Chapter 6

Applications

6.1 Integrated Lightguide Equipped with Polarization Conversion

As the application for thin-film-transistor liquid crystal displays (TFT LCDs) grows, bright and uniform backlight modules become essential. A conventional backlight module consists of a cold cathode fluorescent lamp (CCFL), a lightguide, a reflective sheet, a diffuser, prism sheets, and a reflector, as shown in Fig. 6.1. The rays from the CCFL impinge upon directly or are reflected into the lightguide by the reflector. By the scattering of white ink or microstructures on the bottom surface of the lightguide, the rays are diffused and emitted from the emitting plane with a large angle relative to the normal direction. The prism sheets are used to adjust the emitting direction toward the normal direction of the emitting plane. A polarizer was then stuck on the backlight unit to generate polarized light which can be modulated by the liquid crystal. However, the optical efficiency of the conventional backlight module is very low due to the lack of P-S conversion. A conventional absorbing polarizer subsequently absorbs over 50％ of light energy. In addition, the complicated structure hinders compact packaging.

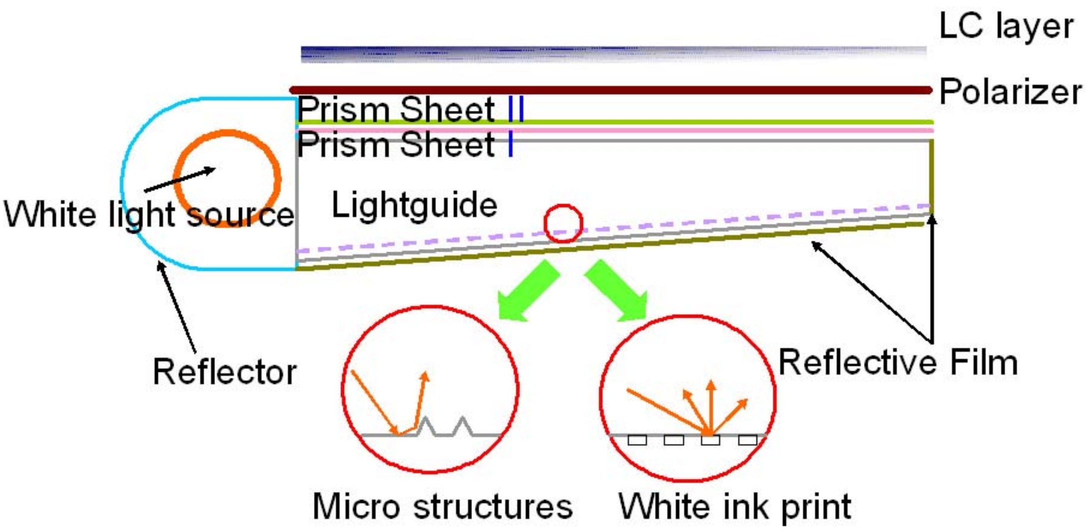

Fig. 6.1 Schematic layout of a conventional backlight module.

An integrated lightguide equipped with polarization conversion for novel backlight module was designed to increase brightness, uniformity and light efficiency for LCD illumination, as shown in Fig. 6.2. The integrated lightguide consists of light source, lightguide with sub-wavelength grating and slot structures on its top surface and bottom surface, a quarter wave plate and a reflective sheet. When unpolarized rays are coupled into the lightguide, they are guided by the slot structures and reflected by the reflective sheet. As the reflected rays are incident on the sub-wavelength grating, only P rays are transmitted while S rays are reflected. By passing through the quarter wave plate twice, S rays are converted into P rays. Therefore, all the emitting rays emitting from the lightguide have the same polarization, which is required for LCD illumination. Light efficiency is then improved due to fully utilizing both P and S rays.

