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(19) **United States**(12) **Patent Application Publication**  
**Yamada et al.**(10) **Pub. No.: US 2001/0019807 A1**(43) **Pub. Date: Sep. 6, 2001**(54) **DEPOSITION MASK AND  
MANUFACTURING METHOD THEREOF,  
AND ELECTROLUMINESCENCE DISPLAY  
DEVICE AND MANUFACTURING METHOD  
THEREOF****Publication Classification**(51) **Int. Cl.<sup>7</sup>** ..... **G03C 5/16**; B05D 1/32;  
B05D 3/00; B05D 5/00; B05D 5/06(52) **U.S. Cl.** ..... **430/139**; 427/272; 427/162(57) **ABSTRACT**

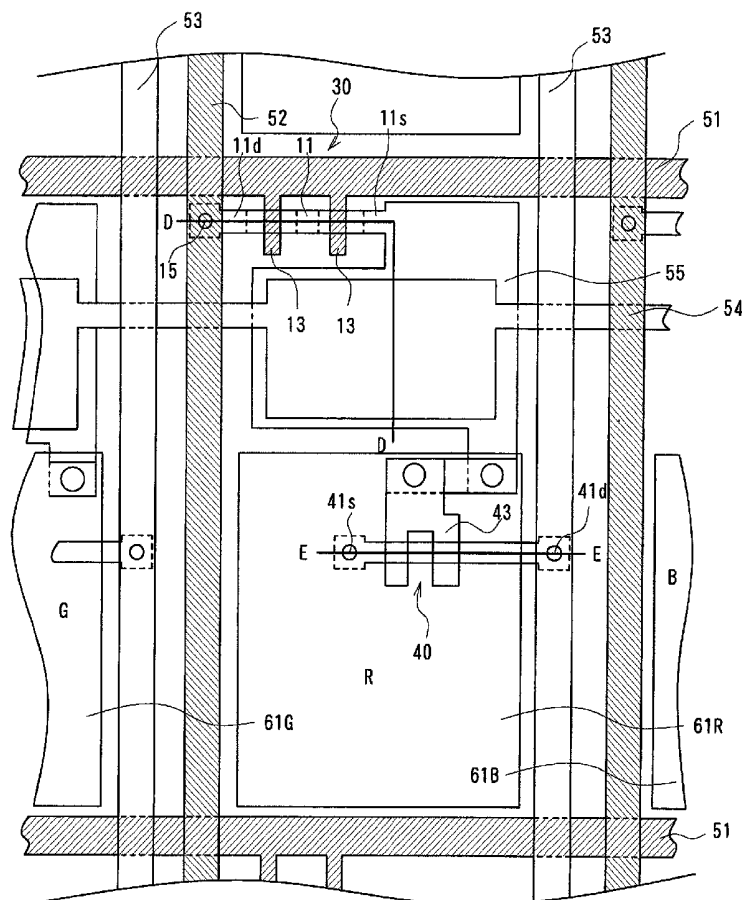
A single crystal or polycrystalline silicon substrate (100) is formed as a semiconductor substrate. Using a resist (103), an SiO<sub>2</sub> film (101) is formed as a first coating on at least part of the outer periphery of the substrate (100). While using this SiO<sub>2</sub> film (101) as a mask, the substrate (100) is etched from the first surface side using KOH or the like. The thickness of the substrate is thus decreased to thereby form an opening forming region M, whereas a region of the substrate covered with the first coating is not etched to thereby form a thick portion 140. Then, on a second surface of the substrate (100), a second coating is formed by applying a resist (104) at a region of the substrate other than where opening are to be formed in the region M. The substrate is then etched using the second coating as a mask to form holes, as openings (110), at regions not covered by the second coating. By using the thus obtained deposition mask (100) as a mask for evaporation, a material can be deposited to a desired location with high accuracy.

