Heat Reduction Scheme for Multimedia Display Device

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Abstract

The information technology is evolved to accomodate the ever changing end users request for new services. As the request for the high data rate multimedia contents explosively increases the related hardware, software and networking technologies are finding ways to effectively satisfy end users expectation. Aligned with this trend the display device becomes thinner to reduce the weight while supporting high resolution quality for both mobile and indoor usage. The LCD device is now an inevitable component in almost all the information processing appliances. The exothermic problem becomes one of the important issues which should be solved for various applications. In LCD adopted device the relative inside areas gets packed with various types of electronic devices as heat generation sources which include the display driver integrated circuit (IC). One of reasons for this problem is that more and more advanced display devices such as LCD and LED require driver ICs with higher degree of circuit integration within a limited area while demanding higher performances. Also a lot of efforts have been made to reduce the edge areas as the big screen display as well as portable mobile devices are getting popular in many fields. In this paper an enhanced heat sink method is proposed to reduce the heat generation problem caused by the driver ICs to maintain the stability of the operation and to protect the circuits in the chip on film package. The proposed method has advantages over the conventional ones in terms of the unit production price and no limitations on the arrangement of the IC.

Keywords: *Display device driver IC, heat sink, chip on film package*

1. Introduction

Increased demands for the multimedia contents without a limitation of the geographical location triggered the advent of various types of high quality display devices tuned to the diverse usage environments. This trend of service requirement now can be realized by the advancement of the network infra structure for both the core and the access part. Some of the technology advancement which can satisfy those user requirements include the processor technology which combines the multimedia data processing and data transmission functions in a highly integrated circuit chips. Also clouding services are spread in mobile environments with the introduction of more versatile mobile terminals such as the lap-top PC and Smartphone. Among all these changes the introduction of the advanced display device plays important roles.

Advancement of display device technology is splendid since the introduction of the liquid crystal display (LCD) [1]. The LCD device has been adopted in flat television and achieved

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great success over the conventional CRT (cathode-ray tube) TV [2, 3, 4]. This success is mainly due to the explosive progress in information technology coupled with massive demands for the high quality multimedia data such as high definition broadcasting, 3D video, smart TV and video streaming through mobile internet access [5]. The earlier version of LCD devices adopted for the TV use the cold cathode fluorescent lamp (CCFL) for the back light. This can dramatically reduce the depth of the appliance over the conventional CRT TV. Currently the worldwide market share of the LCD TV is known as over 80%. Around year 2010, the light-emitting diode (LED) TV was introduced in the market which compensates some of the problems with LCD device. The main difference between these two display devices is the light source. The LED device replaces the CCFL with the LED for the light source of the back light. In other words LED device is a variation of the LCD device. The advantage of the LED TV is that the depth of the device can be further reduced. Also it is more efficient in terms of the electric power consumption. Currently the organic LED (OLED) device is applied to the large screen TV. The OLED TV is the more advanced in terms of the depth of the device and the power consumption. This does not require separate light source which makes the thinner design possible with the improved display quality.

Demands for high quality data anytime and anywhere can be spread out of the office and home area due to the nationwide deployments of the cellular wireless networks and the efficient data infrastructure through mobile cloud computing. However, the mobility requires all the devices be kept small and light while satisfying the expectation on the display size. This is because the expectation of the mobile terminal users is getting closer to the one they could achieve at home or indoor environments. On the other hand in the area of big screen application the high quality multimedia video contents are now ready to be displayed in the wide display device which was useless in older days of the analog broadcasting. These trends triggered the race for the bigger screen size with more efficient display area utilization whether it is for mobile smart phone or indoor home theatre use. One of ways to realize the high area efficiency of the display is keeping the frame of the device as slim as possible which is often called a bezel.

Decrease of the extra areas other than actual display purpose is translated into the reduction of the area where the related circuits driving the LCD operation. This could cause highly squeezed circuit board design upon which the drive ICs are mounted. As the required performances are increased while the size of ICs is kept constant or even smaller new problems of heat generation are created from the driver ICs installed at the edge of the display. This limitation requires highly efficient heat dissipation method which can overcome the location and formation of the circuit board and the ICs. Without the proper solution for the exothermal problem, the semiconductor chips embedded in the display device is likely to fall into functional disorder. In this paper an enhanced heat dissipation method is proposed which can be applicable for super slip bezel display device with an enhanced flexibility in terms of geometrical position for the installation. In the next section the proposed method is described compared with the conventional one. Experimental results are followed which are obtained through laboratory measurements. Conclusions are drawn at the end.

