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Projection Type LC Devices for HDTV

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ABSTRACT
The LCD-projection is most hopeful system to realize a large-screen TV over 40" in place of CRT. That is a reason that compact liquid crystal panel makes the projection system itself small and light for the home-use. In this paper we discuss high density TFT-LCD for projection TV, particularly for HDTV, and describe IC mount method for high density TFT-LCD and cost performance.

1. INTRODUCTION

HDTV, which has been focused as the TV for next generation, requires a large screen over 40" in order to feel and enjoy the excitement and reality of the image.

The liquid-crystal projection TV introducing TFT-LCD as the light valve becomes in focus[1]. That was because, it made possible to realize high compact and light-weight in proportion to panel. Many research institutes are recently working on appliance of TFT-LCD into the projection TV and on development of TFT-LCD for EDTV[2][3] and/or HDTV[4][5].

The key point of the TFT-LCD design in realizing a compact and light-weight projection HDTV will be in how the following factor can be designed.

(1) High aperture ratio

(2) Design method of high density TFT-LCD.

(3) Cost performance

This paper describes about the design method of high density panel which is necessary to TFT-LCD for projection HDTV.

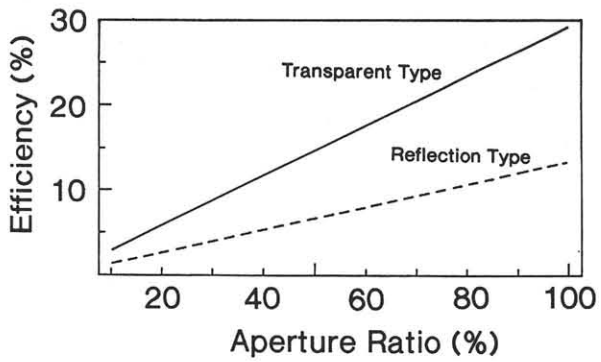

Fig. 1 Relationship between the aperture ratio of the panel and the efficiency of optical utilization

2. OPTICAL CHARACTERISTICS

Display resolution and brightness characteristics are one of the important factor for HDTV system.

The essential subject for TFT-LCD when making it in high density for HDTV, is the consistency of maintaining high aperture ratio of the pixels. Now we would like to discuss about the aperture ratio and the pixel pitch required for the projection HDTV.

Figure 1 shows the relation between the aperture ratio of the panel and the efficiency of optical utilization. Figure 2

shows the screen brightness versus efficiency of optical utilization by the panel of a 40" screen(G=5), where highly efficient metal-halide-lamp is used for the light source and dichroic mirror is used for the color separation system. As for liquid crystal panel, transparent-type and reflection -type were respectively calculated, and a polarized beam-splitter was used in the reflection type.

The light gathering efficiency was supposed to be 8.8%, but in case concave-mirror-type is used[2], the light gathering efficiency can be improved to 23% and the brightness will be improved up to approximately 3 times. Therefore if the aperture ratio could be 30% with a transparent-type panel, a brightness of 250ft-L can be achieved on a 40" screen. And with reflection-type panel, aperture ratio can be easily gained so that if a light source with coherency, which increases the projection efficiency, 'could be used, then the brightness can gained as well.

TV lines and (C)240 TV lines.

Figure 3 shows the size of square pixels versus diagonal size of the display screen(aspect ratio 16:9). If 1,000 lines of resolution is required on a 40" screen, pixel size for 3" panel will be approximately 40 μm.

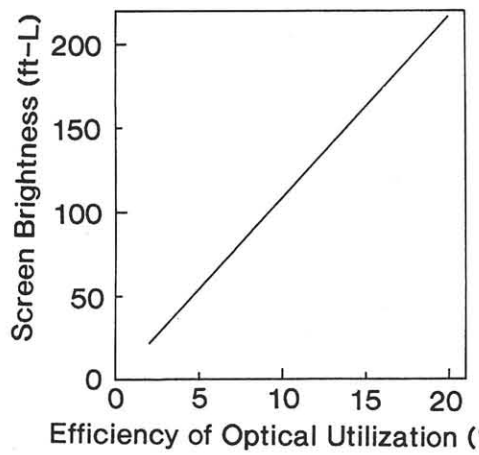

Fig.2 The screen brightness versus efficiency of optical utilization by the panel

