Chapter 1

Introduction

1.1 Planar-integrated free space optics (Planar optics)

Planar-integrated free-space optics (PIFSO), also called planar optics, has been researched during the past two decades for various applications.[1],[2] Generally, planar optics refers to an optical device with a planar substrate and multiple free-space optical elements located on the surfaces of the substrate. With the planar optics, the required longitudinal dimension of an optical system can be reduced sufficiently. Using the compatible micro-electro-mechanical-systems (MEMS) technique, planar optics can be further miniaturized and exhibits the superiority in compactness. Consequently, planar optics can be a potential optical platform to perform optical functions compactly and efficiently.

1.2 Flat panel display (FPD)

In an era of multimedia, display technologies experience tremendous growth. Particularly, the flat panel displays (FPDs), such as liquid crystal displays (LCDs), organic light-emitting diodes (OLEDs), and plasma display, become more and more popular within recent few years. Not only the worldwide transition to high-definition digital TV (HDTV) provides a phenomenal opportunity for the display industry, but also the potable displays such as mobile phones and entertainment displays keep breathtakingly growing. However, the state-of-art FPDs should possess the characteristics of high brightness, high contrast ratio, large color gamut, good light uniformity, and low power consumption. Therefore, numerous researchers and engineers in the display community are eager for designing various novel devices for improving the optical performances of FPDs.

1.3 Motivation and objectives of this thesis

Planar optics enables a compact platform for optical devices and systems, such as beam-deflectors, fan-out modules, and multi-processors.[3],[4] Particularly, the planar feature of planar optics is inherently compatible to the rapid-growing display: FPDs. Take LCDs, the mainstream of FPDs, as an example. The structure of LCDs is layered and the operation can be regarded as the synergy of multiple planar optical components, as shown in Fig. 1-1. [5] As shown in Fig. 1-2, since more than 1/4 expense of backlight lies in films, along with other compensation films and polarizers, about 40% of the LCD cost goes to planar optical components. [5] Apparently, the principle components of LCDs and the light extraction films of other FPDs can be related to planar optics, as illustrated in Fig.1-3. Consequently, the planar optics, which meets the needs of economical fabrication and flexible design, is a potential cost-effective optical component for improving FPD optical performance.

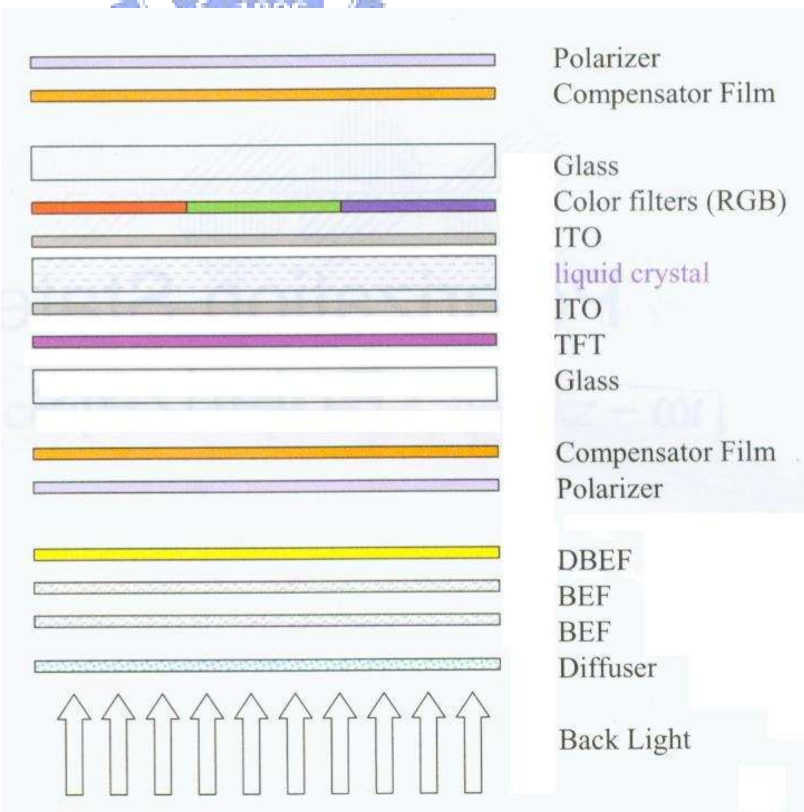

Fig.1-1 Optical components in LCDs.

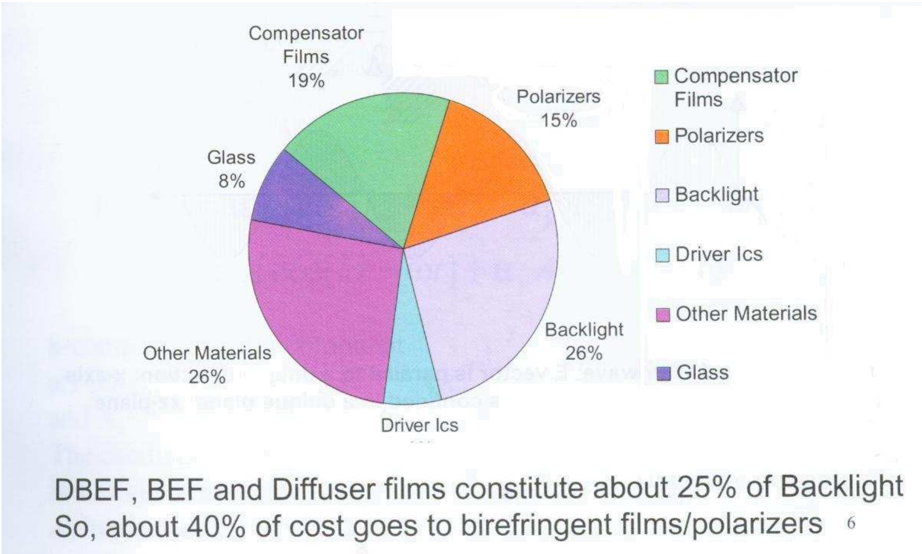

Fig. 1-2 Material and component cost of LCDs.

