The research of improving pooling of LCM after THB

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Abstract

Pooling is a general issue in Liquid Crystal Module（LCM）after RA test (The high temperature and high humidity). Disassembling the module, We Found that the lighting guide plate (LGP) became to reverse warping at the condition of high temperature and high humidity. Then lighting on the module at gray pattern, and pressing the module, the LGP intervene with the films and the cell at the Z direction. In this paper, we do a lot of tests to find the root cause of the LGP reverse warping, including the different LGP material and the different gaps between the LGP and frame at the X,Y,Z direction; In conclusion, the PC and MS material is better than polymethyl methacylate (PMMA); the pooling is slight if the LGP's Z direction is bigger. The printed LGP is more stability than the injection LGP in tough environment.

Key words: pooling；gap；reverse warping

1. Introduction

The Liquid Crystal Display (LCD) is one of the most popular display device, which has been used in smart ph one, digital camera, notebook , TV and industrial devices，and almost covered all screen sizes. They have low power、low weight and thin thickness. The Liquid Crystal Module（LCM）is the important component of the LCD, which is usually consist of light source, light guide plate(LGP), prism sheets, diffuser sheets and a r eflective sheet. The LCM as a self-product, we must do some reliability test before shipment. The reliability te st of the product refer to the necessary function's failure probability in the given conditions in a given period o f the time. The reliability test can check product's reliability status, including the environment resistant ability, maintainability, availability and reliability of design. Especially industrial and automotive products, which were b een used at a far wider range of conditions (temperature from -20℃~80℃,humidity from 50%RH~95%RH),even being demanded the long lifetime(Min. 50,000hrs). So the high temperature and the high humidity test are ind ispensable items at the module's reliability test .

2.The reliability test and the describe of the pooling issue

The reliability test of module includes as following (Tab. 1). After these tests, the module can not appear new issues, this put forward higher requirements for the material and the design of LCM. Currently, the module for industrial and automotive used are required to press or shake to check the display performance after the reliability test, so the pooling was found. This issue is most obvious at the 92 gray pattern.

Item		Test Condition
Reliability test	High Temp. operating	60°, 500hrs
	High Temp. Storage	70°, 500hrs
	High Temp./High Humidity operating	50°, 90%RH, 500hrs
	High Temp./High Humidity Storage	60°, 95%RH, 500hrs
	Thermal shock	-25°C,30min,65C,30min,200cycles

Tab. 1 Reliability test items of LCM

In this paper, using M1501 module as an example. this module has pooling after THB(High Temp. and High Humidity operating) test. Disassembling the module, we found the LGP had a serious reverse warping.

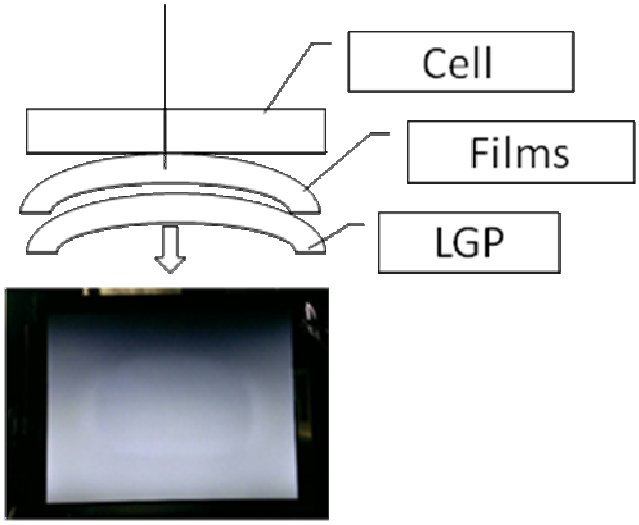

Fig.1 M1501 module's pooling after the THB test

Scanning the LGP using 3D, the LGP had about 0.8mm reverse warping at the center area. When pressing the panal, the LGP pushed the films and the Cell ,then appearing the pooling. when LGP at normal warping, The performance of the module is OK, but when the LGP has reverse warping, and the LGP and films fixed by frame at the around of the module, so the pooling is appearing. This LGP material is polymethyl methacylate (PMMA) and this LGP was injection molding, belonging to wedge-shpaed plate (3mm~1.2mm).LGP vender adjusted the molding condition, the pooling have some improvement, but still being.

3.The Countermeasures and status

Solving this issue, the most important thing is to solve the LGP reverse warping. First, we used M1501 LGP to do high temp. / high humidity test. The result is as below (Tab. 2). From this result, the LGP is in free status, LGP can expansion and warping randomly. Only 48hrs, the max. warping is up to 2mm and the max. expansion is up to 1mm;if the test is going on, the LGP would further expansion and warpage. So LGP reverse warping maybe caused by lack of expansion area. Then we made a tool which can adjust the X,Y,Z direction's gap around the LGP to verify the LGP reverse warping.

