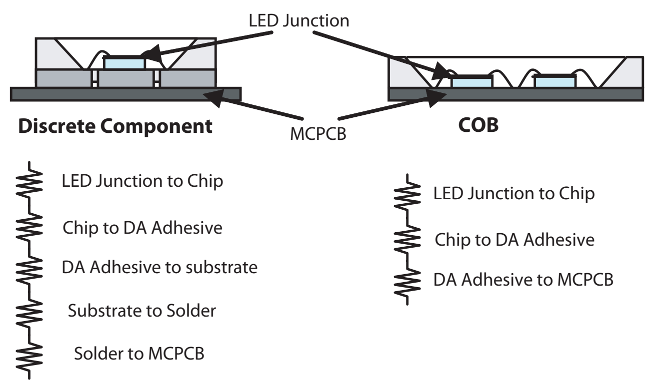

Figure 5. Thermal path comparison of discrete component to COB approach

The light aperture outline is a long and rectangular strip. This fix extends to the edge of the LGP. Light from the LED chips is then channeled to the LGP without much loss.

Result

Two rows of COB packages were retrofitted into the CCFL backlight unit (BLU) for the performance investigation. The BLU consisted of an LGP, where a reflector was put underneath the LGP and a diffuser and prism sheet was placed on top of the LGP. The measurement was then taken on the prism sheet.

Simple Thermal Management

The COB packages are mounted directly onto the back metal so the heat generated from the LED chips spread efficiently on the large metal frame; The heat then dissipates. Besides the existing metal frame, no extra heat sink is added to the BLU. In this configuration, the entire BLU is able to maintain its temperature below 70°C (as shown in Figure 6).

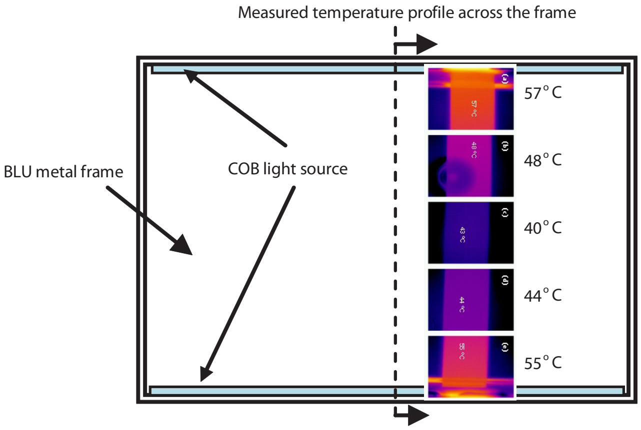

Figure 6. Thermal analysis on the COB package in the edge emit BLU application

Good Color Mixing

The light from Red, Green and Blue is mixed in the reflector cavity. The premix white light is observed on the area just after it enters the LGP. Nine point measurement is done to characterize the uniformity of the BLU (refer to Figure 7). The color uniformity in du'v' is 0.007 (Refer to Table 1) and brightness uniformity is over 85% (Refer to Table 2). The above result matches the CCFL performance.

The assembly of the package to the BLU does not require any special equipment. The COB package is mounted by a screw and the electric connection is done through a plug and play connector. The cost of this solution is low in comparison because it can fit into the existing CCFL BLU without any major modifications.

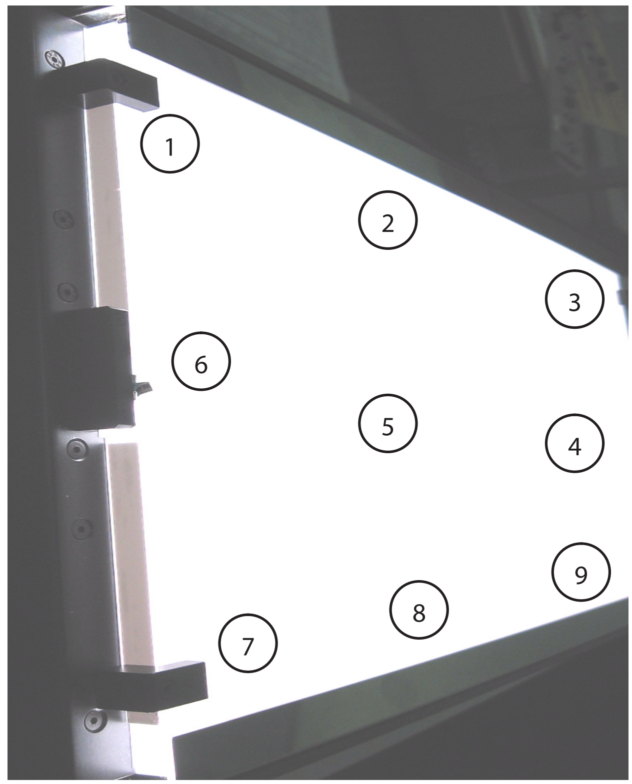

Figure 7. Measurement points on the backlight unit for uniformity characterization

Table 1. Brightness uniformity over the BLU with RGB COB packages on top and bottom edge

Point	x	y	Brightness
1	0.2969	0.2929	4335
2	0.2975	0.2890	4148
3	0.2922	0.2927	4211
4	0.3000	0.2912	4370
5	0.2943	0.2909	4425
6	0.2963	0.2937	4460
7	0.2968	0.2924	4475
8	0.2977	0.2906	4727
9	0.2983	0.2907	4484
Ave	0.2967	0.2916	4404
Min	0.2922	0.2890	4148
Max	0.3000	0.2937	4727
Uniformity	97.40%	98.40%	87.75%

Table 2. Color uniformity over the BLU with RGB COB packages on top and bottom edge

Point	u′	v′
1	0.2006	0.4452
2	0.2026	0.4429
3	0.1972	0.4444
4	0.2036	0.4446
5	0.1995	0.4436
6	0.1998	0.4456
7	0.2007	0.4449
8	0.2021	0.4439
9	0.2025	0.4441
Ave	0.2009	0.4443
Min	0.1972	0.4429
Max	0.2036	0.4456

$du' = u'_{max} - u'_{min} = 0.0064$

$dv' = v'_{max} - v'_{min} = 0.0027$

$du'v' = (du'^2 + dv'^2)^{1/2} = 0.0070$

Conclusion

A COB solution is a better solution to use in LCD backlighting when compared to conventional discrete LED packages. The advantages achieved in terms of thin outline, better color mixing and simple thermal management, matches the requirements of customers. In addition, the BLU assembly process of the COB package is similar to the CCFL. Chip-on-board packaging is an ideal solution to enable RGB LED to meet the needs of the LCD backlight market.

Acknowledgement

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Reference

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[2] S.I. Pang, S.L. Oon, "Thermal Analysis Report", Avago Technologies Malaysia, 2006