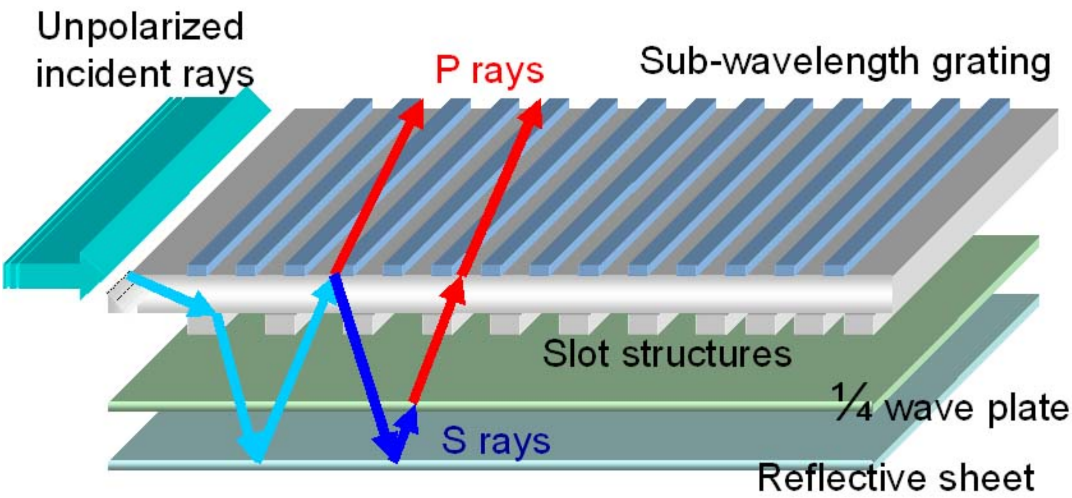

Fig. 6.2 Schematic layout of an integrated lightguide.

6.2 Liquid Crystal Projection System

Liquid crystal projector is a popular system of displaying large image. A conventional liquid crystal projector is shown in Fig. 6.3. Light is emitted from the lamp, and two dichroic mirrors are used to separate three primary colors, i.e. red, green and blue. Polarizers are then utilized to make the three primary colors polarized, which can be modulated by the LCD and generate three monochromatic images. After recombining by the X-prism, a full color image is projected by the projection lens.

Plastic polarizers, which are ordinarily of low heat-resistance, are used in the conventional LCD. However, the temperature inside a projector is always extremely high due to the high power lamp, which may deform the plastic polarizer. The deformation of the polarizer will cause a serious loss of light. For this reason, we have to employ a higher heat-resistant polarizer, e.g. sub-wavelength grating, to replace conventional plastic polarizer for generating polarized light.

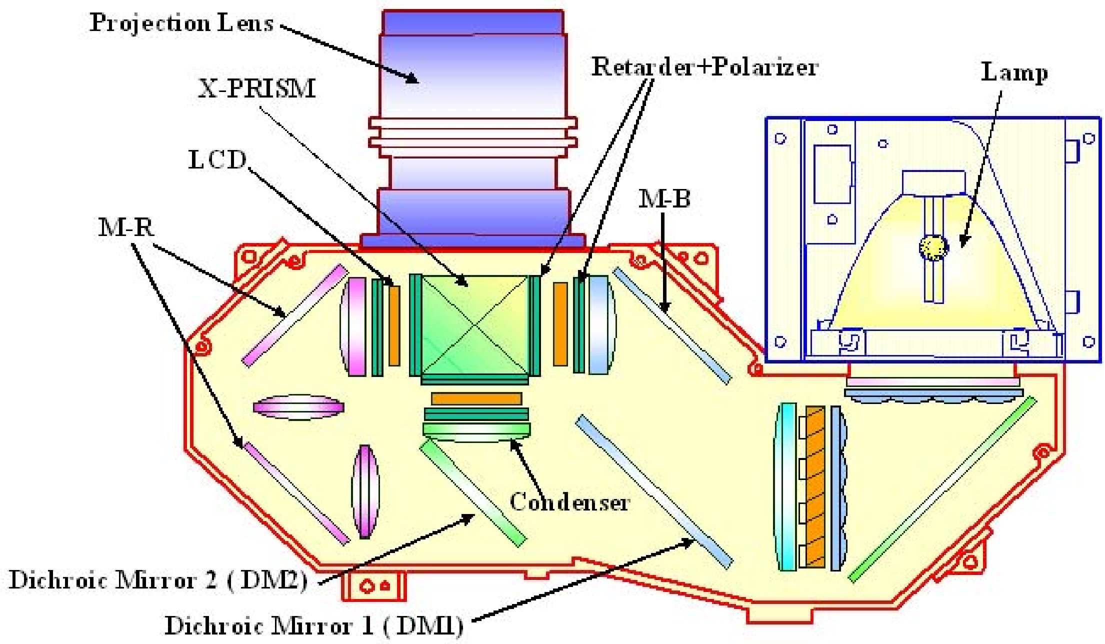

Fig. 6.3 Schematic layout of an liquid crystal projector.

