

A full resolution autostereoscopic 3D display based on polarizer parallax barrier

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A full resolution autostereoscopic three-dimensional (3D) display prototype is developed. It is composed of a time division thin film transistor liquid crystal display panel with an optical controlled birefringence liquid crystal polarization switch and a polarizer parallax barrier. Fast driving circuits operating at 120-Hz frame rate are fabricated. The 3D images on the display have the same resolution as the corresponding two-dimensional images, which is significantly different from conventional parallax barrier autostereoscopic 3D displays having degraded 3D image resolution.

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The realization of a three-dimensional (3D) display for mankind is a long fostered dream. With the development of autostereoscopic 3D displays, by which observers see glasses-free 3D images, the dream has come within reach recently^[1-4]. The parallax barrier method having superior characteristics is one of the common autostereoscopic displays. However, it has some disadvantages such as half resolution or worse resolution for 3D images compared with two-dimensional (2D) images and so on^[5,6]. A parallax polarizer barrier autostereoscopic 3D display system has been developed for projection displays, however it can not be applied to direct-view displays^[7]. In this letter, we propose an autostereoscopic 3D direct-view display system using a time division flat display panel with a polarization switch and a polarizer parallax barrier. The 3D images on the system have the same resolution as the corresponding 2D images.

The autostereoscopic 3D display system, as shown in Fig. 1(a), consists of a flat display panel, a polarization switch, and a polarizer parallax barrier. The polarizer parallax barrier includes a striped half wave plate, a diffusion screen, and a striped polarizer. Figure. 1(b) shows the operation principle. The horizontal and vertical arrows in Fig. 1(b) represent horizontal and vertical polarization directions of the image light, respectively. In order to analyze the system, a dashed line is virtually added to separate the system into two parts. The polarization direction of the image light from the display panel is supposed to orient vertically.

The upper part of Fig. 1(b) shows the system operating for the left-eye image display (denoted by “L”), where the polarization switch is “off” and the polarization direction of the left image is rotated to horizontal after the image light passes through the polarization switch. Then the image light passes through the striped half wave plate and is separated into the odd and even columns with orthogonal polarization directions. The striped polarizer acts as a parallax barrier for the odd and even columns of the image light, respectively. The image light forms some left eye position areas as

shown in Fig. 1(b) and a viewer’s left eye can only see the left images with full resolution as 2D images.

The lower part in Fig. 1(b) shows the system operating for the right-eye image display (denoted by “R”), where the polarization switch is “on” and the polarization direction of the right images does not change. The striped half wave plate and the striped polarizer have the same function to right images as the left images, so the right image light forms some right eye position areas at a distance of two eyes

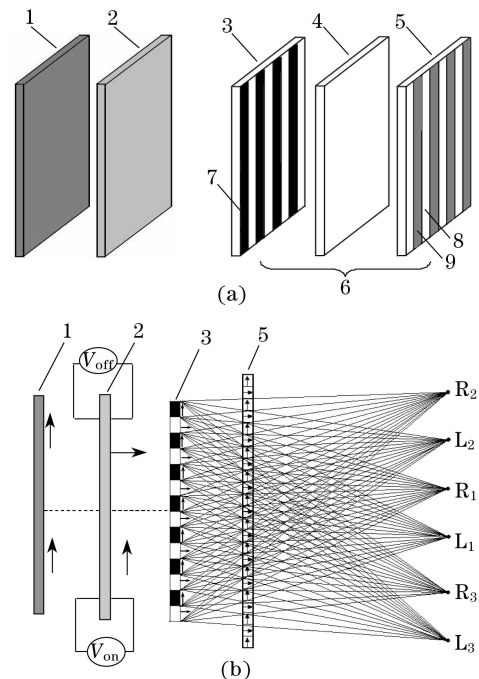


Fig. 1. (a) Structure and (b) operation principle of the full resolution autostereoscopic 3D display system based on polarization switch and polarizer parallax barrier. 1: liquid crystal display panel; 2: polarization switch panel; 3: striped half wave plate; 4: diffusion screen; 5: striped polarizer; 6: polarizer parallax barrier; 7: half wave plate; 8: horizontal polarizer; 9: vertical polarizer.

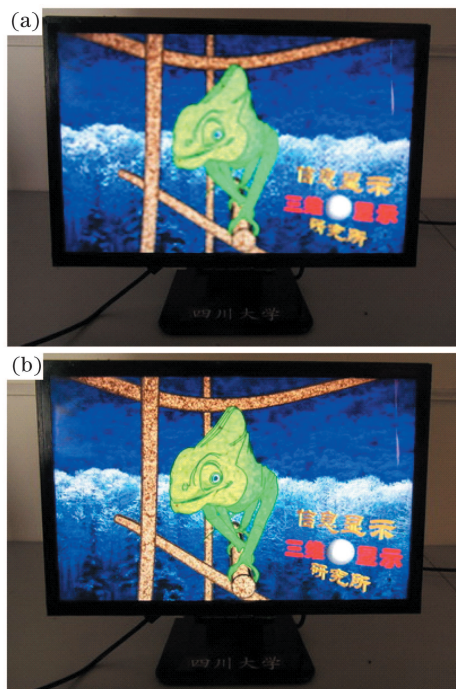


Fig. 2. 3D images. (a) The conventional autostereoscopic 3D display based on parallax barrier and (b) the full resolution autostereoscopic 3D display.

as shown in Fig. 1. Similarly, a viewer's right eye can only see the full resolution right images.

In reality, the two cases as described previously happen sequentially on the whole display panel. For the first period, the panel displays the left-eye images; and for the second period, the panel displays the right-eye images. These operations are repeated. In this method, spatial division and time division are employed simultaneously. As a result, each eye can see all pixels of images and the resolution of 3D images does not degrade, which is significantly different from conventional parallax barrier autostereoscopic 3D displays.

According to the above structure and principle, a 15-inch autostereoscopic 3D display prototype was developed. A thin film transistor (TFT) liquid crystal display panel having polarized image light was used to display the left-eye and right-eye images at a frame rate of 120 Hz alternatively. Optical controlled birefringence (OCB)

mode liquid crystal polarization switch was fabricated for fast switch. Fast driving circuits were developed for both the TFT liquid crystal display panel and the OCB mode liquid crystal polarization switch. The striped half wave plate was made from a broadband 90° twisted nematic liquid crystal cell. The striped polarizer was fabricated by litho etching method. The prototype presents stereoscopic 3D images. The optimal viewing distance is about 1000 mm, and the resolution of 3D images is 1024×768 pixels, which is the same as 2D images. The comparison between the stereoscopic 3D image on the full resolution autostereoscopic 3D display and that on a conventional autostereoscopic 3D display based on parallax barrier is shown in Fig. 2. It is obvious that the quality of stereoscopic 3D images is improved a lot.

In conclusion, we have developed a full resolution autostereoscopic 3D display prototype. The system includes a time division TFT liquid crystal display panel, an OCB mode liquid crystal polarization switch, and a polarizer parallax barrier. Fast driving circuits operating at 120-Hz frame rate are fabricated for both the display panel and the polarization switch. The 3D images on the prototype have the same resolution as the corresponding 2D images, which is significantly different from conventional parallax barrier autostereoscopic 3D displays having degraded 3D image resolution.

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