US009557594B2

(12) **United States Patent**
Mo et al.

(10) **Patent No.: US 9,557,594 B2**
(45) **Date of Patent: Jan. 31, 2017**

(54) **LIQUID-CRYSTAL DISPLAY SCREEN WITH TOUCH-CONTROL FUNCTION AND MANUFACTURING METHOD THEREOF AND ELECTRONIC APPARATUS**

(71) Applicant: **FocalTech Systems, Ltd.**, George Town, Grand Cayman (KY)

(72) Inventors: **Lianghua Mo**, Guangdong (CN); **Xinxi Jiang**, Guangdong (CN); **Hua Li**, Guangdong (CN); **Peng Wang**, Guangdong (CN)

(73) Assignee: **FOCALTECH SYSTESM, LTD.**, George Town (KY)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 490 days.

(21) Appl. No.: **13/942,508**

(22) Filed: **Jul. 15, 2013**

(65) **Prior Publication Data**

US 2014/0204288 A1 Jul. 24, 2014

(30) **Foreign Application Priority Data**

Jan. 18, 2013 (CN) 2013 1 0020039

(51) **Int. Cl.**
G02F 1/1335 (2006.01)
G02F 1/1333 (2006.01)

(52) **U.S. Cl.**
CPC ***G02F 1/13338*** (2013.01)

(58) **Field of Classification Search**
CPC G02F 1/13338; G02F 1/133707; G06F 3/0412
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,007,329 B2 * 4/2015 Lee et al. 345/174
2008/0100590 A1 * 5/2008 Hur G06F 3/0412 345/173
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101925872 12/2010
CN 102760017 10/2012
(Continued)

OTHER PUBLICATIONS

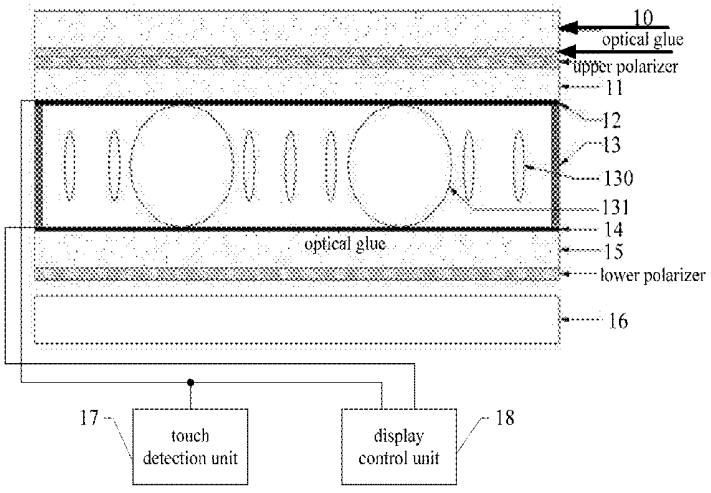
102120181, May 6, 2015, Taiwanese Office Action and Partial English Translation.

Primary Examiner — Nathanael R Briggs
Assistant Examiner — William Peterson
(74) *Attorney, Agent, or Firm* — Workman Nydegger

(57) **ABSTRACT**

The present invention discloses a liquid-crystal display screen with touch-control function and a manufacturing method thereof and an electronic apparatus. The liquid-crystal display screen includes a first sensing electrode and a second sensing electrode, which are included in a common electrode in display electrodes of the liquid-crystal display screen, and are connected to a touch detection unit. Furthermore, the touch detection unit and a display control unit operate in a timesharing manner. In this way, in the touch-control display screen, the common electrode may also be used as an electrode for detecting a touch on the touch-control display screen, and the structure of the display screen is simplified. Moreover, the touch-control display screen has a better light transmittance and the detecting for the touch and the control for the display may not interact with each other.

14 Claims, 6 Drawing Sheets



(58) **Field of Classification Search**
USPC 349/12
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0309167	A1	12/2010	Nam	
2011/0102732	A1*	5/2011	Washizawa	349/187
2012/0056835	A1	3/2012	Choo et al.	
2012/0218482	A1	8/2012	Hwang et al.	
2012/0274603	A1*	11/2012	Kim et al.	345/174
2013/0127747	A1	5/2013	Ding et al.	
2014/0152602	A1	6/2014	Miyamoto et al.	
2014/0204287	A1	7/2014	Jiang et al.	

FOREIGN PATENT DOCUMENTS

CN	102841718	12/2012
CN	103076935	5/2013
JP	2012079238	4/2012
KR	20120035874	4/2012
TW	201224903	6/2012
TW	M431372	6/2012
TW	201248475	12/2012
TW	201305889	2/2013

* cited by examiner

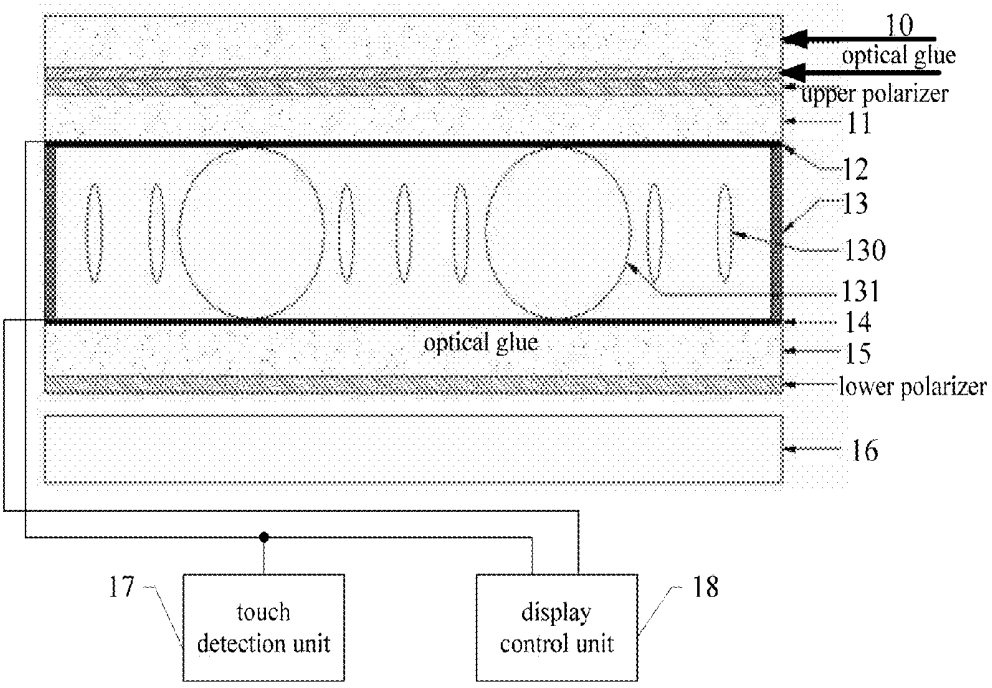

10
optical glue
upper polarizer
11
12
13
130
131
14
optical glue
15
lower polarizer
16
17
touch detection unit
display control unit
18

