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(54) **LIGHT SENSITIVE DISPLAY WITH SELECTED INTERVAL OF LIGHT SENSITIVE ELEMENTS**

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This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**
G02F 1/136 (2006.01)

(52) **U.S. Cl.** **349/53**

(58) **Field of Classification Search** 349/41, 349/42, 48, 96, 114, 12, 24; 345/87, 92, 345/102

See application file for complete search history.

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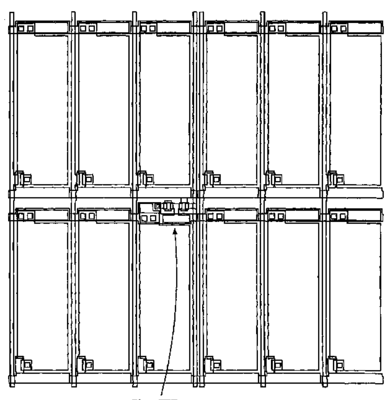
(57) **ABSTRACT**

A liquid crystal device comprises a front electrode layer, a rear electrode layer, and a liquid crystal material located between the front electrode layer and the rear electrode layer. The electrical potential is changed between the rear electrode layer and the front electrode layer to selectively modify portions of the liquid crystal material to change the polarization of the light incident thereon. A plurality of light sensitive elements located together with the rear electrode layer and a processor that determines at least one of the plurality of light sensitive elements that has been inhibited from sensing ambient light.

4 Claims, 11 Drawing Sheets



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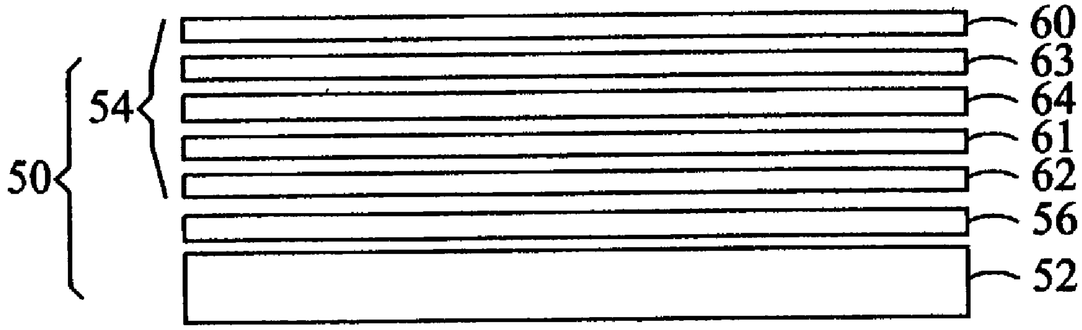
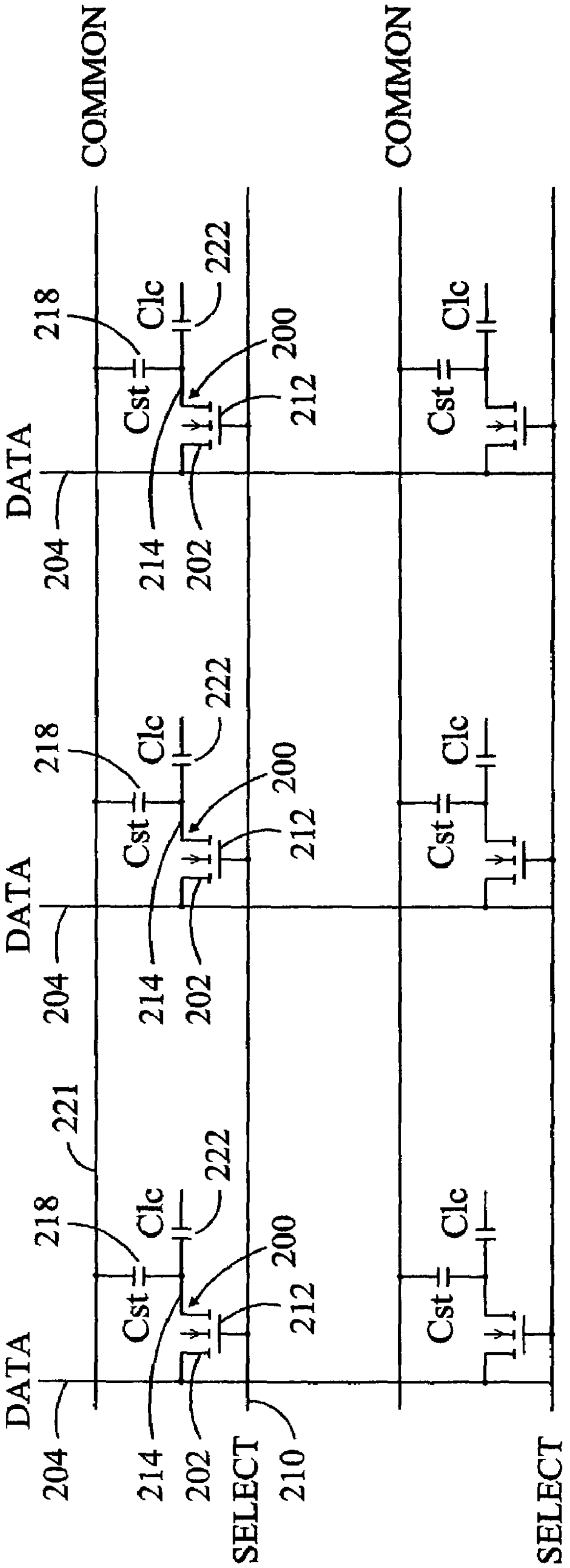


