Holographic phase gratings in back- and frontlights for LCD's

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Abstract

The light and energy-efficiency of classical liquid crystal displays is notoriously poor due to the use of absorption-based linear polarisers and colour filters. For instance, the light efficiency of PVAL polarisers is typically between 40 and 45 % and the colour filters have a typical efficiency below 35 % which results in a total light and energy-efficiency of the display below 10 %.

In the past, a variety of polarizers were developed with an enhanced efficiency in generating linearly polarized light. Typically, these polarizers are based on the polarisation-selective reflection, scattering or refraction of light i.e. one polarisation direction of light is directly transmitted to the LCD/viewer and the other polarization direction of light is depolarised and recycled which results in a typical efficiency for generating linearly polarized light of 70-85 %. Also, special colour filters have been proposed based on chiral-nematic reactive mesogens which increase the efficiency of generating colour. Despite the enormous progress in this field, a need persists for improved methods for generating polarized light and colour based on low cost optical components with a high efficiency.

Here, the use of holographic phase gratings is reported for the generation of polarized light and colour. The phase grating are recorded in a photopolymer which is coated onto a back- or frontlight for LCDs. Typically the recording is performed in the transmisson mode or in the waveguiding mode and slanted phase gratings are generated with their refractive index modulation at an angle between 20^{o} and 45^{o} with the normal of the substrate. It is shown that phase gratings with a high refractive index modulation and a high efficiency can be generated by a proper selection of the photopolymer and illumination conditions. These phase gratings couple-out linearly polarized light with a high contrast (> 100) and the light is directed directly to the LCD/viewer without the need for redirection foils. Dependent on the type of phase grating, the different colours are coupled-out at a slightly different angle which potentially increases the efficiency of classical colour filters. Moreover, the phase gratings are completely transparent in direct view which opens the possibility to use them in frontlights for LCDs.

Holographic polarization gratings posses a periodic pattern in the polarization state of light (and not in the intensity of light). A periodic pattern in the polarization direction of linearly polarized light is obtained upon interference of two circularly polarized laser beams. In the second part of the lecture, it is shown that these periodic polarization patterns can be recorded in a linear photo-polymerizable polymer (LPP) and that such an alignment layer induces a period rotation in the director of (reactive and non-reactive) liquid crystals. By a proper design, optical components can be produced with only first order diffraction and with a very high efficiency (> 0.98). It is shown that these diffraction gratings are potentially useful in projection displays with a high brightness and energy efficiency