Fig 1

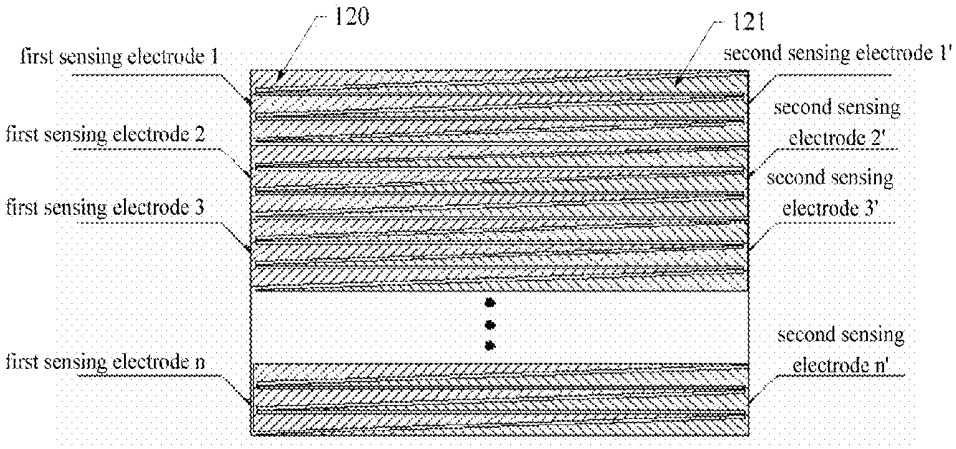

120
121
first sensing electrode 1
second sensing electrode 1'
first sensing electrode 2
second sensing electrode 2'
first sensing electrode 3
second sensing electrode 3'
first sensing electrode n
second sensing electrode n'

Fig. 2

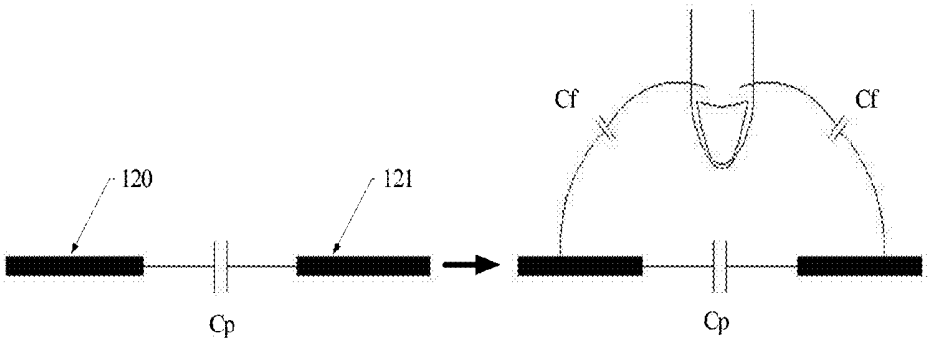

120
121
Cp
Cf
Cf
Cp

Fig. 3

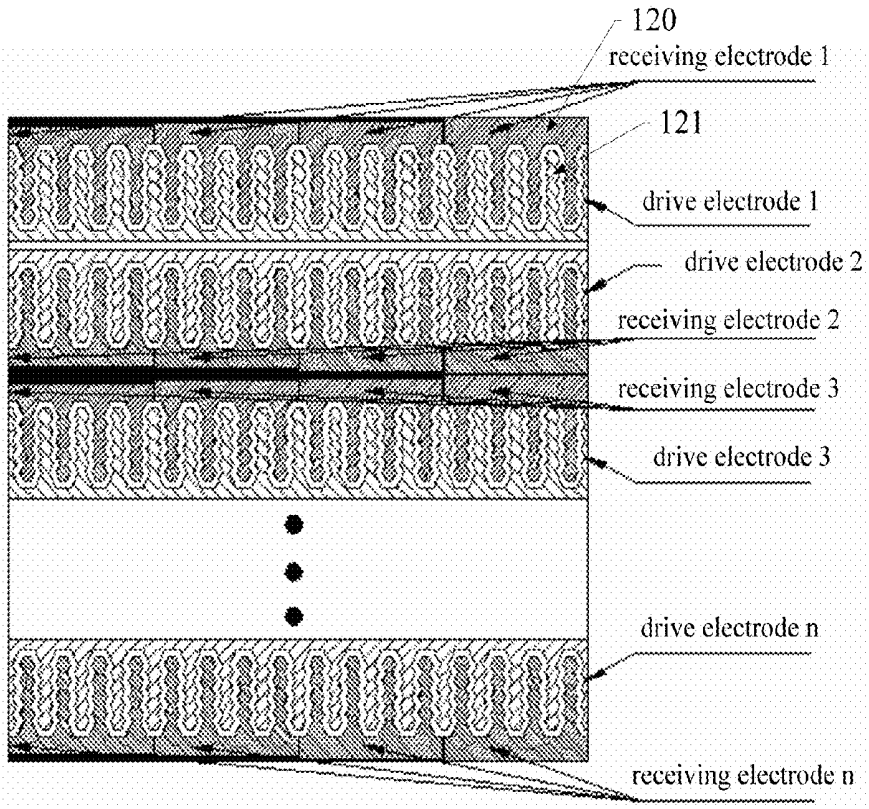

120
receiving electrode 1
121
drive electrode 1
drive electrode 2
receiving electrode 2
receiving electrode 3
drive electrode 3
drive electrode n
receiving electrode n