FIG. 1



COMMON
COMMON
DATA
DATA
DATA
SELECT
SELECT
Cst
Clc
204
214
202
210
212
200
218
222
221

FIG. 2

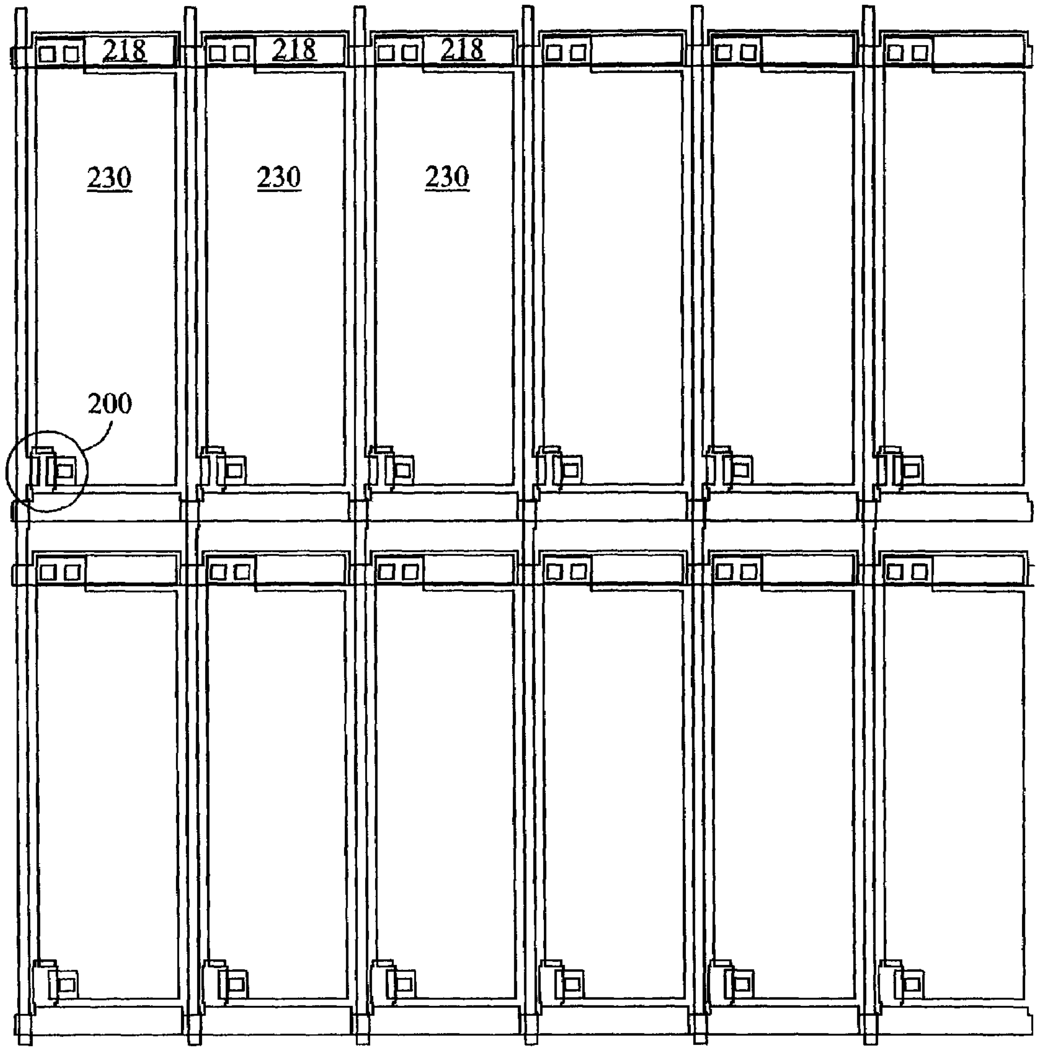
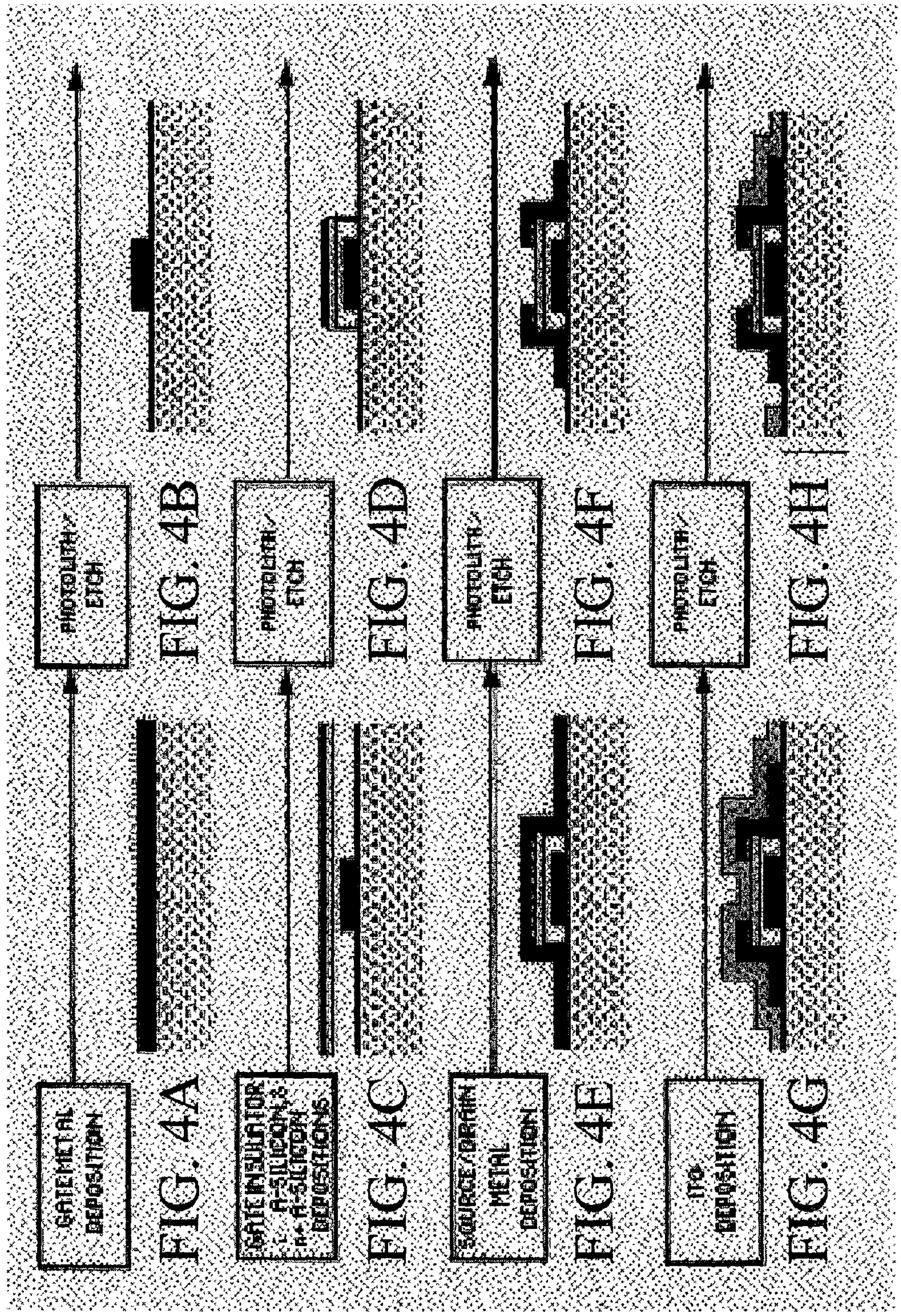


FIG. 3


GATE METAL DEPOSITION
FIG. 4A
PHOTOLITH/ ETCH
FIG. 4B
GATE INSULATOR, A-SILICON, & n+ A-SILICON DEPOSITIONS
FIG. 4C
PHOTOLITH/ ETCH
FIG. 4D
SOURCE/DRAIN METAL DEPOSITION
FIG. 4E
PHOTOLITH/ ETCH
FIG. 4F
ITO DEPOSITION
FIG. 4G
PHOTOLITH/ ETCH
FIG. 4H

FIGS. 4A-4H

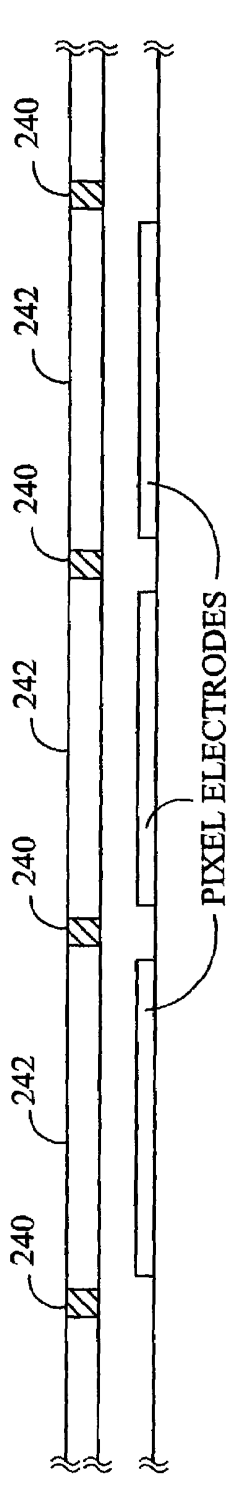

240
242
240
242
240
242
240
PIXEL ELECTRODES

FIG. 5

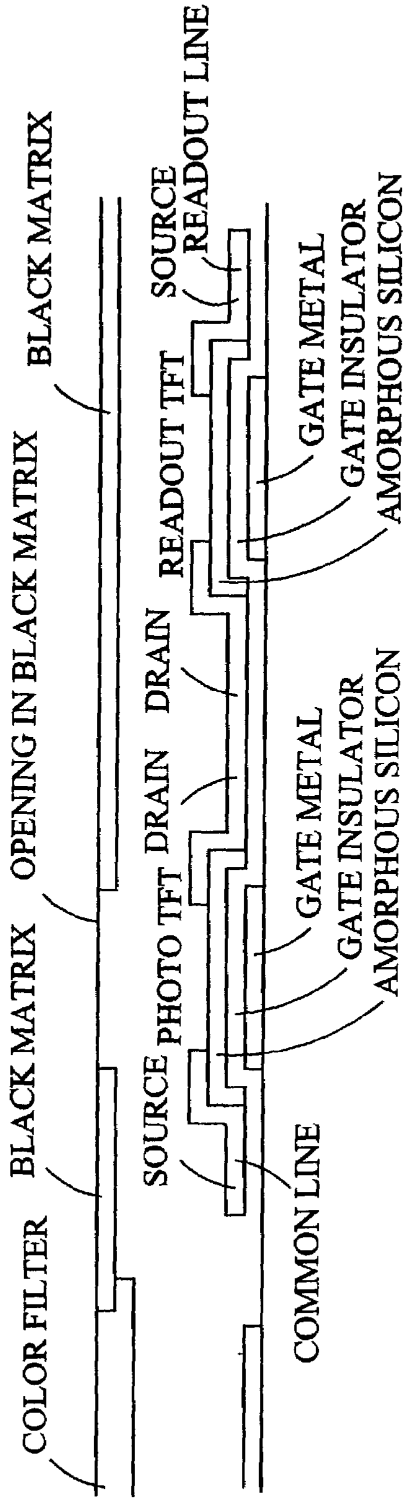

COLOR FILTER
BLACK MATRIX
OPENING IN BLACK MATRIX
BLACK MATRIX
SOURCE
PHOTO TFT
DRAIN
DRAIN
READOUT TFT
SOURCE
READOUT LINE
COMMON LINE
GATE METAL
GATE INSULATOR
AMORPHOUS SILICON
GATE METAL
GATE INSULATOR
AMORPHOUS SILICON