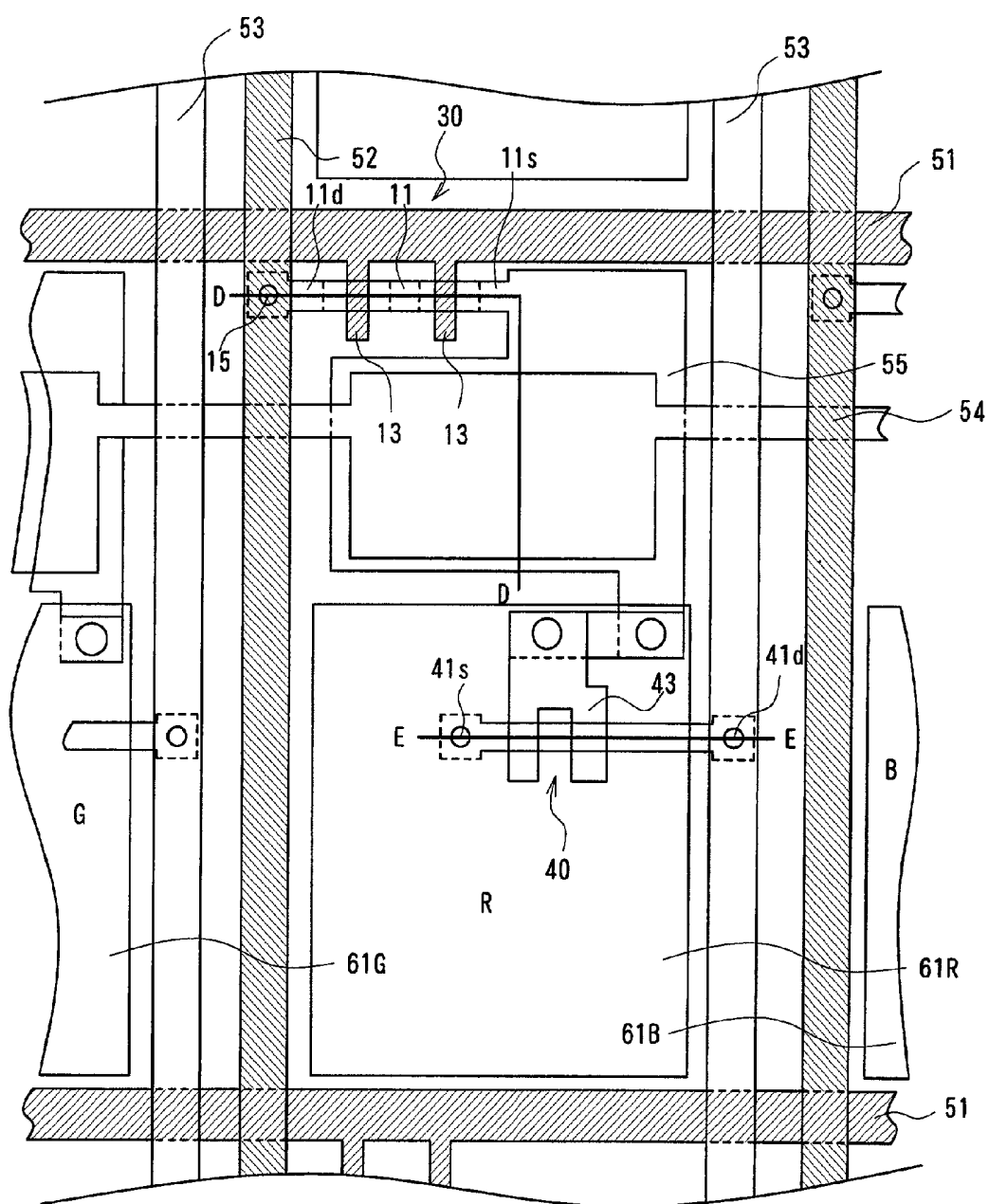
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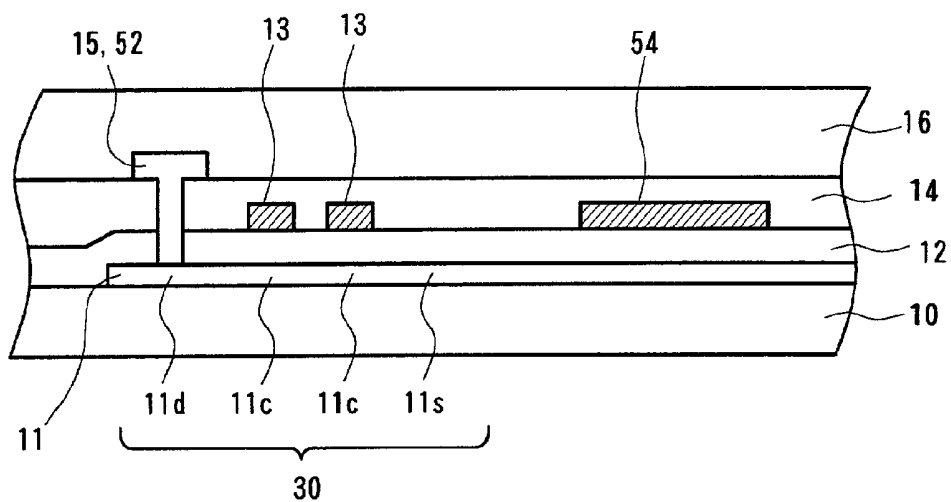
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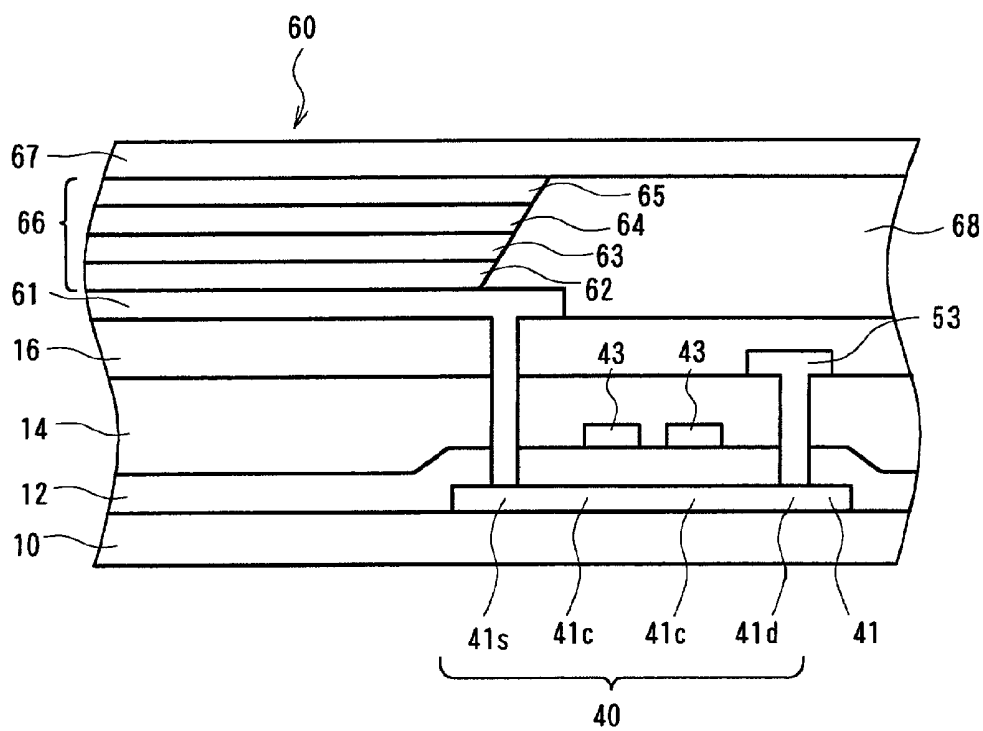