Fig. 4

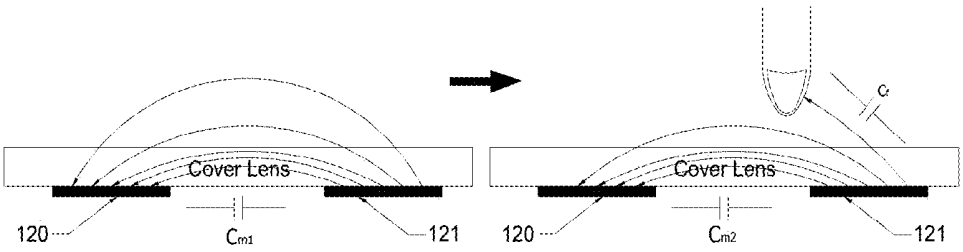

Cf
Cover Lens
120
Cm1
121
Cover Lens
120
Cm2
121

Fig. 5

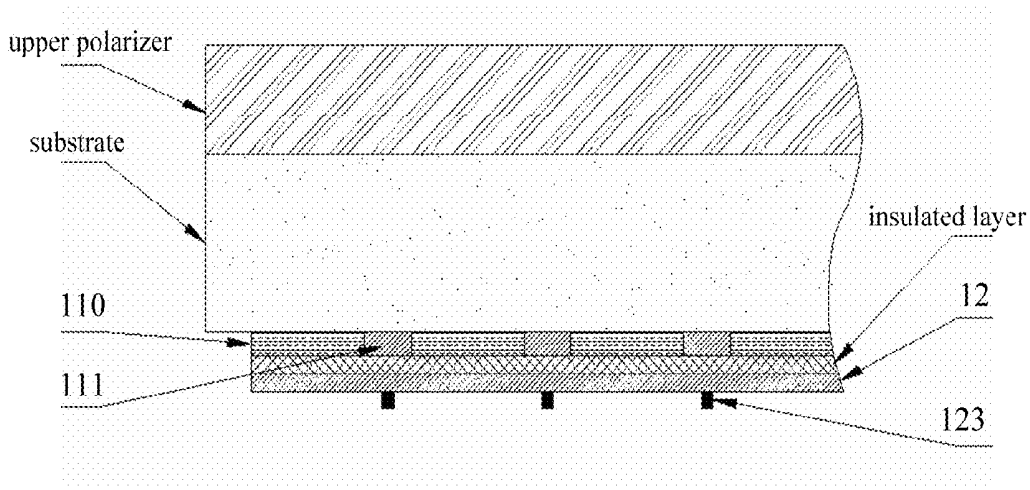

upper polarizer
substrate
insulated layer
110
12
111
123

Fig. 6

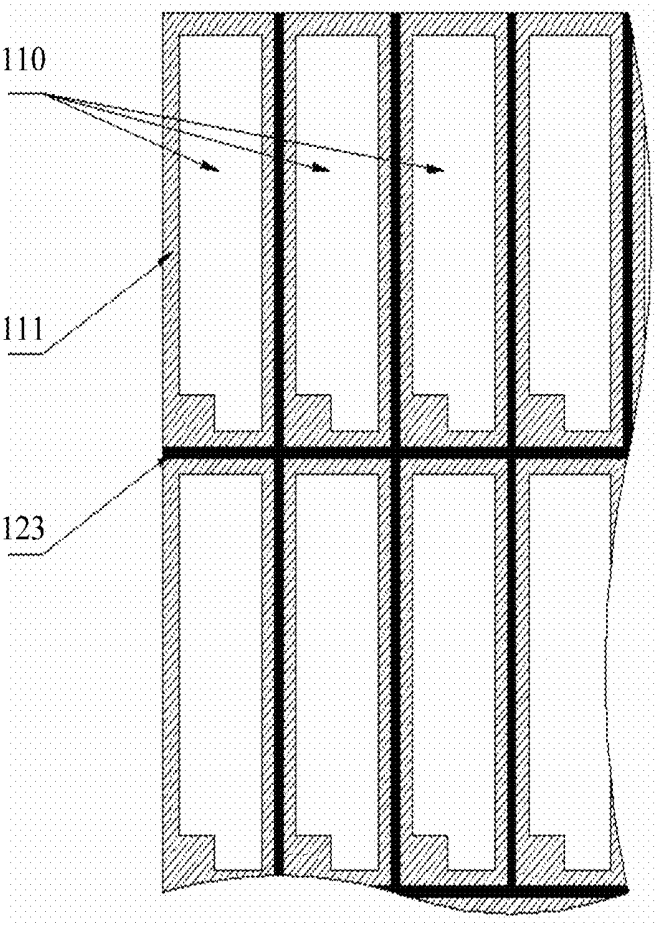


Fig.7

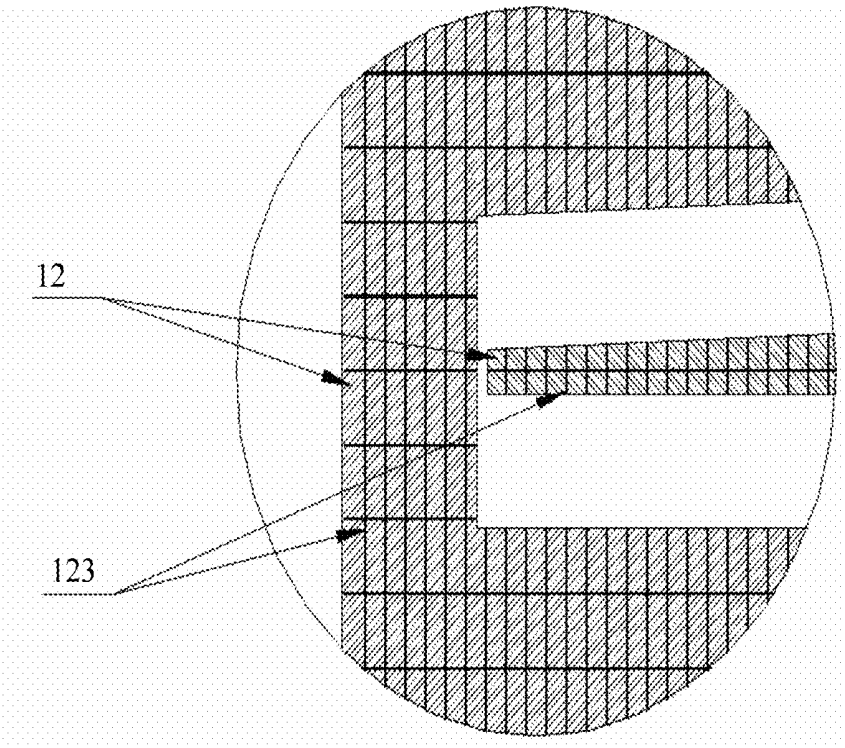

12
123

Fig. 8

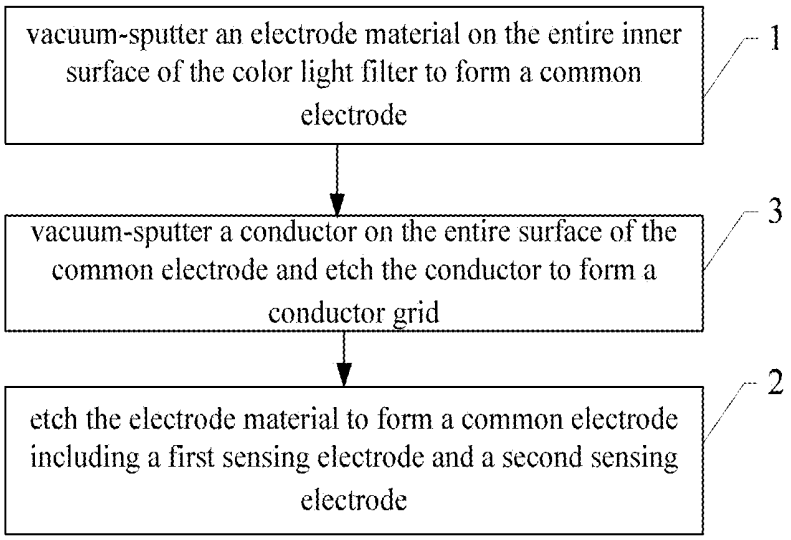

vacuum-sputter an electrode material on the entire inner surface of the color light filter to form a common electrode
1
vacuum-sputter a conductor on the entire surface of the common electrode and etch the conductor to form a conductor grid
3
etch the electrode material to form a common electrode including a first sensing electrode and a second sensing electrode
2

Fig. 9

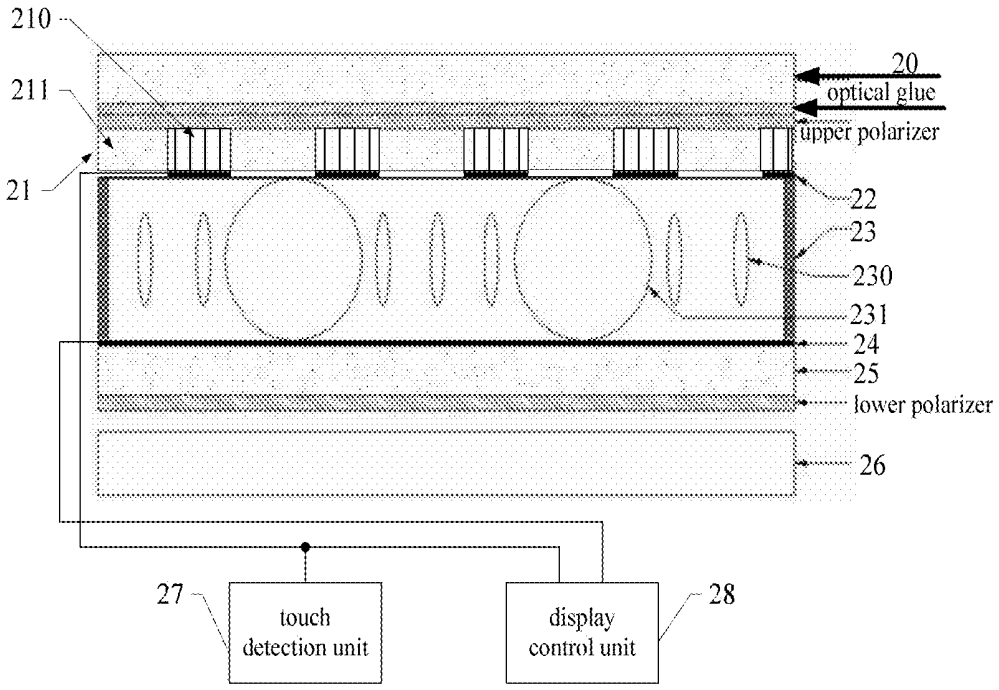

210
211
21
20
optical glue
upper polarizer
22
23
230
231
24
25
lower polarizer
26
27
touch
detection unit
display
control unit
28