FIG. 7

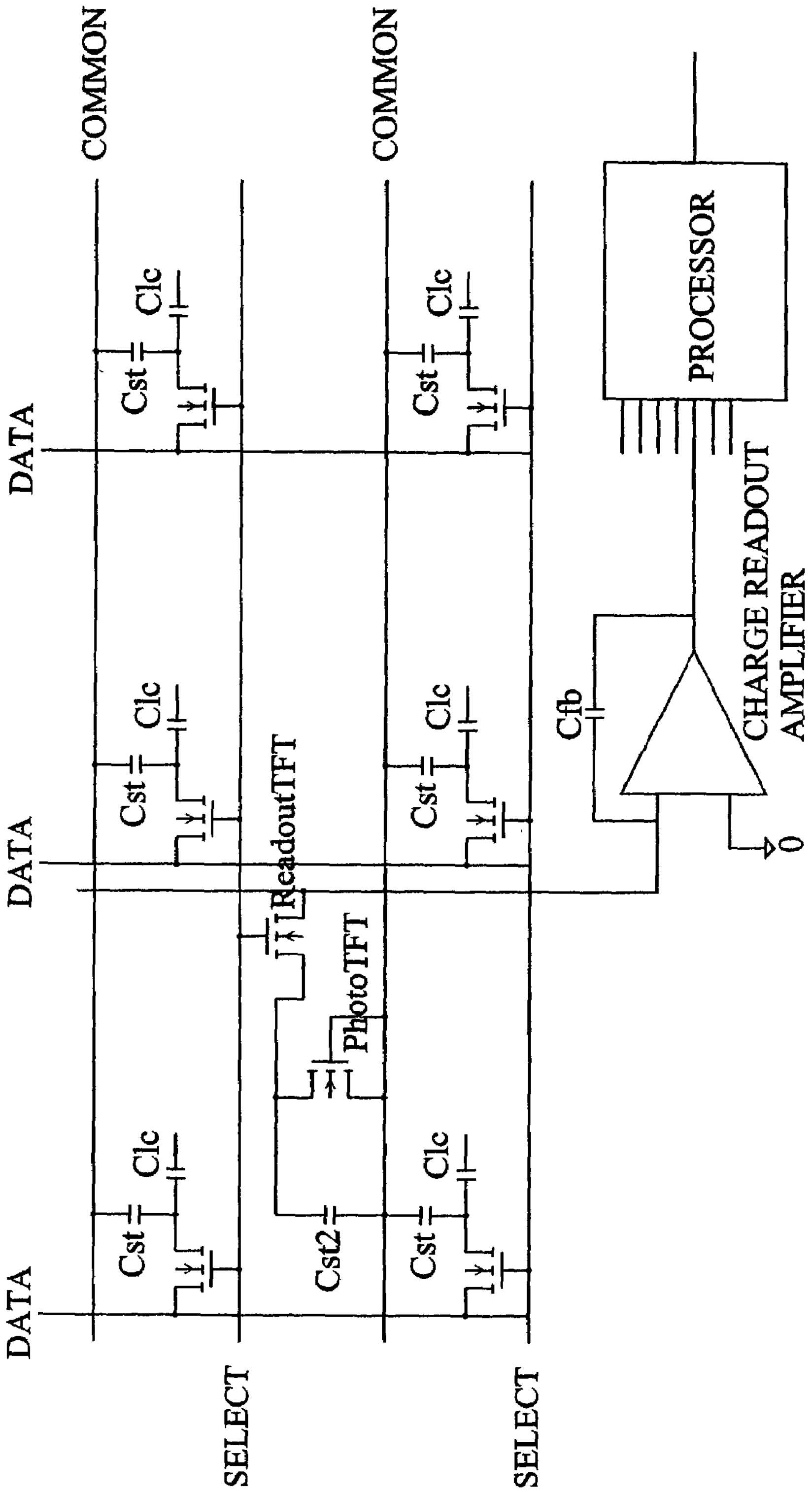

COMMON
COMMON
DATA
DATA
DATA
SELECT
SELECT
Cst
Clc
Cst2
ReadoutTFT
PhotoTFT
Cfb
PROCESSOR
CHARGE READOUT AMPLIFIER
0

FIG. 6

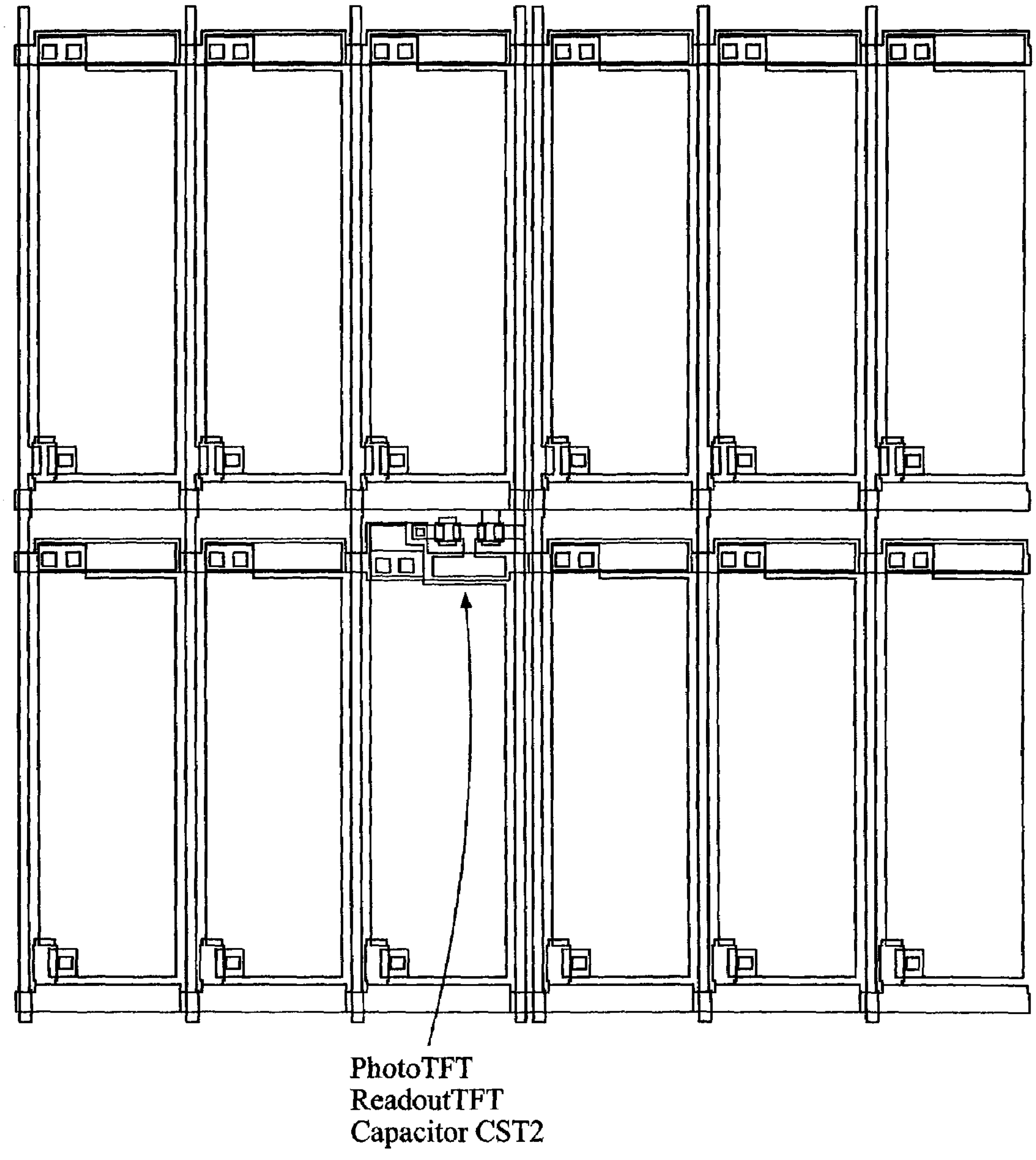


FIG. 8

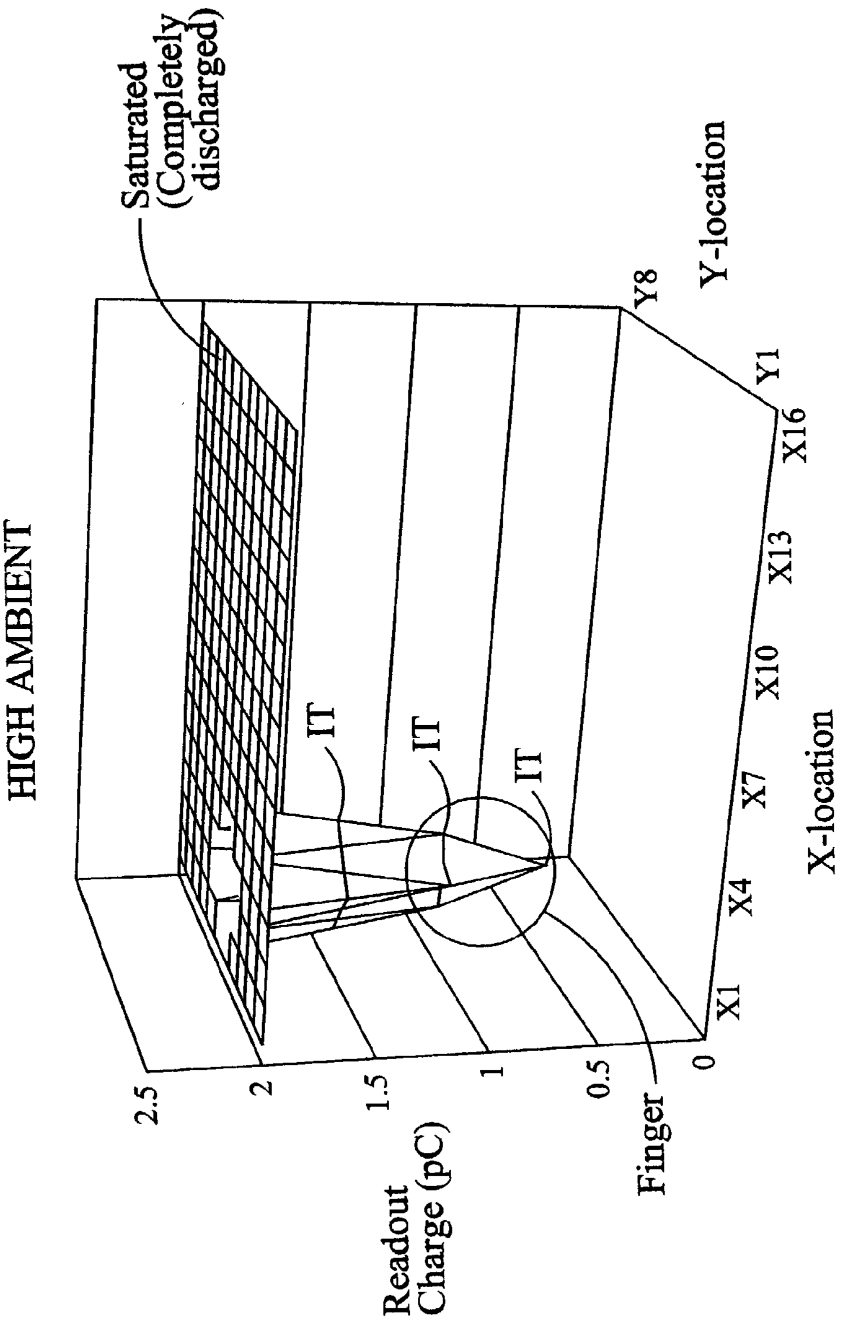

HIGH AMBIENT
