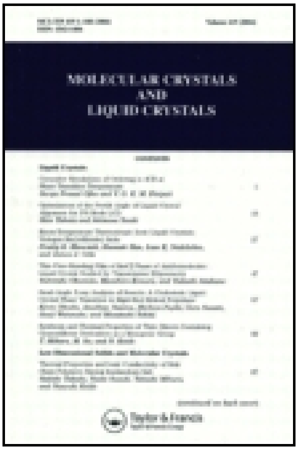

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Soo Young Choi [a] , Dong-Hae Suh [a] , Young Il Park [a] , Dae Kyu Lee [a] , Ock Soo Son [a] & Gon Son [a]

[a] LCD R&D Center, Boe Hydis Technology Co., Ltd, Ichon-si, Gyeonggi-do, Korea

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Advanced AFFS Monochrome TFT-LCD using Ion Beam Alignment Technology

Soo Young Choi, Dong-Hae Suh, Young Il Park, Dae Kyu Lee, Ock Soo Son, and Gon Son
LCD R&D Center, Boe Hydis Technology Co., Ltd, Ichon-si, Gyeonggi-do, Korea

We compared a polyimide alignment technology by ion beam to that by conventional rubbing, and realized the medical products with high contrast ratio, image quality and good image sticking in AFFS mode. Especially we improved the contrast ratio as optimizing the off-angle of ion beam.

Keywords: contrast ratio; FFS; ion beam alignment; medical; non-contact alignment

INTRODUCTION

It had been gone recently much researches of the ion beam technology as the alternative to the conventional rubbing method for liquid crystal (LC) alignment layer [1,2]. The conventional rubbing process has competitiveness for mass production of display manufacturing because of its high productivity but always has several problems such as scratch, debris and electrostatic discharge etc. This problem has become more serious as the display resolution and brightness has increased. Polarized UV alignment method as non-contact LC alignment method also has been researched for long time but has been difficult to displace the rubbing process as weak anchoring energy and low reliability of material. But, Ion beam alignment technology can use conventional polyimide (PI) that stability is proved as the alignment layer, and have advantage that can overcome various kinds shortcoming of rubbing method [3,4].

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Address correspondence to Soo Young Choi, LCD R&D Center, Boe Hydis Technology Co., Ltd, Ichon-si, Gyeonggi-do, 467-701, Korea (ROK). E-mail: sychoi@boehydis.com

In this paper, we investigated the electro-optic properties of TFT-LCD panels applied ion beam alignment technology for PI alignment layer in comparison with that by conventional rubbing process. We could confirm a possibility as alignment technology of mass production.

EXPERIMENTAL

The material of LC alignment was used polyimide, made by JSR Corporation. the polyimide was printed on the TFT and color filter substrate by using APR plate and cured at 230°C. And then Ar ion beam was exposed for LC alignment. The major parameters of ion beam alignment are incident angle, exposure time, stage speed, ion beam current and energy, etc. In this investigation, the ion beam was exposed by changing the ion beam energy and exposure time. The ion beam incident angle is fixed on 15 degree. The ion beam exposed substrates were assembled in anti-parallel. The LC for FFS mode was injected into the assembled panel in vacuum. The fabricated panels are our product under mass production for medical application, which is 20.8″ QXGA monochrome panel of AFFS technology. The comparative panel was also fabricated equally except using conventional rubbing process of LC alignment.

RESULTS AND DISCUSSION

Table 1 is the result of the electro-optic properties of TFT-LCD modules applied ion beam process and conventional rubbing as polyimide alignment technology respectively. Both alignment methods show the nearly same electro-optic characteristics. Figure 1 shows the voltage-transmittance curves and Figure 2 is the contour of viewing angle

TABLE 1 The Results of Electro-Optic Properties of TFT-LCD by Using Ion Beam and Rubbing Method

EO characteristics		Ion beam	Rubbing
Chromaticity	x	0.286	0.297
White	y	0.295	0.300
Bright max [cd/m^2]		859.9	885.3
View Angle	H	>170	>170
(CR > 10)	V	>170	>170
Response time [msec]	Tr	8.53	9.81
	Tf	14.39	13.82

