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(54) METHOD OF MANUFACTURING ELECTROLUMINESCENCE DISPLAY APPARATUS

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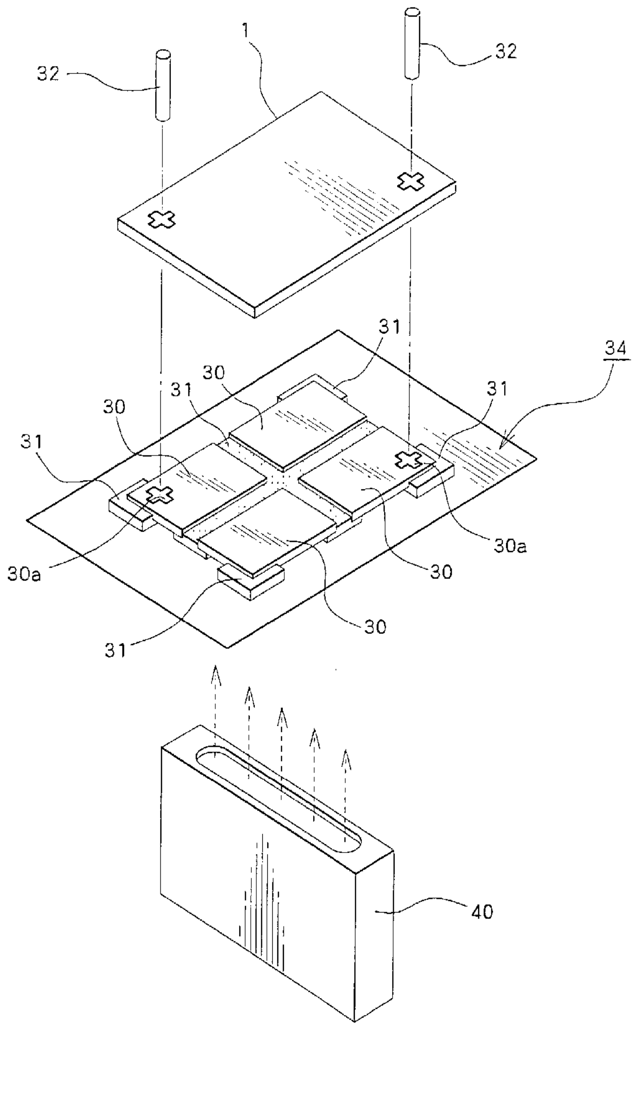
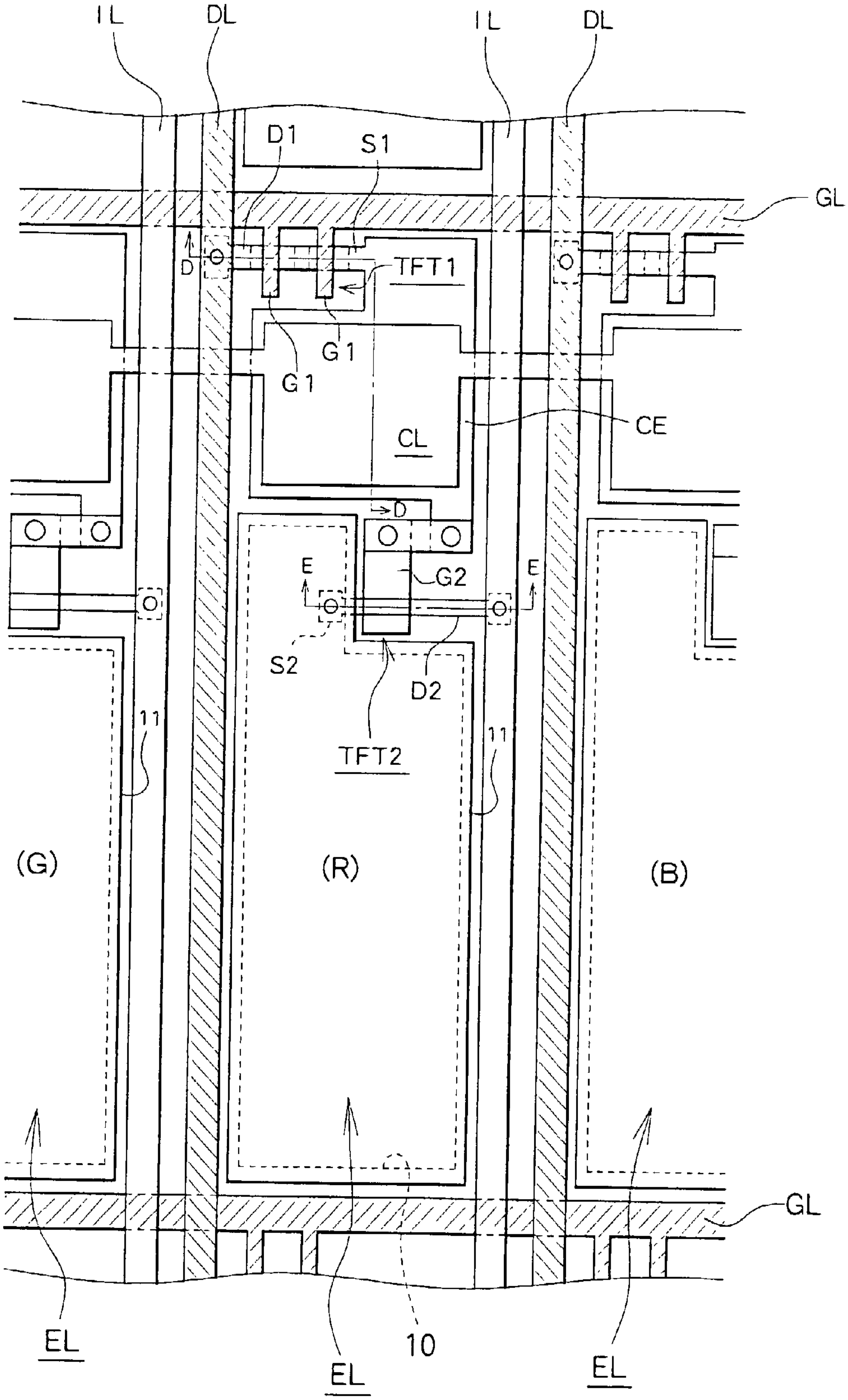
(57) **ABSTRACT**

A glass substrate is placed within a vacuum chamber, with a surface of the glass substrate on which an emissive layer forming an electroluminescence element is to be formed by evaporation facing downward. A mask is disposed within the vacuum chamber. A material of the emissive layer is adhered to the glass substrate through an opening of the mask, to thereby form the emissive layer. While the glass substrate and the mask are aligned with each other, the glass substrate is supported by pins provided at the mask side.




IL
DL
IL
DL
D1
S1
GL
D
TFT1
G1
G1
CE
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D
E
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11
11
(G)
(R)
(B)
GL
EL
EL
10
EL

Fig. 1

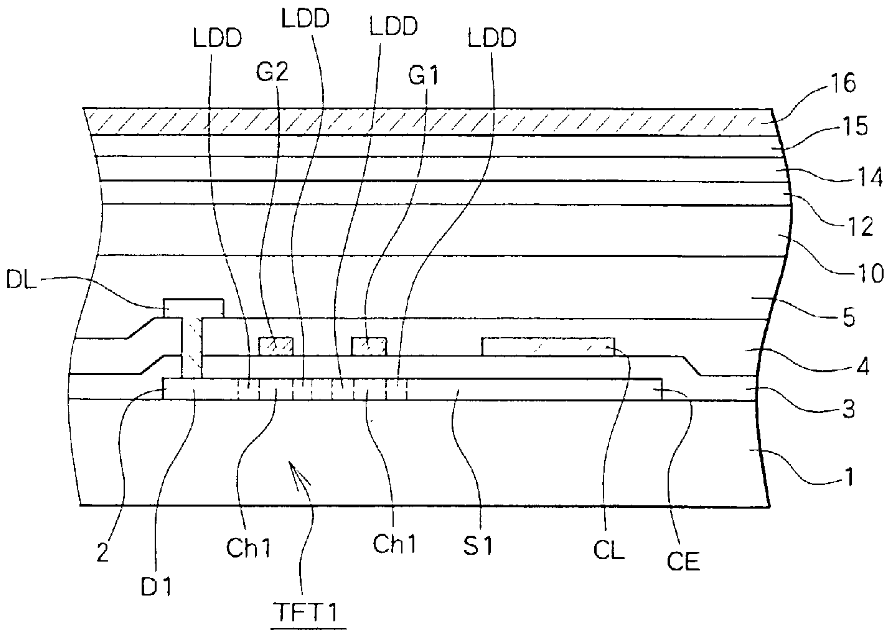
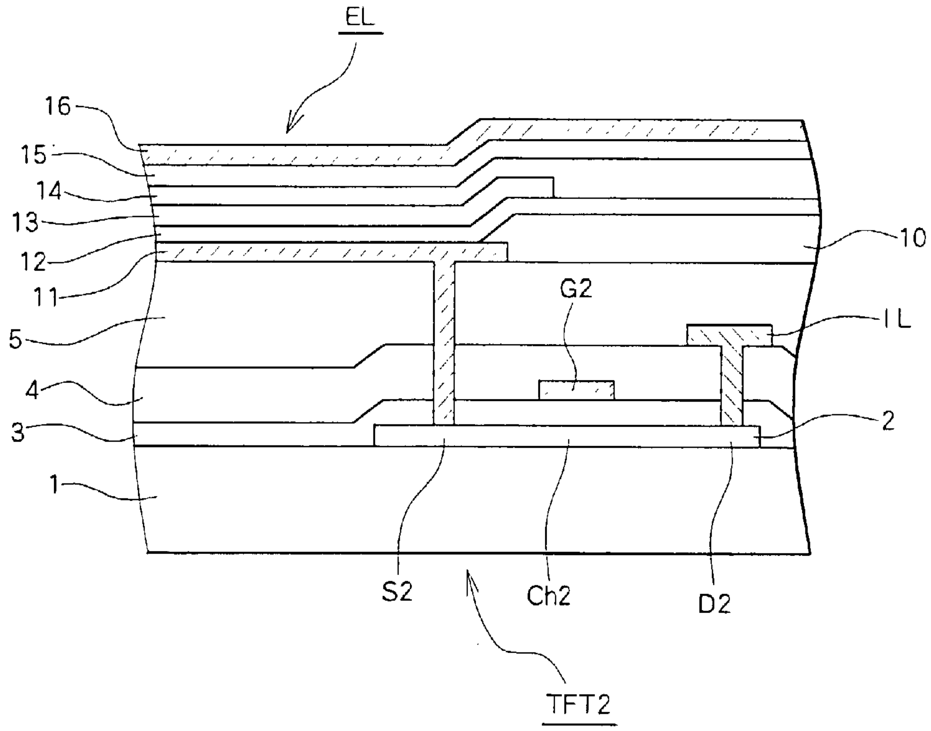