Saturated
(Completely
discharged)
Readout
Charge (pC)
2.5
2
1.5
1
0.5
0
IT
IT
IT
Finger
X1
X4
X7
X10
X13
X16
X-location
Y1
Y8
Y-location

FIG. 9

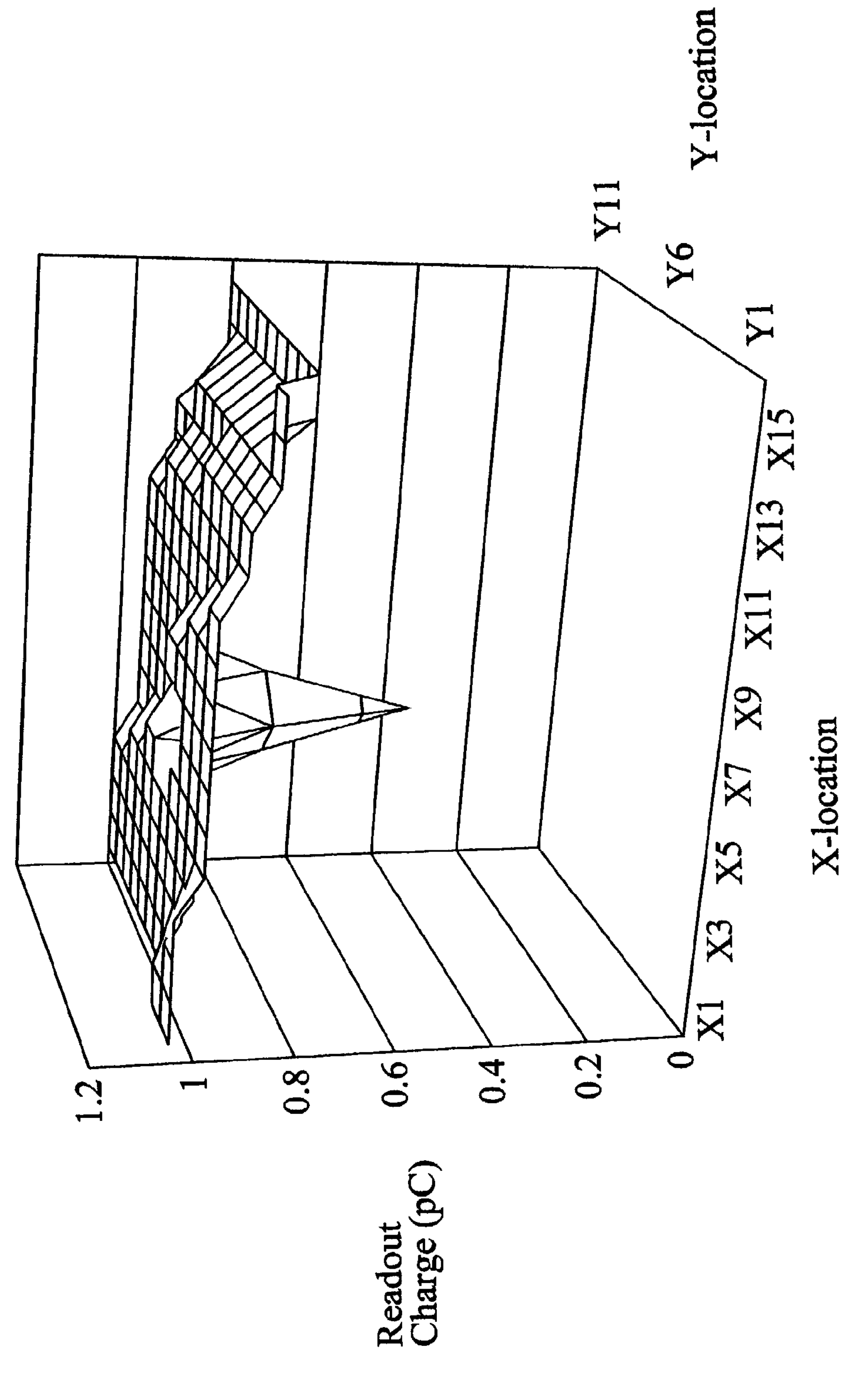

Readout Charge (pC)
1.2
1
0.8
0.6
0.4
0.2
0
X1
X3
X5
X7
X9
X11
X13
X15
X-location
Y1
Y6
Y11
Y-location

