Two domain TN structure with stable TN boundaries

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Abstract

On the half area of a pixel, pretilt angle was decreased by UV radiation and two domain TN was induced by the pretilt difference. In this structure, ITO slit was made inside pixel electrode on the TFT substrate to stabilize domain boundaries. The result shows that this structure is more resistant to outside stress and unwanted domain deformation is prevented.

1. Objective and background

Two domain TN shows better viewing angle compared to TN and is brighter than other wide-viewing angle modes. Various methods were proposed to make 2 domain structures [1-4], one of which is the change of the pretilt size of alignment layer by UV radiation[4]. Due to the splay structure of high and low pretilt angles, LC alignments are more easily affected by fringe field, compared to conventional TN. So occurrence of reverse-tilt domain should be precisely controlled to reduce light leakage from disclination line. For this purpose, ITO slit was newly made along the border of UV radiation area to stabilize domain boundaries.

2. Result

We made two domain TN by radiating UV light partially to PI alignment layer of each pixel (Fig.1). Typical 14.1" XGA module was used. Alignment layer and LC were materials used for mass-production. Non-polarized UV light was radiated from the normal direction through UV mask. UV mask pattern was horizontal stripes of half pixel pitch. Pretilt of radiated and non-radiated regions were measured to be about 1 and 4 degree. Reverse-twist domain was prevented by the selection of LC and alignment layer.

