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Display Device for Wearable and Other Products

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In a watch or other display device, the functionality of the device can be enhanced by using a display that pairs a transparent organic light-emitting diode (TOLED) layer with an underlying display, with the TOLED layer being placed on top of the underlying display instead of below it. There are two main embodiments: (a) one in which the display is a liquid crystal display (LCD) or other transparent display paired with a TOLED layer, and (b) one in which an electrophoretic display such as E-Ink or E-paper is paired with a TOLED layer. Additional layers can, of course, be added in other embodiments.

Fig. 1

Fig.1 illustrates a first embodiment in which the display includes a liquid crystal display (LCD) layer. In one embodiment the LCD layer can be a seven-segment LCD layer such as a kind associated with digital watches that can display digits 0–9 and some letters. In other embodiments the LCD layer can be another type of LCD display with a greater number of segments and different display capabilities.

A transparent organic light-emitting diode (transparent OLED, or TOLED) layer is placed on top of the LCD layer. The TOLED layer is substantially transparent when inactive but emits light when active. When the transparent OLED is inactive, the LCD layer below it and whatever is being displayed by the LCD layer is visible to the user because the inactive TOLED is substantially transparent. In one embodiment the TOLED layer can have a transmissivity greater than 80%, but in other embodiments the TOLED layer can have a higher or lower transmissivity.

A reflective layer can be positioned below the LCD layer. The TOLED layer emits light in two directions: (i) toward the user and (ii) away from the user through the LCD layer. The reflective layer positioned below the LCD layer reflects downward emissions from the TOLED layer back through the LCD and through the TOLED layer to the user, brightening the display.

A touch layer can be positioned on top of the TOLED layer so that the TOLED layer is sandwiched between the touch layer and the LCD layer. The touch layer senses user touch, allowing a user to interact with and control the display. In another

embodiment, the touch capability need not be provided by a separate layer, but can instead be provided in the TOLED layer itself by integrating the TOLED and touch functions in a single layer.

Fig. 2

Fig. 2 shows another embodiment that is similar to the embodiment of Fig. 1; the primary difference is that embodiment (b) replaces the LCD layer with an E-ink or E-paper layer. E-ink is most commonly found in devices such as the Amazon Kindle reader. It has very low power consumption and has greater display capabilities than liquid crystal displays since it is not limited to small number of display segments. It also provides a high-contrast display because its whites are very white and its blacks are very black.

As in the embodiment of Fig. 1, a TOLED layer is placed on top of the E-Ink layer. The TOLED layer is substantially transparent when inactive and when active emits light. When the TOLED is inactive the E-Ink layer below it, and whatever is being displayed, is visible to the user because the TOLED layer is substantially transparent. Because the E-Ink layer is mostly white it is substantially reflective, so its use eliminates the need for the reflective layer of Fig. 1.

A touch layer can be positioned on top of the TOLED layer, so that the TOLED layer is sandwiched between the touch layer and the E-Ink layer. As before, the touch layer senses user touch, allowing the user interact with and control the display. In another embodiment, the touch capability need not be in a separate layer but can instead be integrated into the TOLED layer itself, thus eliminating the need for a separate touch layer.

Figs. 3–4

An additional feature that can be used in the embodiments of Figs. 1–2 is to use selected LEDs from the TOLED layer as a source of illumination of the underlying display layer, whether an LED as in embodiment (a) or an electrophoretic display such as the e-ink of embodiment (b). Fig. 3 illustrates this feature in an embodiment of Fig. 2 in which the touch layer has been remove, but the arrangement would be similar with a touch layer and would also be similar in the embodiment of Fig. 1.

Fig. 3 illustrates an embodiment in which LEDs from the perimeter of the TOLED layer are used to illuminate the e-Ink layer. These LEDs could be permanently on, thus always illuminating the underlying layer, or could be illuminated selectively, for instance by having a user press a button or by software upon the occurrence of some condition.

Fig. 4 illustrates some configurations of LEDs that could be used in a round display such as a watch to illuminate the underlying layer, as shown in Fig. 3. In the configuration on the left, the illumination LED form a continuous ring around the perimeter of the TOLED layer. In the configuration on the right, discrete LEDs from the TOLED layer are used instead of a continuous ring; eight LEDs are illustrated, but of course in other embodiments there could be more or less than eight.