LDD
LDD
LDD
LDD
G2
G1
16
15
14
12
10
DL
5
4
3
1
2
D1
Ch1
Ch1
S1
CL
CE
TFT1

Fig. 2A


EL
16
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11
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G2
IL
2
S2
Ch2
D2
TFT2

Fig. 2B

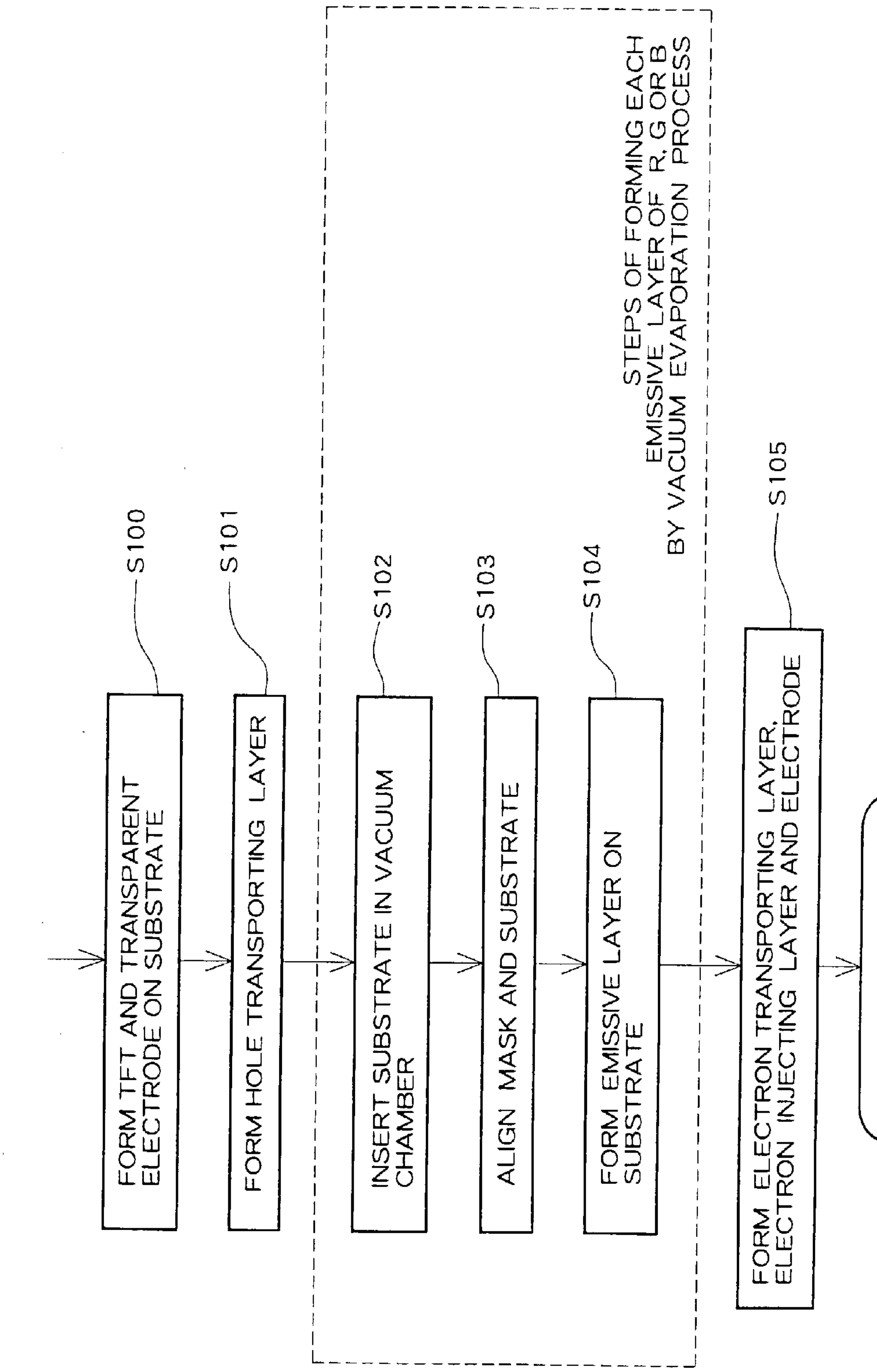

FORM TFT AND TRANSPARENT ELECTRODE ON SUBSTRATE
S100
FORM HOLE TRANSPORTING LAYER
S101
INSERT SUBSTRATE IN VACUUM CHAMBER
S102
ALIGN MASK AND SUBSTRATE
S103
FORM EMISSIVE LAYER ON SUBSTRATE
S104
STEPS OF FORMING EACH EMISSIVE LAYER OF R, G OR B BY VACUUM EVAPORATION PROCESS
FORM ELECTRON TRANSPORTING LAYER, ELECTRON INJECTING LAYER AND ELECTRODE
S105
TO SUBSEQUENT STEP