Fig. 10

LIQUID-CRYSTAL DISPLAY SCREEN WITH TOUCH-CONTROL FUNCTION AND MANUFACTURING METHOD THEREOF AND ELECTRONIC APPARATUS

This application claims the priority of the Chinese Patent Application No. 201310020039.5, entitled "LIQUID-CRYSTAL DISPLAY SCREEN WITH TOUCH-CONTROL FUNCTION AND MANUFACTURING METHOD THEREOF AND ELECTRONIC APPARATUS", filed with the Chinese Patent Office on Jan. 18, 2013 which is herein incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to the technical field of electronic apparatus, and in particular to a liquid-crystal display screen with touch-control function (hereinafter referred to as a touch-control display screen for short) and a manufacturing method thereof and an electronic apparatus.

BACKGROUND OF THE INVENTION

With the development of the touch-control display technology, capacitive touch-control display screens have been applied more and more widely. The touch-control display screen of the existing electronic apparatus generally includes a display layer and a touch sensing layer. The display layer includes electrodes, such as a pixel electrode, a common electrode and a thin film transistor (TFT) array, for implementing a liquid-crystal display. The touch sensing layer includes an electrode for detecting a touch on the touch-control display screen. Generally, the touch sensing layer and the display layer are stacked from the top (the external surface direction of the electronic apparatus) to bottom of the touch-control display screen, so that the touch-control display function is implemented.

SUMMARY OF THE INVENTION

Embodiments according to the present invention provide a liquid-crystal display screen with touch-control function and a manufacturing method thereof and an electronic apparatus, by which the structure of the liquid-crystal display screen with touch-control function is simplified.

An embodiment according to the present invention provides a liquid-crystal display screen with touch-control function, including: a cover plate, a color light filter, a common electrode in display electrodes, a liquid-crystal layer, other display electrodes, a substrate and a backlight, which are stacked from top to bottom, the touch-control display screen further includes a touch detection unit and a display control unit;

where, the common electrode includes a first sensing electrode and a second sensing electrode;

the first sensing electrode and the second sensing electrode are connected to the touch detection unit, the touch detection unit is adapted to detect a self-capacitance formed between the first sensing electrode and the second sensing electrode or a mutual-capacitance formed between the first sensing electrode and the second sensing electrode, and to determine a touch on the touch-control display screen according to the detected self-capacitance or mutual-capacitance;

the common electrode and other display electrodes are all connected to the display control unit which is adapted to control the first sensing electrode, the second sensing electrode and the other display electrodes to perform a liquid-crystal display; and

the display control unit and the touch detection unit operate in a timesharing manner.

An embodiment according to the present invention provides an electronic apparatus including a liquid-crystal display screen with touch-control function;

the liquid-crystal display screen with touch-control function including: a cover plate, a color light filter, a common electrode in display electrodes, a liquid-crystal layer, other display electrodes, a substrate and a backlight, which are stacked from top to bottom. The touch-control display screen further includes a touch detection unit and a display control unit;

where, the common electrode includes a first sensing electrode and a second sensing electrode;

the first sensing electrode and the second sensing electrode are connected to the touch detection unit, the touch detection unit is adapted to detect a self-capacitance formed between the first sensing electrode and the second sensing electrode or a mutual-capacitance formed between the first sensing electrode and the second sensing electrode, and to determine a touch on the touch-control display screen according to the detected self-capacitance or mutual-capacitance;

the common electrode and other display electrodes are all connected to the display control unit which is adapted to control the first sensing electrode, the second sensing electrode and the other display electrodes to perform a liquid-crystal display; and

the display control unit and the touch detection unit operate in a timesharing manner.

An embodiment according to the present invention provides a manufacturing method for a liquid-crystal display screen with touch-control function, the liquid-crystal display screen with touch-control function including: a cover plate, a color light filter, a common electrode in display electrodes, a liquid-crystal layer, other display electrodes, a substrate and a backlight, which are stacked from top to bottom, the touch-control display screen further includes a touch detection unit and a display control unit;

where, the common electrode includes a first sensing electrode and a second sensing electrode;

the first sensing electrode and the second sensing electrode are connected to the touch detection unit, the touch detection unit is adapted to detect a self-capacitance formed between the first sensing electrode and the second sensing electrode or a mutual-capacitance formed between the first sensing electrode and the second sensing electrode, and to determine a touch on the touch-control display screen according to the detected self-capacitance or mutual-capacitance;

the common electrode and other display electrodes are all connected to the display control unit which is adapted to control the first sensing electrode, the second sensing electrode and the other display electrodes to perform a liquid-crystal display; and the display control unit and the touch detection unit operate in a timesharing manner.

Moreover, the method includes:

vacuum-sputtering an electrode material on the entire inner surface of the color light filter of the liquid-crystal display screen with touch-control function to form the common electrode; and

etching the electrode material to form the common electrode including the first sensing electrode and the second sensing electrode.

In the embodiments according to the present invention, the first sensing electrode and the second sensing electrode, which are included in the common electrode in the display electrodes of the liquid-crystal display screen with touch-control function, are connected to the touch detection unit. Furthermore, the touch detection unit and the display control unit operate in a timesharing manner. In this way, in the touch-control display screen, the common electrode may also be used as an electrode for detecting the touch on the touch-control display screen. There is no need additionally arranging a touch sensing layer to carry the electrode for detecting the touch on the touch-control display screen. Therefore, the structure of the touch-control display screen is simplified. Moreover, the touch-control display screen has a better light transmittance since there is no touch sensing layer. Furthermore, the detecting for the touch and the control for the display may not interact with each other since the touch detection unit and the display control unit operate in a timesharing manner.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompany drawings needed to be used in the description of the embodiments or the prior art will be described briefly as follows, so that the technical solutions according to the embodiments of the present invention or according to the prior art will become more clearer. It is clear that the accompany drawings in the following description are only some embodiments of the present invention. For those skilled in the art, other accompany drawings may be obtained according to these accompany drawings without any creative work.

FIG. **1** is a schematic diagram of a structure of a liquid-crystal display screen with touch-control function provided in a first embodiment according to the present invention;

FIG. **2** is a pattern of a common electrode layer in a touch-control display screen provided in an embodiment according to the present invention;

FIG. **3** is a schematic diagram of a capacitance formed between a first sensing electrode and a second sensing electrode when a touch detection unit operates in a touch-control display screen provided in an embodiment according to the present invention operates;

FIG. **4** is a pattern of a common electrode layer in another touch-control display screen provided in an embodiment according to the present invention;

FIG. **5** is a schematic diagram of another capacitance formed between a first sensing electrode and a second sensing electrode when a touch detection unit operates in a touch-control display screen provided in an embodiment according to the present invention operates;

FIG. **6** is a sectional diagram of a partial structure in a touch-control display screen of an embodiment according to the present invention;

FIG. **7** is a plan diagram of a color light filter and a conductor grid which are in a touch-control display screen of an embodiment according to the present invention;

FIG. **8** is a schematic diagram of a relation between a common electrode and a conductor grid which are in a touch-control display screen of an embodiment according to the present invention;

FIG. **9** is a flowchart of manufacturing a liquid-crystal display screen with touch-control function provided in a second embodiment according to the present invention; and

FIG. **10** is a schematic diagram of a structure of a liquid-crystal display screen with touch-control function provided in a fourth embodiment according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The technical solution according to the embodiments of the present invention will be described clearly and completely as follows in conjunction with the accompany drawings in the embodiments of the present invention. It is clear that the described embodiments are only a part of but not all of the embodiments according to the present invention. All the other embodiments obtained by those skilled in the art based on the embodiments in the present invention without any creative work belong to the scope of the present invention.