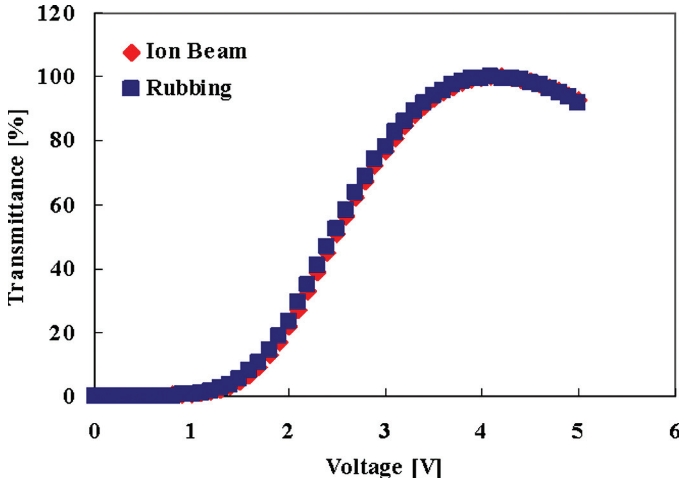


FIGURE 1 Voltage-transmittance curves in two different alignment method of polyimide.

measured with ELDIM's EZContrast. As above results, in spite of both alignment method have different alignment mechanism each other, the same electro-optic properties appear. We could confirm that it is possible that ion beam alignment technology as alignment method of polyimide alignment layer.

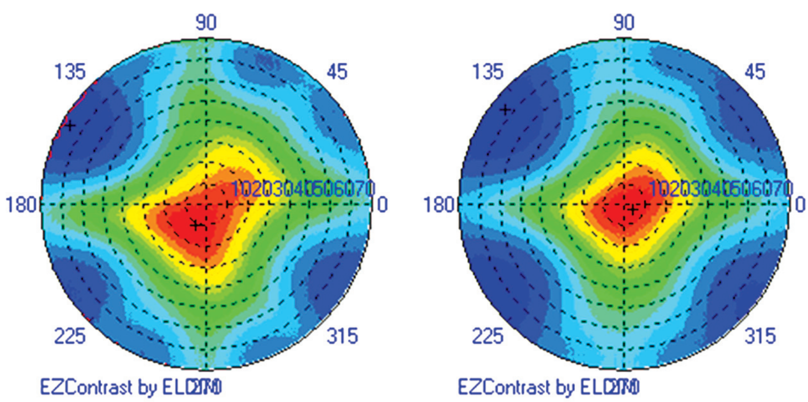


FIGURE 2 Characteristics of the viewing angle of panel with (a) rubbing and (b) ion beam process.

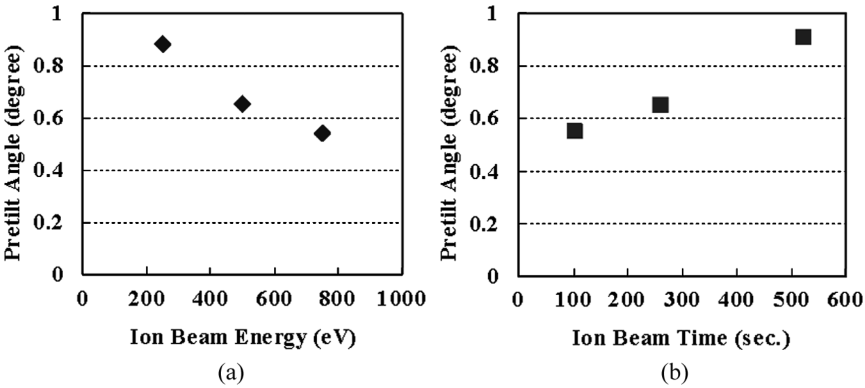
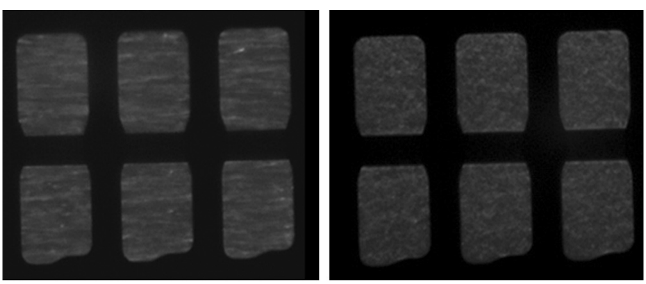


FIGURE 3 Pretilt angle measured as a function of (a) ion beam energy and (b) ion beam exposure time.

We confirmed the alignment properties of polyimide layer treated with ion beam and rubbing. Pretilt angle was measured by crystal rotation method. First, we confirmed the change of pretilt angle by ion beam energy and ion beam exposure time (Fig. 3). As the ion beam energy is increased, it looks tendency that pretilt angle is decreased and as to ion beam exposure time, could confirm reverse tendency. Generally, the incident angle of ion beam is the main parameter for the pretilt angle. But, ion beam energy and exposure time also can control the alignment property. Figure 4 is the polarizing optical microscope (POM) results of LC texture of panels processed by rubbing and ion beam alignment method. In case of panel which is controlled with rubbing methods, it will be able to confirm much light leakage because of scratch by the rubbing cloths. But it was shown very



(a) (b)

FIGURE 4 Microphotograph of the LC texture in the pixel of panel with (a) Rubbing and (b) ion beam process.