Fig. 3

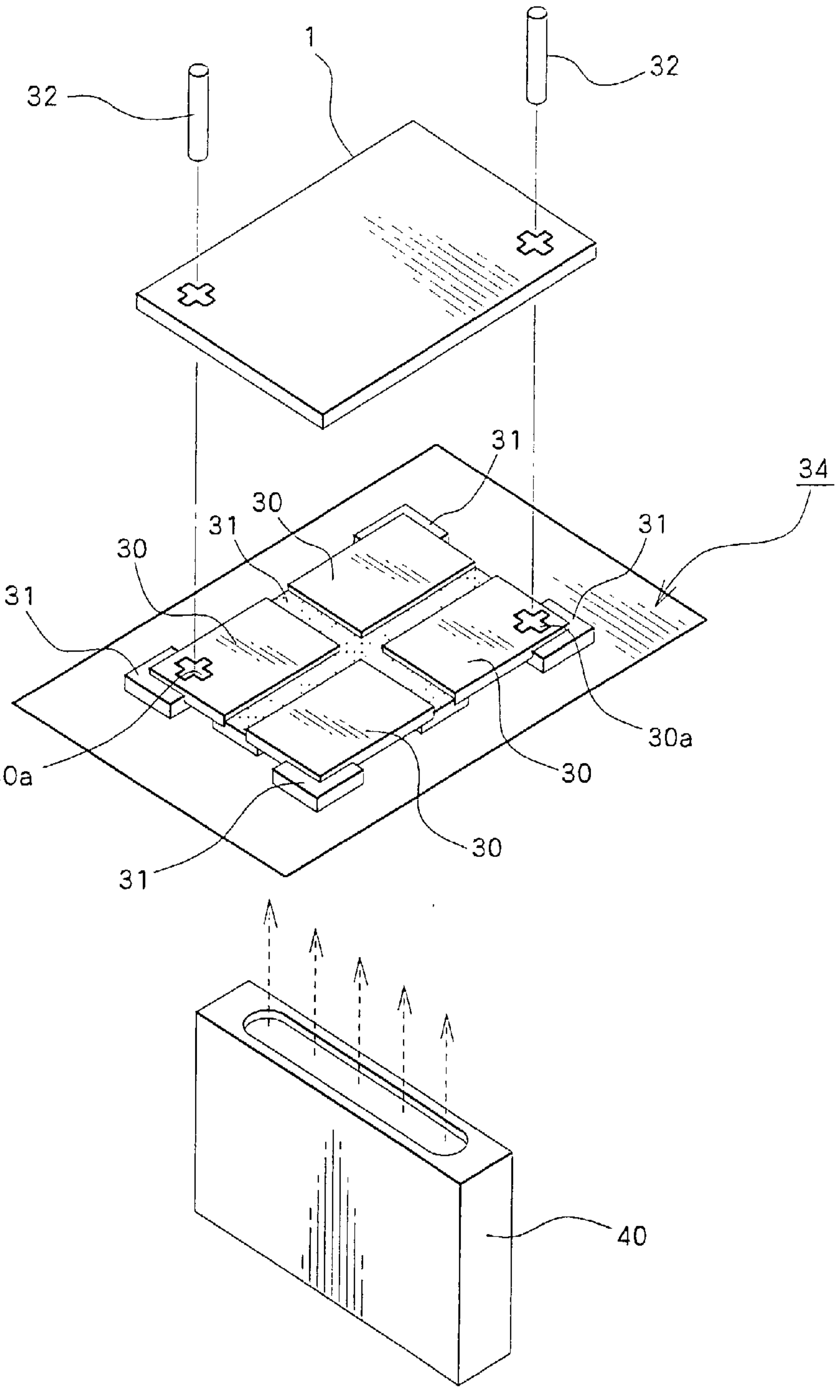


Fig. 4

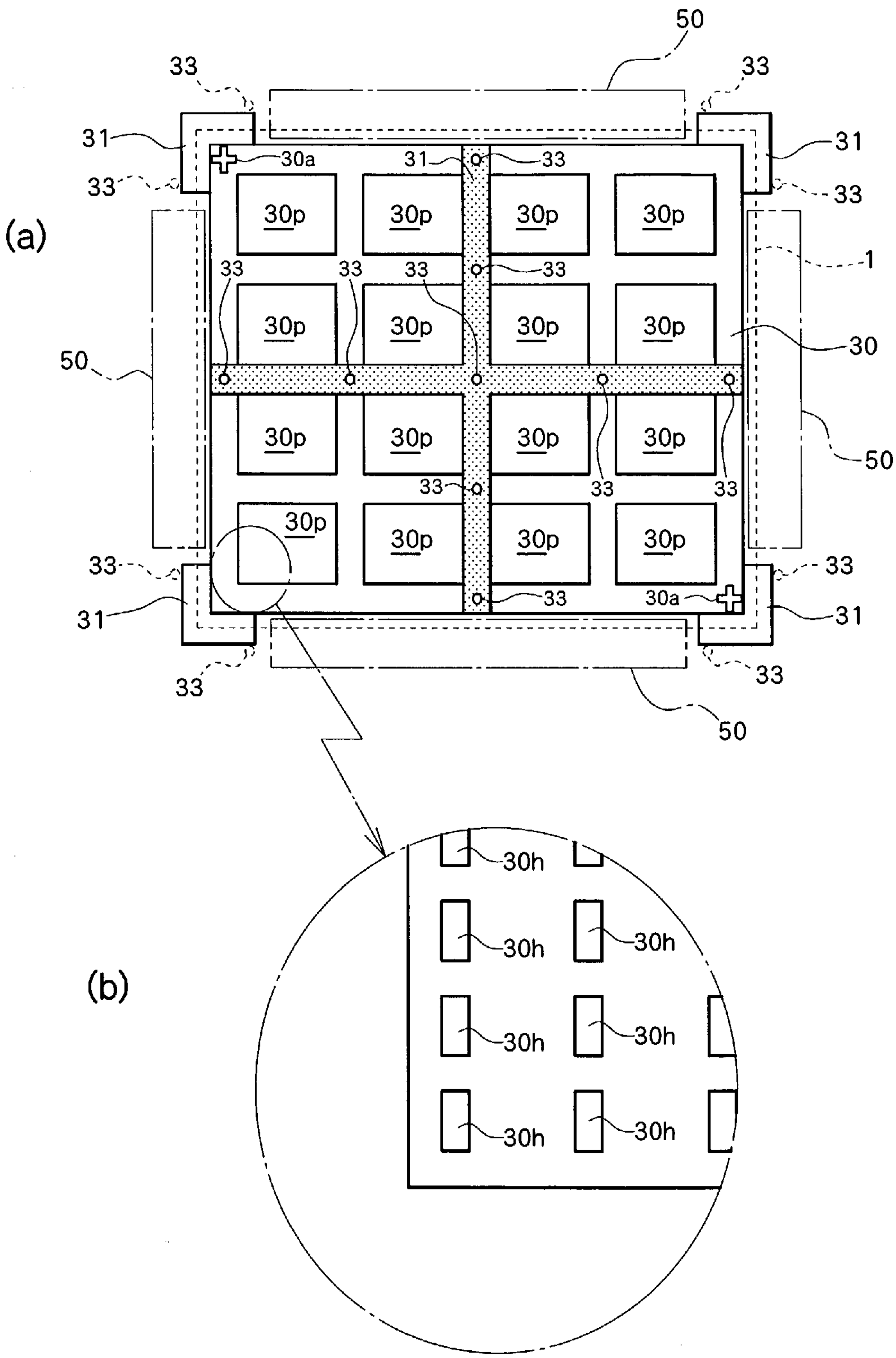


Fig. 5

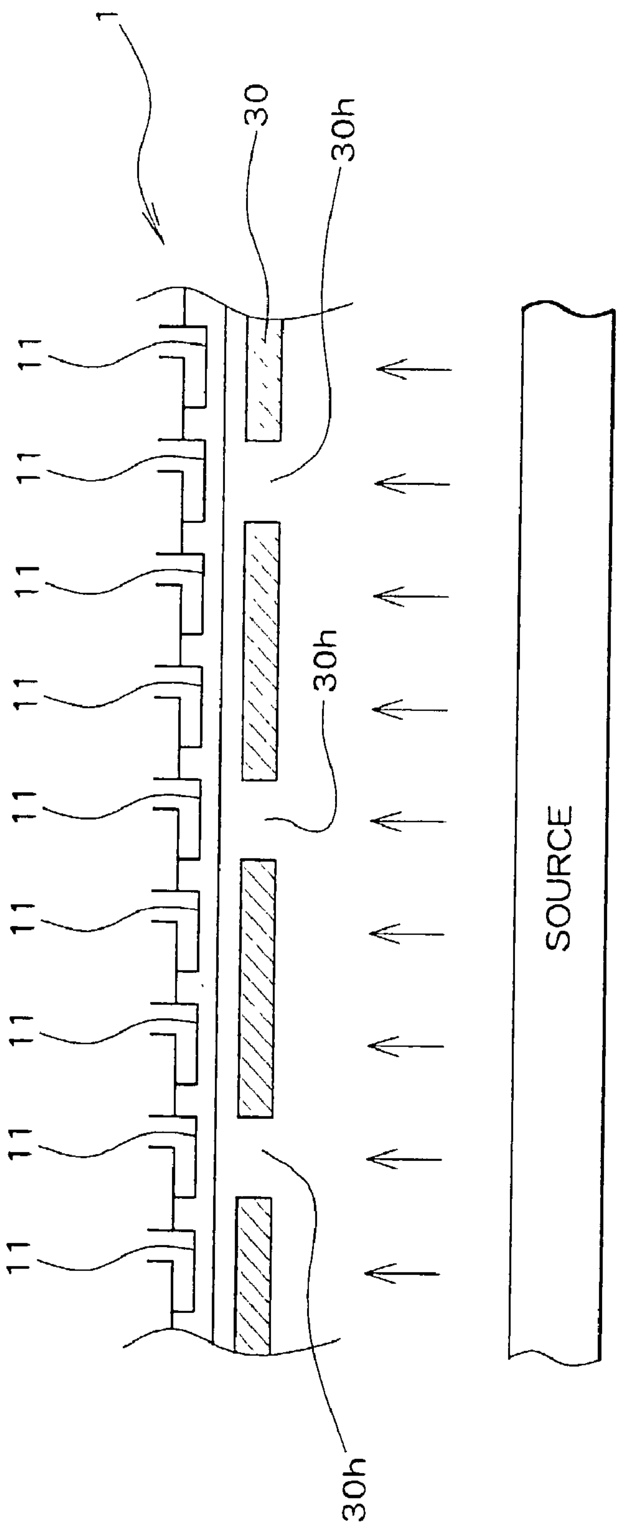


Fig. 6

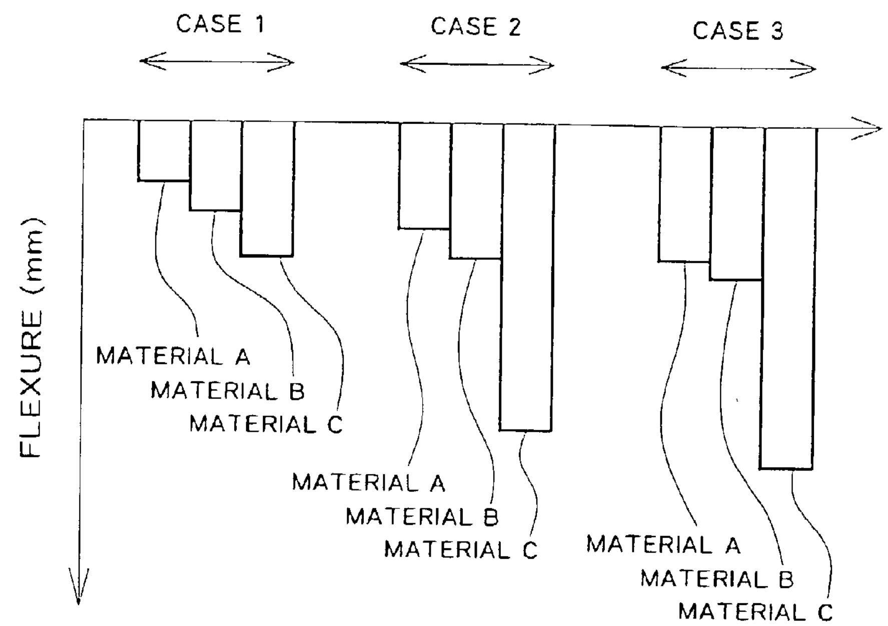


Fig. 7A

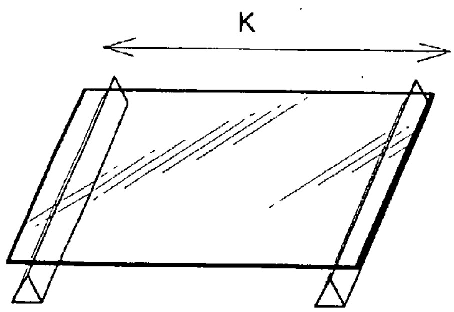


Fig. 7B

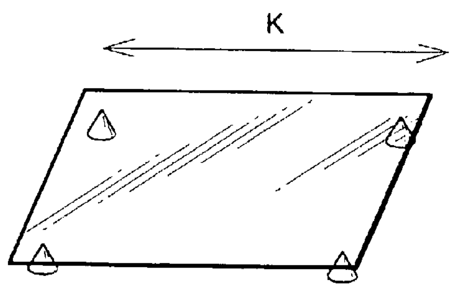
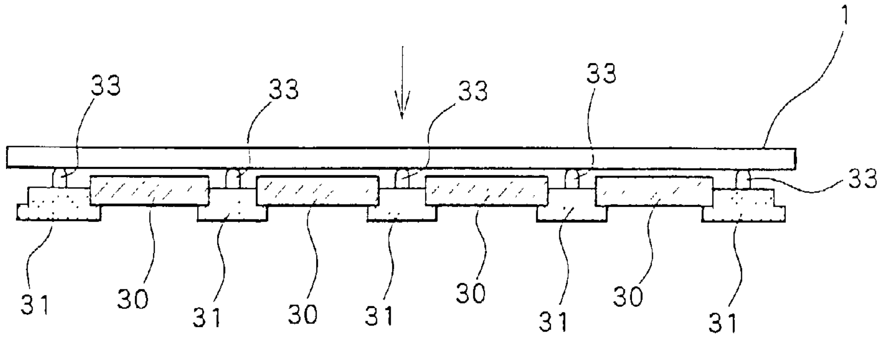