FIG. 10

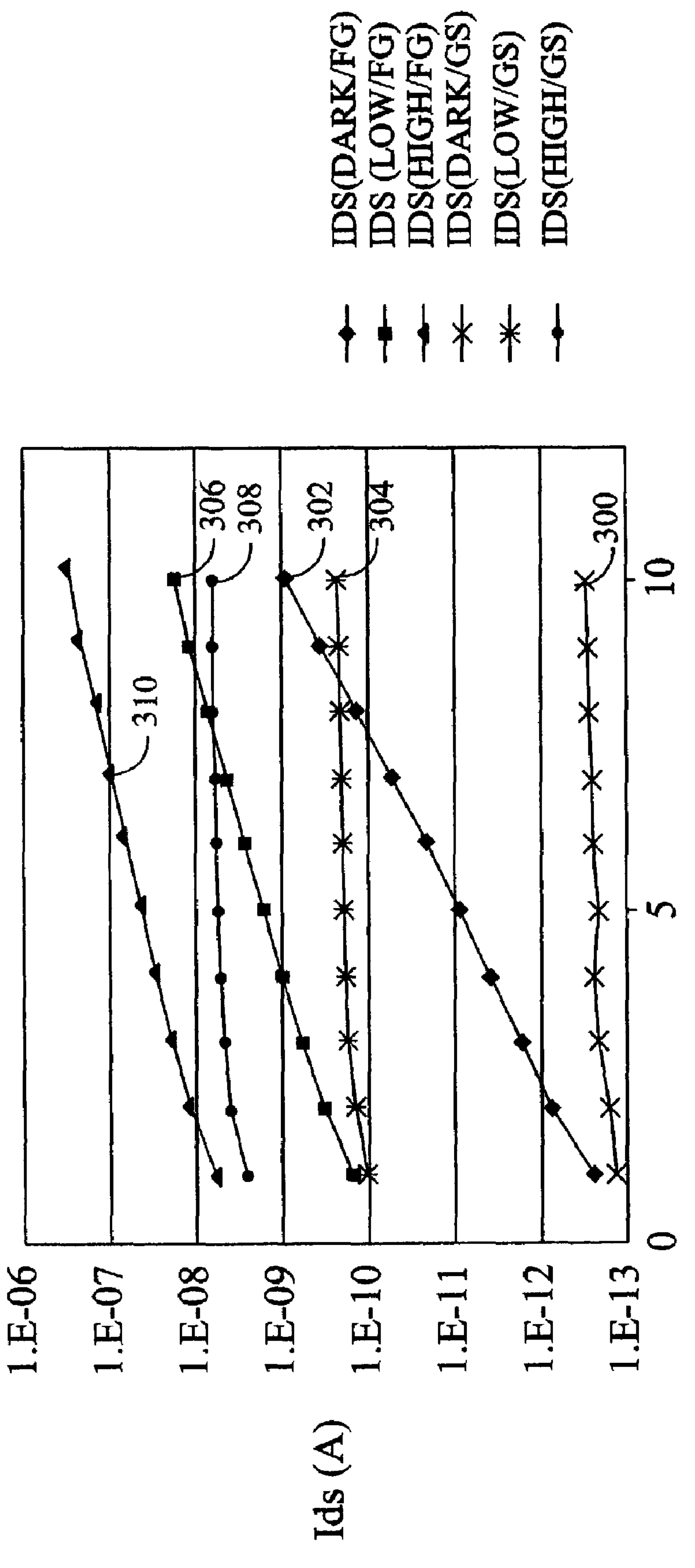

IDS(DARK/FG)
IDS (LOW/FG)
IDS(HIGH/FG)
IDS(DARK/GS)
IDS(LOW/GS)
IDS(HIGH/GS)
Ids (A)
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
0
5
10
Vds (V)
300
302
304
306
308
310

FIG. 11

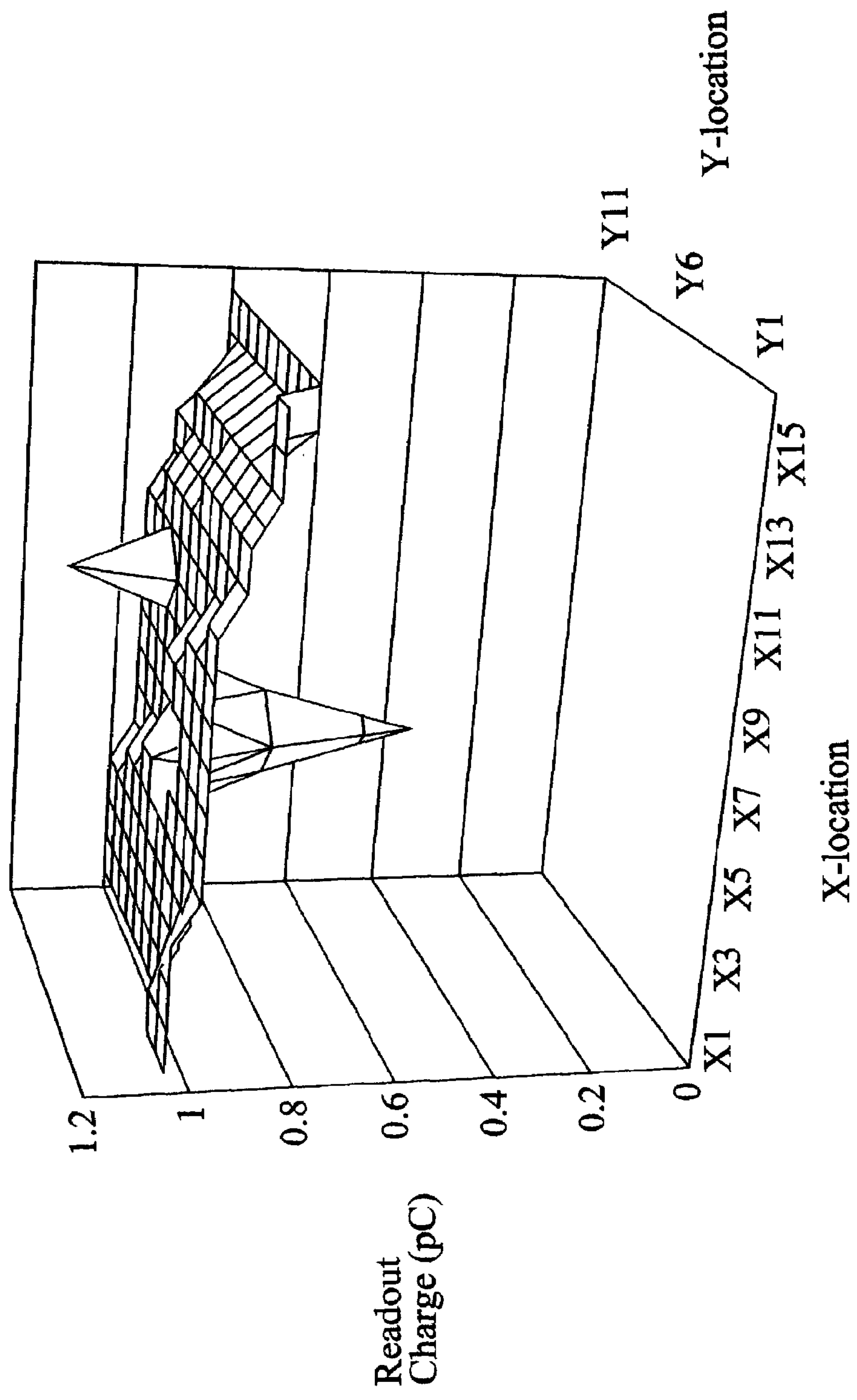

Readout Charge (pC)
1.2
1
0.8
0.6
0.4
0.2
0
X1
X3
X5
X7
X9
X11
X13
X15
X-location
Y1
Y6
Y11
Y-location

FIG. 12

LIGHT SENSITIVE DISPLAY WITH SELECTED INTERVAL OF LIGHT SENSITIVE ELEMENTS

BACKGROUND OF THE INVENTION

The present invention relates to touch sensitive displays.

Touch sensitive screens ("touch screens") are devices that typically mount over a display such as a cathode ray tube. With a touch screen, a user can select from options displayed on the display's viewing surface by touching the surface adjacent to the desired option, or, in some designs, touching the option directly. Common techniques employed in these devices for detecting the location of a touch include mechanical buttons, crossed beams of infrared light, acoustic surface waves, capacitance sensing, and resistive membranes.

For example, Kasday, U.S. Pat. No. 4,484,179 discloses an optically-based touch screen comprising a flexible clear membrane supported above a glass screen whose edges are fitted with photodiodes. When the membrane is flexed into contact with the screen by a touch, light which previously would have passed through the membrane and glass screen is trapped between the screen surfaces by total internal reflection. This trapped light travels to the edge of the glass screen where it is detected by the photodiodes which produce a corresponding output signal. The touch position is determined by coordinating the position of the CRT raster beam with the timing of the output signals from the several photodiodes. The optically-based touch screen increases the expense of the display, and increases the complexity of the display.

Denlinger, U.S. Pat. No. 4,782,328 on the other hand, relies on reflection of ambient light from the actual touch source, such as a finger or pointer, into a pair of photosensors mounted at comers of the touch screen. By measuring the intensity of the reflected light received by each photosensor, a computer calculates the location of the touch source with reference to the screen. The inclusion of the photosensors and associated computer increases the expense of the display, and increases the complexity of the display.

May, U.S. Pat. No. 5,105,186, discloses a liquid crystal touch screen that includes an upper glass sheet and a lower glass sheet separated by spacers. Sandwiched between the glass sheets is a thin layer of liquid crystal material. The inner surface of each piece of glass is coated with a transparent, conductive layer of metal oxide. Affixed to the outer surface of the upper glass sheet is an upper polarizer which comprises the display's viewing surface. Affixed to the outer surface of glass sheet is a lower polarizer. Forming the back surface of the liquid crystal display is a transflector adjacent to the lower polarizer. A transflector transmits some of the light striking its surface and reflects some light. Adjacent to transflector is a light detecting array of light dependent resistors whose resistance varies with the intensity of light detected. The resistance increases as the light intensity decreases, such as occurs when a shadow is cast on the viewing surface. The light detecting array detect a change in the light transmitted through the transflector caused by a touching of viewing surface. Similar to touch sensitive structures affixed to the front of the liquid crystal stack, the light sensitive material affixed to the rear of the liquid crystal stack similarly pose potential problems limiting contrast of the display, increasing the expense of the display, and increasing the complexity of the display.

Touch screens that have a transparent surface which mounts between the user and the display's viewing surface have several drawbacks. For example, the transparent surface, and other layers between the liquid crystal material and the transparent surface may result in multiple reflections which decreases the display's contrast and produces glare. Moreover, adding an additional touch panel to the display increases the manufacturing expense of the display and increases the complexity of the display. Also, the incorporation of the touch screen reduces the overall manufacturing yield of the display.