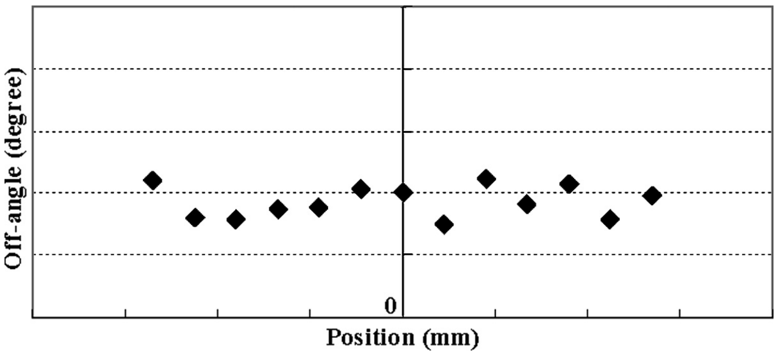


FIGURE 5 Off-angle distributions of ion beam.

uniform LC alignment in ion beam aligned panel by pixel photographs. This ion beam alignment does not damage in polyimide surfaces as non-contact alignment method. We confirmed contrast ratio of the panels where it had become alignment with the above-mentioned two methods. It was expected that contrast ratio of ion beam treated panel will be higher than rubbed panel because this panel has no scratch like that of mechanical rubbing. But the measurement data was similar to. There are many factors that affect contrast ratio of TFT-LCD panels. But all panels of this investigation were equally processed except polyimide alignment method, ion beam process or rubbing. Therefore this is because of error of ion beam alignment. The incident angle of ion beam in the plane (off-angle) was related with twist angle of panel. The off-angle of ion beam was measured by using ion beam monitor. As shown in Figure 5, off-angle of ion beam was missed from original direction, 0 degree. Because in FFS mode, aligned substrates were assembled in anti-parallel, contrast ratio is decreased as off-angle is increased. We corrected off-angle from the ion beam monitoring data by rotating substrates and we could improve the contrast ratio about 30 percents.

In case of ion beam treated LCD panel, the image sticking could be serious because the ion beam could break and change a chemical bond of polyimide. But, the result shows very good characteristics of image sticking. After 1hr aging, image sticking pattern was disappeared within 15sec. The image sticking pattern is 5×5 check.

CONCLUSIONS

We have fabricated AFFS mode 20.8″ QXGA monochrome TFT-LCD for medical application by using the ion beam alignment technology

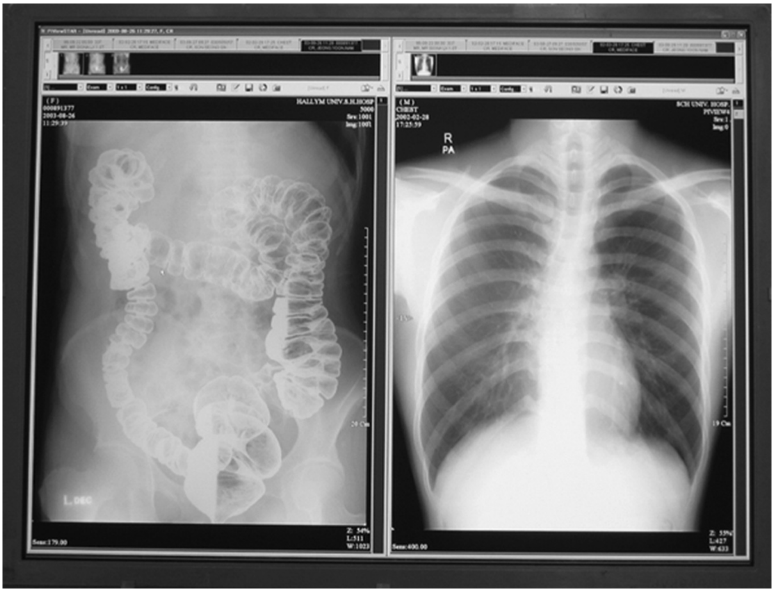


FIGURE 6 Photograph of AFFS mode 20.8″ QXGA monochrome TFT-LCD for medical application using the PI and ion beam alignment technology.

on the polyimide film in Figure 6. The Contrast ratio was improved than that of rubbing technology and it was shown the more uniform image quality. Ion beam alignment technology is very useful for high-end application products with high contrast ratio, high transmittance, and high image quality.

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