CONTRAST ENHANCEMENT FOR AN ELECTRONIC DISPLAY DEVICE BY USING A BLACK MATRIX AND LENS ARRAY ON OUTER SURFACE OF DISPLAY

[0001] This patent application claims the benefit of priority from U.S. Provisional application No. 60/074,922 filed Feb. 17, 1998.

BACKGROUND OF THE INVENTION

[0002] The present invention concerns electronic display devices and, in particular, electronic display devices having features which enhance the contrast of images displayed on the devices.

[0003] Electronic displays are devices that produce patterns of light in response to electrical signals. Flat panel displays typically are fabricated with top and bottom substrates that contain the display materials. Display devices in which the display materials generate light are known as emissive displays. One type of display materials that are used in electronic displays is organic light emitting diode (OLED) materials. Other types of emissive displays include plasma displays, field emissive displays and electroluminescent displays. Another type of display device only passes or reflects light. Displays of this type are known as light-valves.

[0004] For both emissive and light valve displays, it is important that the displays be bright and yet exhibit strong contrast. Contrast is one of the most important performance parameters of a display. It is an important factor in the ability to use information that is displayed, and it plays a strong role in buyer preference. The simple definition is that the contrast of an emissive display is the ratio of the useful light (e.g. the signal) emitted by the display to the unwanted light coming form the display (e.g. the noise). In all practical environments, the unwanted light is dominated by reflected light from the ambient.

[0005] Reflected light can be either specular or diffuse. Specular reflection is particularly annoying because the viewer sees a reflected image of the source of the ambient light superimposed on the image, and because it is concentrated at the specular reflection angle it degrades the image contrast at that specific angle. Diffusely reflected light superimposes a haze over the displayed image that reduces contrast, limits the range of viewable gray scale and consequently limits the information content detectable by the viewer.

[0006] It is desirable to minimize the reflected light from a display surface in order to maximize the performance of the display device. It is also desirable to have any reflective component that remains to be diffusive rather than specular

SUMMARY OF THE INVENTION

[0007] The present invention is embodied in a display device having features which enhance the contrast of displayed images.

[0008] According to one aspect of the invention, the display device has active elements which define a relatively small aperture and a black matrix positioned above the plane of the active elements.

[0009] According to another aspect of the invention, the display device is a tiled display device and the black matrix is implemented on the surface of an optical integrator plate on to which the individual tiles are mounted.

[0010] According to another aspect of the invention, the display device includes an electronics section and a display section which are joined by an adhesive and the adhesive is dark-colored to absorb ambient light which is transmitted through the display section.

[0011] According to another aspect of the invention, the display device has a pixel structure which defines a plurality of spaced sub-pixel elements which, together, define an aperture of less than 50%

[0012] According to yet another aspect of the invention, the display device includes a plurality of lenses which act to concentrate light provided by the active elements into an area smaller than the area of the active elements. The lenses may be reflective, refractive or a combination of reflective and refractive.

[0013] According to another aspect of the invention, the lenses are formed with relatively steep sides wherein adjacent lenses form a light trap which inhibits reflection of light which enters the area between lenses.

[0014] According to yet another aspect of the invention, the area between the lenses is coated with a dark-colored material to form a black matrix structure.

[0015] According to another aspect of the invention, the pixel structure includes a metal row electrode, the active element, a transparent column electrode and a transparent front panel, wherein the portions of the metal row electrode which may be visible from the viewer side of the display are coated with or deposited upon a dark-colored material.

DETAILED DESCRIPTION

[0016] **FIG. 1** is an exploded perspective drawing of an exemplary display structure which may use contrast enhancements according to the present invention.

[0017] **FIG. 2** is an exploded perspective drawing which illustrates an alternative display structure that may use contrast enhancements according to the present invention.

[0018] **FIG. 3** is a back plan view of a tile having the structure shown in **FIG. 1**.

[0019] **FIG. 4** is a back plan view of a tile having the structure shown in **FIG. 2**.

[0020] **FIG. 5** is a front-plan view of four tiles of a tiled display, each tile having the structure shown in **FIG. 1**.

[0021] **FIG. 6** is a front-plan view of four tiles of a tiled display, each tile having the structure shown in **FIG. 2**.

[0022] **FIG. 7** is a partial front plan view of a single color pixel format for a display device having the structure shown in **FIG. 2**.

[0023] **FIG. 8** is a partial front plan view of a an alternative single color pixel format for a display device having the structure shown in **FIG. 2**.

[0024] **FIG. 9** is a front plan view of a tile having the structure shown in **FIG. 2** which illustrates an exemplary