Accordingly, what is desired is a touch screen that does not significantly decrease the contrast ratio, does not significantly increase the glare, does not significantly increase the expense of the display, and does not significantly increase the complexity of the display.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross sectional view of a traditional active matrix liquid crystal display.

FIG. **2** is a schematic of the thin film transistor array.

FIG. **3** is a layout of the thin film transistor array of FIG. **2**.

FIGS. **4**A-**4**H is a set of steps suitable for constructing pixel electrodes and amorphous silicon thin-film transistors.

FIG. **5** illustrates pixel electrodes, color filters, and a black matrix.

FIG. **6** illustrates a schematic of the active matrix elements, pixel electrode, photo TFT, readout TFT, and a black matrix.

FIG. **7** illustrates a pixel electrode, photo TFT, readout TFT, and a black matrix.

FIG. **8** is a layout of the thin film transistor array of FIGS. **6** and **7**.

FIG. **9** is a graph of the capacitive charge on the light sensitive elements as a result of touching the display at high ambient lighting conditions.

FIG. **10** is a graph of the capacitive charge on the light sensitive elements as a result of touching the display at low ambient lighting conditions.

FIG. **11** is a graph of the photo-currents in an amorphous silicon TFT array.

FIG. **12** is a graph of the capacitive charge on the light sensitive elements as a result of touching the display and providing light from a light wand.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a liquid crystal display (LCD) **50** (indicated by a bracket) comprises generally, a backlight **52** and a light valve **54** (indicated by a bracket). Since liquid crystals do not emit light, most LCD panels are backlit with flourescent tubes or arrays of light-emitting diodes (LEDs) that are built into the sides or back of the panel. To disperse the light and obtain a more uniform intensity over the surface of the display, light from the backlight **52** typically passes through a diffuser **56** before impinging on the light valve **54**.

The transmittance of light from the backlight **52** to the eye of a viewer **58**, observing an image displayed on the front of the panel, is controlled by the light valve **54**. The light valve **54** normally includes a pair of polarizers **60** and **62** separated by a layer of liquid crystals **64** contained in a cell gap between the polarizers. Light from the backlight **52** impinging on the first polarizer **62** comprises electromagnetic waves vibrating in a plurality of planes. Only that portion of the light vibrating in the plane of the optical axis of a polarizer passes through the polarizer. In an LCD light valve, the optical axes of the first **62** and second **60** polarizer are typically arranged at an angle so that light passing through the first polarizer would normally be blocked from passing through the second polarizer in the series. However, the orientation of the translucent crystals in the layer of liquid crystals **64** can be locally controlled to either "twist" the vibratory plane of the light into alignment with the optical axes of the polarizer, permitting light to pass through the light valve creating a bright picture element or pixel, or out of alignment with the optical axis of one of the polarizes, attenuating the light and creating a darker area of the screen or pixel.

The surfaces of the a first glass substrate **61** and a second glass substrate **63** form the walls of the cell gap are buffed to produce microscopic grooves to physically align the molecules of liquid crystal **64** immediately adjacent to the walls. Molecular forces cause adjacent liquid crystal molecules to attempt to align with their neighbors with the result that the orientation of the molecules in the column of molecules spanning the cell gap twist over the length of the column. Likewise, the plane of vibration of light transiting the column of molecules will be "twisted" from the optical axis of the first polarizer **62** to a plane determined by the orientation of the liquid crystals at the opposite wall of the cell gap. If the wall of the cell gap is buffed to align adjacent crystals with the optical axis of the second polarizer, light from the backlight **52** can pass through the series of polarizers **60** and **62** to produce a lighted area of the display when viewed from the front of the panel (a "normally white" LCD).

To darken a pixel and create an image, a voltage, typically controlled by a thin film transistor, is applied to an electrode in an array of transparent electrodes deposited on the walls of the cell gap. The liquid crystal molecules adjacent to the electrode are attracted by the field produced by the voltage and rotate to align with the field. As the molecules of liquid crystal are rotated by the electric field, the column of crystals is "untwisted," and the optical axes of the crystals adjacent to the cell wall are rotated progressively out of alignment with the optical axis of the corresponding polarizer progressively reducing the local transmittance of the light valve **54** and attenuating the luminance of the corresponding pixel. Conversely, the polarizers and buffing of the light valve can be arranged to produce a "normally black" LCD having pixels that are dark (light is blocked) when the electrodes are not energized and light when the electrodes are energized. Color LCD displays are created by varying the intensity of transmitted light for each of a plurality of primary color (typically, red, green, and blue) sub-pixels that make up a displayed pixel.

The aforementioned example was described with respect to a twisted nematic device. However, this description is only an example and other devices may likewise be used, including but not limited to, multi-domain vertical alignment, patterned vertical alignment, in-plane switching, and super-twisted nematic type LCDs. In addition other devices, such as for example, plasma displays, electroluminescent displays, liquid crystal on silicon displays, reflective liquid crystal devices may likewise be used. For such displays the light emitting portion of the display, or portion of the display that permits the display of selected portions of light may be considered to selectively cause the pixels to provide light.

For an active matrix LCD (AMLCD) the inner surface of the second glass substrate **63** is normally coated with a continuous electrode while the first glass substrate **61** is patterned into individual pixel electrodes. The continuous electrode may be constructed using a transparent electrode, such as indium tin oxide. The first glass substrate **61** may include thin film transistors (TFTs) which act as individual switches for each pixel electrode (or group of pixel electrodes) corresponding to a pixel (or group of pixels). The TFTs are addressed by a set of multiplexed electrodes running along the gaps between the pixel electrodes. Alternatively the pixel electrodes may be on a different layer from the TFTs. A pixel is addressed by applying voltage (or current) to a select line which switches the TFT on and allows charge from the data line to flow onto the rear pixel electrodes. The combination of voltages between the front electrode and the pixel electrodes sets up a voltage across the pixels and turns the respective pixels on. The thin-film transistors are typically constructed from amorphous silicon, while other types of switching devices may likewise be used, such as for example, metal-insulator-metal diode and polysilicon thin-film transistors. The TFT array and pixel electrodes may alternatively be on the top of the liquid crystal material. Also the light sensitive elements may likewise be located on the top of the liquid crystal material, if desired.

Referring to FIG. **2**, the active matrix layer may include a set of data lines and a set of select lines. Normally one data line is included for each column of pixels across the display and one select line is included for each row of pixels down the display, thereby creating an array of conductive lines. To load the data to the respective pixels indicating which pixels should be illuminated, normally in a row-by-row manner, a set of voltages are imposed on the respective data lines **204** which imposes a voltage on the sources **202** of latching transistors **200**. The selection of a respective select line **210**, interconnected to the gates **212** of the respective latching transistors **200**, permits the voltage imposed on the sources **202** to be passed to the drain **214** of the latching transistors **200**. The drains **214** of the latching transistors **200** are electrically connected to respective pixel electrodes and are capacitively coupled to a respective common line **221** through a respective Cst capacitor **218**. In addition, a respective capacitance exists between the pixel electrodes enclosing the liquid crystal material, noted as capacitances Clc **222** (between the pixel electrodes and the common electrode on the color plate). The common line **221** provides a voltage reference. In other words, the voltage data (representative of the image to be displayed) is loaded into the data lines for a row of latching transistors **200** and imposing a voltage on the select line **210** latches that data into the holding capacitors and hence the pixel electrodes.

Referring to FIG. **3**, a schematic layout is shown of the active matrix layer. The pixel electrodes **230** are generally grouped into a "single" effective pixel so that a corresponding set of pixel electrodes **230** may be associated with respective color filters (e.g., red, green, blue). The latching transistors **200** interconnect the respective pixel electrodes **230** with the data lines and the select line. The pixel electrodes **230** may be interconnected to the common line **221** by the capacitors Cst **218**.

Referring to FIG. **4**, the active matrix layer may be constructed using an amorphous silicon thin-film transistor fabrication process. The steps may include gate metal deposition (FIG. **4**A), a photolithography/etch (FIG. **4**B), a gate insulator and amorphous silicon deposition (FIG. **4**C), a photolithography/etch (FIG. **4**D), a source/drain metal deposition (FIG. **4**E), a photolithography/etch (FIG. **4**F), an ITO deposition (FIG. **4**G), and a photolithography/etch (FIG. **4**H). Other processes may likewise be used, as desired.

The present inventors considered different potential architectural touch panel schemes to incorporate additional optical layers between the polarizer on the front of the liquid crystal display and the front of the display. These additional layers include, for example, glass plates, wire grids, transparent electrodes, plastic plates, spacers, and other materials. In addition, the present inventors considered the additional layers with different optical characteristics, such as for example, birefringence, non-birefringence, narrow range of wavelengths, wide range of wavelengths, etc. After an extensive analysis of different potential configurations of the touch screen portion added to the display together with materials having different optical properties and further being applied to the different types of technologies (e.g., mechanical switches, crossed beams of infrared light, acoustic surface waves, capacitance sensing, and resistive membranes), the present inventors determined that an optimized touch screen is merely a tradeoff between different undesirable properties. Accordingly, the design of an optimized touch screen is an ultimately unsolvable task. In contrast to designing an improved touch screen, the present inventors came to the realization that modification of the structure of the active matrix liquid crystal device itself could provide an improved touch screen capability without all of the attendant drawbacks to the touch screen configuration located on the front of the display.