Fig. 7C


1
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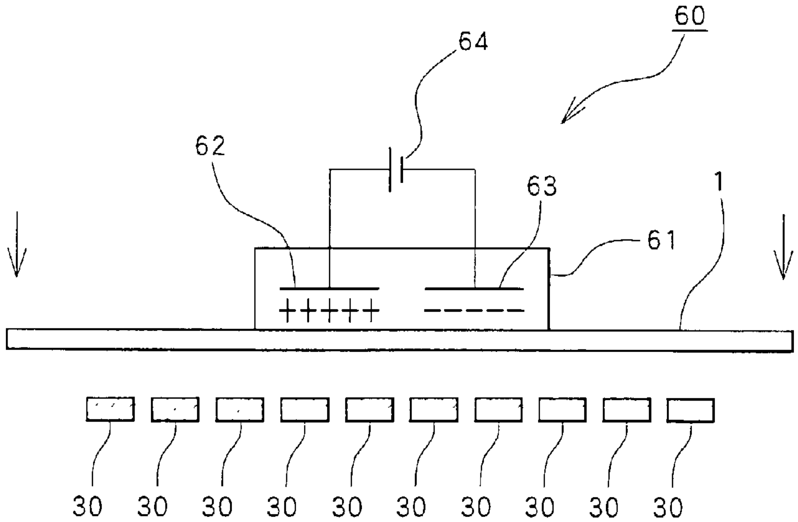
31

Fig. 8


60
64
62
63
1
61
+++++

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30

Fig. 9

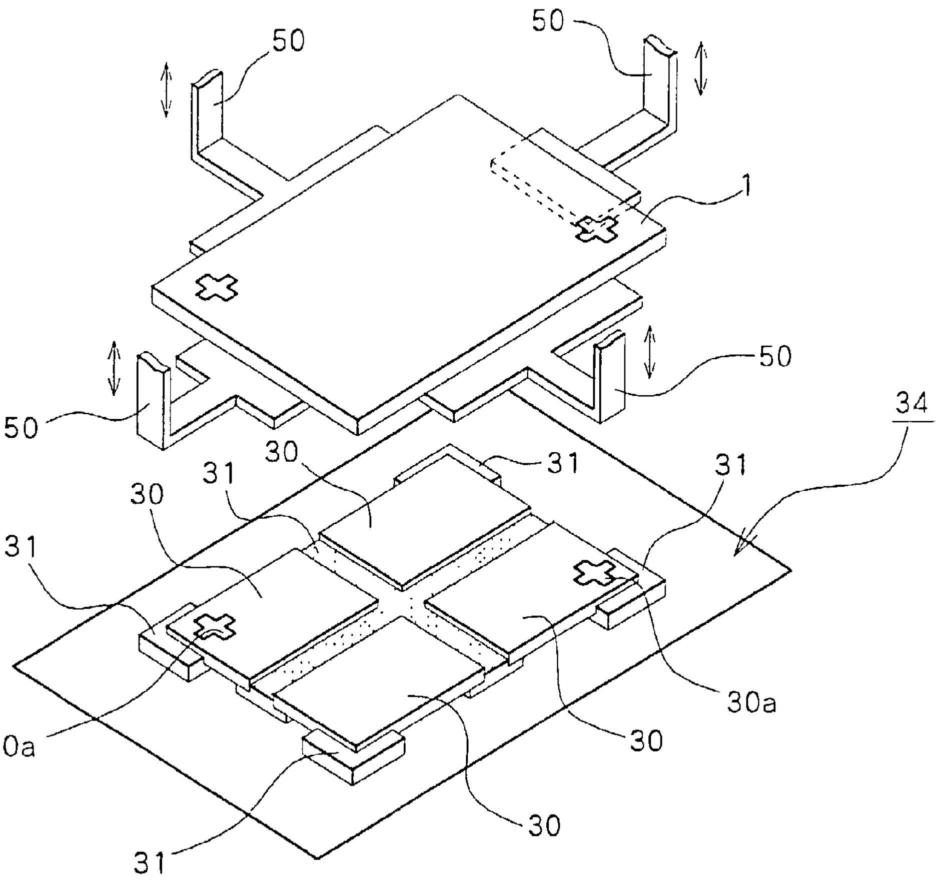

Fig. 10

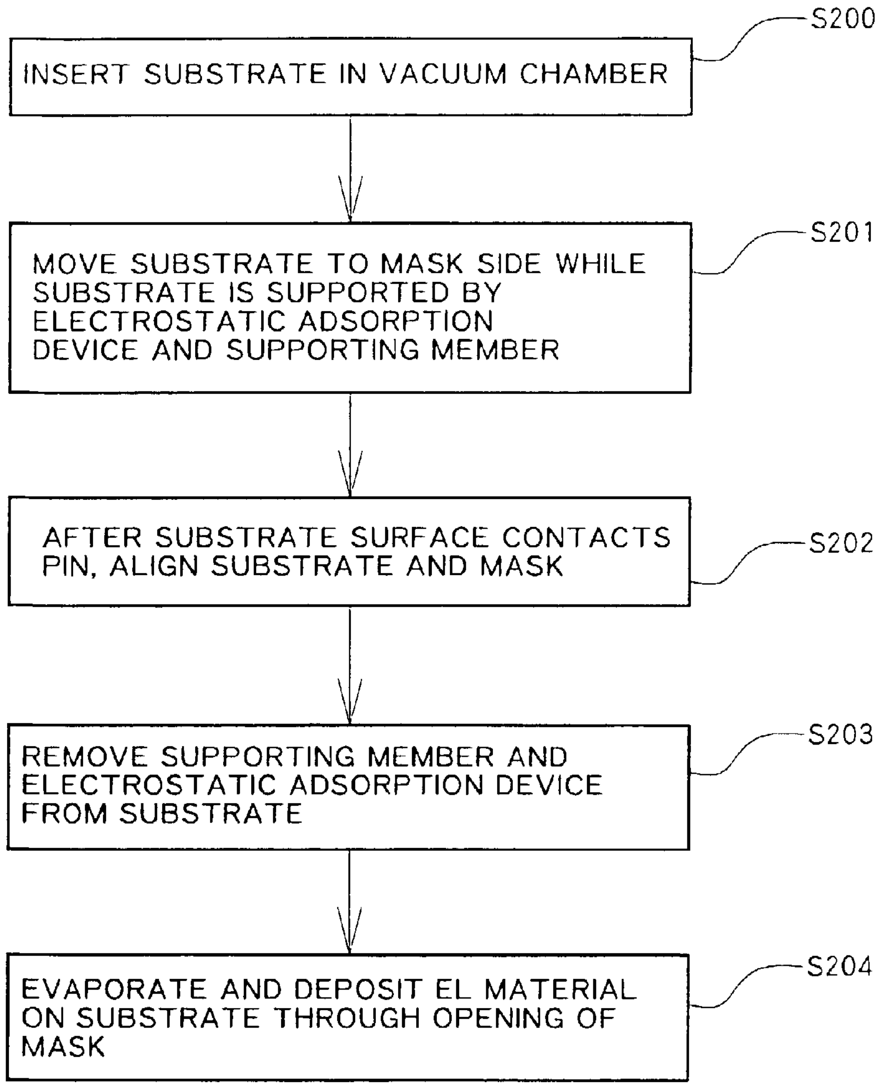
S200
INSERT SUBSTRATE IN VACUUM CHAMBER
S201
MOVE SUBSTRATE TO MASK SIDE WHILE SUBSTRATE IS SUPPORTED BY ELECTROSTATIC ADSORPTION DEVICE AND SUPPORTING MEMBER
S202
AFTER SUBSTRATE SURFACE CONTACTS PIN, ALIGN SUBSTRATE AND MASK
S203
REMOVE SUPPORTING MEMBER AND ELECTROSTATIC ADSORPTION DEVICE FROM SUBSTRATE
S204
EVAPORATE AND DEPOSIT EL MATERIAL ON SUBSTRATE THROUGH OPENING OF MASK

Fig. 11

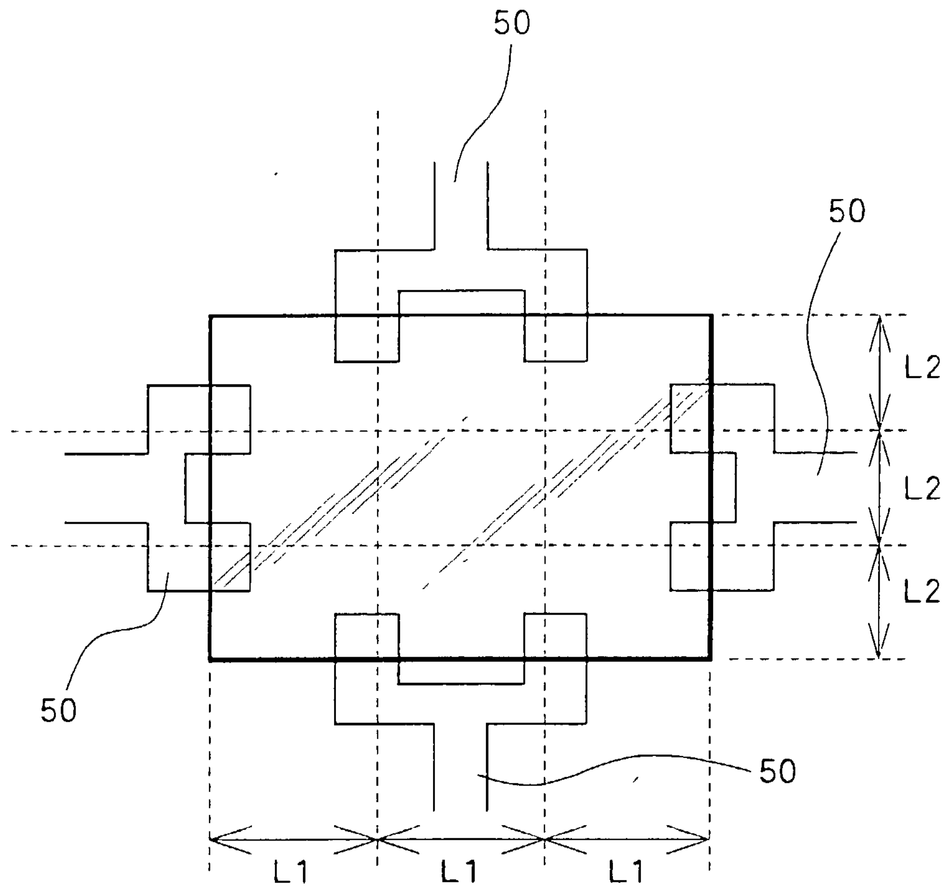

Fig. 12

METHOD OF MANUFACTURING ELECTROLUMINESCENCE DISPLAY APPARATUS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method of manufacturing an electroluminescence (EL) display apparatus, and more particularly to a method of manufacturing an EL display apparatus, in which an EL element is formed on a substrate surface using a mask.