2. Proposed Exothermic Reduction Method

One of the major exothermic problems in the current display device is originated from the drive integrated circuit (IC). Here the display device includes various types such as LCD, LED and OLED. In general the image is represented on the LCD by adjusting the light transmittance of the display which can be controlled by electric field intensity. To implement this mechanism the device requires the panel where the liquid crystal cells are arranged in the matrix format. The other component is the driving IC which operates the display panel. The driving IC consists of the source driver and gate driver which control the column and the row of cells in the panel, respectively. The driver ICs are mounted on the tape carrier package (TCP). After the packaging process they are normally applied to the LCD panel with tape automated bonding method or mounted on the panel with chip on glass (COG) method. As discussed above the LCD devices are widely used in many areas including the mobile terminals such as the smartphone, the tablet and the lap-top computer as well as the big screen TV. The heat generation problems have become a big issue since the introduction of the high resolution display and highly integrated circuit for the production cost reduction of the component. This heat problem could cause the instability of the driver IC function and could threaten the threshold of the resistance temperature limit of the flexible base film.

There have been many studies for this problem [6, 7, 8]. One of the conventional solutions uses the tape type material applied to the ICs to reduce the temperature of the circuit. This requires additional process and materials which might cause an excessive increase of the production cost. Also these conventional methods are not enough for the uneven surface although some of the methods use the thin film metal based material such as aluminum. Those metal based thin film inherently have a limit when it is applied to the target component surface with irregular ruggedness. Another limitation of the conventional thin film based tape type sheet is the inflexibility of the shape design. In other words as the shape and the dimension are changed for the target device the heat reduction sheet should be custom designed for the required specification. Also this heat sink sheet may require extra processing equipment for the lamination. Due to these limitations the conventional techniques are not suitable for mass production which might be sensitive to the increase of the production cost.

The proposed method compensates those problems by spraying an exothermic reduction substance above or below berth of the driver IC as shown in Figure 1 [9]. In order to implement the proposed heat sink package the exothermic reduction material is applied on the unfilled insulating layer and base film surface which protects the upper part of the chip on films type packaged IC [10]. This method has more flexibility in term of the shape of the application target and relatively simple process to implement compared with the conventional method.

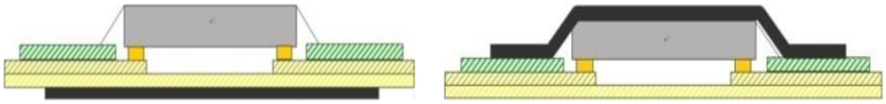


Figure 1. Sectional view of the upper/lower exothermic reduction package

With the proposed method the limitation on the geometric location and/or the inaccessibility of the material can be overcome. And also the simplification of the processing stage can help keep the cost increase minimal. This can be achieved by controlling the amount of sprayed material and the duration of the spraying time which can effectively the depth of the exothermic layer. This eventually can lead to the elimination of the unnecessary use of the material. In terms of the extra processing stage this can be implemented by utilizing the conventional nozzle spray equipment which is commonly used in the semiconductor manufacturing. In Figure 2 fictitious equipments are illustrated to help understand the operation related to the proposed scheme for the mass production. The spray should control the amount of material and time duration to cover the film pattern side where driver chip is mounted. In this figure the nozzle spray type of application method is illustrated although other method such as screen print type can also be adopted although more thorough comparative analysis should be carried out for the optimal selection of the final method. This should be done based on the cost analysis due to the extra process stage for the proposed heat sink method. Some of the rough requirement for this equipment for mass production should include the controllability of the coating thickness on the surface. As illustrated in the figure the contactless operation between the injection nozzle and the package surface where PCB, the film and the IC device will increase the reliability of the component and decrease the possible defect of the final product. As it can be seen in the figure the hidden locations where the penetration of the heat reduction paste can be eliminated by fine injection through the controlled nozzle which can not be implemented with the conventional method.