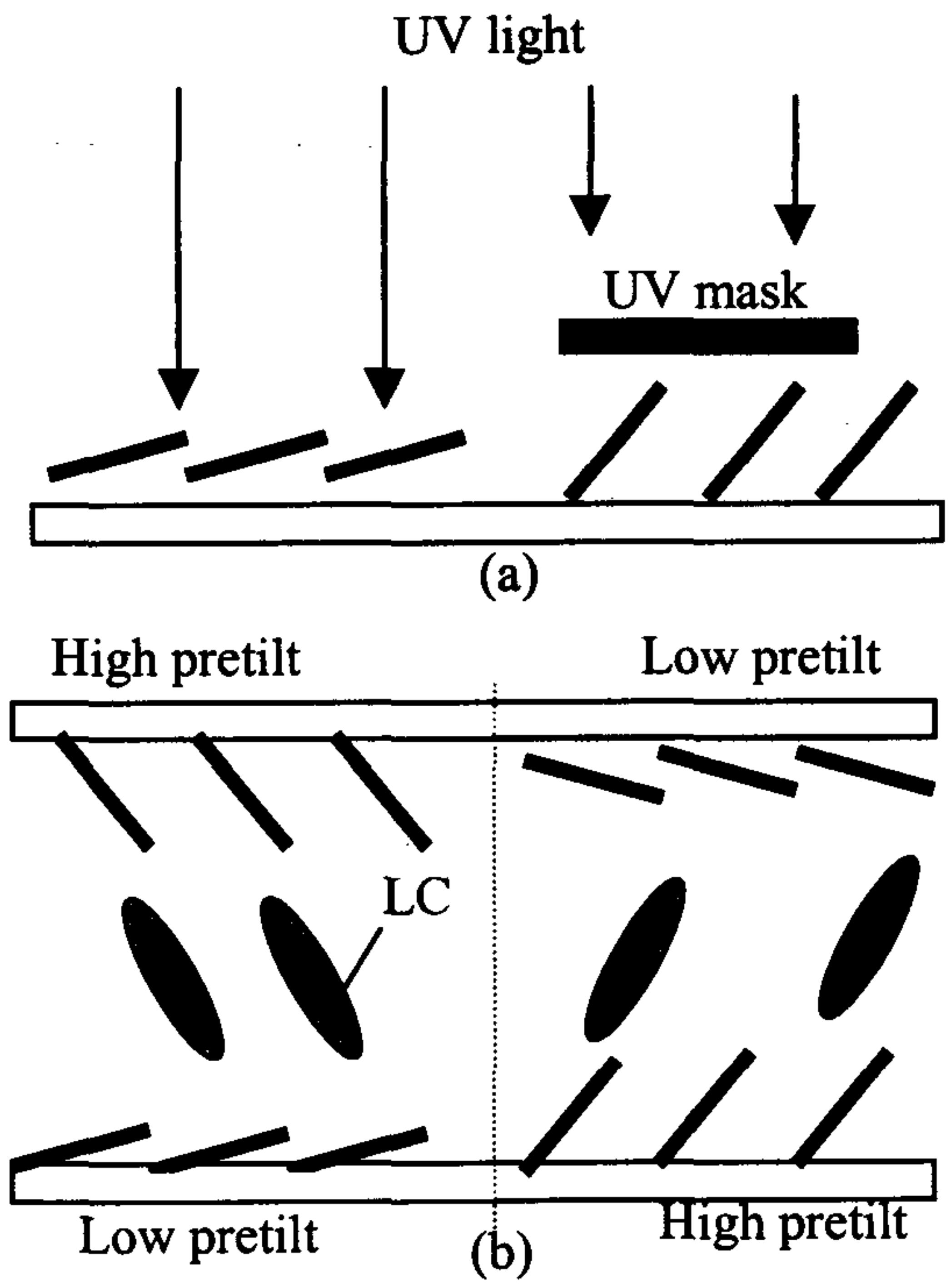
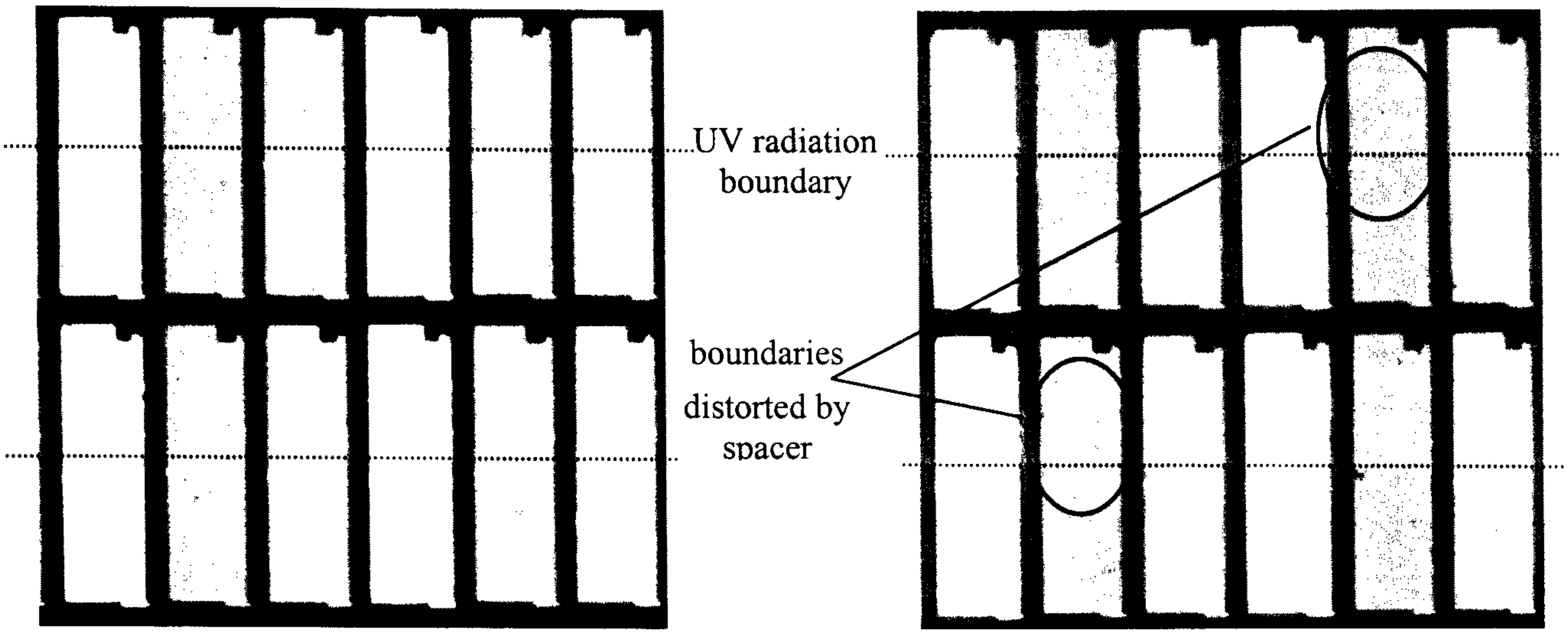


Fig. 1. Two domain TN generation by pretilt difference (a) UV radiation and (b) LC configuration