[0003] 2. Description of Related Art

[0004] In recent years, display apparatuses using an EL element have attracted great attention.

[0005] Such an EL element may be constituted, for example, by an anode formed by a transparent electrode made of ITO (Indium Tin Oxide) or the like, a hole transporting layer made of MTDATA (4,4',4"-tris(3-methylphenylphenylamino)triphenylamine) or TPD (N,N'-diphenyl-N,N'-di(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine), an emissive layer made of $BeBq_2$ (bis(10-hydroxybenzo[h]quinolinato)beryllium) including quinacridone derivative or the like, an electron transporting layer made of $BeBq_2$ or the like, and an electrode (cathode) made of a magnesium indium alloy or the like, which are sequentially accumulated in a laminate structure. In such an EL element, holes injected from the anode and electrons introduced from the cathode are recombined in the emissive layer when a required voltage is applied between these electrodes, to thereby excite organic molecules forming the emissive layer to generate excitons. Through the process in which these excitons radiate until deactivation, the emissive element projects light which is directed externally from the transparent anode through the transparent insulating substrate, whereby desired emission is obtained.

[0006] When a display apparatus using such an EL element, i.e. an EL display apparatus, is constituted as a color image display apparatus, the EL display apparatus has a structure of a dot matrix display apparatus in which EL elements each emitting light corresponding to one of three colors, for example, red (R), green (G), and blue (B) are arranged in a matrix. In order to drive these EL elements arranged in a dot matrix pattern, a passive matrix method or an active matrix method can be employed.

[0007] In the passive matrix method, the EL elements arranged in a matrix pattern on the display panel to form respective pixels are directly driven externally in synchronization with a scanning signal. In this case, the display region in the display apparatus is constituted only by the EL elements.

[0008] In the active matrix method, on the other hand, a pixel driving element (an active element) is provided for each of the EL elements arranged in a matrix to form the respective pixels. The pixel driving element acts as a switch element which switches between on and off states in accordance with a scanning signal. The EL element is driven in such a manner that a data signal (a display signal or a video signal) is transmitted to the anode of the EL element through the pixel driving element which is in the on state, and predetermined current corresponding to the data signal flows between the anode and cathode of the EL element.

[0009] For the formation of EL elements used in such a display apparatus, a vacuum evaporation process is often employed. The formation of an EL element using the vacuum evaporation process basically includes the following two steps:

[0010] (1) within a vacuum chamber, covering, with a mask, portions of a substrate other than portions where EL elements are to be formed and placing the substrate such that the masked surface faces in the vertically downward direction; and

[0011] (2) heating a material for forming the EL element, including a material of an emissive layer or the like, to evaporate the material from under the substrate, thereby depositing the material on the substrate surface and forming the EL element.

[0012] In order to form the EL element on the substrate surface in the above-described manner, it is necessary, especially for the formation of the emissive layer, to very accurately align the substrate and the mask. However, if at the time of alignment the substrate is supported in such manner that the EL element forming surface of the substrate constitutes a lower surface which faces downward, it is not possible to dispose this lower surface in direct contact with the mask because most of the lower surface forms the display panel region on which the EL element or the like is to be formed. In other words, it is necessary to support the end portions of the substrate, regions other than the display panel region with an appropriate support hand or the like. When the end portions of the substrate are supported, however, flexure is likely to be generated in the center portion of the substrate. As a result, when the substrate is moved toward the mask side, the center portion of the substrate first comes into contact with the mask. If, under this state, the substrate and the mask are moved relative to each other so as to make alignment, there is a possibility that the film surface of the substrate is damaged, and accurate alignment cannot be obtained.

[0013] On the other hand, from the standpoint of the accuracy of alignment and of film deposition, it is desirable to place the substrate and the mask as close to each other as possible, which further exacerbates the above problem.

[0014] Further, the above-described problem that flexure in the substrate makes alignment difficult occurs not only with the vacuum evaporation process but also when the EL element is formed by other methods. Therefore, this problem is generally in common in various manufacturing methods as long as accurate alignment is required between the substrate and the mask.

SUMMARY OF THE INVENTION

[0015] The present invention was conceived in view of the above described problems of the related art and an object of the present invention is to enable more accurate alignment between a mask and a substrate when forming an electroluminescence element using a mask.

[0016] In accordance with one aspect of the present invention, there is provided a method of manufacturing an electroluminescence display apparatus in which, after a substrate and a mask disposed below the substrate are aligned with each other, a material of an electroluminescence element is adhered to the substrate via an opening of the mask to form an electroluminescence element layer, said method comprising fixing and positioning the mask with respect to a mask frame prior to the alignment of the substrate and the mask, and aligning the substrate with the mask, with the substrate being supported on the mask using a plurality of pins provided on the mask frame.

[0017] In accordance with another aspect of the invention, there is provided a method of manufacturing an electroluminescence display apparatus in which, after a substrate and a mask disposed below the substrate are aligned with each other, a material of an electroluminescence element is adhered to the substrate via an opening of the mask to form an electroluminescence element layer, said method comprising fixing and positioning the mask with respect to a mask frame disposed on a supporting table prior to the alignment of the substrate and the mask; and aligning the substrate with the mask, with the substrate being supported on the mask using a plurality of pins provided on at least one of the mask frame and the supporting table.

[0018] By supporting the substrate during alignment using a plurality of pins provided on the mask frame which fixes and supports the mask, or on the supporting table, generation of flexure in the substrate at the time of alignment can be suppressed, which allows accurate alignment of the mask and the substrate. Further, it is possible to prevent the element forming surface of the substrate being damaged by the mask, as would otherwise be caused were the element forming surface to bend and contact the mask disposed below.

[0019] In accordance with another aspect of the present invention, the plurality of pins are disposed symmetrically with respect to the substrate.

[0020] When the substrate is supported by the pins which are symmetrically disposed as described above, the lower surface (element forming surface) of the substrate can be supported uniformly, thereby preventing uneven flexure of the substrate which results from uneven distribution of the pins.

[0021] In accordance with another aspect of the present invention, the plurality of pins are capable of expansion and contraction in the vertical direction. Further, the plurality of pins may be capable of expansion and contraction and may be contracted such that an element forming surface of the substrate is supported at a position which is substantially the same level as a surface of the mask which opposes the substrate when the substrate is disposed on the plurality of pins.

[0022] By using pins capable of expansion and contraction as descried above, when the substrate contacts these pins disposed below, that is when the substrate is supported by the pins, each of the pins can be contracted in accordance with a force generated by the weight of the substrate, thereby simplifying the inhibition of slight winding and flexure in the element forming surface of the substrate.

[0023] In accordance with another aspect of the present invention, at least three sides of the substrate are supported by side supporting members while the substrate is aligned with the mask.

[0024] Further, of the side supporting members, a pair of the side supporting members which support opposing sides of the substrate may be symmetrical with respect to each other, at least with respect to contact and support portions of the side supporting members which contact and support the substrate.

[0025] By supporting the substrate using both the side supporting members and the above-described pins while the substrate is aligned as described above, flexure in the substrate can be more reliably suppressed.

[0026] In accordance with another aspect of the present invention, at least the alignment of the substrate and the mask is performed within a vacuum chamber. The vacuum chamber may be, for example, an evaporation chamber for the electroluminescence element layer.

[0027] According to the method of the present invention, alignment of a mask and a substrate can be performed even in a vacuum chamber. Further, when a substrate is aligned with a mask used in evaporation of an electroluminescence element material within an evaporation chamber (a vacuum evaporation chamber) for the electroluminescence element as descried above, it is possible to start the process of forming an element layer immediately after completion of the alignment. It is therefore possible to form the element layer by evaporation quickly and accurately without changing the relative positions of the mask and the substrate after the alignment.

[0028] In accordance with another aspect of the present invention, while the substrate is aligned with the mask within the vacuum chamber as described above, at least three sides of the substrate are supported by side supporting members, or an upper surface of the substrate is supported by adsorption using an electrostatic adsorption mechanism. Use of these members enables more reliable support of the substrate within a vacuum container.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] These and other objects of the invention will be explained in the description below, in connection with the accompanying drawings, in which:

[0030] **FIG. 1** is a plan view of an active matrix type EL display apparatus as seen from above;

[0031] **FIGS. 2A and 2B** are cross sectional views each showing a partial sectional structure of an active matrix type EL display apparatus;

[0032] **FIG. 3** is a flowchart showing manufacturing procedures in a method of manufacturing an EL display apparatus according to a first embodiment of the present invention;

[0033] **FIG. 4** is a perspective view showing alignment of a mask and a glass substrate in a vacuum chamber in accordance with the first embodiment of the present invention;

[0034] **FIG. 5** is a plan view showing disposition of a mask and a glass substrate according to the first embodiment;

[0035] **FIG. 6** is a side view schematically showing formation of an EL element by evaporation according to the first embodiment;

[0036] **FIGS. 7A, 7B**, and **7C** are diagrams for explaining the relationship between the size and support type of a glass substrate and the flexure generated in the glass substrate;

[0037] **FIG. 8** is a cross sectional view showing support of a glass substrate according to the first embodiment of the present invention;

[0038] **FIG. 9** is a cross sectional view schematically showing support of a glass substrate according to a second embodiment of a method of manufacturing an EL display apparatus of the present invention;

[0039] **FIG. 10** is a perspective view showing support of a glass substrate according to a third embodiment a method of manufacturing an EL display apparatus of the present invention;

[0040] **FIG. 11** is a flowchart showing the procedures for formation of an EL element by evaporation according to the third embodiment; and

[0041] **FIG. 12** is a plan view showing support of a glass substrate as a modification example of the above embodiments.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0042] (First Embodiment)

[0043] A first embodiment of a method of manufacturing an EL display apparatus of the present invention, which is implemented as a method of manufacturing an active matrix type color EL display apparatus, will be described with reference to the drawings.