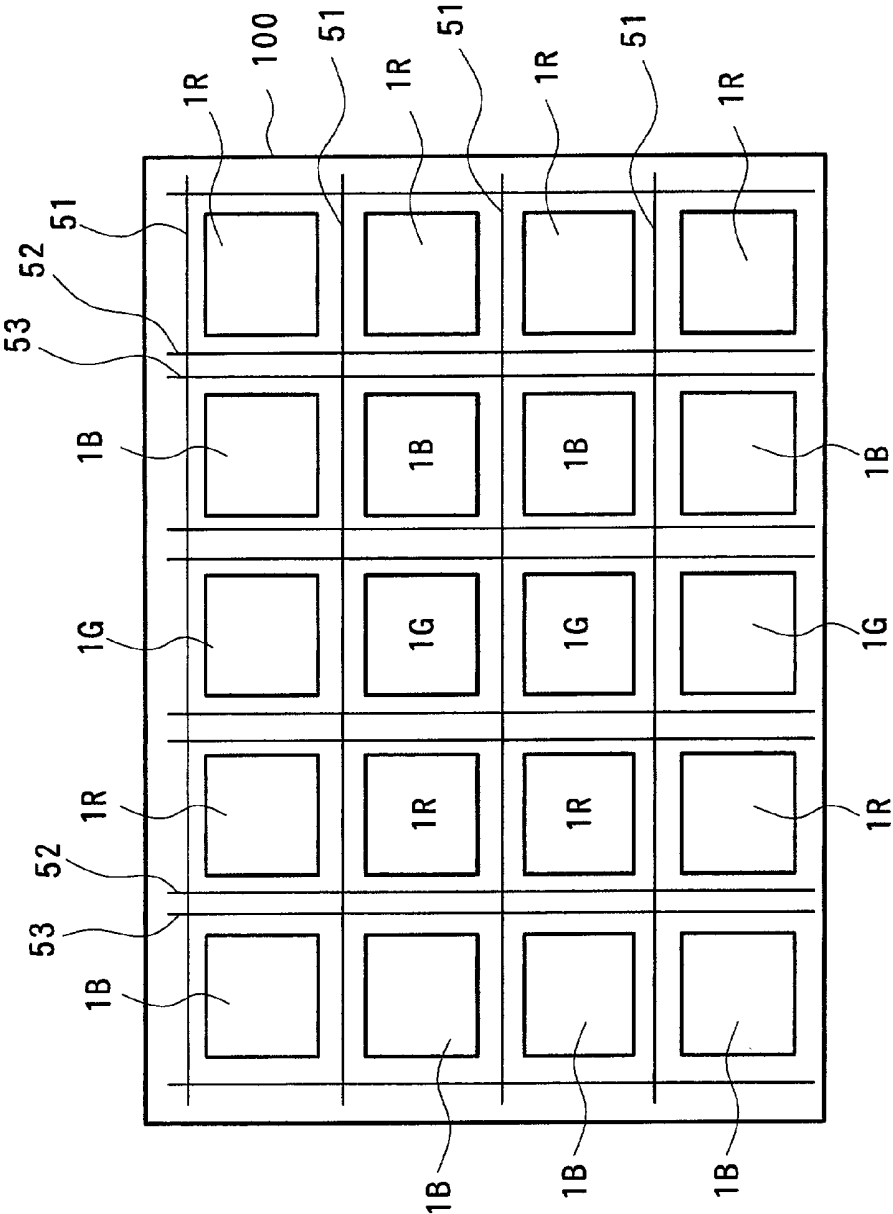
**Fig.1**



**Fig. 2A**



**Fig. 2B**



**Fig. 3**