Referring to FIG. **5**, with particular attention to the latching transistors of the pixel electrodes, a black matrix **240** is overlying the latching transistors so that significant ambient light does not strike the transistors. Color filters **242** may be located above the pixel electrodes. Ambient light striking the latching transistors results in draining the charge imposed on the pixel electrodes through the transistor. The discharge of the charge imposed on the pixel electrodes results in a decrease in the operational characteristics of the display, frequently to the extent that the display is rendered effectively inoperative. With the realization that amorphous silicon transistors are sensitive to light incident thereon, the present inventors determined that such transistors within the active matrix layer may be used as a basis upon which to detect the existence of or non-existence of ambient light incident thereon (e.g., relative values thereto).

Referring to FIG. **6**, a modified active matrix layer may include a photo-sensitive structure or elements. The preferred photo-sensitive structure includes a photo-sensitive thin film transistor (photo TFT) interconnected to a readout thin film transistor (readout TFT). A capacitor Cst**2** may interconnect the common line to the transistors. Referring to FIG. **7**, a black matrix may be in an overlying relationship to the readout TFT. The black matrix is preferably an opaque material or otherwise the structure of the display selectively inhibiting the transmission of light to selective portions of the active matrix layer. Preferably the black matrix is completely overlying the amorphous silicon portion of the readout TFT, and at least partially overlying the amorphous silicon portion of the readout TFT. Preferably the black matrix is completely non-overlying the amorphous silicon portion of the photo TFT, and at least partially non-overlying the amorphous silicon portion of the photo TFT. Overlying does not necessarily denote direct contact between the layers, but is intended to denote in the general sense the stacked structure of materials. In some embodiments, the black matrix inhibits ambient light from impacting the amorphous silicon portion of the readout TFT to an extent greater than inhibiting ambient light from impacting the amorphous silicon portion of the photo TFT.

As an example, the common line may be set at a negative voltage potential, such as −10 volts. During the previous readout cycle, a voltage is imposed on the select line which causes the voltage on the readout line to be coupled to the drain of the photo TFT and the drain of the readout TFT, which results in a voltage potential across Cst**2**. The voltage coupled to the drain of the photo TFT and the drain of the readout TFT is approximately ground (e.g., zero volts) with the non-inverting input of the operational amplifier connected to ground. The voltage imposed on the select line is removed so that the readout TFT will turn "off".

Under normal operational conditions ambient light from the front of the display passes through the black matrix and strikes the amorphous silicon of the photo TFT. However, if a person touches the front of the display in a region over the opening in the black matrix or otherwise inhibits the passage of light through the front of the display in a region over the opening in the black matrix, then the photo TFT transistor will be in an "off" state. If the photo TFT is "off" then the voltage across the capacitor Cst**2** will not significantly discharge through the photo TFT. Accordingly, the charge imposed across Cst**2** will be substantially unchanged. In essence, the voltage imposed across Cst**2** will remain substantially unchanged if the ambient light is inhibited from striking the photo TFT.

To determine the voltage across the capacitor Cst**2**, a voltage is imposed on the select line which causes the gate of the readout TFT to interconnect the imposed voltage on Cst**2** to the readout line. If the voltage imposed on the readout line as a result of activating the readout TFT is substantially unchanged, then the output of the operational amplifier will be substantially unchanged (e.g., zero). In this manner, the system is able to determine whether the light to the device has been inhibited, in which case the system will determine that the screen has been touched at the corresponding portion of the display with the photo TFT.

During the readout cycle, the voltage imposed on the select line causes the voltage on the respective drain of the photo TFT and the drain of the readout TFT to be coupled to the respective readout line, which results in resetting the voltage potential across Cst**2**. The voltage coupled to the drain of the photo TFT and the drain of the readout TFT is approximately ground (e.g., zero volts) with the non-inverting input of the operational amplifier connected to ground. The voltage imposed on the select line is removed so that the readout TFT will turn "off". In this manner, the act of reading the voltage simultaneously acts to reset the voltage potential for the next cycle.

Under normal operational conditions ambient light from the front of the display passes through the black matrix and strikes the amorphous silicon of the photo TFT. If a person does not touch the front of the display in a region over the opening in the black matrix or otherwise inhibits the passage of light through the front of the display in a region over the opening in the black matrix, then the photo TFT transistor will be in an "on" state. If the photo TFT is "on" then the voltage across the capacitor Cst**2** will significantly discharge through the photo TFT, which is coupled to the common line. In essence the voltage imposed across Cst**2** will decrease toward the common voltage. Accordingly, the charge imposed across Cst**2** will be substantially changed in the presence of ambient light. Moreover, there is a substantial difference in the voltage potential across the hold capacitor when the light is not inhibited verus when the light is inhibited.

Similarly, to determine the voltage across the capacitor Cst**2**, a voltage is imposed on the select line which causes the gate of the readout TFT to interconnect the imposed voltage to the readout line. If the voltage imposed on the readout line as a result of activating the readout TFT is substantially changed or otherwise results in an injection of current, then the output of the operational amplifier will be substantially non-zero. The output voltage of the operational amplifier is proportional or otherwise associated with the charge on the capacitor Cst**2**. In this manner, the system is able to determine whether the light to the device has been uninhibited, in which case the system will determine that the screen has not been touched at the corresponding portion of the display with the photo TFT.

Referring to FIG. **8**, a layout of the active matrix layer may include the photo TFT, the capacitor Cst**2**, the readout TFT in a region between the pixel electrodes. Light sensitive elements are preferably included at selected intervals within the active matrix layer. In this manner, the device may include touch panel sensitivity without the need for additional touch panel layers attached to the front of the display. In addition, the additional photo TFT, readout TFT, and capacitor may be fabricated together with the remainder of the active matrix layer, without the need for specialized processing. Moreover, the complexity of the fabrication process is only slightly increased so that the resulting manufacturing yield will remain substantially unchanged. It is to be understood that other light sensitive elements may likewise be used. In addition, it is to be understood that other light sensitive electrical architectures may likewise be used.

Referring to FIG. **11**, a graph of the photo-currents within amorphous silicon TFTs is illustrated. Line **300** illustrates a dark ambient environment with the gate connected to the source of the photo TFT. It will be noted that the leakage currents are low and relatively stable over a range of voltages. Line **302** illustrates a dark ambient environment with a floating gate of the photo TFT. It will be noted that the leakage currents are generally low and relatively unstable over a range of voltages (significant slope). Line **304** illustrates a low ambient environment with the gate connected to the source of the photo TFT. It will be noted that the leakage currents are three orders of magnitude higher than the corresponding dark ambient conditions and relatively stable over a range of voltages. Line **306** illustrates a low ambient environment with a floating gate of the photo TFT. It will be noted that the leakage currents are generally three orders of magnitude higher and relatively unstable over a range of voltages (significant slope). Line **308** illustrates a high ambient environment with the gate connected to the source of the photo TFT. It will be noted that the leakage currents are 4.5 orders of magnitude higher than the corresponding dark ambient conditions and relatively stable over a range of voltages. Line **310** illustrates a high ambient environment with a floating gate of the photo TFT. It will be noted that the leakage currents are generally 4.5 orders of magnitude higher and relatively unstable over a range of voltages (significant slope). With the significant difference between the dark state, the low ambient state, and the high ambient state, together with the substantially flat responses over a voltage range (source-drain voltage), the system may readily process the data in a confident manner, especially with the gate connected to the source.

Referring to FIG. **9**, under high ambient lighting conditions the photo TFT will tend to completely discharge the Cst**2** capacitor to the common voltage, perhaps with an offset voltage because of the photo TFT. In this manner, all of the photo TFTs across the display will tend to discharge to the same voltage level. Those regions with reduced ambient lighting conditions or otherwise where the user blocks ambient light from reaching the display, the Cst**2** capacitor will not fully discharge, as illustrated by the downward spike in the graph. The downward spike in the graph provides location information related to the region of the display that has been touched.

Referring to FIG. **10**, under lower ambient lighting conditions the photo TFT will tend to partially discharge the Cst**2** capacitor to the common voltage. In this manner, all of the photo TFTs across the display will tend to discharge to some intermediate voltage levels. Those regions with further reduced ambient lighting conditions or otherwise where the user blocks ambient light from reaching the display, the Cst**2** capacitor will discharge to a significantly less extent, as illustrated by the downward spike in the graph. The downward spike in the graph provides location information related to the region of the display that has been touched. As shown in FIGS. **9** and **10**, the region or regions where the user inhibits light from reaching the display may be determined as localized minimums. In other embodiments, depending on the circuit topology, the location(s) where the user inhibits light from reaching the display may be determined as localized maximums or otherwise some measure from the additional components.