15.0 LGP	Expanion（mm）		Warpage(mm）
Conditions	X	Y	Z
50°,48hrs	0.4	0.2	1.2
40°，95%RH,48hrs	0.85	0.6	1.8
50°，95%RH,48hrs	1	0.8	2
50°，85%RH,48hrs	0.9	0.6	1.5

Tab. 2 the LGP expansion and warpage after RA test

3.1 Increase the gap of LGP at X、Y direction

The one side gap between LGP and frame is 0.6mm at X,Y direction in M1501 module, we used tool to increase this gap to 2mm to eliminate the influence caused by the lack of space for expansion. Then put the tool into the THB test. The LGP were measured the flatness before the test, the LGP is the forward warping (Fig. 2).After the test, the pooling is obvious, the LGP changed to reverse warping(Fig.3).This test illustrated that increasing the gap at X,Y direction can not improve the pooling issue.

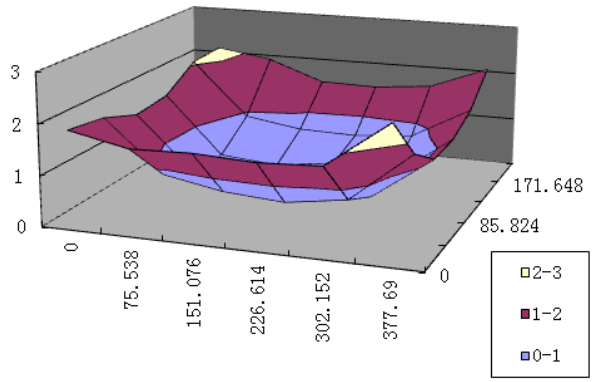

Fig. 2 The LGP warping data before THB test

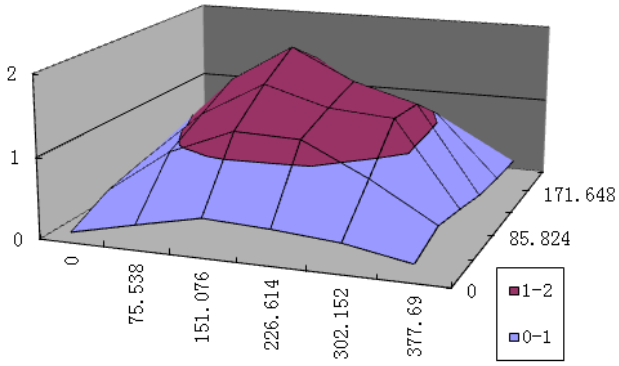

Fig. 3 The LGP warping data after THB test

3.2 Increase the gap of LGP at Z direction

The Z-direction gap between film and polarizer down is 0.5mm in M1501 module， we used tool to increase this gap to 2mm. Then put the tool into the THB test. The LGP were measured the flatness before the test, the LGP is the forward warping (Fig. 4).After the test, the LGP did not reverse warping(Fig.5). This test illustrated that increasing the Z-direction gap can mitigate the pooling issue . If the gap increase big enough, the pooling is disappear, but this requires the bigger thickness of module, so this maybe can't use at lots of projects.

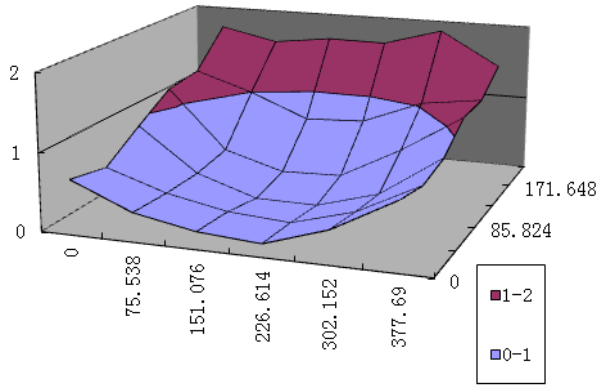

Fig. 4 The LGP warping data before THB test

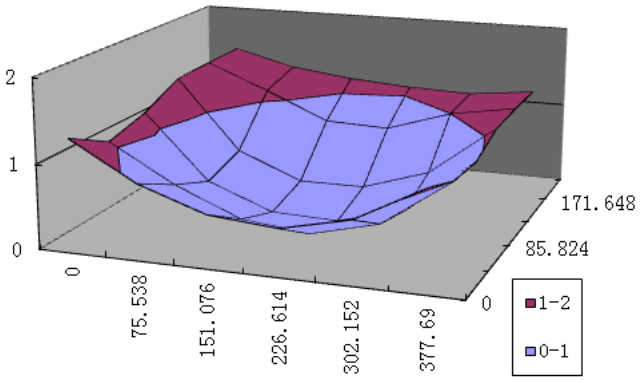

Fig. 5 The LGP warping data after THB test

3.3 change the material of LGP

The commonly used material of LGP and these features are as below(Tab.3), so we selected the MS LGP to verify the pooling status.