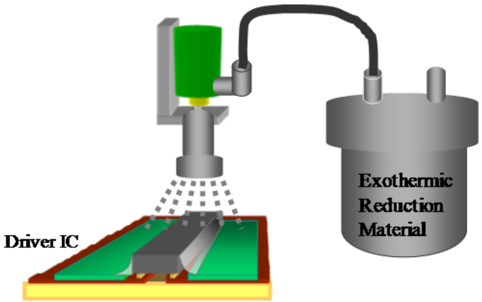


Figure 2. An illustration for the process of the proposed method

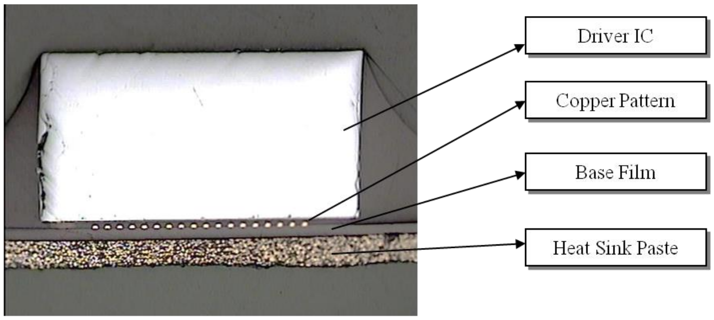


Figure 3. Tomography of the driver IC package with the proposed heat sink method

In Figure 3 the picture of the sectional view is shown. The top white part is the driver IC mounted on the base film. The driver IC and the copper patterns on the film are inter-connected with each other. As illustrated above the application of the heat reduction material can be applied either on top of the IC or on the beneath the film. This picture shows the case where the heat sink material is applied at the bottom of the film. The ingredient of the heat sink paste consists of ceramic silicon, organic or inorganic insulating coating materials and/or conductive materials such as metal paste, carbon nano tube or graphite

3. Proposed Optimization Method

For the experiment, driver ICs in the operation of three different modes are tested on the 42 inch LCD panel. They are grouped into two sets: one group of IC packages is applied with the proposed heat dissipation method and the other group has no other extra heat sink. The conventional configuration of the driver ICs on the LCD device is shown in Figure 4 where 42 inch TV is assumed for the experiment and the ICs are mounted at the top edge of the panel. In general one driver IC covers about 960 channels and 6 to 8 driver ICs are required for one panel. The pictures taken at the panel edge for the samples for test are shown in Figure 5.

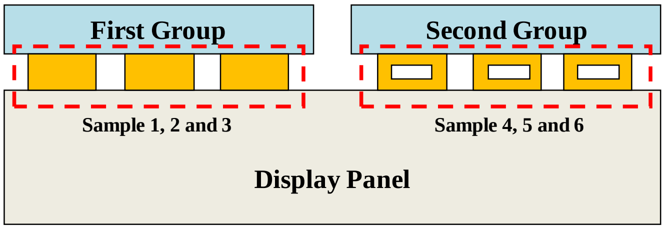


Figure 4. The configuration of the driver ICs for the experiment

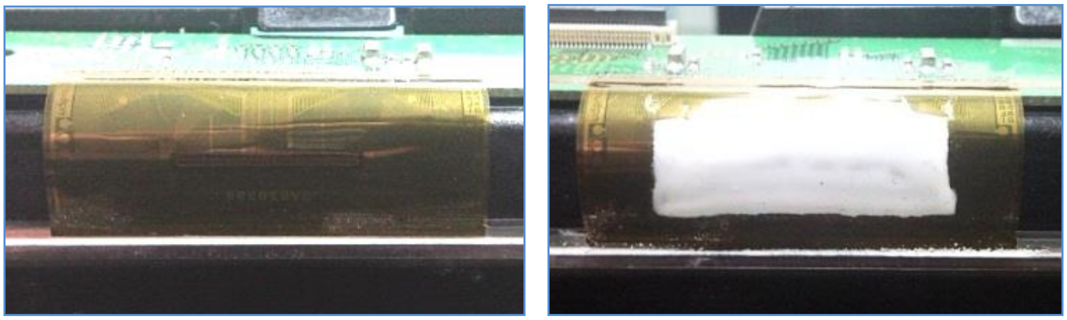


Figure 5. Pictures of the IC without (left) and with (right) the application of proposed method

Each group consists of three ICs operating in the same mode which are labeled as White, Black or V-strip, respectively. In the white pattern mode the driver IC operates in such a way the entire display shows white color all the time. The black mode also keeps the display in the black color. The V-strip mode is the state the driver IC operates to change the color of the display in white and black in alternate way. This mode consumes the most power consuming state which is a good test condition for extreme heat generation from the ICs.

The detailed conditions for the experiment are summarized in Table 1. The actual pictures of samples mounted in the edge of the TV panel for the experiments are shown in Figure 6. The white portion of the picture in the righthand side represents the proposed heat reduction paste applied. Some of the pictures taken from the measurement equipment display are shown in Figure 7. In this experiment the white pattern mode is maintained for the measurement and the lefthand side picture represents the temperature taken from the sample 1 in the group 1. This has the conventional package with no reduction paste applied. The righthand side picture represents the test results from the sample 4 in group 2 where all the samples are equipped with the proposed reduction material. As shown in the figure the lefthand side represents higher temperature around the center of the driving IC package (114.4 ^{o}C) than the righthand side where the maximum temperature is measured at 89.8 ^{o}C. The surrounding temperature measured in the laboratory is in the range of 22~24 ^{o}C. In the conventional package cases the operation mode does not make much difference on the temperature of the package. The average value for this group is about 114 ^{o}C. The average temperature measured at the samples in the second group is about 88 ^{o}C. The overall measurement results show about 23% of temperature drop with the samples of proposed scheme compared with the non applied samples as shown in Figure 8.