In the circuit topology illustrated, the value of the capacitor Cst**2** may be selected such that it is suitable for high ambient lighting conditions or low ambient lighting conditions. For low ambient lighting conditions, a smaller capacitance may be selected so that the device is more sensitive to changes in light. For high ambient lighting conditions, a larger capacitance may be selected so that the device is less sensitive to changes in light. In addition, the dimensions of the photo transistor may be selected to change the photo-leakage current. Also, one set of light sensitive elements (e.g., the photo TFT and the capacitance) within the display may be optimized for low ambient lighting conditions while another set of light sensitive elements (e.g., the photo TFT and the capacitance) within the display may be optimized for high ambient lighting conditions. Typically, the data from light sensitive elements for low ambient conditions and the data from light sensitive elements for high ambient conditions are separately processed, and the suitable set of data is selected. In this manner, the same display device may be used for high and low ambient lighting conditions. In addition, multiple levels of sensitivity may be provided. It is to be understood that a single architecture may be provided with a wide range of sensitivity from low to high ambient lighting conditions.

Another structure that may be included is selecting the value of the capacitance so that under normal ambient lighting conditions the charge on the capacitor only partially discharges. With a structure where the capacitive charge only partially discharges, the present inventors determined that an optical pointing device, such as a light wand or laser pointer, may be used to point at the display to further discharge particular regions of the display. In this manner, the region of the display that the optical pointing device remains pointed at may be detected as local maximums (or otherwise). In addition, those regions of the display where light is inhibited will appear as local minimums (or otherwise). This provides the capability of detecting not only the absence of light (e.g., touching the panel) but likewise those regions of the display that have increased light incident thereon. Referring to FIG. **12**, a graph illustrates local minimums (upward peaks) from added light and local maximums (downward peaks) from a lack of light. In addition, one set of light sensitive elements (e.g., the photo TFT and the capacitance) within the display may be optimized for ambient lighting conditions to detect the absence of light while another set of light sensitive elements (e.g., the photo TFT and the capacitance) within the display may be optimized for ambient lighting conditions to detect the additional light imposed thereon.

A switch associated with the display may be provided to select among a plurality of different sets of light sensitive elements. For example, one of the switches may select between low, medium, and high ambient lighting conditions. For example, another switch may select between a touch sensitive operation (absence of light) and a optical pointing device (addition of light). In addition, the optical pointing device may communicate to the display, such as through a wire or wireless connection, to automatically change to the optical sensing mode.

It is noted that the teachings herein are likewise applicable to transmissive active matrix liquid crystal devices, reflective active matrix liquid crystal devices, transflective active matrix liquid crystal devices, etc. In addition, the light sensitive elements may likewise be provided within a passive liquid crystal display. The sensing devices may be, for example, photo resistors and photo diodes.

Alternatively, light sensitive elements may be provided between the rear polarizing element and active matrix layer. In this arrangement, the light sensitive elements are preferably fabricated on the polarizer, or otherwise a film attached to the polarizer. In addition, the light sensitive elements may be provided on a thin glass plate between the polarizer and the liquid crystal material. In addition, the black matrix or otherwise light inhibiting material is preferably arranged so as to inhibit ambient light from striking the readout TFT while free from inhibiting light from striking the photo TFT. Moreover, preferably a light blocking material is provided between the photo TFT and/or the readout TFT and the backlight, such as gate metal, if provided, to inhibit the light from the backlight from reaching the photo TFT and/or the readout TFT.

Alternatively, light sensitive elements may be provided between the front polarizing element and the liquid crystal material. In this arrangement, the light sensitive elements are preferably fabricated on the polarizer, or otherwise a film attached to the polarizer. In addition, the light sensitive elements may be provided on a thin glass plate between the polarizer and the liquid crystal material. The light sensitive elements may likewise be fabricated within the front electrode layer by patterning the front electrode layer and including suitable fabrication techniques. In addition, a black matrix or otherwise light inhibiting material is preferably arranged so as to inhibit ambient light from striking the readout TFT while free from inhibiting light from striking the photo TFT. Moreover, preferably a light blocking material is provided between the photo TFT and/or the readout TFT and the backlight, if provided, to inhibit the light from the backlight from reaching the photo TFT and/or the readout TFT.

Alternatively, light sensitive elements may be provided between the front of the display and the rear of the display, normally fabricated on one of the layers therein or fabricated on a separate layer provided within the stack of layers within the display. In the case of a liquid crystal device with a backlight the light sensitive elements are preferably provided between the front of the display and the backlight material. The position of the light sensitive elements are preferably between (or at least partially) the pixel electrodes, when viewed from a plan view of the display. This may be particularly useful for reflective displays where the pixel electrodes are opaque. In this arrangement, the light sensitive elements are preferably fabricated on one or more of the layers, or otherwise a plate attached to one or more of the layers. In addition, a black matrix or otherwise light inhibiting material is preferably arranged so as to inhibit ambient light from striking the readout TFT while free from inhibiting light from striking the photo TFT. Moreover, preferably a light blocking material is provided between the photo TFT and/or the readout TFT and the backlight, if provided, to inhibit the light from the backlight from reaching the photo TFT and/or the readout TFT.

In many applications it is desirable to modify the intensity of the backlight for different lighting conditions. For example, in dark ambient lighting conditions it may be beneficial to have a dim backlight. In contrast, in bright ambient lighting conditions it may be beneficial to have a bright backlight. The integrated light sensitive elements within the display stack may be used as a measure of the ambient lighting conditions to control the intensity of the backlight without the need for an additional external photo-sensor. One light sensitive element may be used, or a plurality of light sensitive element may be used together with additional processing, such as averaging.

The invention claimed is:

1. A light sensitive display comprising:

(a) said display selectively causing pixels to provide light, wherein said display include a front electrode layer, a rear electrode layer, a liquid crystal material located between said front electrode layer and said rear electrode layer, changing an electrical potential between said rear electrode layer and said front electrode layer to selectively modify portions of said liquid crystal material to change the polarization of the light incident thereon, a plurality of light sensitive elements located together with said rear electrode layer;

(b) a backlight within said display;

(c) at least one light sensitive elements located together with said rear electrode layer within said display within the boundaries of the display matrix suitable to determine a change in the light level to a level less than the ambient light level;

(d) modifying the intensity of said backlight based upon said sensing of said ambient light by said at least one light sensitive elements;

(e) wherein said light sensitive elements are located at selected intervals within said display matrix in a manner such that selected pixels do not have an associated said light sensitive element.

2. The device of claim **1** wherein said interval of said light sensitive elements is every 12^{th} pixel of said display matrix.

3. The device of claim **1** wherein said interval of said light sensitive elements is every 9^{th} pixel of said display matrix.

4. The device of claim **1** wherein said interval of said light sensitive elements is every 6^{th} pixel of said display matrix.

* * * * *

专利名称(译)	光敏显示器，具有选定的光敏元件间隔		
公开(公告)号	US7408598	公开(公告)日	2008-08-05
申请号	US10/217798	申请日	2002-08-12
[标]申请(专利权)人(译)	波尔WILLEM DEN ABILEAH ADIEL		
申请(专利权)人(译)	波尔WILLEM DEN ABILEAH ADIEL		
当前申请(专利权)人(译)	Planar系统，INC.		
[标]发明人	DEN BOER WILLEM ABILEAH ADIEL		
发明人	DEN BOER, WILLEM ABILEAH, ADIEL		
IPC分类号	G02F1/136 F16M13/02 G02F1/133 G02F1/1335 G06F1/16 G06F3/033 G06F3/041 G06F3/042 G06F3/048 G09G3/34 G09G3/36 H01L29/04		
CPC分类号	G02F1/13338 G06F1/1611 G06F3/03542 G06F3/03545 G06F3/0412 G06F3/0418 G06F3/042 G06F3/0488 G06K9/0004 G09G3/3648 G06F2203/04109 G09G2300/0439 G09G2300/0809 G09G2300/0842 G09G2320/029 G09G2320/0626 G09G2360/144 G02F2001/13312 G02F1/133512 G02F1/133514 G02F1/133528 G02F1/13394 G02F1/134336 G02F1/136286 G02F1/1368 G02F2001/133302 G02F2001/134345 G02F2201/123 G06F3/0416 G06F3/0421 G06F2203/04106		
审查员(译)	粗鲁，TIMOTHY		
其他公开文献	US20030156230A1		
外部链接	Espacenet USPTO		

摘要(译)

液晶装置包括前电极层，后电极层和位于前电极层和后电极层之间的液晶材料。在后电极层和前电极层之间改变电势，以选择性地改变部分液晶材料，以改变入射在其上的光的偏振。多个光敏元件与后电极层一起定位，并且处理器确定已被禁止感测环境光的多个光敏元件中的至少一个。