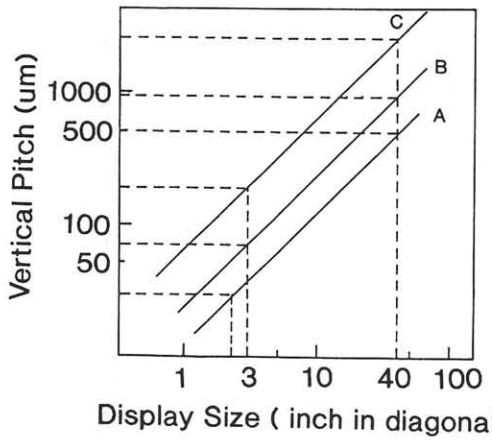

Fig.3 Pixel size versus diagonal display size:(A)1,000 TV lines, (B)525

3. DESIGN OF HIGH DENSITY TFT-LCD

When the panel becomes high density such that pixel size is less than 40 μm, following subject matters:

(1) The effect of electric field leakage from the wiring[6].

(2) Bonding technique with the driver IC[7][8].

3.1 DISPROPORTION OF ELECTRIC FIELD AMONG PIXELS

The 2-dimensional simulation of the electric field disproportion caused by the signal line wiring are shown in the figure 4(a) when pixel electrode and signal line wiring are fromed in the same layer, and figure 4(b) when they are formed in a different layer isolated by an insulator respectively. The pixel size is supposed to be 40μm x 40μm square, cell gap is supposed to be 4 μm. The voltage of counter electrode and pixel electrode is supposed to be 0V and 1V respectively, while the signal line is carried at 4V.

The disproportion of the electric field decreases when the wiring electrode and the pixel electrode are formed in a different layer compared with when they are formed in

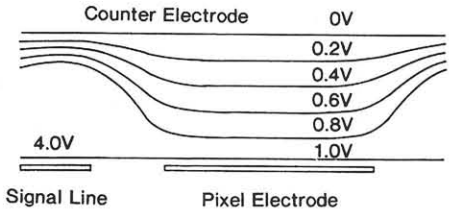

Fig.4(a) Potential distribution that pixel electrode are formed in the same layer

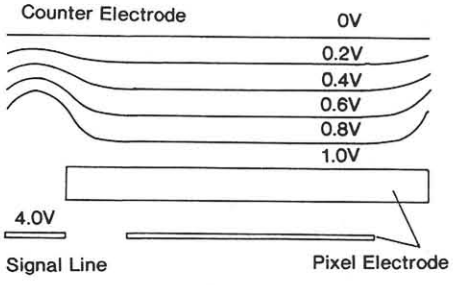

Fig.4(b) Potential distribution that electrodes in different layers

a same layer. Although the condition of the disproportion may depends on permeability of the insulator, film thickness or the thickness of the pixel electrode, it is more advantageous than to from in a same layer. But forming those in a different layer requires additional processes and the S-D coupling increases.

Figure 5(a) and 5(b) shows the voltage input to pixel electrode and to wiring electrode when they are in inverse phase. Figure 4(a) and 5(a) correspond to the upper part and the lower part of the scanning screen. The electric field gathers into the edges of the pixel when the voltage of pixel electrode and the wiring electrode are in inverse phase. The influence in disproportion of electric field between the identical phase and the inverse phase appears as the difference of the brightness in vertical direction. By black-matrix on the counter substrate, the disproportion must be covered. In that sense this effects a aperture ratio of the pixel.