Table 1. Summary of the experimental conditions

Target Module	Equipment for measurement	Surrounding Temp.	Aging Time	Distance
42” TV Panel	Fluke Thermal Image (Ti 55)	24±1℃	60Min	10cm (IC ↔ Ti 55)

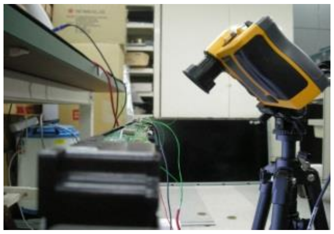
Thermal Camera	Samples and Measuring Equipment	Visual Image
		

Figure 6. Measurement equipment settings for the experiment

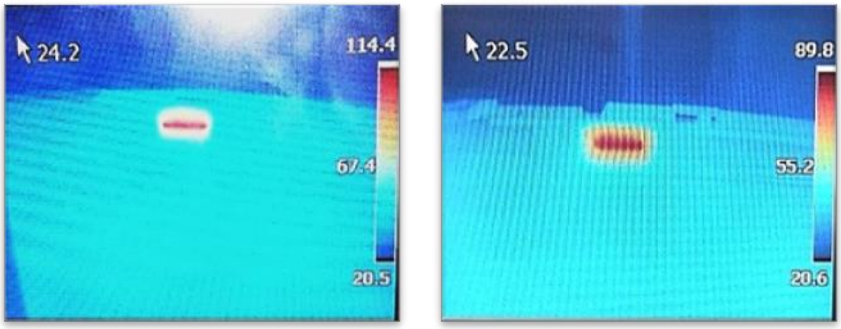
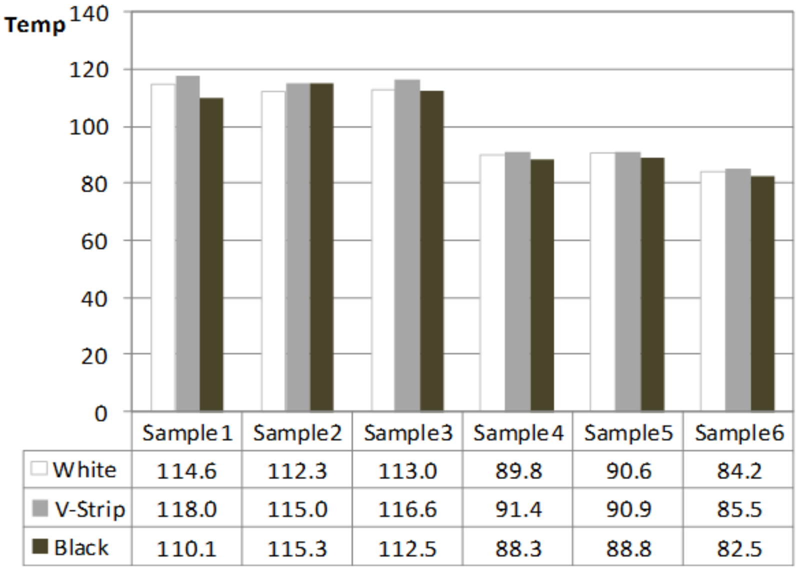


Figure 7. Sample temperatures measured from group 1 and 2, respectively (white pattern case)



	Sample1	Sample2	Sample3	Sample4	Sample5	Sample6
☐ White	114.6	112.3	113.0	89.8	90.6	84.2
▨ V-Strip	118.0	115.0	116.6	91.4	90.9	85.5
■ Black	110.1	115.3	112.5	88.3	88.8	82.5

Figure 8. Comparison of measurement results

4. Conclusion

The advanced display devices such as LCD and LED play important roles in a fast changing environment of the information technology where demands are being increased for the multimedia contents anytime and anyplace. In this paper, an enhanced heat dissipation method is proposed for the driver IC packages adopted in LCD device to reduce the exothermic problem in an effort to maintain the stability of the IC operation and to protect the circuits in the chip on film package. For the experiment, driver ICs in the operation of various modes which simulate real field environments are tested on the big screen TV adopting the LCD panel. Laboratory tests show that the method is effective in terms of reduction of unnecessary materials and the related equipment for processing which might eventually result in manufacturing costs increase. Experimental results show that temperature reduction effect is about 23% over the conventional package in all experimental conditions. The enhanced flexibility covering any geometrical shapes is also expected to be quite suitable for recent or upcoming advanced types of slim bezel display device which gets more and more important in ubiquitous information infrastructure environments.

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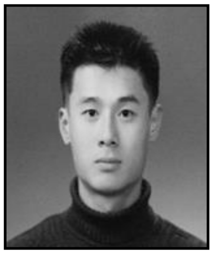

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