Properties	Unit	MS (styrene-methyl methacrylate Copolymer)	PMMA (polymethyl methacylate)	PC (Polycarbonate)
Water absorption	%	0.2	2	0.4
Specific gravity	g/ cm^3	1.13	1.19	1.19
Light transmission	%	91	92	90
Refractive index	--	1.53	1.49	1.58
Glass transition temperature	°C	105	95	140
Coefficient of thermal expansion	10^{-6} m/K	8	8	7

Tab. 3 the LGP material and these features

First we used MS and PMMA LGP (12.1 inch, 2mm flat plate, printed plate) to do high temp. / high humidity test at the same time. The result is as below (Tab. 4). This test can show that MS LGP performance is better that PMMA at high temp. / high humidity.

Condition	MS LGP			PMMA LGP		
	X	Y	Z	X	Y	Z
50°，85%RH	0.35	0.2	0.05	0.45	0.25	0.35
50°	0.32	0.19	0.15	0.43	0.22	0.3
40°，95%RH	0.36	0.21	0.18	0.46	0.26	0.37
50°，95%RH	0.41	0.23	0.2	0.48	0.31	0.39

Tab. 4 the MS&PMMA LGP expansion and warpage after RA test

Then put the MS LGP and the PMMA LGP module into the THB test, MS LGP is all along in forward warpi ng before and after the test(Fig. 6&7) and the module do not have pooling;

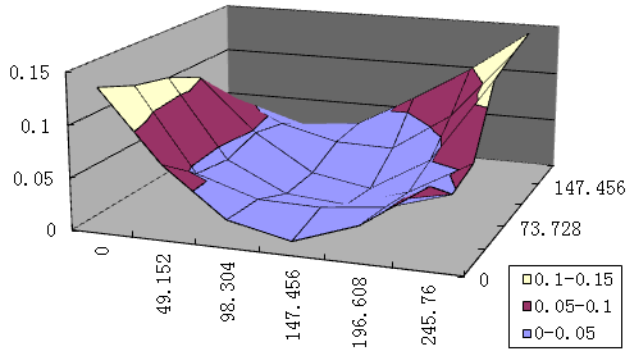

Fig. 6 The LGP warping data before THB test

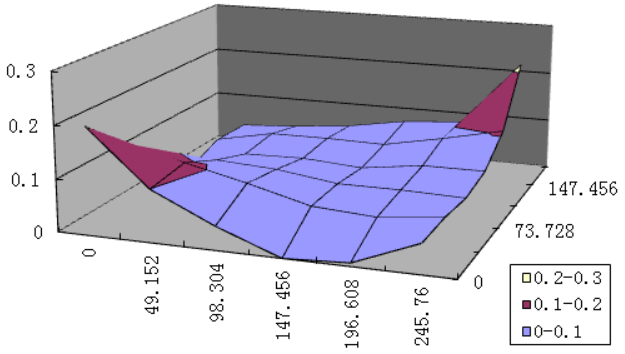

Fig. 7 The LGP warping data after THB test

but the PMMA LGP from the forward warping(Fig. 8) before the test changed to reverse warping after the test (Fig. 9).

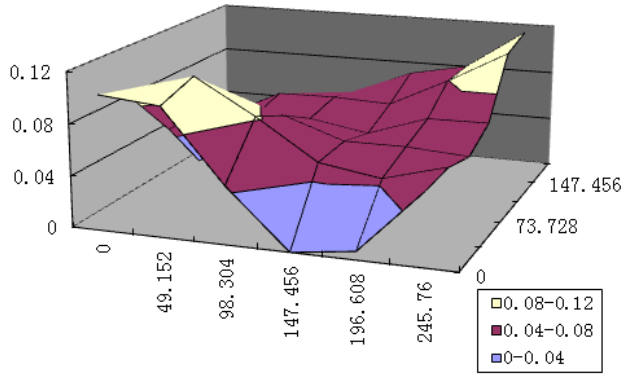

Fig. 8 The LGP warping data before THB test

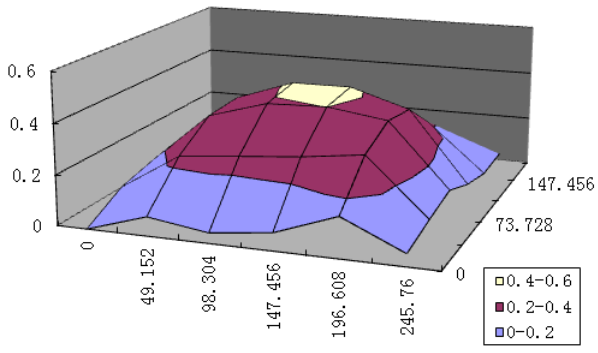

Fig. 9 The LGP warping data after THB test

From these tests, we can gain the following conclusions:

1. The injection plate has worse stability than the printed plate, because the injection LGP has relatively large internal residual stress, when the temp. is higher，the heterogeneous stress releasing leads to the LGP reverse warping.
2. PMMA LGP has worse stability than MS LGP, because of bigger water absorption of PMMA LGP

4. Conclusion

When designing a project, the gap of LGP at X,Y,Z directions must big enough; In addition, we should select printed plate first; if must use injected plate, molding conditions must be controlled well to keep the internal stress uniformity; or adding the process after injection to release the stress. In addition, if the RA test is rigorous, we should select PC&MS material.