First Embodiment According to the Present Invention

A liquid-crystal display screen with touch-control function (hereinafter referred to as a touch-control display screen for short) is provided, which is mainly of an In-cell type and so on. Among display electrodes in such type of liquid-crystal display screen, a common electrode and other display electrodes (such as a pixel electrode and a TFT) are not in the same layer and are separated by the liquid-crystal. The touch-control display screen is generally used in an electronic apparatus and a schematic diagram of the specific structure of the touch-control display screen is shown in FIG. **1**, including:

a cover plate **10**, a color light filter **11**, a common electrode **12** in display electrodes, a liquid-crystal layer, other display electrodes **14**, a substrate **15** and a backlight **16**, which are stacked from top to bottom. The touch-control display screen further includes a touch detection unit **17** and a display control unit **18**. An outer surface direction of the electronic apparatus is an up direction and an inner surface direction of the electronic apparatus is a down direction.

Polarizers are respectively arranged above the color light filter **11** and below the substrate **15** to change circularly polarized light into linearly polarized light, so as to achieve a liquid-crystal display. Specifically, an upper polarizer is arranged between the cover plate **10** and the color light filter **11**, and the upper polarizer may be adhered to the inner surface of the cover plate **10** with transparent optical glue; and a lower polarizer is arranged between the backlight **16** and the substrate **15**.

The color light filter **11** may allow a color picture to be displayed on the touch-control display screen. The color light filter **11** mainly includes a red light-filtering area, a blue light-filtering area and a green light-filtering area. The liquid-crystal layer includes liquid-crystal molecules **130** and spacer particles **131**. The liquid-crystal molecules **130** and the spacer particles **131** may be arranged between the common electrode **12** in the display electrodes and the other display electrodes **14** by frame glue **13**. Specifically, the spacer particles **131** may support the color light filter **11** to prevent the color light filter **11** from deforming and provide the liquid-crystal a certain space to rotate; the frame glue **13** is used to bond the color light filter **11** and the substrate **15** together to form a sealed space. The common electrode **12** and the other display electrodes **14** are electrodes for implementing the liquid-crystal display. The common electrode **12** includes a first sensing electrode **120** and a second sensing electrode **121**. The common electrode **12** and the other electrodes **14** may be made of Indium Tin Oxides (ITO) which has good transparency and conductivity.

The first sensing electrode **120** and the second sensing electrode **121** are both connected to the touch detection unit **17**. The touch detection unit **17** is adapted to detect a self-capacitance formed between the first sensing electrode **120** and the second sensing electrode **121** or a mutual-capacitance formed between the first sensing electrode **120** and the first sensing electrode **121**, and to determine a touch on the touch-control display screen according to the detected self-capacitance or mutual-capacitance. The common electrode **12** and other electrodes **14** are all connected to the display control unit **18**. The display control unit **18** is adapted to control the first sensing electrode **120**, the second sensing electrode **121** and other display electrodes **14** to perform the liquid-crystal display. In the present embodiment, the touch detection unit **17** and the display control unit **18** may operate in a timesharing manner according to a preset arrangement. In another specific embodiment, another control unit is arranged and connected to the touch detection unit **17** and to the display control unit **18**, so as to control the touch detection unit **17** and the display control unit **18** to operate in a timesharing manner. For example, when the display control unit **18** controls the display, the touch detection unit **17** stops detecting the touch on the touch-control display screen.

In the present embodiment, the other electrodes may include a pixel electrode, a signal electrode, a TFT or the like, and the pixel electrode is connected to the signal electrode via the TFT. When being in an operating status, the display control unit **18** may control the voltage of the first sensing electrode **120** in the common electrode **12** and the voltage of the second sensing electrode **121** in the common electrode **12** to be equal, so that the two electrodes are both taken as one electrode for the liquid-crystal display. Moreover, the display control unit **18** may control the TFT to be open. In this case the TFT is equivalent to two reverse-biased diodes connected together, and it is impossible for the current of the signal electrode to flow through the TFT to the drain electrode of the TFT. Since the pixel electrode is connected to the drain electrode of the TFT, it is also impossible for the current of the signal electrode to flow to the pixel electrode. Therefore, an electric field can not be established between the pixel electrode in the other display electrodes **14** and the common electrode **12**, so that the light of the backlight **16** can not arrive at the upper polarizer after passing through the lower polarizer and arriving at the other display electrodes **14** and the common electrode **12** layer, and the touch-control display screen is black. The display control unit **18** may also control the TFT to be closed. Thus the current of the signal electrode flows through the TFT to the drain electrode of the TFT. In this case, an electric field is established between the pixel electrode in the other electrodes **14** and the common electrode **12**, and the liquid-crystal molecules **130** in the liquid-crystal layer located on the other display electrodes **14** rotate under the influence of the electric field, so that the light of the backlight **16** may pass through the rotating liquid-crystal molecules **130** and the upper polarizer and finally arrive at the cover plate **10** after passing through the lower polarizer and arriving at the other electrodes **14**. Thereby, the display control unit **18** controls the display electrodes and implements the liquid-crystal display. In addition to the above operating mode, there are further other operating modes which will not be described herein.

When being in an operating status, the touch detection unit **17** may control the voltage of the first sensing electrode **120** in the common electrode **12** and the voltage of the second sensing electrode **121** in the common electrode **12** to be different, so that the first sensing electrode **120** and the second sensing electrode **121** are respectively taken as one electrode of the self-capacitance or one electrode of the mutual-capacitance. In a specific implementation, there may be the following two manners for the first sensing electrode **120** and the second sensing electrode **121** in the common electrode **12**, and correspondingly, the detecting of the touch on the touch-control display screen by the touch detection unit **17** also has two manners, specifically as follows.

(1) As shown in FIG. **2**, the entire common electrode **12** may be divided into multiple pairs of blocks in different shapes, with each pair of blocks including one first sensing electrode **120** and one second sensing electrode **121**. The first sensing electrode **120** and the second sensing electrode **121** may be in any shape. For example, in FIG. **2**, the first sensing electrode **120** is multiple triangular electrodes with one edge of each of the triangular electrodes being connected together (the part filled with left oblique lines in FIG. **2**), the second sensing electrode **121** is also multiple triangular electrodes with one edge of each of the triangular electrodes being connected together (the part filled with right oblique lines in FIG. **2**). Moreover, the first sensing electrode **120** and the second sensing electrode **121** are not connected together, and the unconnected portions of the triangular electrodes of the first sensing electrode and the unconnected portions of the triangular electrodes of the second sensing electrode are arranged to fit each other. That is, the unconnected portions of the triangular electrodes included in one of the sensing electrodes are arranged in the interspaced portions of the other sensing electrode, thus the occupied area is saved. What FIG. **2** shows is only one of the specific implementations, and the first sensing electrode **120** and the second sensing electrode **121** may also have other shapes.