[0044] **FIG. 1** is a plan view of an EL element (which is an organic EL element in this embodiment and is indicated as "EL" in **FIG. 1**) and its peripheral section, of an EL display apparatus to be manufactured according to the present embodiment. Referring to **FIG. 1**, the EL display apparatus comprises a display pixel formed by the EL element, and a thin film transistor (TFT) which is an active element provided for each corresponding display dot.

[0045] More specifically, as shown in **FIG. 1**, gate signal lines GL and drain signal lines (data signal lines) DL are arranged in a matrix as signal lines for performing drive control of the EL element. An EL element (display pixel) is provided corresponding to each intersection of these signal lines. In the EL display apparatus shown in **FIG. 1**, each display pixel corresponds to any one of the primary colors R, G and B, to thereby enable color image display.

[0046] Additional elements are also provided so as to perform drive control of each of the EL elements separately. First, near the above-described intersection of the signal lines, a thin film transistor (TFT1), which is connected with the gate signal line GL and functions as a switching element to be turned ON due to the activity of the gate signal line GL, is formed. A source **S1** of this TFT1 serves also as a capacitor electrode CE and a storage capacitor is formed between the capacitor electrode CE and a capacitor line CL made of a refractory metal such as chromium (Cr) and molybdenum (Mo). When the TFT1 is turned ON, an electrical charge in accordance with the voltage of a data signal supplied from the data line DL is accumulated in the storage capacitor.

[0047] The capacitor electrode CE is connected to a gate G2 of a thin film transistor (TFT2) which drives the EL element. Further, a source S2 of the TFT2 is connected with a transparent electrode **11** which is an anode of the EL element, while a drain D2 of the TFT2 is connected with a drive power source line IL which is a current source for supplying an electrical current to the EL element. With this structure, a voltage in accordance with the electrical charge stored in the storage capacitor is applied from the capacitor electrode CE to the gate G2, such that a current in accordance with the applied voltage is supplied from the drive power source line IL to the EL element.

[0048] **FIGS. 2A and 2B** are cross sectional views taken along lines D-D and E-E of **FIG. 1**, respectively. As shown in **FIGS. 2A and 2B**, the above-described EL display apparatus is formed by sequentially forming a thin film transistor and an EL element on a glass substrate **1** in a laminated structure.

[0049] First, the TFT1 which serves as a switching transistor for performing charging control of the storage capacitor is formed in a manner shown in **FIG. 2A**. Specifically, on the glass substrate **1**, a poly-silicon layer **2** is formed. In this polysilicon layer **2**, the above-described source **S1** and the drain **D1** as well as channels Ch**1** are formed, while LDDs (Lightly Doped Drains) are further provided on both outer sides of the channels Ch**1**. The poly-silicon layer **2** also serves as a storage capacitor electrode CE. On the poly-silicon layer **2** and the storage capacitor electrode CE, a gate insulating film **3**, the above-described gate signal line GL made of a refractory metal such as Cr and Mo and a gate electrode **G1** which is integral with the gate signal line GL, and a storage capacitor electrode line CL are formed. Further, over these layers, an interlayer insulating film **4** formed by accumulating a silicon oxide film and silicon nitride film, in this order, in a laminate structure is provided. This interlayer insulating film **4** has an opening at a position corresponding to the drain **D1**. By filling this opening with a conductive material such as aluminum, the drain **D1** comes into electrical contact with the drain signal line DL. Further, on these drain signal line DL and the interlayer insulating film **4**, a planarization insulating film **5** made of, for example, an organic resin, is formed for surface planarization.

[0050] On the other hand, the TFT2 for driving the EL element is formed in a manner as shown in **FIG. 2B**. Specifically, on the glass substrate **1**, a poly-silicon layer **2** which is equal to that shown in **FIG. 2A** is formed. In this poly-silicon layer **2**, a channel Ch**2**, a source S**2**, and a drain D**2** of the TFT2 are formed. On this poly-silicon layer **2**, a gate insulating film **3** which is equal to that shown in **FIG. 2A** is formed, and on the portion of the gate insulating film **3** which is located above the channel Ch**2**, a gate **G2** made of a refractory metal such as chromium (Cr) and molybdenum (Mo) is provided. Over the gate **G2** and the gate insulating film **3**, an interlayer insulating film **4** and a planarization insulating film **5** which are equal to those shown in **FIG. 2A** are sequentially formed in a laminate structure. The interlayer insulating film **4** has an opening at a position corresponding to the drain D**2**, and by filling this opening with an conductive material such as aluminum, the drain **D2** comes in electrical contact with the drive power source line IL. Also, a contact hole is formed through portions of the interlayer insulating film **4** and the planarization insulating film **5** which correspond to the source S**2**. Then, ITO (Indium Tin Oxide) is formed so as to fill this contact hole, so that the source S**2** comes in electrical contact with an transparent electrode **11** made of ITO or the like. The transparent electrode **11** constitutes an anode of the EL element. It should be noted that the source S**2** is not necessarily brought in direct contact with the ITO, and the source S**2** and the ITO may be connected in the following manner, for example. That is, a contact hole is first formed in the interlayer insulating film **4** and the gate insulating film **3**, and the hole is filled with a conductive material such as aluminum simultaneously with the formation of the contact (the drain electrode) between the drain D**2** and the power source line IL. Then, another contact hole is formed at a corresponding portion of the planarization insulating film **5**, which is subsequently formed, and ITO is formed so as to fill this contact hole.

[**0051**] As an example, the EL element may comprise the following layers sequentially accumulated in a laminate structure:

[**0052**] a) a transparent electrode **11**;

[**0053**] b) a hole transporting layer **12** made of NBP;

[**0054**] c) an emissive layer **13** for red (R) obtained by doping a dopant of red color (DCJTB) into a host material (Alq_3), for green (G) obtained by doping a dopant of green color (Coumarin 6) into a host material (Alq_3), or for blue (B) obtained by doping a dopant of blue color (Perylen) into a host material (BAlq);

[**0055**] d) an electron transporting layer **14** made of Alq_3;

[**0056**] e) an electron injecting layer **15** made of lithium fluoride (LiF); and

[**0057**] f) an electrode (cathode) **16** made of aluminum (Al).

[**0058**] The abbreviations used in the above description refer to the following materials:

[**0059**] "NBP" refers to N,N'-di((naphthalene-1-yl)-N,N'-diphenylbenzidine);

[**0060**] "Alq_3" refers to tris(8-hydroxyquinolinato)aluminum;

[**0061**] "DCJTB" refers to (2-(1,1-dimethylethyl)-6-(2-(2,3,6,7-tetrahydro-1,1,7,7-tetramethyl-1H,**5**H-benzo[ij]quinolizin-9 yl)ethenyl)-4H-pyran-4-ylidene)propanedinitrile;

[**0062**] "Coumarin 6" refers to "3-(2-benzothiazolyl)-7-(diethylamino)coumarin; and

[**0063**] "BAlq" refers to (1,1'-bisphenyl-4-Olato-)bis(2-methyl-8-quinolinplate-N1,08)Aluminum.

[**0064**] The hole transporting layer **12**, the electron transporting layer **14**, the electron injecting layer **15** and the electrode **16** are also formed in the regions shown in **FIG. 2A** as common layers. However, the emissive layer **13**, which is formed in an individual island shape for each pixel so as to correspond to the transparent electrode **11**, is not shown in **FIG. 2A**. It should be noted that, as shown in **FIGS. 2A and 2B**, an insulating film **10** is formed on the planarization insulating film **5**.

[**0065**] An example method of manufacturing an EL display apparatus according to the present embodiment will now be described.

[**0066**] **FIG. 3** shows the procedures for manufacturing an EL display apparatus according to the present embodiment. Referring to **FIG. 3**, this series of procedures starts with step s**100** where a TFT and a transparent electrode **11** are formed on a glass substrate **1**. Further, the hole transporting layer **12** is formed using vacuum evaporation or the like on substantially all the surface of the substrate **1** (step s**101**).

[**0067**] The glass substrate **1** on which the hole transporting layer **12** has been formed is then transported into a vacuum chamber which is used, in this example, for forming an emissive layer, without being exposed to the air (step s**102**). At this time, the substrate **1** is transported with the surface having the hole transporting layer **12** formed thereon facing downward. Inside the chamber, a mask **30** made, for example, of nickel (Ni) and having an opening (not shown) which has been previously formed so as to correspond to the shape of the emissive layer, is provided. Specifically, the mask **30** is fixedly secured to a holding plate **34** having an opening at least in the mask region, by means of a mask frame **31** provided on the holding plate **34**.

[**0068**] Once the glass substrate **1** having the hole transporting layer **12** formed thereon is inserted in the vacuum chamber, the glass substrate **1** and the mask **30** located below the substrate **1** are aligned. Specifically, while the position of an alignment mark **30***a* formed in the mask **30** and the position of an alignment mark **1***a* formed on the glass substrate **1** are monitored using a CCD (Charge Coupled Device) camera **32** or the like, the glass substrate **1** and the mask **30** are aligned with each other such that alignment marks **30***a* and **1***a* correspond with each other (step s**103** in **FIG. 3**). Although these alignment marks **30***a* and **1***a* are shown in **FIG. 4** in an enlarged manner for the convenience of drawing, the example marks are actually square crosses having 50 μm bars. Naturally, the shape and the size of the alignment mark is not limited to this example.

[**0069**] Actually, in the above steps, it is necessary to form pixels corresponding to three main colors R, G, and B on a single panel so as to obtain a color display apparatus. Therefore, the emissive layers for R, G, and B are to be formed individually. More specifically, when different emissive materials are used for each of R, G, and B, the glass substrate **1** on which the hole transporting layer **12** has been formed is inserted into each of the individual vacuum chambers in turn, for forming the emissive layer **13** corresponding to each of the primary colors R, G, and B. In each of these vacuum chambers, a mask having an opening at a portion corresponding to the transparent electrode (anode) **11** which is used for light emission of a predetermined primary color is provided as the above-described mask **30**. Namely, a mask corresponding to one of the colors R, G, and B is provided in each of the vacuum chambers. It is therefore possible to form an emissive layer corresponding to each of the primary colors at a predetermined position, in each chamber.

