be straight, or curved (convex, concave, or combinations of both), but straight and parallel to the plane of the display is not the preferred shape because it contributes to specular reflection

[0101] The combined shapes of the sides of the lenses **1910** and the apertures of the lenses together with the properties of the light emitted by the active emission region of the pixel determine the distribution of light that is emitted from the display. As is well know, by selecting the lens material based on its refractive index and by suitably designing the reflecting structures on the sides of the lenses, emission of light from the lens aperture at angles up to plus and minus 90 degrees horizontally and vertically is possible. It may be desirable to design the lens structures **1910** to tailor this distribution in a way which concentrates the displayed light in the likely viewer directions. This provides some gain in observed brightness relative to the display surface without the optics. This tailoring of the light distribution may also improve the perceived contrast of the display device for these preferred directions.

[0102] The right side of **FIG. 19** and **FIG. 20** show examples of bottom emitting OLED displays. Each of these examples consists of two structures, an electronics section **102** and a display section **104**, each composed of multiple layers. The display section consists of a glass substrate **120** on which are deposited active display materials **1912'** including transparent hole injecting electrodes (e.g. ITO), OLED material(s), electron injecting electrodes (e.g. calcium), and contact layer(s) **1922**. Light is emitted by the OLED material(s) and exits the display through the transparent electrode and glass substrate (this is termed a bottom emitter structure because the light exits through the substrate for the OLED material). The electronics section **102** consists of an insulating substrate **110** with contact layer(s) **1920** that match the contact layers **1922** on the display layers, electrical vias **112** that connect these contacts to conductors on the other surface, and an IC(s) **134**. The electronics section **102** simultaneously functions as a barrier layer for sealing the display, a back substrate for the display, and as an electrical circuit board. These two structures form a display by joining them with a material **1924** that simultaneously makes electrical connection between the matching contacts on the display and circuit board structures, encapsulates the OLED materials (sealing them from oxygen and water vapor), and adheres these two structures together.

[0103] The material used to join the display and circuit board layers typically is made with epoxy resins, other two part heat or photo curable adhesives, moisture catalyzed adhesives, and thermoset or thromoplastic polymers that are loaded with conductive additives such as conducting particles, particles with a conducting coating, conducting filaments, conducting flakes, and conducting filaments and flakes that are magnetic. These materials are not typically black.

[0104] This material may be made black by adding a black pigment or dye. Carbon black is an example of a suitable black pigment. If carbon black is added at too high a concentration it will make the sealing material too conductive and interfere with making contacts. Concentrations from 0.1% to 10% (based on weight) effectively absorb light but do not make the sealing material too conductive. Black organic dyes do not add conductivity. These may be added in concentrations that make the sealing material a good light absorber.

[0105] These black sealing materials may be applied as a fluid or paste, but may also be supplied as a preformed sheet or as a powder. Examples of processes for applying the seal/contact materials can include printing (silk screen, inkjet, contact, roller, and others); dispensing from a syringe or similar dispenser; or doctor blade coating. Actual mechanical bonding results from the adhesive nature of the seal materials. Examples of processes for activating adhesion include catalysts, heat, or electromagnetic energy, or alternatively, physical processes such as ultrasonic welding and pressure may be used. The asymmetric electrical properties are imparted to these seal/conductor materials by performing an asymmetric unit process. Examples of asymmetric processes for achieving asymmetrical conductivity are application of pressure, material flow, electric field or magnetic field alignment, and electromigration.

[0106] As described above with reference to **FIGS. 1 and 2**, because the electron injecting electrodes are located between the viewer and the black sealing material, these electrodes may contribute to specular reflections which locally reduce the contrast of the display. Reflections from these electrodes can be minimized by minimizing their area or by coating the viewer side of these electrodes black. Minimizing their area simultaneously maximizes the area of the black material available to absorb ambient light. Coating the viewer side of the electron injecting electrode black can be accomplished by first depositing a black coating in all areas where metal electrodes will be later deposited.

[0107] Although the invention has been described in terms of exemplary embodiments, it is contemplated that it may be practiced as generally described above within the scope of the appended claims.

What is claimed:

1. A display device having a plurality of picture element (pixels), comprising:

a pixel structure for the plurality of pixels which pixel structure defines a pixel area including an active pixel area and an inactive pixel area in which only the active pixel area provides light and in which the ratio of the active pixel area to the pixel area is less than 50 percent;

a transparent cover plate having a outer surface and an inner surface wherein the inner surface is in close proximity to the pixel area;

a black matrix formed on the outer surface of the transparent cover plate, the black matrix defining openings surrounded by a dark colored material, the openings being aligned with the active pixel areas of the display device.

2. A display device according to claim 1, wherein the pixel area has width P including an active pixel area which has a width d_p and the transparent cover plate has an index of refraction n_{glass}, which defines a critical angle of Θc, and a thickness t_{glass} and the black matrix is formed from dark-colored stripes having a width W_m defined by the inequality $W_m \leqq P-2\ (t_{glass} \tan(\Theta c))-d_p$.