The touch detection unit **17** may provide a signal source for the two sensing electrodes, here the first sensing electrode **120** and the second sensing electrode **121**, in each pair of blocks, so as to form a self-capacitance between the first sensing electrode **120** and the second sensing electrode **121**. As shown in FIG. **3**, if there is no touch subject touching the touch-control display screen, the touch detection unit **17** detects the value of the capacitance between the first sensing electrode **120** and the second sensing electrode **121** as Cp; if there is a touch subject touching the touch-control display screen, a capacitance Cf existed between the touch subject and each of the sensing electrodes is superimposed to the original capacitance existed between the first sensing electrode **120** and the second sensing electrode **121**, then the touch detection unit **17** detects the value of the capacitance between the first sensing electrode **120** and the second sensing electrode **121** as Cp'=Cp//(Cf+Cf). It can be seen that the touch detection unit **17** judges whether there is a touch subject touching the touch-control display screen by detecting the value of the capacitance formed between the first sensing electrode **120** and the second sensing electrode **121**, and calculates a position where the touch subject touches according to a corresponding algorithm.

(2) As shown in FIG. **4**, the entire common electrode **12** may be divided into multiple first sensing electrodes **120** and multiple second sensing electrodes **121**. The first sensing electrodes **120** and the second electrodes **121** may be in any shapes. For example, in FIG. **4**, the first sensing electrode **120** is multiple strip-shaped electrodes with one terminal of each of the strip-shaped electrodes being connected together (the part filled with left oblique lines in FIG. **4**), the second sensing electrode **121** is also multiple strip-shaped electrodes with one terminal of each of the strip-shaped elec-

trodes being connected together (the part filled with right oblique lines in FIG. **4**). Moreover, the first sensing electrode **120** and the second sensing electrode **121** are not connected together, and the unconnected portions of the strip-shaped electrodes of the first sensing electrode and the unconnected portions of the strip-shaped electrodes of the second sensing electrode are arranged to fit each other. That is, the unconnected portions of the strip-shaped electrodes included in one of the sensing electrodes are arranged in the interspaced portions of the other sensing electrode, so that the occupied area is saved. What FIG. **4** shows is only one of the specific implementations.

The touch detection unit **17** may provide a signal source for one of the first sensing electrode **120** and the second sensing electrode **121**, and which operates as a drive electrode and the other sensing electrode without the signal source operates as a receiving electrode for receiving the signal, so that a mutual-capacitance is formed between the first sensing electrode **120** and the second sensing electrode **121**. Specifically, the first sensing electrode **120** may act as the receiving electrode and the second sensing electrode **121** may act as the drive electrode. As shown in FIG. **5**, if there is no touch subject touching the touch-control display screen, the touch detection unit **17** detects the value of the mutual-capacitance formed between the drive electrode and the receiving electrode as Cm**1**; if there is a touch subject touching the touch-control display screen, a capacitance Cf may be formed between the touch subject and the drive electrode, thus a part of the signal of the drive electrode is absorbed by the touch subject and the touch detection unit **17** may detect that the value of the mutual-capacitance formed between the drive electrode and the receiving electrode becomes smaller and is Cm**2**. It can be seen that the touch detection unit **17** judges whether there is a touch subject touching the touch-control display screen by detecting the value of the mutual-capacitance formed between the drive electrode and the receiving electrode, and calculates a position where the touch subject touches according to a corresponding algorithm.

It can be seen that, in the embodiments according to the present invention, the first sensing electrode and the second sensing electrode, which are included in the common electrode in the display electrodes of the liquid-crystal display screen with touch-control function, are connected to the touch detection unit. Furthermore, the touch detection unit and the display control unit operate in a timesharing manner. In this way, in the touch-control display screen, the common electrode may also be used as an electrode for detecting the touch on the touch-control display screen, without additionally arranging a touch sensing layer to carry the electrode for detecting the touch on the touch-control display screen. Therefore, the structure of the touch-control display screen is simplified. Moreover, the touch-control display screen has a better light transmittance since there is no touch sensing layer. Furthermore, the detecting for the touch and the control for the display may not interact with each other since the touch detection unit and the display control unit operate in a timesharing manner.

It should be noted that the common electrodes **12** in the touch-control display screen of the embodiment according to the present invention are electrodes divided into multiple blocks unconnected with each other. Therefore, an impedance of a single block of electrode is great. With the touch detection unit **17** and the display control unit **18** operating in a timesharing manner, the function of the common electrode **12** may also change in a timesharing manner. If the touch detection unit **17** is in the operating status, charging and discharging are performed continuously between the first sensing electrode **120** and the second sensing electrode **121** in the common electrode **12**. If in such process the display control unit **18** is switched to be in the operating status, electric charges on the common electrode **12** may not be released timely due to the great impedance, thus a crosstalk may occur.

FIG. **6** illustrates a sectional diagram of a partial structure in a touch-control display screen, and FIG. **7** illustrates a plan diagram of a color light filter and a conductor grid in a touch-control display screen. In order to eliminate the crosstalk, a conductor grid **123** is needed to be arranged below the common electrode **12**, so as to provide a better conductivity for current conduction and to reduce the crosstalk caused due to the great impedance of the common electrode **12**. The envelope of the conductor grid **123** is consistent with the shapes of the first sensing electrode **120** and the second sensing electrode **121** in the common electrode **12**. That is, as shown in FIG. **8**, there is the conductor grid **123** at a position below and corresponding to the first sensing electrode **120** and the second sensing electrode **121** in the common electrode **12** layer, and there is no conductor grid **123** at a position below and corresponding to a interspaced portion in the common electrode **12** layer. Moreover, in the color light filter **11** of the touch-control display screen, color light-filtering areas **110**, such as a red light-filtering area, a green light-filtering area and a blue light-filtering area, separated by a black matrix **111** are generally included, so as to prevent colors displayed on the touch-control display screen from interfering with each other. The above-mentioned conductor grid **123** below the common electrode **12** needs to be arranged at a position corresponding to the black matrix **111**, so that the conductor grid **123** may be obstructed by the black matrix **111**, and a user can not see the conductor grid **123** from the top of the touch-control display screen. The conductor grid **123** may be grid-like, and may be made of a conductive material with good conductivity, such as metal or graphene.

Second Embodiment According to the Present Invention

There is provided a manufacturing method for the liquid-crystal display screen with touch-control function described in the first embodiment. A flowchart of the method is shown in FIG. **9**, including:

1. vacuum-sputtering an electrode material such as ITO on the entire inner surface of the color light filter **11** to form a common electrode **12**; alternatively, before vacuum-sputtering the ITO on the inner surface of the color light filter **11**, vacuum-sputtering or coating an insulated flat layer on the entire inner surface of the color light filter **11**, then sputtering the ITO; and

2. etching the electrode material such as ITO to form the common electrode **12** including a first sensing electrode **120** and a second sensing electrode **121**. The patterns of the first sensing electrode **120** and the second sensing electrode **121** which are formed by etching is as described in the above-mentioned first embodiment and will not be described herein.

In order to eliminate the crosstalk, a conductor grid is needed to be arranged below the common electrode **12**. In a specific embodiment, a step 3 is further needed to be performed before the above-mentioned step 2, that is, a conductor is vacuum-sputtered on the entire surface of the common electrode **12** formed in the step 1 and the conductor is etched to form the conductor grid **123**. The etching of the conductor and the etching of the electrode material may be performed in a corresponding manner, so that the envelope

of the conductor grid **123** is consistent with the shapes of the first sensing electrode **120** and the second sensing electrode **121**.

