照明系統在提升
液晶顯示器之影像品質的應用

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摘　要

隨著多媒體資訊與網際網路時代的來臨，消費性電子產品不斷朝向可攜式化、輕薄短小化、省電、低功率輸出的方向前進。液晶顯示器(Liquid crystal display)由於具有薄型化、重量輕、多樣性、高可讀性及低耗電量等優點，遂成為目前相當重要的顯示應用技術。液晶顯示器為非主動發光元件，需仰賴內建的照明系統，即所謂的背光模組，來產生影像。然而，液晶顯示器的照明系統仍面臨了許多的問題，諸如影像亮度(brightness)、影像均勻度（uniformity）、與系統光利用效率（light utilization efficiency）等。為了改善這些問題，本論文提出了三種不同的照明系統應用於多樣的液晶顯示器，使其影像品質獲得提昇。本論文並發展利用微機械加工、電子束微影、射出壓印及射出成形等各種製程技術來開發照明系統中的微結構及光學薄膜等元件，有效的減化其製程步驟並提昇元件之光學功能。

傳統液晶顯示器的照明系統仍存在著光學結構複雜及影像的光學品質不佳等缺點，而本論文研究成功的開發出「具偏極化的背光模組(Polarized backlights)」，整合次波長光柵(Sub-wavelength grating)及微溝槽(Slot strucutres) 在導光板的前後兩面，使光源具有偏光轉換(Polarization conversion)及再利用(recycling)的特性，以大幅提升顯示器影像之亮度、均勻度及光利用效率，同時也簡化了結構的複雜。此外，我們成功的開發出利用光的選擇性全反射(Selective totally internal reflection)之偏極化背光模組，此背光模組是利用微機械加工

(Micro-machining)與射出壓印(Embossing)的技術將結構製作於塑膠薄膜上，再將此薄膜貼附於導光板的表面，其優點在於可簡化偏極化背光模組的製程與組裝。

在論文中，不論是利用次波長光柵或是光的選擇性全反射，主要的目的都在改善照明系統的光效率，因此，本論文的第三部份，我們提出一種時間多工(Time-multiplexed)之立體影像顯示器，利用具「方向性背光模組(Directional backlights)」搭配可快速切換的液晶面板，以產生立體影像，來進一步改善影像品質，時間多工立體影像顯示器與現有液晶顯示器的技術相容，同時，此種架構不需使用視差遮罩(Parallax barrier)，也不會有光使用效率與解析度的損失，且沒有對位上的問題，利用可快速切換的方向性背光模組，我們將觀賞者左右眼間的影像干擾(Image crosstalk)減少到 10%以下，觀賞者也可以小幅地移動其前後觀賞位置，此外，我們同時或是依序地點亮左右邊的光源，更提供了二維/三維(2D/3D)影像切換的功能。

論文中所展現的偏極化及方向性背光模組大幅提升了液晶顯示器的影像品質，同時，也提供了系統設計者更多的設計創意空間與技術來開發更佳的照明系統；而結合光學設計與微光學元件的製程技術，也將使液晶顯示器的照明系統，在未來多樣且新穎的應用領域中，具有益形重要的地位。

Illumination Systems for Image Performance Enhancing on Liquid Crystal Display Applications

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Abstract

In the era of multimedia, internet and mobile communication, features of portable, thin, light weight, and power saving are required for the consuming electronic products. Liquid crystal displays (LCDs), which have the remarkable merits of planar structure, low cost, design flexibility, readability and low power consumption, have become a key technology of the display applications. LCDs are non-emissive devices, so that built-in illumination systems (the so-called LCD backlights) become indispensable for producing display images. Nevertheless, LCD illumination systems still have several issues like low brightness, poor uniformity, and inadequate light utilization efficiency.

In this thesis, three novel illumination systems were designed to further alleviate the concerned issues; thereby improving image performances of LCDs. Fabrication technologies, including micro-machining process, e-beam lithography, embossing/extrusion technology, and injection molding are adopted to develop the micro structures and optical foils of illumination systems in a simpler procedure and enhance optical functionalities of devices.

Conventional LCD illumination systems have a space to be further improved in terms of complex optical structures and inadequate optical performances. Therefore, we proposed “polarized backlights” which integrate the sub-wavelength grating and slot strucutres on both sides of lightguides to achieve polarization conversion and

recycling of light for much enhanced brightness, uniformity of the images and light utilization efficiency. At the same time, the complex structures can be simplified. Another approach to implement polarized backlight systems via selective totally internal reflection (T.I.R) was also discussed in this thesis. We utilized micro-machining processes and embossing/extrusion technology to fabricate the designed patterns on a thin transparent plastic foil, then, laminated it on a clear lightguide for easy fabrication and assembling.

Either the sub-wavelength grating or selective T.I.R is used to improve the optical efficiency of illumination systems. In the third part of this thesis, a time-multiplexed display composed of a directional backlight and a fast switching LC panel was proposed for generating the stereoscopic image. Time-multiplexed stereoscopic displays are compatible with LCDs. In addition, degradation of light utilization efficiency and image resolution can be avoided by leaving out the parallax barrier. At the same time, critical alignment is less demanded. Using the fast switching and directional backlights, the image crosstalk between left and right eyes is reduced less than 10%. As a result, the viewer can slightly move his viewing positions. 2D/3D compatibility is also provided by switching two light sources simultaneously or sequentially.

The demonstrated polarized backlights and directional backlights highly enhanced image performances of LCDs. In addition, the research work provides a potential route to explore more creative aspects and technologies in illumination systems. Moreover, by further combining the optical design and the fabrication of micro-optical devices, LCD illumination systems shall become more and more significant for variety of novel applications in the near future.