[**0070**] **FIG. 5**(*a*) shows how the glass substrate **1** (indicated by a dot line in this drawing) is aligned with respect to the mask **30**. In this embodiment, the mask **30** is constituted so as to form a large number of display panels from a single glass substrate. More specifically, as illustrated in **FIG. 5**(*a*), the mask **30** according to this embodiment includes **16** panel forming sections **30***p* so as to form **16** display panels simultaneously. These **16** panel forming sections **30***p* are formed by **4** masks **30** each having **4** panel forming sections **30***p*. In each panel forming section **30***p*, openings **30***h* are formed in such a manner that each opening **30***h* corresponds to the transparent electrode **11** used for emission of light of a desired primary color.

[**0071**] When the mask **30** and the glass substrate **1** are aligned with each other as shown in **FIG. 5**(*a*), the glass substrate **1** is then supported by the mask frame **31** or the like. Then, by heating a material for the emissive layer **13** to evaporate from the evaporation source **40** located below the holding plate **34** as shown in **FIG. 4**, the material is deposited onto the surface of the glass substrate **1** through the openings of the mask (step s**104**).

[**0072**] The formation of the emissive layer via the mask as described above is schematically shown in **FIG. 6**. Referring to **FIG. 6**, of the respective transparent electrodes (anodes) **11**, portions other than regions where the transparent electrodes corresponding to a desired primary color for each chamber are formed, are covered with the mask **30**. An EL material (an organic EL material) corresponding to the desired primary color is heated within the source, is evaporated, and is then deposited on the glass substrate **1** (to be specific, on the hole transporting layer **12**) through the opening **30***h* of the mask **30**.

[**0073**] After the emissive layer of the corresponding primary color is thus formed by evaporation within each chamber, the glass substrate **1** is removed from the vacuum chamber used for forming the emissive layer, and then transported into another vacuum chamber where the electron transporting layer **14**, the electron injecting layer **15**, and the electrode (cathode) **16** are formed (step s**105** in **FIG. 5**). It should be noted that formation of the electron transporting layer **14**, the electron injecting layer **15** and the electrode (cathode) **16** are carried out in separate chambers.

[**0074**] As described above, there is a problem that flexure is generated in the glass substrate **1** and the mask **30** when the glass substrate **1** and the mask **30** are aligned with each other within the vacuum chamber in a manner as described above. In particular, when a large size glass substrate **1** is used so as to form a plurality of display panels simultaneously as in the present embodiment, significant flexure is likely to be generated in the glass substrate **1**.

[**0075**] The relationship between the size and support type of the glass substrate and the flexure generated in the glass substrate will be described with reference to FIGS. **7**A-**7**C.

[**0076**] **FIG. 7A** shows a relationship between the size and support type of a glass substrate and the flexure generated in the glass substrate. Referring to **FIG. 7**A, the case 1 indicates the amount of flexure of a glass substrate having a length K and made of one of different materials A, B, and C when the substrate is supported in a manner shown in **FIG. 7B**. The case 2 indicates the amount of flexure of a glass substrate having a length L (L>K) and made of one of different materials A, B, and C when the substrate is supported in a manner shown in **FIG. 7B**. The case 3 indicates the amount of flexure of a glass substrate having a length K and made of one of different materials A, B, and C when the substrate is supported in a manner shown in **FIG. 7C**.

[**0077**] As is obvious from **FIG. 7**A, compared to when the glass substrate is point supported (**FIG. 7C**), flexure can be reduced to a greater extent when the glass substrate is supported along its sides (**FIG. 7B**). It can also be seen from **FIG. 7A** that the shorter the glass substrate, the less flexure will be produced. When the gravitational acceleration is g, the Poisson ratio is σ, the density of the glass is ρ, the Young's modulus of the glass is E, and the thickness of the glass is t, the flexure n generated when a glass substrate is supported in a manner shown in **FIG. 7B** can be expressed by the following equation (c1):

$$n=K^4 g\rho(1-\sigma^2)/6.4Et^2 \tag{c1}$$

[**0078**] As can be seen from the above equation (c1), as the length of the glass substrate increases, the amount of flexure will drastically increase.

[**0079**] Accordingly, in order to suppress flexure in the large size glass substrate, in accordance with the present embodiment, a plurality of pins **33** made of a resin, a metal, or the like are provided on the mask frame **31**, as shown in **FIG. 5**(*a*). The contact surface of each pin **33** which abuts the glass substrate **1** is spherical, as shown in **FIG. 8**. While the glass substrate **1** and the mask **30** are aligned with each other, the glass substrate **1** is supported by these spherical contact surfaces, thereby suppressing flexure at the time of alignment without damaging the glass substrate **1**. These pins **33** are preferably arranged symmetrically with respect to the surface of the glass substrate **1**. More specifically, in the example shown in **FIG. 5**(*a*), these pins **33** are equally spaced such that they divide the surface of the glass substrate **1** into equal areas, both vertically and horizontally. Further, in the example of **FIG. 5**(*a*), the pins **33** are disposed such that each pin is located at a midpoint between a pair of the panel forming parts **30***p*. With this arrangement, even when the glass substrate **1** is bent to some extent due to the contact between the glass substrate **1** and a pin **33**, toward the panel region **30***p* adjacent to the pin **33**, the influence of such flexure can be substantially disregarded. These pins **33** are not disposed inside the panel regions **30***p*, and are evenly distributed at regular intervals in the remaining regions, especially in the center region of the glass substrate **1**. In the example of **FIG. 5**(*a*), the pins **33** are arranged so as to equally divide the length of each side of the glass substrate **1**. It should be noted that, when a single panel is formed from a single glass substrate **1**, these pins are disposed within the display region and that, in such a case, the pins **33** are disposed as evenly as possible at positions where no mask openings are formed.

[**0080**] Further, in this embodiment, the pin **33** is made capable of expansion and contraction by, for example, including a spring (including a flat spring) at the lower portion. Therefore, the pin **33** can contract due to the weight of the glass substrate **1** to thereby support the glass substrate appropriately. Further, the pin **33** is designed to be contracted to the level of the mask **30**, so that, after completion of the alignment, the pin **33** can be contracted to substantially the same level as the upper surface of the mask **30** by the weight of the glass substrate **1** or an external force. In addition, when the pin **33** is designed such that the height of the pin **33**, even when fully contracted, is higher than the level of the mask **30**, it is possible to maintain a gap between the mask **30** and the glass substrate **1**, to thereby more reliably prevent the glass substrate **1** from being damaged by the mask **30**.

[**0081**] According to the foregoing embodiment, the following advantages can also be achieved.

[**0082**] (1) By performing alignment of the glass substrate **1** and the mask **30** while the glass substrate **1** is being supported by the pins **33**, it is possible, at the time of alignment, to suitably suppress the flexure generated in the glass substrate **1** and also to prevent the deposition surface of the glass substrate **1** from being damaged by the mask **30**.

[**0083**] (2) Because the pin **33** is designed such that it is capable of expansion and contraction in the perpendicular direction, after the glass substrate **1** and the mask **30** are aligned, it is possible to smoothly support the glass substrate **1** by the mask **30** or the like, and also to maintain a gap between the mask **30** and the glass substrate **1**.

[**0084**] (Second Embodiment)

[**0085**] A second embodiment of a method of manufacturing an EL display apparatus of the present invention, which is implemented as a method of manufacturing an active matrix type color EL display apparatus, will be described mainly with regard to the difference from the above-described first embodiment, and with reference to the drawings.

[**0086**] In the second embodiment, at the time of the alignment of the glass substrate **1** and the mask **30** according to the first embodiment, a supporting method for a substrate as will be described below is simultaneously employed.

[**0087**] More specifically, in this embodiment, at the time of alignment of the glass substrate **1** and the mask **30**, the upper surface of the glass substrate **1** is supported using electrostatic adsorption. Namely, within a vacuum chamber, it is not possible to support the upper surface of the glass substrate **1** by, for example, suction using a pressure lower than the air. Accordingly, by supporting the upper surface of the glass substrate **1** by electrostatic adsorption, supporting of the glass substrate **1** by adsorption can be achieved even in the vacuum chamber.

[**0088**] **FIG. 9** shows the principle of the electrostatic adsorption. Referring to **FIG. 9**, an electrostatic adsorption device **60** used in this embodiment comprises a pair of electrodes **62**, **63** provided in the adsorption section **61** made of ceramic or the like and a battery **64** whose anode and cathode are connected to the pair of electrodes **62**, **63**, respectively. By supporting the glass substrate **1** by means of adsorption using the electrostatic adsorption device **60**, it is possible to further reduce the flexure generated in the glass substrate **1**.

[**0089**] According to this embodiment described above, in addition to the above advantages (1) and (2) of the first embodiment, the following advantage can be further achieved.

[**0090**] (3) Because the upper surface of the glass substrate **1** is supported by electrostatic adsorption, it is possible, at the time of alignment between the glass substrate **1** and the mask **30**, to still further suppress the generation of flexure in the glass substrate **1** and accordingly to appropriately align the glass substrate **1** with the mask **30**.

[**0091**] The above-described second embodiment may be appropriately modified, such as, for example, as follows.

[**0092**] Specifically, the EL element may be formed by evaporation with the glass substrate **1** being supported by the electrostatic adsorption device **60**.

[**0093**] (Third Embodiment)

[**0094**] In the third embodiment, at the time of the alignment of the glass substrate **1** and the mask **30** according to the second embodiment, the following supporting method is additionally used.

[**0095**] Specifically, because the four sides of the glass substrate **1** are supported by the side supporting members **50** in the manner shown in **FIG. 10**, generation of flexure in the glass substrate **1** is suppressed. In other words, because the flexure increases as the length of the unsupported side of the glass substrate **1** increases, as previously described with reference to **FIGS. 7A** to **7C**, any increase in flexure because of the increase of the length of the glass substrate is suppressed by supporting the four sides of the glass substrate **1**.

[**0096**] Further, the four sides of the glass substrate **1** are supported by the side supporting members **50** such that the side supporting members **50** which face each other and support each pair of opposing sides of the glass substrate **1** are disposed as symmetrically as possible, thereby further inhibiting the generation of flexure in the glass substrate **1**. More specifically, a pair of side supporting members **50** supporting the opposing sides of the glass substrate **1** are designed to be the same size and of symmetrical shape to the greatest possible extent. Also, all the supporting members **50** are coordinated such that the levels of their supporting surfaces are aligned. The operation of the four supporting members **50** can be controlled individually or, for example, for each pair of opposing members **50**. Further, when the glass substrate **1** and the mask **30** are aligned with each other, it is preferable that the plurality of supporting members **50** be adjusted to prevent their relative positions from being misaligned.