Furthermore, in order to protect the common electrode **12** layer, a protective layer may be further vacuum-sputtered or coated on the entire surface of the common electrode **12** after the above-mentioned step 2 is finished.

Third Embodiment According to the Present Invention

There is provided an electronic apparatus, including a liquid-crystal display screen with touch-control function. The structure of the liquid-crystal display screen with touch-control function is as described in the above-mentioned first embodiment and will not be described herein.

Fourth Embodiment According to the Present Invention

There is provided another liquid-crystal display screen with touch-control function (hereinafter referred to as a touch-control display screen for short). The touch-control display screen is mainly of an In-cell type and so on and is generally used in an electronic apparatus. Referring to FIG. **10**, the touch-control display screen in the present embodiment including:

a cover plate **20**, a color light filter **21**, a common electrode **22** in display electrodes, a liquid-crystal layer, other display electrodes **24**, a substrate **25** and a backlight **26**, which are stacked from top to bottom. The touch-control display screen further includes a touch detection unit **27** and a display control unit **28**. In order to change circularly polarized light into linearly polarized light to implement a liquid-crystal display, an upper polarizer is needed to be arranged between the cover plate **20** and the color light filter **21** and a lower polarizer is arranged between the backlight **26** and the substrate **25**.

The color light filter **21** may allow a color picture to be displayed on the touch-control display screen and includes color light-filtering areas **211** separated by a black matrix **210**. The color light-filtering areas **211** mainly include a red light-filtering area, a blue light-filtering area and a green light-filtering area. The liquid-crystal layer includes liquid-crystal molecules **230** and spacer particles **231**. The liquid-crystal molecules **230** and the spacer particles **231** may be arranged between the common electrode **22** in the display electrodes and the other display electrodes **24** by frame glue **23**. The spacer particles **231** may support the color light filter **21** to prevent the color light filter **21** from deforming and provide the liquid-crystal a certain space to rotate.

The common electrode **22** includes a first sensing electrode and a second sensing electrode, and for the common electrode **22** in the touch-control display screen of the embodiment, a conductor grid may be arranged below the black matrix **210** on the color light filter **21** in the touch-control display screen to act as the common electrode **22**, without dividing the entire surface of the common electrode into different sensing electrodes. Such conductor grid may include a first sensing electrode and a second sensing electrode whose patterns are similar to the patterns of the first sensing electrode **120** and the second sensing electrode **121** described in the above-mentioned first embodiment and will not be described herein. Thus, comparing with the touch-control display screen in the first embodiment, the conductor grid for preventing the crosstalk is used as an electrode both for implementing the liquid-crystal display and for detecting a touch. An individual common electrode layer is not needed to carry these electrodes, so that the structure of the touch-control display screen is further simplified.

The first sensing electrode **120** and the second sensing electrode **121** are both connected to the touch detection unit **27**. The touch detection unit **27** is adapted to detect a self-capacitance formed between the first sensing electrode **120** and the second sensing electrode **121** or a mutual-capacitance formed between the first sensing electrode **120** and the second sensing electrode **121**, and to determine a touch on the touch-control display screen according to the detected self-capacitance or mutual-capacitance. The common electrode **22** and other display electrodes **24** are all connected to the display control unit **28**. The display control unit **28** is adapted to control the first sensing electrode, the second sensing electrode and other display electrodes **24** to perform the liquid-crystal display. In the present embodiment, the touch detection unit **27** and the display control unit **28** may operate in a timesharing manner according to a preset arrangement.

In the process of manufacturing the touch-control display screen of the present embodiment, a conductor material such as metal or graphene may be vacuum-sputtered on the entire inner surface of the color light filter **21**. Alternatively, before the conductor material is vacuum-sputtered on the inner surface of the color light filter **21**, an insulated flat layer may be vacuum-sputtered or coated on the entire inner surface of the color light filter **21** and then the conductor material is sputtered. Then the conductor material is etched, so that the conductor grid at the position corresponding to the black matrix **210** in the color light filter **21** is arranged, and such conductor gird includes a first sensing electrode and a second sensing electrode. Thus the common electrode **22** is formed.

Furthermore, in order to protect the common electrode **22**, a protective layer may also be vacuum-sputtered or coated on the entire surface of the common electrode **22** after the common electrode **22** is etched and formed.

In an embodiment according to the present invention, there is further provided an electronic apparatus mainly including the touch-control display screen described in the fourth embodiment and will not be described herein.

The liquid-crystal display screen with touch-control function and the manufacturing method thereof and the electronic apparatus, which are provided in the embodiments according to the present invention, are described in detail in the above. Specific examples are used herein to set forth the principle and embodiments of the present invention, and the above-mentioned description of the embodiments is only for helping to understand the method and the core concept of the present invention. Furthermore, for those skilled in the art, changes may be made to the specific embodiments and the application range according to the concept of the present invention. In summary, the specification should not be understood as limiting the present invention.

The invention claimed is:

1. A liquid-crystal display screen with touch-control function, comprising: a cover plate, a color light filter, a common electrode in display electrodes, a liquid-crystal layer, other display electrodes, a substrate and a backlight, which are stacked from top to bottom, the touch-control display screen further comprising a touch detection unit and a display control unit;

wherein the common electrode comprises a first sensing electrode and a second sensing electrode;

the first sensing electrode and the second sensing electrode are connected to the touch detection unit, the touch detection unit is adapted to detect a self-capacitance formed between the first sensing electrode and the second sensing electrode or a mutual-capacitance formed between the first sensing electrode and the second sensing electrode, and to determine a touch on

the touch-control display screen according to the detected self-capacitance or mutual-capacitance;

the common electrode and the other display electrodes are all connected to the display control unit which is adapted to control the first sensing electrode, the second sensing electrode and the other display electrodes to perform a liquid-crystal display; and

the display control unit and the touch detection unit operate in a timesharing manner,

wherein the color light filter comprises color light-filtering areas separated by a black matrix; and

a conductor grid arranged throughout the surface of the first sensing electrode and the surface of the second sensing electrode, wherein the conductor grid is arranged at a position below the common electrode and corresponds to the black matrix, and the first sensing electrode and the second sensing electrode completely cover the conductor grid.

2. The liquid-crystal display screen with touch-control function according to claim **1**, wherein

the first sensing electrode and the second sensing electrode are both multiple triangular electrodes with one edge of each of the triangular electrodes being connected together, the first sensing electrode and the second sensing electrode are not connected, and are arranged to fit each other; or,

the first sensing electrode and the second sensing electrode are both multiple strip-shaped electrodes with one terminal of each of the strip-shaped electrodes being connected together, the first sensing electrode and the second sensing electrode are not connected, and are arranged to fit each other.

3. The liquid-crystal display screen with touch-control function according to claim **1**, wherein the conductor grid is made of metal or graphene.

4. The liquid-crystal display screen with touch-control function according to claim **2**, wherein the conductor grid is made of metal or graphene.

5. The liquid-crystal display screen with touch-control function according to claim **1**, wherein

the color light filter comprises color light-filtering areas separated by a black matrix; and

the common electrode is a conductor grid arranged below the black matrix.

6. The liquid-crystal display screen with touch-control function according to claim **2**, wherein

the color light filter comprises color light-filtering areas separated by a black matrix; and

the common electrode is a conductor grid arranged below the black matrix.