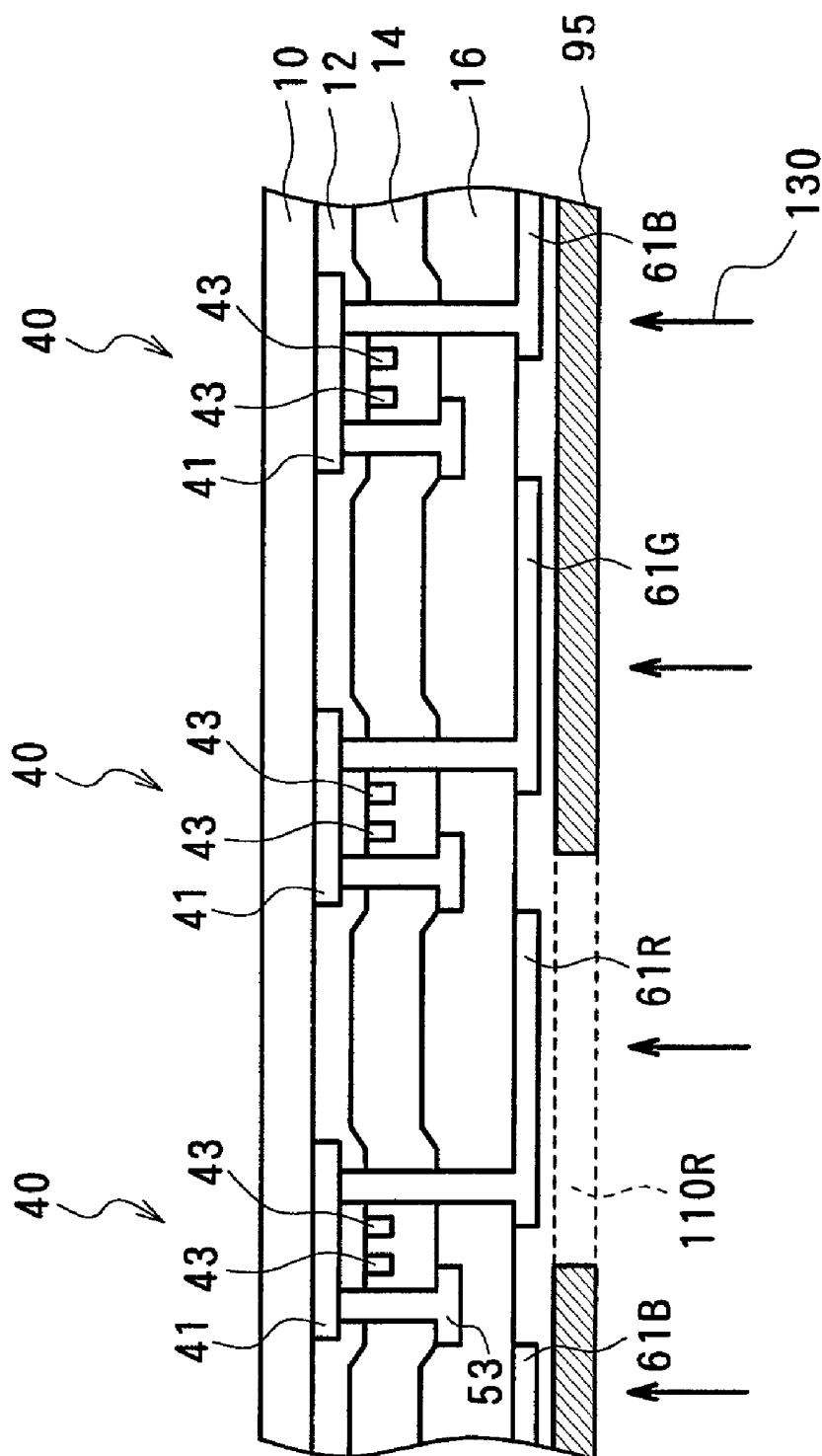
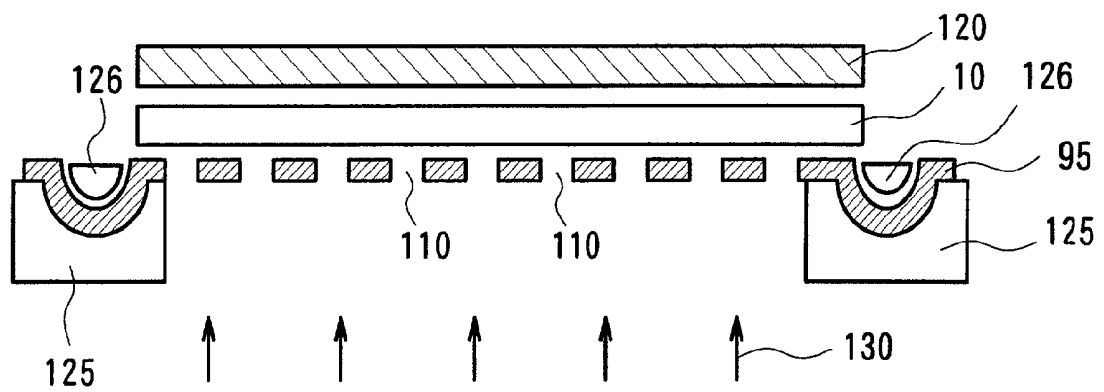
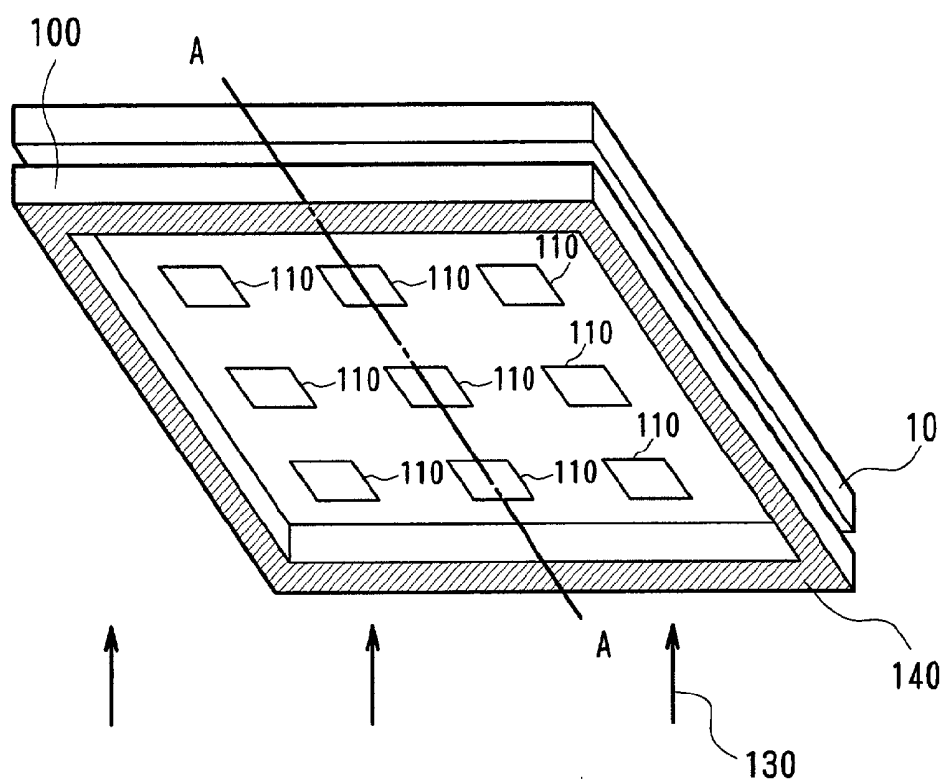