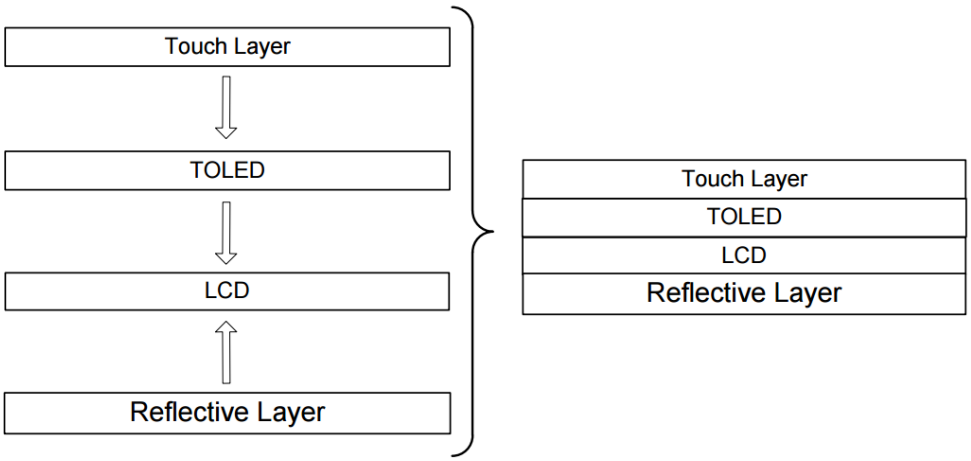
Touch Layer
TOLED
LCD
Reflective Layer
Touch Layer
TOLED
LCD
Reflective Layer

Fig. 1

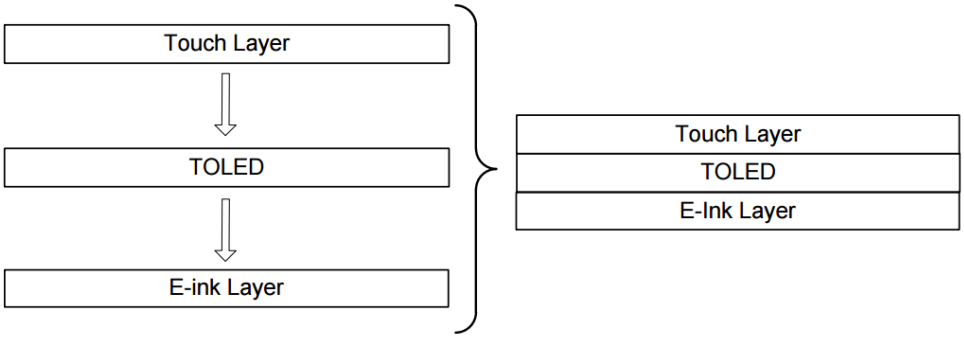
Touch Layer
TOLED
E-ink Layer
Touch Layer
TOLED
E-Ink Layer

Fig. 2

2/2

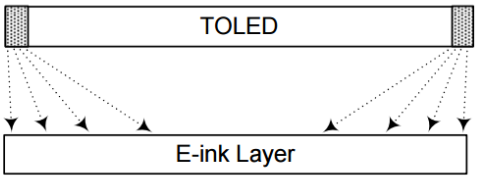

Fig. 3

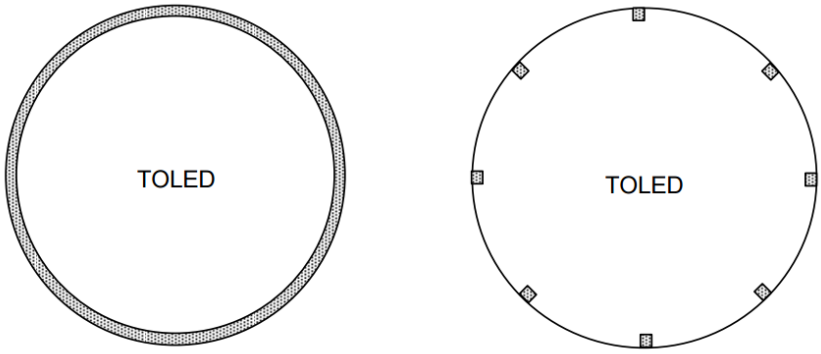

Fig. 4