Chapter 6

Conclusions

6.1 Conclusion

As the population of internet and wireless communication, transflective LCDs become an important display technology. Light weight, high brightness, high resolution, high readability and good color saturation are major concerns. Although several configurations of transflective LCDs have been proposed for applications, low aperture ratio, low backlight utilization and different color saturation still are critical issues. Therefore, a novel transflective LCD consists of a backlight collective component, micro-lens array, was proposed to overcome the issue of lower backlight utilization. The proposed structure can collect the incident backlight and focus it on the aperture of reflective regions. By designing properly, the minimum spot size of collected backlight can be obtained, thus, the aperture size of reflective regions can be reduced as small as possible. As a result, higher backlight efficiency can be achieved while maintaining the reflective light efficiency.

Micro-lens can be classified into circular and lenticular-types. Because lenticular-lens can provide higher fill factor, lenticular-lens structure was adopted as backlight collective component in the following design and fabrication. In simulations, the divergent angle of incident backlight affects the spot size focused on the aperture of reflective regions, thus, a 15° of divergent angle of directional backlight, which consists of a upper reversed prism sheet and a bottom grooved light guide, was proposed. Utilizing a light source with divergent angle of 15°, the lenticular-lens structure was optimized. The optimized radius and diameter of lenticular-lens structure and aperture size of reflective regions were 66um, 68um and 22um, respectively. From calculations, the light efficiency enhancement in transmissive and reflective modes can be increased by a factor of 1.9 and 1.3, respectively.

Using conventional fabrication processes to fabricate the proposed structure, misalignment between the lenticular-lens structures and the aperture of reflective regions will be caused and then results in light leakage to decrease contrast ratio, thus, a fabrication process including self-aligned exposure was proposed to minimize the alignment error and fabricate lenticular-lens structure. In initial fabrications, a conventional UV light source was used to expose photoresist. Because of its higher collimation, diffraction effect was occurred to produce undesirable shape of lenticular-lens structure, thus, a UV light source with small divergent angle was utilized in the following fabrications. From fabrication results, exposure time was a dominant parameter to determine the thickness of lenticular-lens structure. Therefore, the thickness of lenticular-lens structure was firstly controlled to be around 9um by tuning exposure time and then different aperture sizes of reflective regions were used to obtain the designed structure. Finally, the lenticular-lens structure whose radius and diameter and aperture size of reflective regions are 66um, 68um and 27um, respectively, was demonstrated.

Because the angular distribution of fabricated directional backlight was not similar to the designed angular distribution, the light enhancement was not noticeable. However, the angular distribution of OMRON backlight was closer to the designed one, thus, OMRON backlight was used as light source to evaluate the performance of lenticular-lens structure. From measurement, 1.4 of gain factor can be obtained, it can be concluded that the lenticular-lens array can collect backlight and enhance the backlight efficiency. Although the factor is not as high as the designed value, it can be further increased by reducing the loss in reflection and increasing the fill factor of lenticular-lens array. Finally, a lenticular-lens array with higher fill factor was demonstrated by using the compensated reflective regions.

6.2 Future Works

According to the experimental results, the proposed backlight collective component, lenticular-lens array, can effectively enhance the light efficiency of transflective LCD. However, the gain factor is not as high as the designed value due to undesirable fill factor and the loss caused by reflection. Therefore, several methods were proposed to solve these issues in the following sections.

6.2.1 Solution of Fill Factor

Fill factor will affect the amount of collected backlight and then resulting in the influence of light efficiency enhancement. Therefore, compensated reflective regions were demonstrated to increase the fill factor of lenticular-lens array. According to the experimental results (Fig. 5.21), a fill factor of 0.92 was obtained. Nevertheless, the radius of lenticular-lens array fabricated by compensated reflective regions did not achieve the optimized value. Although the shape of compensated reflective regions is similar to the regular reflective regions, the energy profile illuminating on the photoresist would be redistributed and then the exposure conditions need to be readjusting. Therefore, in the future work, the fabrication condition, exposure time, will be controlled to obtain a higher fill factor of lenticular-lens structure with radius of 66um, diameter of 68um by using a compensated reflective regions.

6.2.2 Solution of Loss in Reflection

The loss caused by reflection is also a reason to decrease the light efficiency enhancement. In general, anti-reflection film is coated on the surface of lens to reduce the loss caused by reflection. However, in our configuration, the lenticular-lens structure is composed of photoresist so that the adhesion between anti-reflection film and the lenticular-lens structure becomes a critical issue. Before passing through the aperture of reflective regions, the collected backlight will transmit several materials with different refractive index, such as photoresist and glass, thus resulting loss in reflection. Therefore, Reactive Ion Etching (RIE) technology, which can transfer the patterned photoresist to substrate, was proposed to overcome the issue of loss in reflection. As shown in Fig. 6.1, RIE can transfer the lenticular-lens structure onto glass substrate. As a result, the loss caused by reflection can be reduced.

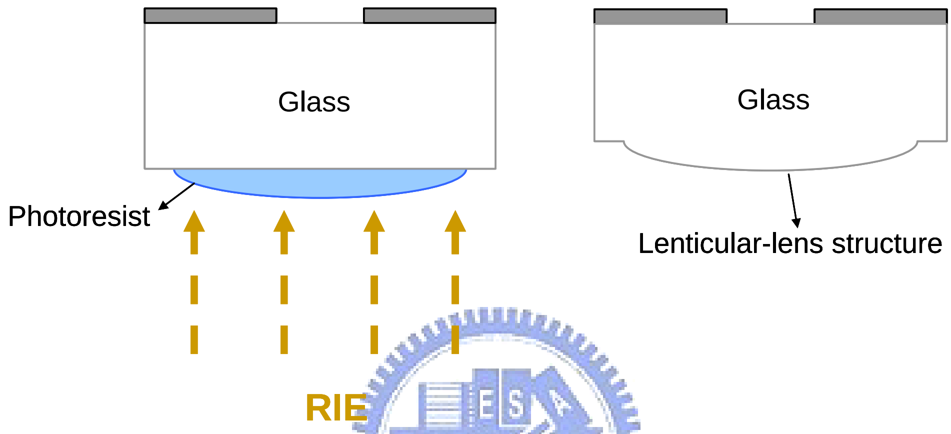

Fig. 6.1. Illustration of Reactive Ion Etching (RIE) technology to transfer patterned photoresist onto glass substrate