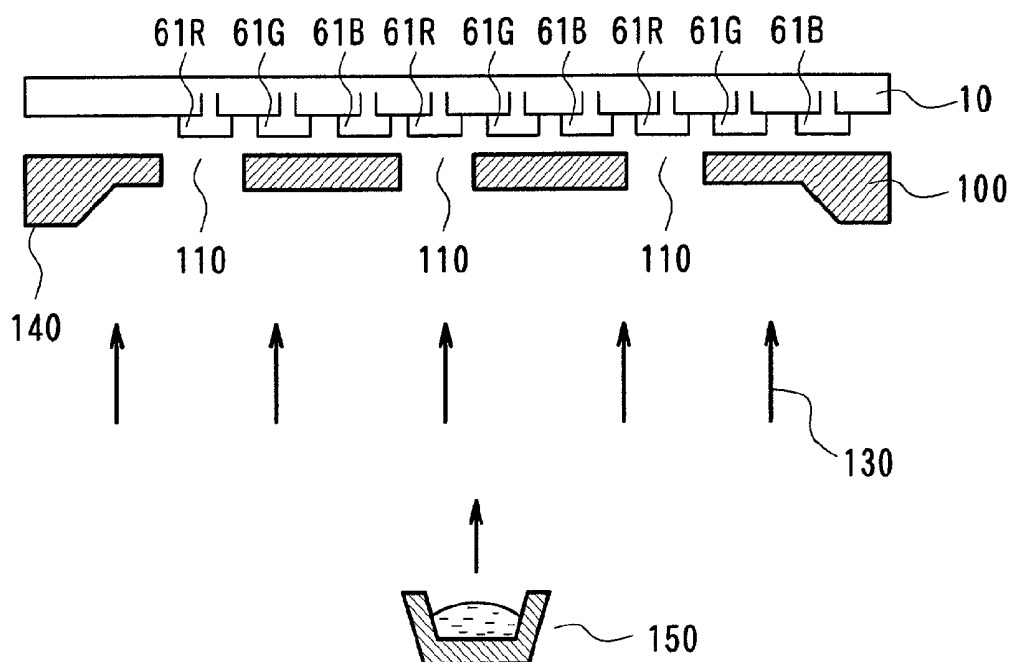
Fig. 4



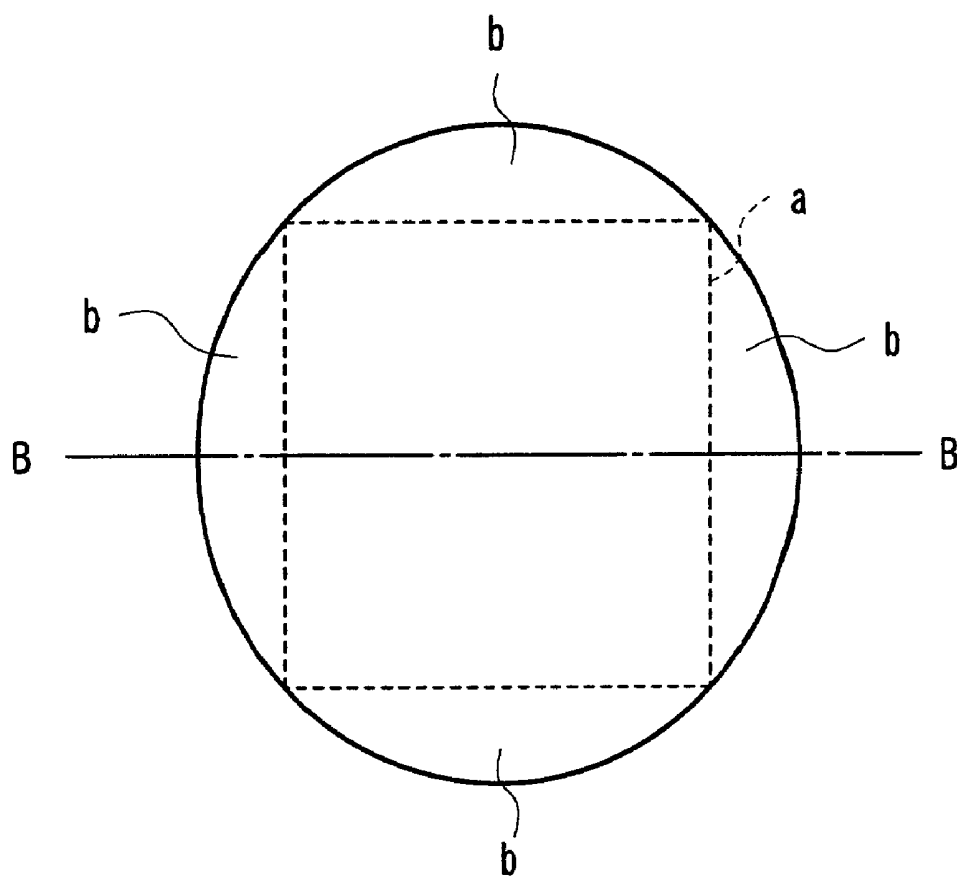
**Fig. 5**



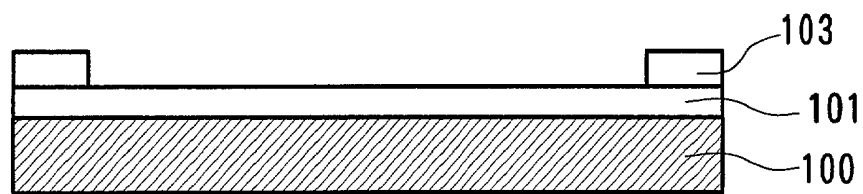
**Fig. 6A**



**Fig. 6B**

**Fig.7**

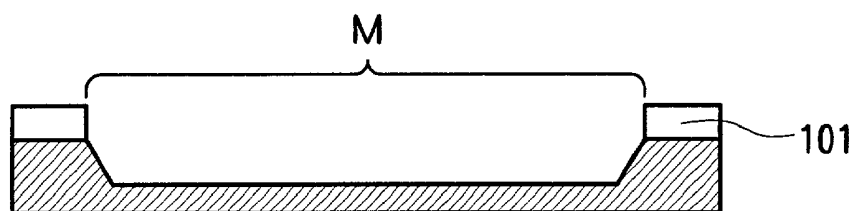




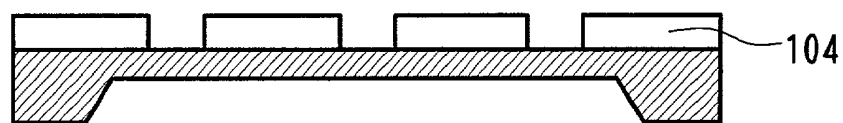
**Fig. 8A**



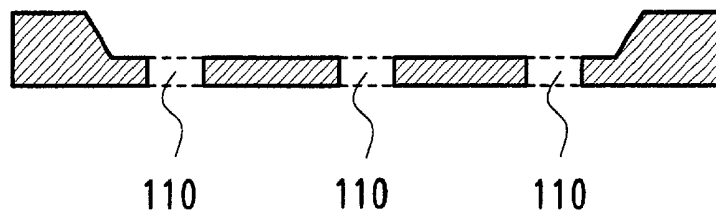
**Fig. 8B**



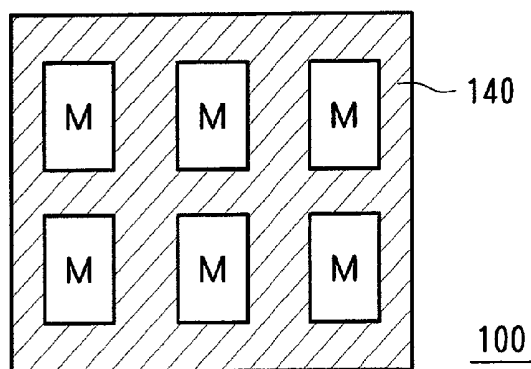
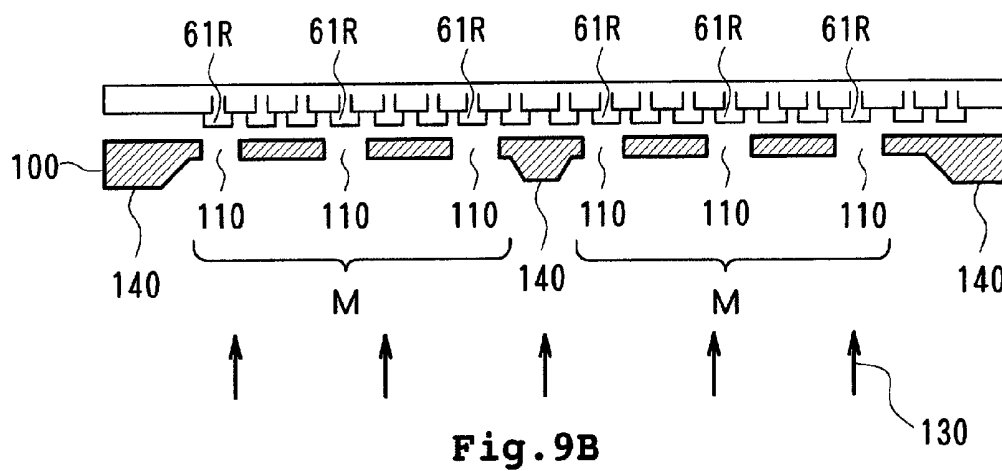
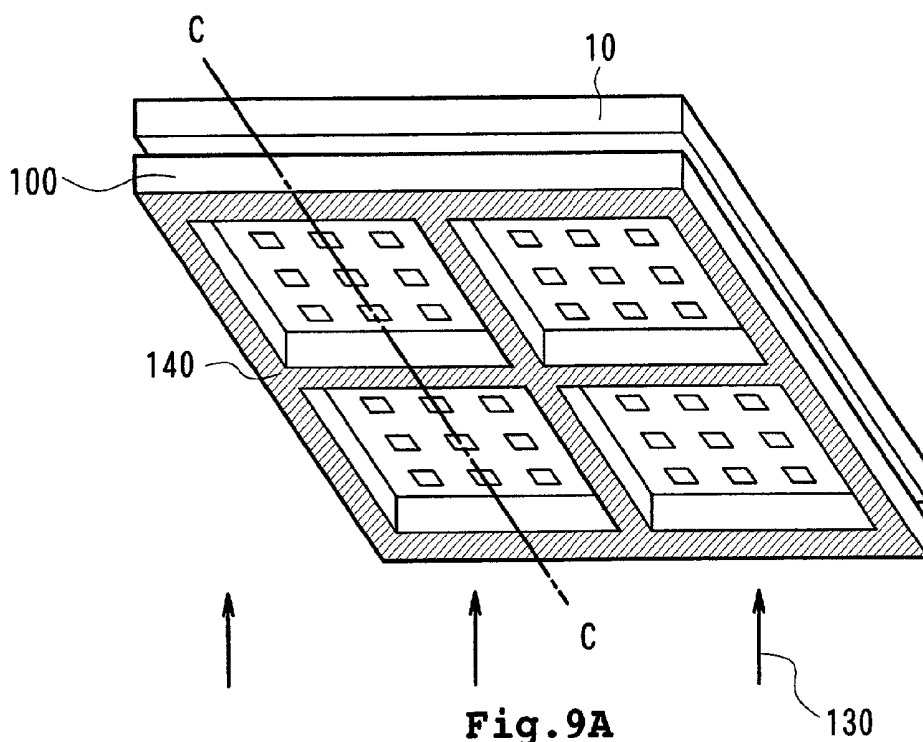
**Fig. 8C**



**Fig. 8D**



**Fig. 8E**



# DEPOSITION MASK AND MANUFACTURING METHOD THEREOF, AND ELECTROLUMINESCENCE DISPLAY DEVICE AND MANUFACTURING METHOD THEREOF

## BACKGROUND OF THE INVENTION

### [0001] 1. Field of the Invention

[0002] The present invention relates to a deposition mask (evaporation mask) used when evaporating an emissive layer material onto an electroluminescence (referred to hereinafter as "EL") element, and to a method for manufacturing such a deposition mask. The present invention also relates to an EL display device manufactured using such a deposition mask, and to a method for manufacturing such an EL display device.