Fig.2 shows pictures of pixels. Due to the interaction between the alignment layer and the fringe field of pixel edge, domain boundary at the center of the pixel is not a straight line[5]. Moreover, spacers near the UV border tend to deform the domain boundaries. This problem due to spacers become more serious

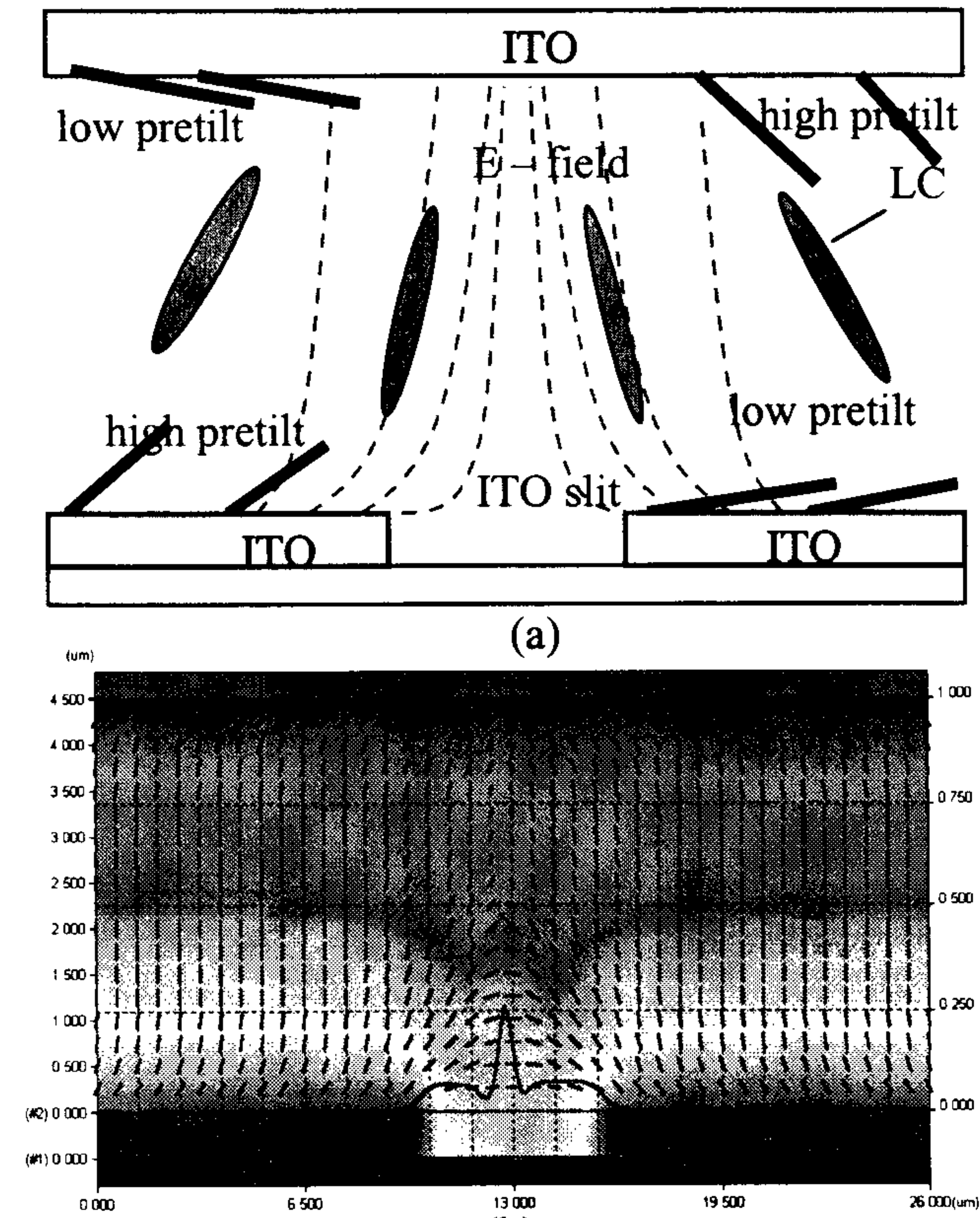


(a) (b)

Fig.2 Shape of domain boundaries (a) before stress and (b) 5minutes after stress

when stress is applied. Once distorted, domain boundary near spacers does not recover to original shape until pixel data is turned to full white.(Fig.2b) Maximum contrast ratio of this sample was measured to be less than 60. Therefore, to block light leakage completely, width of Black Matrix should be much wider than width of disclination line.