7. An electronic apparatus, comprising a liquid-crystal display screen with touch-control function, the liquid-crystal display screen with touch-control function comprising: a cover plate, a color light filter, a common electrode in display electrodes, a liquid-crystal layer, other display electrodes, a substrate and a backlight, which are stacked from top to bottom, the touch-control display screen further comprising a touch detection unit and a display control unit;

wherein the common electrode comprises a first sensing electrode and a second sensing electrode;

the first sensing electrode and the second sensing electrode are connected to the touch detection unit, the touch detection unit is adapted to detect a self-capacitance formed between the first sensing electrode and the second sensing electrode or a mutual-capacitance formed between the first sensing electrode and the second sensing electrode, and to determine a touch on the touch-control display screen according to the detected self-capacitance or mutual-capacitance;

the common electrode and the other display electrodes are all connected to the display control unit which is adapted to control the first sensing electrode, the second sensing electrode and the other display electrodes to perform a liquid-crystal display; and

the display control unit and the touch detection unit operate in a timesharing manner,

wherein the color light filter comprises color light-filtering areas separated by a black matrix; and

a conductor grid arranged throughout the surface of the first sensing electrode and the surface of the second sensing electrode, wherein the conductor grid is arranged at a position below the common electrode and corresponds to the black matrix, and the first sensing electrode and the second sensing electrode completely cover the conductor grid.

8. The electronic apparatus according to claim **7**, wherein

the first sensing electrode and the second sensing electrode are both multiple triangular electrodes with one edge of each of the triangular electrodes being connected together, the first sensing electrode and the second sensing electrode are not connected, and are arranged to fit each other; or,

the first sensing electrode and the second sensing electrode are both multiple strip-shaped electrodes with one terminal of each of the strip-shaped electrodes being connected together, the first sensing electrode and the second sensing electrode are not connected, and are arranged to fit each other.

9. The electronic apparatus according to claim **7**, wherein the conductor grid is made of metal or graphene.

10. The electronic apparatus according to claim **7**, wherein

the color light filter comprises color light-filtering areas separated by a black matrix; and

the common electrode is a conductor grid arranged below the black matrix.

11. A manufacturing method for a liquid-crystal display screen with touch-control function, the liquid-crystal display screen with touch-control function comprising: a cover plate, a color light filter, a common electrode in display electrodes, a liquid-crystal layer, other display electrodes, a substrate and a backlight, which are stacked from top to bottom, the touch-control display screen further comprising a touch detection unit and a display control unit; the common electrode comprising a first sensing electrode and a second sensing electrode; wherein the first sensing electrode and the second sensing electrode are connected to the touch detection unit, the touch detection unit is adapted to detect a self-capacitance formed between the first sensing electrode and the second sensing electrode or a mutual-capacitance formed between the first sensing electrode and the second sensing electrode, and to determine a touch on the touch-control display screen according to the detected self-capacitance or mutual-capacitance; the common electrode and the other display electrodes are all connected to the display control unit which is adapted to control the first sensing electrode, the second sensing electrode and the other display electrodes to perform a liquid-crystal display; the display control unit and the touch detection unit operate in a timesharing manner, wherein the color light filter comprises color light-filtering areas separated by a black matrix; and

a conductor grid is arranged throughout the surface of the first sensing electrode and the surface of the second sensing electrode, wherein the conductor grid is

arranged at a position below the common electrode and corresponds to the black matrix, and the first sensing electrode and the second sensing electrode completely cover the conductor grid;

wherein the method comprises:

vacuum-sputtering an electrode material on the entire inner surface of the color light filter of the liquid-crystal display screen with touch-control function to form the common electrode;

vacuum-sputtering a conductor on the entire surface of the formed common electrode, and etching the conductor to form the conductor grid; and

etching the electrode material to form the common electrode comprising the first sensing electrode and the second sensing electrode.

12. The manufacturing method according to claim **11**, wherein the conductor grid is made of metal or grapheme.

13. A manufacturing method for a liquid-crystal display screen with touch-control function, the liquid-crystal display screen with touch-control function comprising: a cover plate, a color light filter, a common electrode in display electrodes, a liquid-crystal layer, other display electrodes, a substrate and a backlight, which are stacked from top to bottom, the touch-control display screen further comprising a touch detection unit and a display control unit; the common electrode comprising a first sensing electrode and a second sensing electrode; wherein the first sensing electrode and the second sensing electrode are connected to the touch detection unit, the touch detection unit is adapted to detect a self-capacitance formed between the first sensing electrode and the second sensing electrode or a mutual-capacitance formed between the first sensing electrode and the second sensing electrode, and to determine a touch on the touch-control display screen according to the detected self-capacitance or mutual-capacitance; the common electrode and the other display electrodes are all connected to the display control unit which is adapted to control the first sensing electrode, the second sensing electrode and the other display electrodes to perform a liquid-crystal display; the display control unit and the touch detection unit operate in a timesharing manner; the first sensing electrode and the second sensing electrode are both multiple triangular electrodes with one edge of each of the triangular electrodes being connected together, the first sensing electrode and the second sensing electrode are not connected, and are arranged to fit each other; or, the first sensing electrode and the second sensing electrode are both multiple strip-shaped electrodes with one terminal of each of the strip-shaped electrodes being connected together, the first sensing electrode and the second sensing electrode are not connected, and are arranged to fit each other, wherein the color light filter comprises color light-filtering areas separated by a black matrix; and

a conductor grid is arranged throughout the surface of the first sensing electrode and the surface of the second sensing electrode, wherein the conductor grid is arranged at a position below the common electrode and corresponds to the black matrix, and the first sensing electrode and the second sensing electrode completely cover the conductor grid,

wherein, the method comprises:

vacuum-sputtering an electrode material on the entire inner surface of the color light filter of the liquid-crystal display screen with touch-control function to form the common electrode;

vacuum-sputtering a conductor on the entire surface of the formed common electrode, and etching the conductor to form the conductor grid; and

etching the electrode material to form the common electrode comprising the first sensing electrode and the second sensing electrode.

14. The manufacturing method according to claim **13**, wherein the conductor grid is made of metal or grapheme.

* * * * *

专利名称(译)	具有触控功能的液晶显示屏及其制造方法和电子设备		
公开(公告)号	US9557594	公开(公告)日	2017-01-31
申请号	US13/942508	申请日	2013-07-15
[标]申请(专利权)人(译)	敦泰科技有限公司		
申请(专利权)人(译)	FOCALTECH系统. , LTD.		
当前申请(专利权)人(译)	FOCALTECH系统. , LTD.		
[标]发明人	MO LIANGHUA JIANG XINXI LI HUA WANG PENG		
发明人	MO, LIANGHUA JIANG, XINXI LI, HUA WANG, PENG		
IPC分类号	G02F1/1335 G02F1/1333		
CPC分类号	G02F1/13338		
代理机构(译)	WORKMAN NYDEGGER		
助理审查员(译)	彼得森，WILLIAM		
优先权	201310020039.5 2013-01-18 CN		
其他公开文献	US20140204288A1		
外部链接	Espacenet USPTO		

摘要(译)

本发明公开了一种具有触摸控制功能的液晶显示屏及其制造方法和电子设备。液晶显示屏包括第一感测电极和第二感测电极，它们包括在液晶显示屏的显示电极中的公共电极中，并且连接到触摸检测单元。此外，触摸检测单元和显示控制单元以分时方式操作。这样，在触摸控制显示屏中，公共电极也可以用作用于检测触摸控制显示屏上的触摸的电极，并且简化了显示屏的结构。此外，触摸控制显示屏幕具有更好的透光率，并且对触摸的检测和对显示的控制可以不彼此交互。