### [0003] 2. Description of the Related Art

[0004] In recent years, EL display devices comprising EL elements have gained attention as potential replacements for CRTs and LCDs.

[0005] Research has been directed to the development of EL display devices using thin film transistors (referred to hereinafter as "TFT") as switching elements for driving the EL elements.

[0006] FIG. 1 is a plan view showing an area around one display pixel of an organic EL display device according to a related art. FIG. 2A shows a cross-sectional view taken along line D-D of FIG. 1, while FIG. 2B shows a cross-sectional view taken along line E-E of FIG. 1.

[0007] As shown in FIG. 1, surrounding the region in which each display pixel is formed are gate lines 51 and drain lines 52. A first TFT 30 serving as a switching element is disposed near an intersection of those lines. The source 11s of the TFT 30 simultaneously functions as a capacitor electrode 55 such that, together with the opposing storage capacitor electrode line 54 described later, it forms a capacitor. The source 11s is connected to a gate 43 of a second TFT 40 for driving the EL element. The source 41s of the second TFT 40 is connected to the anode 61 of the organic EL element 60. The drain 41d is connected to a power source line 53 which supplies current to the organic EL element 60.

[0008] Near the TFTs, a storage capacitor electrode line 54 is disposed in parallel with a gate line 51. The storage capacitor electrode line 54 is made of a material such as chromium. The storage capacitor electrode line 54 opposes to the capacitor electrode 55 via a gate insulating film 12 and together stores charges, forming a capacitor. The capacitor electrode 55 is connected to the source 11s of the TFT 30. This storage capacitor is provided for retaining voltage applied to the gate 43 of the second TFT 40.

[0009] As shown in FIGS. 2A and 2B, the organic EL display device is formed by sequentially laminating the TFTs and the organic EL element on a substrate 10 made of a material such as glass or synthetic resin, or on a conductive or semiconductor substrate.

[0010] The first TFT 30, or the switching TFT, will now be explained.

[0011] As shown in FIG. 2A, on an insulator substrate 10 made of quartz glass, non-alkali glass, or a similar material, an amorphous silicon film (a-Si film) is formed using a CVD

or other method. The a-Si film is irradiated with a laser beam to be polycrystallized, forming a polycrystalline silicon film (p-Si film) 11 which serves as an active layer. A gate insulating film 12 is formed over the p-Si film 11. Further on top are disposed gate lines 51 which are made of a refractory metal such as chromium (Cr) or molybdenum (Mo) and which also serve as gate electrodes 13. An interlayer insulating film 14 is then provided over the entire substrate surface over the gate lines 51. Drain signal lines 52 composed of aluminum (Al), which also serve as drain electrodes 15, are disposed on the interlayer insulating film 14.

[0012] The interlayer insulating film 14 formed by sequential lamination of a SiO<sub>2</sub> film, a SiN film, and a SiO<sub>2</sub> film is provided on the entire surface over the gate insulating film 12, the gate electrodes 13, power source lines 53, and storage capacitor electrode lines 54. A contact hole is formed through the gate insulating film 12 and the interlayer insulating film 14 in a position corresponding to a drain lid. This contact hole is filled with a metal such as Al, forming a drain electrode 15. Further on top, a planarizing insulating film 16 made of an organic resin or a similar material is formed covering the entire substrate surface for planarization.

[0013] The second TFT 40, or the TFT for driving the organic EL element, will next be described.

[0014] As shown in FIG. 2B, sequentially formed on the insulator substrate 10 made of a material such as quartz glass or non-alkali glass are an active layer 41 composed of a p-Si film disposed at the same time with the active layer of the first TFT 30, a gate insulating film 12, and gate electrodes 43 made of a refractory metal such as Cr or Mo. The active layer 41 includes channels 41c, and, on respective sides of these channels 41c, a source 41s and a drain 41d. The above-described interlayer insulating film 14 is provided on the entire surface over the active layer 41, the gate insulating film 12 and gate electrodes 43. A contact hole is formed through the gate insulating film 12 and the interlayer insulating film 14 in a position corresponding to the drain 41d. This contact hole is filled with a metal such as Al, forming a power source line 53 connected to a power source. Further, a planarizing insulating film 16 made of an organic resin or a similar material may be formed over the entire surface for planarization. A contact hole is then formed through the planarizing insulating film 16, the interlayer insulating film 14, and the gate insulating film 12 in a position corresponding to the source 41s. A transparent electrode made of ITO (indium tin oxide) that contacts the source 41s through this contact hole, namely, the anode 61 of an organic EL element, is formed on the planarizing insulating film 16.

[0015] The organic EL element 60 is formed by first laminating the anode 61 constituted by a transparent electrode made of ITO or a similar material, over which the emissive element layer 66 is then superimposed. The emissive element layer 66 comprises a first hole-transport layer 62 composed of a material such as MTDATA (4,4',4"-tris(3-methylphenylphenylamino)triphenylamine), a second hole-transport layer 63 composed of a material such as TPD (N,N'-diphenyl-N,N'-di(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine), an emissive layer 64 composed of, for example, Beq<sub>2</sub> (bis(10-hydroxybenzo[h]quinolinato)beryllium) including quinacridone derivatives, and an electron transport layer 65 composed of Beq<sub>2</sub> or a similar material. Subsequently, a cathode 67, which may be composed of a mag-

nesium-indium alloy, is formed. All of the above-noted layers of the organic EL element **60** are laminated in the described order. An insulating film **68** is provided to prevent short-circuiting between an edge of the anode **61** and the cathode **67**. The organic EL element **60** as described above constitutes a display pixel.