[**0097**] Also, according to the present embodiment, each of the supporting members **50** supports an edge side of a surface of the glass substrate **1** which faces the mask **30**. By supporting the glass substrate **1** by the side supporting members **50** along each side in a line supporting manner, it is possible to support the glass substrate **1** without the side supporting members **50** contacting the display region of the glass substrate **1**.

[**0098**] More specifically, as shown in **FIG. 10**, each of the side supporting members **50** has an L shape. The glass substrate **1** is supported by the side supporting members **50**, with the element forming surface of the glass substrate **1**, in this example, a surface on which the hole transporting layer **12** has been formed, facing downward and setting on the end portion of the L shaped members **50**.

[**0099**] The length of each side supporting member **50** is designed to be shorter than each side of the glass substrate **1**. More specifically, the length of the portion of the side supporting member **50** on which the glass substrate **1** is disposed is made shorter than the interval between two adjacent mask frames **31** of the mask frames **31** provided corresponding to the periphery of the glass substrate **1**. It is thereby possible to prevent interference between the mask frames **31** and the side supporting members **50**, as shown in **FIG. 5**. After the alignment between the glass substrate **1** and the mask **30** is completed, the side supporting members **50** are removed. By setting the length of the side supporting members **50** as described above, the glass substrate **1** can be supported by the side supporting members **50** at positions indicated in **FIG. 5**(*a*) by one dotted chain line. It is also possible to remove the side supporting members **50** in a simple manner without making the supporting members **50** contact with the mask frames **31**, by, for example, withdrawing each supporting member **50** in the direction parallel to the lower surface of the glass substrate **1** and away from the substrate **1**.

[**0100**] Referring to **FIG. 11**, the procedure for alignment between the glass substrate **1** and the mask **30** according to the present embodiment will be summarized.

[**0101**] In this procedure, when the glass substrate **1** is inserted into a vacuum chamber (step s**200**), the glass substrate **1** is moved toward the mask **30** side with the glass substrate **1** being supported by the electrostatic adsorption device **60** and the supporting members **50** (step s**201**). Then, after the glass substrate **1** comes into contact with the pins **33**, the glass substrate **1** is aligned with the mask **30** (step s**202**). When the alignment is complete, the glass substrate **1**, which is at this point supported by the electrostatic adsorption device **60** and the supporting members **50**, is lowered. Then, with the glass substrate being supported by the mask **30** or the pins **33**, the electrostatic adsorption device **60** and the supporting members **50** are removed (step s**203**). The EL material is then deposited to the glass substrate **1** which has been thus aligned with the mask **30** (step s**204**).

[**0102**] According to this embodiment as described above, in addition to the above advantages (1) and (2) of the first embodiment, and the above advantage (3) of the second embodiment, the following advantage can be further achieved.

[**0103**] (4) Because the glass substrate **1** and the mask **30** are aligned with each other while the four sides of the glass substrate **1** is being supported by the side supporting members **50**, it is possible to suppress the flexure generated in the glass substrate **1** more suitably and to prevent the evaporation surface of the glass substrate **1** from being damaged by the mask **30**.

[**0104**] The third embodiment as described above may be appropriately modified, such as, for example, in the following manner.

[**0105**] It is also possible to perform deposition of the EL material onto the glass substrate **1** while the glass substrate **1** is supported by the side supporting members **50**. To support the glass substrate **1**, electrostatic adsorption may be simultaneously employed.

[**0106**] Further, supporting members other than the side supporting members **50** may also be used for supporting the four sides of the glass substrate **1**. For example, as shown in **FIG. 12, a** supporting member which supports two trisecting points on each side of the glass substrate, which is trisected at equal intervals, may be used. With this structure, it is similarly possible to support four sides of a glass substrate to thereby reduce the flexure when the length of a side is increased. Any method of supporting four sides other than that shown in **FIG. 12** may be also used. In all cases, however, it is preferable that the support portions are symmetrical.

[**0107**] Further, it is also possible to support at least three sides, rather than four sides, of the substrate.

[**0108**] (Other Embodiments)

[**0109**] The following variations may be employed with any of the above-described embodiments.

[**0110**] The mask arrangement for providing a plurality of display panels is not limited to the example shown in **FIG. 5** in which a mask is divided into four parts. When the mask is changed, the mask frame may be appropriately changed as necessary into a suitable shape capable of fixing the mask.

[**0111**] A plurality of display panels need not necessarily be formed simultaneously.

[**0112**] Further, the configuration of the mask frame **31** is not limited to the example shown in **FIG. 5**(*a*).

[**0113**] The present invention is not limited to use with a vacuum evaporation process, and is effective for reducing the flexure generated in the glass substrate when alignment is performed between an EL element forming substrate such as a glass substrate and a mask.

[**0114**] The layer of an EL element which is formed for each R, G, and B region using a mask is not limited to an emissive layer. For example, when it is desired to vary the deposition amount for forming a hole transporting layer or an electron transporting layer among R, G and B, it is effective to form these layers via a mask as in the formation of the emissive layer according to each of the above-described embodiments. Accordingly, the present invention can also be effectively applied to the alignment between the substrate and the mask in such a case.

[**0115**] The present invention is not limited to use for an active matrix type EL display apparatus, but is effective for manufacturing an EL display apparatus of any type such as a passive matrix type.

[**0116**] The arrangement of the pins **33** is not limited to the above-described example, and the pins **33** can be arranged in any other manner as long as the pins **33** can support the glass substrate **1** in the region other than the display region. Alternatively, it is also possible to provide the pins **33** on the holding plate **34** of the mask frame **31** rather than on the mask frame **31**, as shown in **FIG. 5**(*a*) by a dotted line.

[**0117**] The features of the pin **33** are not limited to the capability of expansion and contraction as described. When the pin **33** is not capable of expansion and contraction, the alignment and the evaporation of the EL material may, for example, be performed with the glass substrate **1** being supported by these pins **33**.

[**0118**] In addition, the EL element material is not limited to the examples described in the above-described embodiments, but any material which can be implemented as an EL display apparatus may be used. Further, the materials for the mask or the like are also not limited to the examples described in the above-described embodiments.

[0119] While the preferred embodiments of the present invention have been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the appended claims.

What is claimed is:

1. A method of manufacturing an electroluminescence display apparatus in which, after a substrate and a mask disposed below the substrate are aligned with each other, a material of an electroluminescence element is adhered to the substrate via an opening of the mask to form an electroluminescence element layer, said method comprising:

fixing and positioning the mask with respect to a mask frame prior to the alignment of the substrate and the mask; and

aligning the substrate with the mask, with the substrate being supported on the mask using a plurality of pins provided on the mask frame.

2. A method of manufacturing an electroluminescence display apparatus according to claim 1, wherein

said plurality of pins are disposed symmetrically with respect to the substrate.

3. A method of manufacturing an electroluminescence display apparatus according to claim 1, wherein

said plurality of pins are capable of expansion and contraction in the vertical direction.

4. A method of manufacturing an electroluminescence display apparatus according to claim 1, wherein

said plurality of pins are capable of expansion and contraction and are contracted such that an element forming surface of the substrate is supported at a position which is substantially the same level as a surface of the mask which opposes the substrate when the substrate is disposed on the plurality of pins.

5. A method of manufacturing an electroluminescence display apparatus according to claim 1, wherein

at least three sides of the substrate are supported by side supporting members while the substrate is aligned with the mask.

6. A method of manufacturing an electroluminescence display apparatus according to claim 5, wherein

of the side supporting members, a pair of the side supporting members which support opposing sides of the substrate are symmetrical with respect to each other, at least with respect to a contact and support portion of each side supporting member which contacts and supports the substrate.

7. A method of manufacturing an electroluminescence display apparatus according to claim 1, wherein

at least the alignment of the substrate and the mask is performed within a vacuum chamber.

8. A method of manufacturing an electroluminescence display apparatus according to claim 7, wherein said vacuum chamber is an evaporation chamber for the electroluminescence element layer.

9. A method of manufacturing an electroluminescence display apparatus according to claim 7, wherein

at least three sides of the substrate are supported by side supporting members while the substrate is aligned with the mask.

10. A method of manufacturing an electroluminescence display apparatus according to claim 7, wherein

an upper surface of the substrate is supported by adsorption using an electrostatic adsorption mechanism.

11. A method of manufacturing an electroluminescence display apparatus in which, after a substrate and a mask disposed below the substrate are aligned with each other, a material of an electroluminescence element is adhered to the substrate via an opening of the mask to form an electroluminescence element layer, said method comprising:

fixing and positioning the mask with respect to a mask frame disposed on a supporting table prior to the alignment of the substrate and the mask; and

aligning the substrate with the mask, with the substrate being supported on the mask using a plurality of pins provided on at least one of the mask frame and the supporting table.

12. A method of manufacturing an electroluminescence display apparatus according to claim 11, wherein

said plurality of pins are disposed symmetrically with respect to the substrate.

13. A method of manufacturing an electroluminescence display apparatus according to claim 11, wherein

said plurality of pins are capable of expansion and contraction and are contracted such that an element forming surface of the substrate is supported at a position which is substantially the same level as a surface of the mask which opposes the substrate when the substrate is disposed on the plurality of pins.

14. A method of manufacturing an electroluminescence display apparatus according to claim 11, wherein

at least the alignment of the substrate and the mask is performed within a vacuum chamber.

15. A method of manufacturing an electroluminescence display apparatus according to claim 14, wherein said vacuum chamber is an evaporation chamber for the electroluminescence element layer.

* * * * *

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摘要(译)

将玻璃基板放置在真空室内，其中玻璃基板的表面通过面向下的蒸发形成形成电致发光元件的发光层。掩模设置在真空室内。发光层的材料通过掩模的开口粘附到玻璃基板上，从而形成发光层。在玻璃基板和掩模彼此对准的同时，玻璃基板由设置在掩模侧的销支撑。