As the data voltage increases, the effectiveness of LC alignment decreases, relative to that of E-field. To solve these problems, stabilization by fringe-field of ITO slit was considered. Alignment by deformed E-field will be dominant at high voltage and alignment by rubbing will be more effective at low voltage. If LC alignment directions by fringe-field near pixel silt and by the rubbing are selected to be the same, the LC alignment can be made to be more stable for the whole data voltage range.(Fig.3) Firstly, this idea was confirmed by a commercial simulator. The result shows that alignment layer of low pretilt on the lower substrate has little effect on the direction of LC alignment and LC aligns as expected.



(a)

(b)

Fig. 3 LC alignment by the combined effect of pretilt alignment and fringe field by ITO slit

Secondly this configuration was tested on 14.1 XGA module, Slit of 6μm thickness and 50 μm length was made on each pixel ITO of lower substrate. The position of slit was located on the UV radiation border. During the operation, disclination lines on the center of pixel were observed to remain on pixel slit.(Fig. 4) Slant curve still remained near the end of slit, but we think that this can be removed by optimizing the shape of ITO slit. Even when stress was applied, domain boundary restored to pixel slit in less than a minute.(Fig.4) And spacers induce little

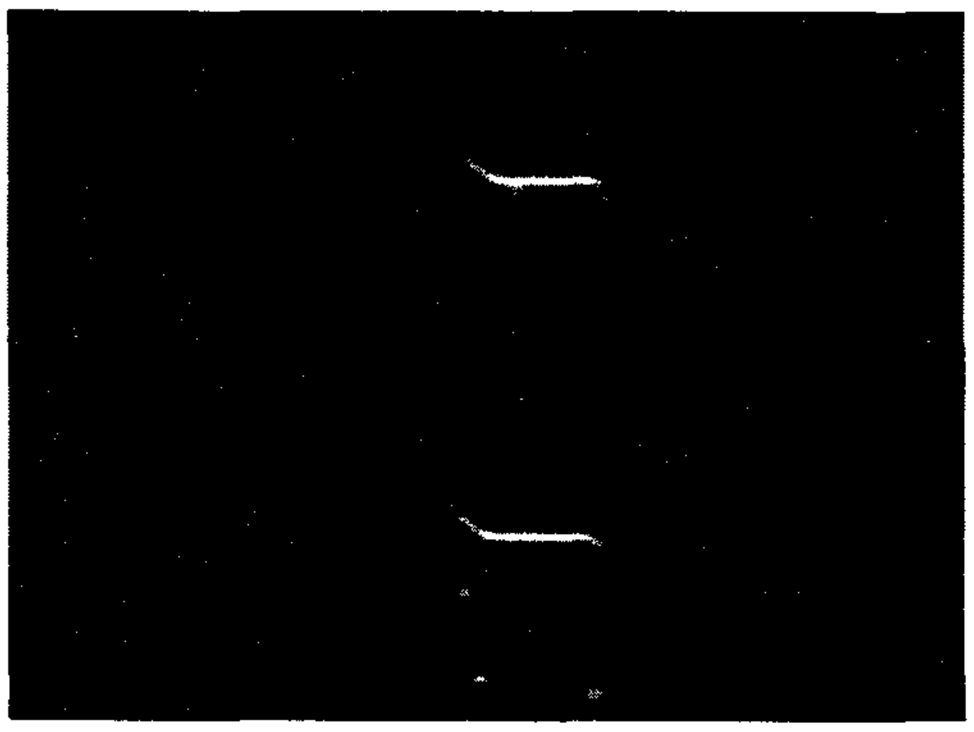


Fig. 4 Picture of pixels of which domain boundaries are stabilized by ITO slit (1 minutes after stress)

perturbation on the position of domain boundary compared with the pixel of no ITO slit.(Fig.4)