6.3 Read-Write Magneto-Optical Data Storage System

The sub-wavelength grating can be also applied in a read-write magneto-optical data storage system. A conventional pickup head is shown in Fig. 6.4. Laser light is emitted from a semiconductor laser. A diffraction grating is utilized to divide laser light into three beams, one for reading data, others for tracking. Two mutually perpendicular polarized lights are spatially separated after being incident on a Wollaston prism. One of the linearly polarized lights is then passed through a quarter wave plate and changes its linear polarization into elliptical polarization. After reading data from the optical disk, the elliptically polarized light will pass through the quarter wave plate again and change its polarization into linear polarization perpendicular to the original one which will be reflected by Wollaston prism. The polarized light with data is then detected by photodiodes. The advantage of using polarized light for data-reading is that it can maximize signal-to-noise ratio of the data detection.

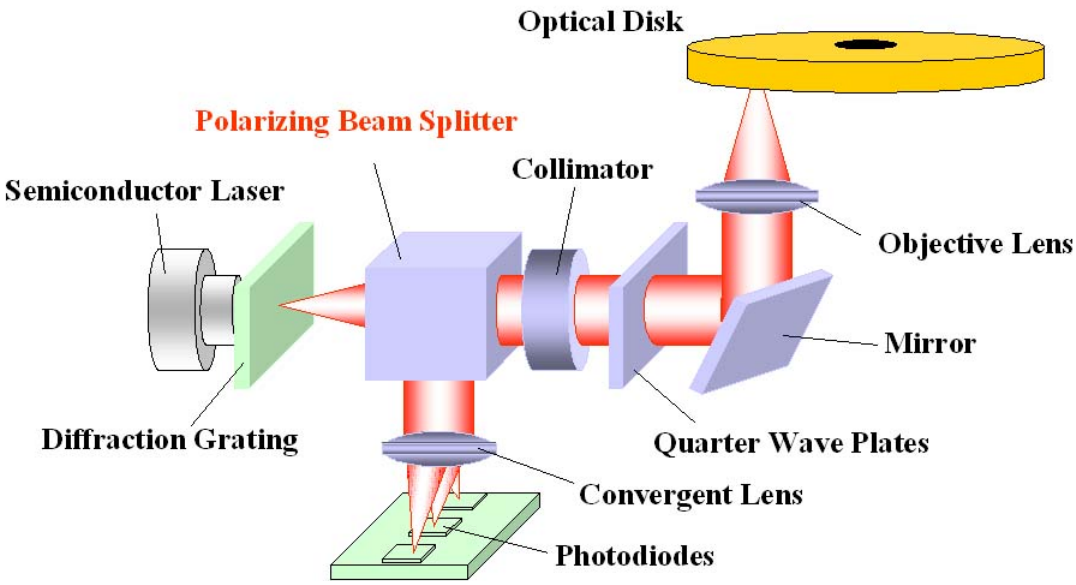

Fig. 6.4 Schematic diagram of a pickup head.

The size and mobility of the pickup are usually limited by the optical system. Among the optical system, the Wollaston prism provides a high efficiency of light separation. Nevertheless, it is quite large and heavy which causes the pickup head bulky and dull. Thus, the large and heavy Wollaston prism can be replaced by a sub-wavelength grating, which is much thinner and lighter, to reduce the size and weight of the read-write magneto-optical data storage system.

6.4 Other Applications

In addition to the examples mentioned above, the sub-wavelength grating can be applied in systems where a PBS or a polarizer is an essential element for separating two orthogonally polarized lights. Such as free-space optical switching networks, polarization-selective computer-generated holograms (CGHs), polarization-sensitive antireflection surfaces, guided-mode resonance effects, narrow-band filters, polarization-based imaging system, etc..