LCD GLARE AVOIDANCE USING A SURFACE-RELIEF DIFFRACTIVE OPTICAL ELEMENT

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Reflective liquid crystal displays (LCD), such as those used in low power portable products, rely on reflected ambient light to illuminate the display. The position of the display, in relation to the light source and the viewer, that provides the brightest image is also the position of glare from the front of the display. This makes the display unreadable and consequently it is viewed at a position just off glare, the position which is not as bright. This approach intentionally mis-aligns the glare light from the useful light reflected from the display to improve considerably the brightness and readability.

Motorola has previously developed reflective holographic approaches[1,2] and transmission holographic approaches[3,4] to improve the glare avoidance in the displays for our products. Reflective Holographic Optical Elements (HOE) are not compatible with reflective LCD's with internal reflective electrodes. In the case of external reflectors, the additional thickness introduced with the rear glass substrate causes a significant amount of incident light to pass through two different color filters, thus reducing the brightness. Most color LCD manufacturers have moved the reflective component of the display inside the cell to alleviate this problem. However, the manufacturing and processing requirements currently prohibit the implementation of the reflective holographic optical element inside the liquid crystal cell.

Transmission HOE's are a viable method, however, they have several limitations. Manufacturing the holographic transmission films is expensive, the light control is limited, there is a significant amount of noise inherent with mass manufacture, and it is not as environmentally stable as some plastics.

The approach taken here is the combination of a conventional reflective (or transflective) LCD that has a transmissive diffractive optical element on the front viewing side of the display that provides glare avoidance by steering the incoming light away from where refraction would guide it. On the path out, however, it does not significantly deflect the light further. The net effect of the diffractive optical element and reflective LCD is to cause the reflected light to be off the glare angle. The diffractive optical element may also diffract light through a defined angular range at each location on the film, thus simulating a diffuser (light scattering element) as well as a beam steering optic (Figure 1).

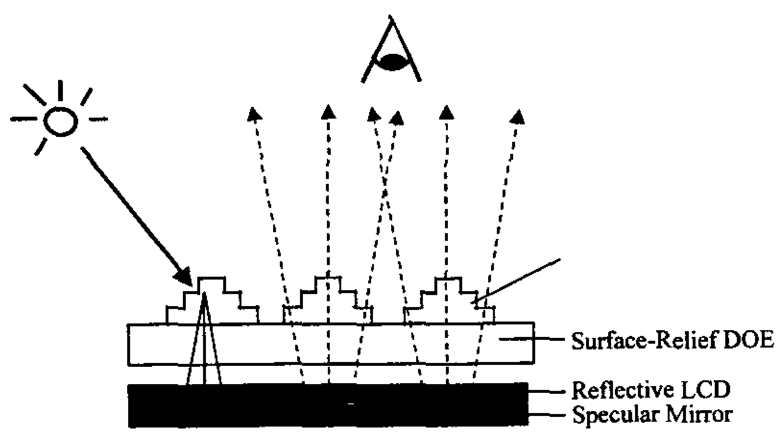

Fig. 1 An example of a diffractive optical element steering and diffusing incident light in conjunction with a reflective color LCD.

Some of the limitations of holographic films can be overcome by computer design of surface-relief diffractive optical elements (DOE's). Examples of methods used for making volume transmission holograms and diffractive optical elements are shown in Fig. 2.

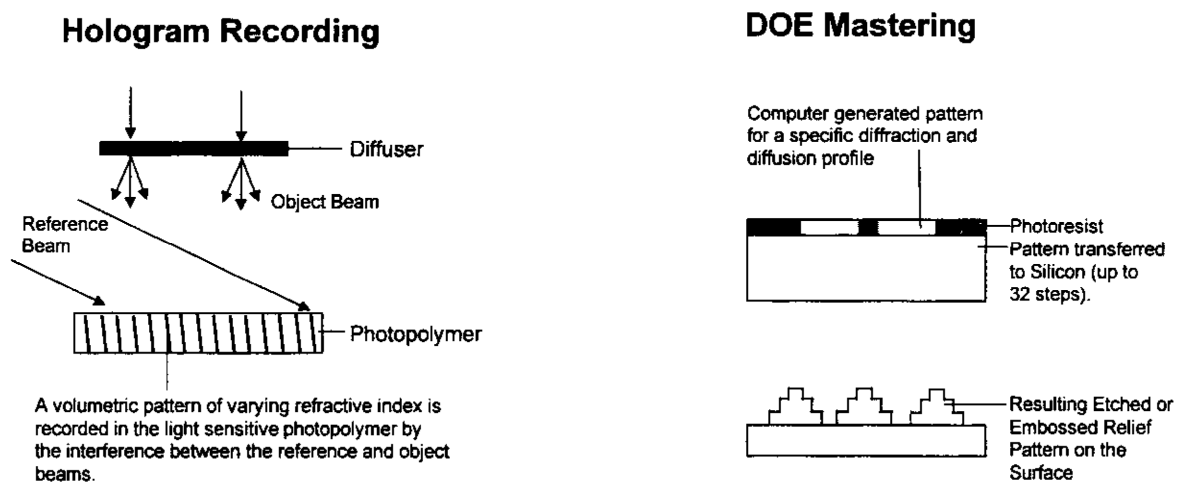

Fig. 2 Manufacturing a transmission hologram and diffractive optical element for LCD glare avoidance in reflective or transflective LCD's.

Normally, DOE's are designed to work for a specific wavelength. For efficient LCD illumination, the beamsteering element should work for the entire visible spectrum. The DOE could be designed to work for many different wavelengths and these could be designed into the resulting etched pattern. Also, variations of the surface profile through processes such as differential etching could produce different edge profiles (for example, rounded edges instead of a step profile). By using computer software, the design could also be incorporated to use more of the incident light than a volume transmission hologram and provide more precisely tailored diffusion.

DOE's can also be copied by high resolution surface embossing which is common in the industry in the use of embossed holograms such as those on the VISA card. These embossing techniques are very efficient, fast, and cheap compared to the optical copying method involved with holograms. The resulting device could be made in a clear plastic that is cheaper and has less haze or noise than traditional holographic materials.

REFERENCES

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