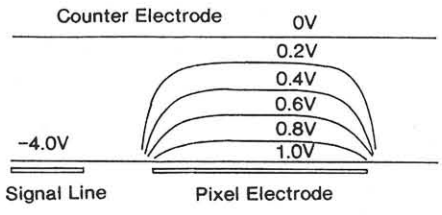

Fig.5(a)Potential distribution in case signals of electrodes in the same layer are in inverse phase

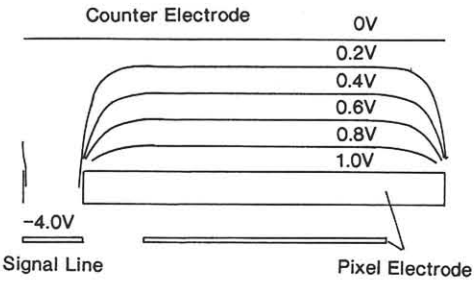

Fig.5(b)Potential distribution in case signals of electrodes in different layers are in inverse phase

3.2 DRIVER IC MOUNTED ON HIGH DENSITY TFT-LCD

Another important subject in designing TFT-LCD for projection HDTV is the bonding with the driver IC. Liquid crystal panel could not be driven unless the technique to connect almost 3000 pins of driver ICs' output each to the TFT wiring. 100μm is the limit for the conventional TAB(Tape Automated Bonding) technique. Thus for high density panel, COG(Chip On Glass) technique that connects IC directly onto the glass board has been studied enthusiastically[7][8]. Figure 6 shows the photograph of stud bump of COG.

4. COST PERFORMANCE

Figure 7 shows the cost of liquid crystal panel versus substrate size in case of high-temperature poly-Si:TFT, a-Si:TFT and low-temperature poly-Si:TFT. The high-temperature poly-Si:TFT is more advantageous

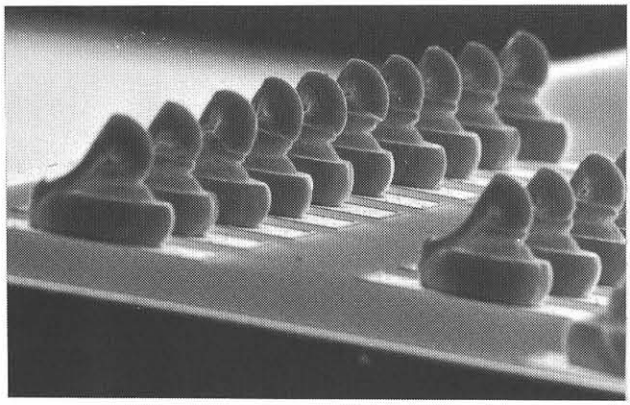

Fig.6 The photo. of stud bump of COG

in small substrate size because of its capability of producing the driver IC on the same substrate. In relatively large size, a-Si:TFT is advantageous which allows to make large size substrate. About 2" size is the cross point where the relation of high-temperature poly-Si:TFT and a-Si:TFT reverses.

Furthermore in case of panel with lots of pixels such as panel for HDTV, the cost of the liquid crystal panel depends on the cost of the peripheral driver IC. Thus the low-temperature poly-Si:TFT array is a noticeable TFT material that has the capability to fabricate both peripheral driver and the switching device for the display pixels at the same time from a large-size substrate.

5. SUMMARY

As the compact and light-weight projection HDTV that applies TFT-LCD will continue being developed, problems to be solved on TFT-LCD are :A)High density pixels and wide open ratio, B)High density device mount. More improvement on developing projection HDTV is expected.

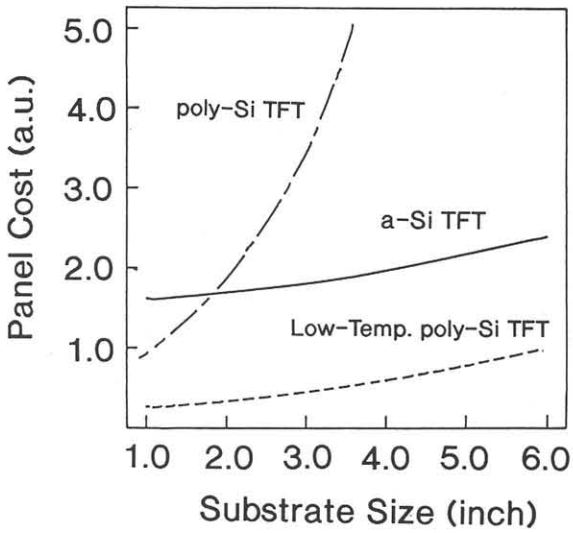

Fig.7 Panel cost versus panel size

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