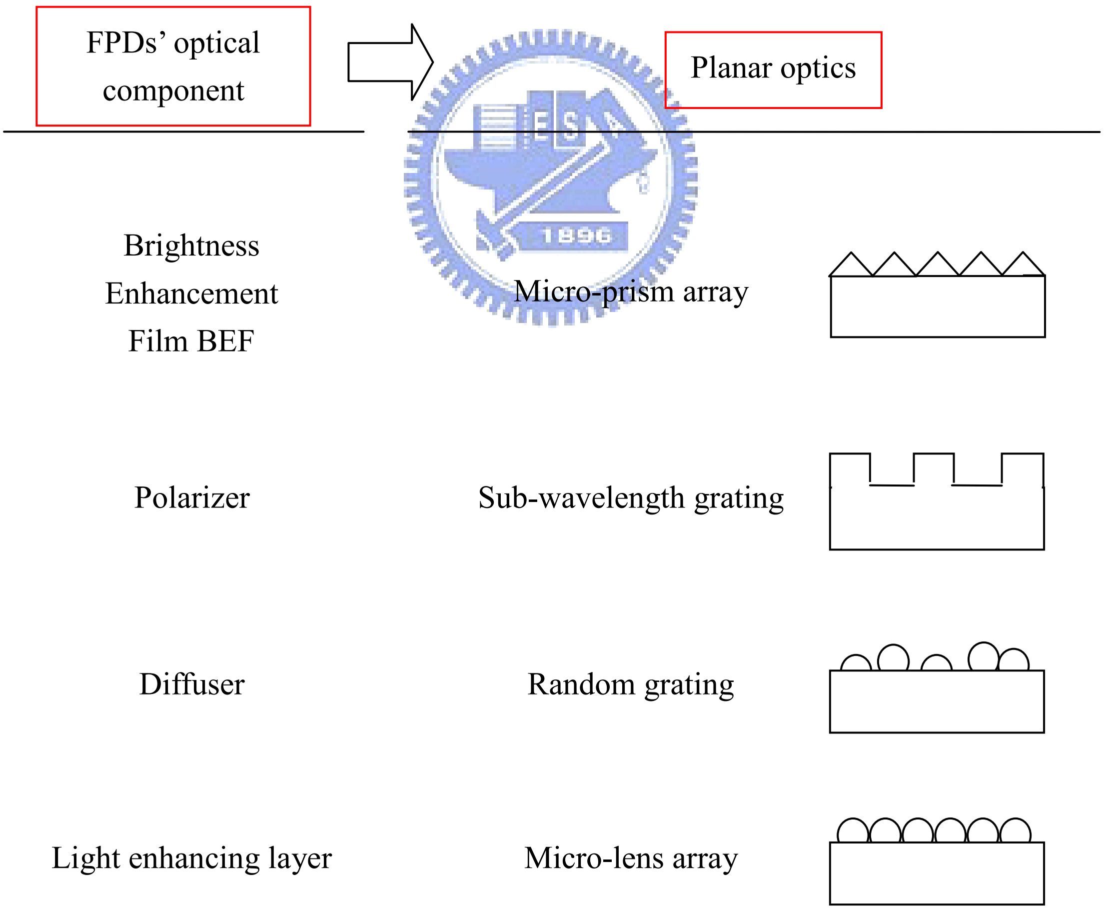

Fig. 1-3 Optical components in FPDs that correspond to planar optics.

The thesis attempts to study the design and fabrication of planar optics and, then, to apply the planar optics to display components for improving performances of FPDs. First, the theory and the operation principle of planar optics are reviewed. Since metal coating is the most common approach to fabricate reflectors in planar optics, the reflectance of metal and adhesion to substrate are then discussed. Next, planar optical components, including planar zoom module, array light-enhancing layer and patched wire-grid polarizer, are designed and investigated to demonstrate the diverse applications of planar optics.

1.4 Organization of this thesis

The rest of this thesis is organized as follows. In **Chapter 2**, the theory and the operation principle of planar optics are described based on the formula proposed by J. Jahns et al. Reflective and diffractive types of components are discussed separately. Then, the fabrication techniques are summarized. One primary issue of planar optics, insufficient out-coupling efficiency resulting from the metal coating, is investigated and solutions are presented. In **Chapter 3**, a planar zoom module (PZM) is proposed for beam-scaling application.[6] The design of PZM is described and simulation results are presented. Then, two planar optical components in FPDs: array light-enhancing layer (ALEL) and wire-grid polarizer (WGP) are investigated. The ALEL with a multi-zoned shape is utilized for enhancing the light efficiency of OLEDs;[7] the modeling, fabrication, measurement and considerations are discussed in **Chapter 4**. In **Chapter 5**, WGP patches, which can be used to improve the polarization conversion efficiency in large size LCDs, are investigated according to the effect of seams between adjacent WGP patches. This effect is modeled using geometric optics or rigorous coupled wave analysis (RCWA) method, which is dependent on the size of seam. If the seam size is much larger than the wavelength, geometric optics is applied;

otherwise, RCWA is utilized to model the WGP. The modeling strategies, results and discussions are also presented. Finally, conclusions of this thesis and recommendations for the future works are given in **Chapter 6**.

1.5 References

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