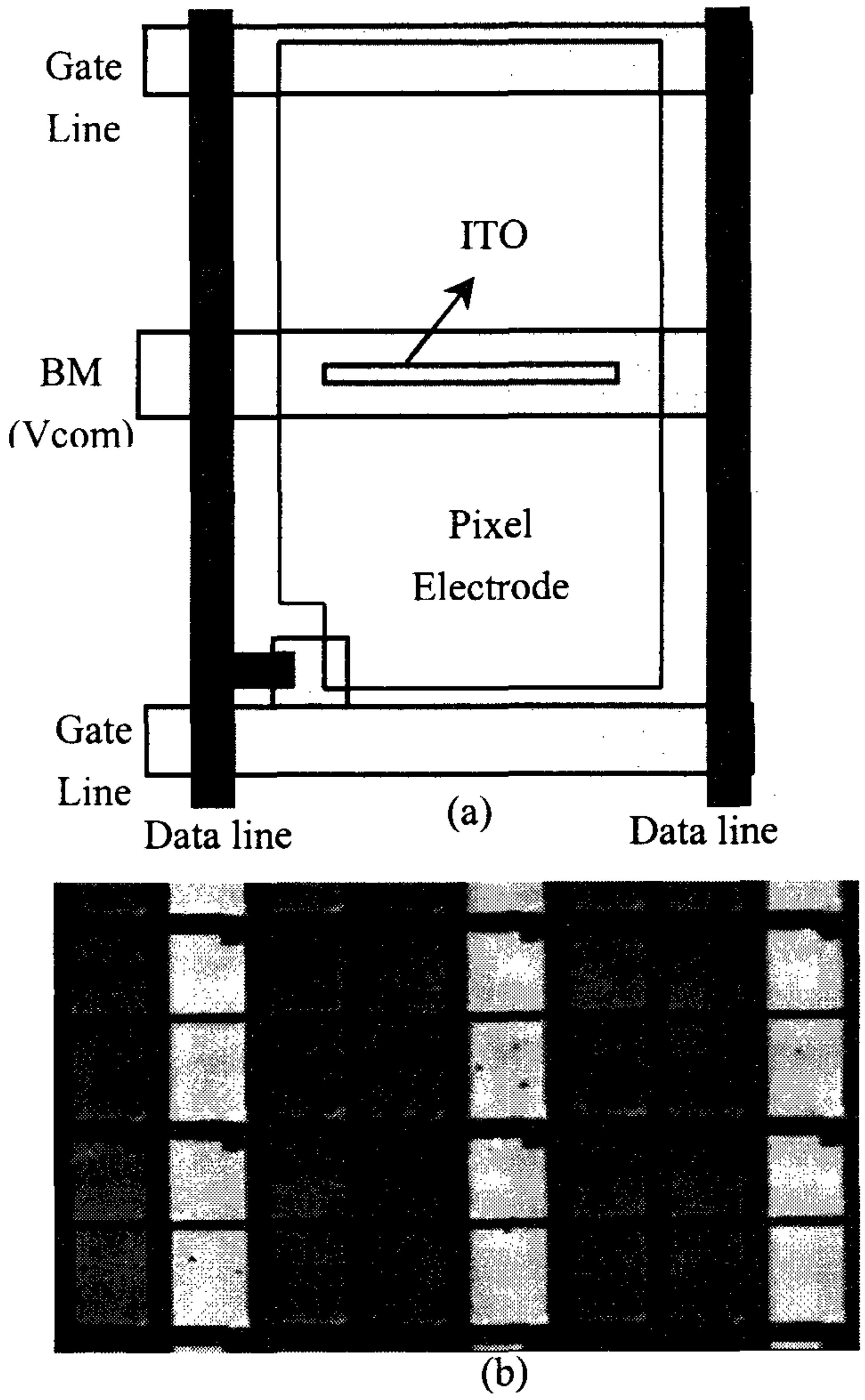


Fig.5 Modified pixel structure of ITO slit and metal BM (a) Pixel layout (b) picture of pixels

Finally, to cover disclination line at the center of pixel, metal BM of 10 μm thickness was added on the lower substrate by modifying the gate mask. And common voltage was applied to this metal BM.(Fig.5) Additional E-field by common electrode does not destroy the stability of the LC domains. The size of BM corresponds to ~4% decrease of total brightness. Contrast ratio improved to the value of more than 100. However, new disclination lines was observed near the gate line and maximum contrast ratio of this LC panel was still less than conventional TN. We think that better contrast can be obtained by further modification near the gate lines.

3. Impact

We made and characterized 2 domain TN by the difference of pretilt angle. ITO pixel was modified by adding slit. Domain boundaries were stabilized by deformed E-field of the slit and stress resistance increased. As a result, thin BM is effective enough to block the light leakage and decrease of aperture ratio was minimized.

4. References

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