[0016] In the organic EL element, holes injected from the anode and electrons injected from the cathode recombine in the emissive layer. As a result, organic molecules constituting the emissive layer are excited, generating excitons. Through the process in which these excitons undergo radiation until deactivation, light is emitted from the emissive layer. This light radiates outward through the transparent anode via the transparent insulator substrate, resulting in light emission.

[0017] As described above, an organic material of the emissive layer in each display pixel is provided on each anode **61**. The organic material may be formed by an evaporation method, for example.

[0018] FIG. 3 diagrammatically shows an arrangement of display pixels **1R**, **1G**, and **1B** for respective colors.

[0019] As shown in the figure, the display pixels **1R**, **1G**, **1B** for the respective colors are formed in regions on an insulator substrate **10** surrounded by gate lines **51** and drain lines **52** and power source lines **53**, and are repeatedly arranged by rows in the order of R, G, and B. The display pixels **1R**, **1G**, **1B** include an anode **61R** corresponding to red, an anode **61G** corresponding to green, and an anode **61B** corresponding to blue, respectively. Each anode **61R**, **61G**, **61B** is formed in an island pattern. On these anodes, the organic emissive materials of the emissive layer are formed to enable emission of light having different colors.

[0020] FIG. 4 is a cross-sectional view illustrating an evaporation process of an organic material constituting an emissive layer. This figure shows, as an example, evaporation of a red organic emissive material. Components that are identical to those in FIGS. 2A and 2B are labeled with the same reference numerals.

[0021] In FIG. 4, an organic material for emitting red light is formed on a red color display electrode (anode) **61R** connected to a second TFT **40** provided on a glass substrate **10**.

[0022] When forming the organic material, a metal mask made of a metal such as nickel (Ni), which has an opening in a position corresponding to the red anode, is placed in contact with each anode. While in this state, a evaporating material, i.e., the red organic material, from a evaporating material source, i.e., the organic material placed in a holder, is evaporated onto a region including the anode **61R** on the glass substrate **10**.

[0023] FIG. 5 is a cross-sectional view illustrating how a metal mask is mounted for performing evaporation of an organic material for each color onto a glass substrate on which TFTs and anodes are formed.

[0024] As shown in FIG. 5, a metal mask **95** having openings **110** in positions corresponding to anodes is installed in an evaporation mask holder **125** including a mask fixture **126** in the surrounding periphery portion, and is arranged on a glass substrate **10** having components formed thereon up to the anodes as shown in FIG. 4. To

prevent the mask from deflecting, the metal mask **95** is held in tension by the four sides of the evaporation mask holder **125** while the mask is being arranged on the substrate **10**. In addition, a magnet **120** is placed on a side of the glass substrate **10** opposite from the side on which the metal mask **95** is arranged. Furthermore, the mask fixing jig **125** disposed in a region surrounding the substrate has a groove formed therein, and the periphery portion of the mask **95** is placed along the position of the groove. From a side of the mask **95** opposite from the side contacting the jig **125**, the fixture **126** is fitted into the groove of the jig **125** while the mask is sandwiched in between. By employing the jig **125** and the fixture **126** in this manner, warping of the metal mask **95** is prevented.

[0025] However, even when the metal mask **95** is held on its periphery portions and fixed using a magnet from the opposite side as described above, deflection results. From the center towards the periphery portion of the metal mask **95**, the openings **110** of the mask **95** become misaligned with respect to the positions of the anodes **61** onto which the organic material is to be evaporated. The emissive material is therefore evaporated at positions shifted from the positions at which evaporation should actually be performed. This causes the drawback that predetermined colors cannot appropriately be emitted by the EL display device.

[0026] When forming the openings **110** of the metal mask **95**, photolithography can be used to form openings in the metal mask material, which may be Ni. However, when the thickness of the metal mask **95** is relatively large, for example, approximately 100  $\mu\text{m}$ , an error of approximately  $\pm 10 \mu\text{m}$  is generated in the size of the openings, resulting in a poor machining accuracy of the openings **110**.

[0027] The metal mask **95** may be formed using a mask electroforming technique. According to this technique, a metal piece on which electrodeposition is performed to form the metal mask **95** is placed in an electrolyte containing Ni. When the electrodeposited metal piece is removed from the electrolyte after Ni is electrodeposited thereon, the Ni surface disadvantageously becomes greatly warped due to volumetric shrinkage. Similar warping of the Ni surface also results in a metal mask **95** formed using the above-noted photolithographic technique.

[0028] Further, when the electrodeposition technique is employed, projections are formed in the Ni surface. The projections may contact the glass substrate and scar the substrate surface.

[0029] Another existing drawback of a conventional deposition mask is that it may break during an attempt to remove the organic material which became attached to the mask through its repeated use in depositions.

## SUMMARY OF THE INVENTION

[0030] The present invention was formed in light of the above disadvantages. The purpose of the present invention is to obtain a highly precise deposition mask for evaporation, and to provide an EL display device wherein organic materials are very accurately formed in predetermined positions using such a deposition mask.

[0031] To achieve the above purposes, the present invention provides a deposition mask for placing between a depositing material and a medium on which deposition is

performed, including a pattern for allowing the depositing material to be selectively attached to a desired position on the medium, wherein the mask is composed of a semiconductor substrate.

[0032] It is another aspect of the present invention to provide a deposition mask for placing between a depositing material and a medium on which deposition is performed, comprising a semiconductor substrate including an opening forming region having a reduced thickness provided with at least one opening for allowing the depositing material to be selectively attached to a desired position on the medium, and a thick portion formed in at least one portion of an outer periphery region of the mask.

[0033] A further aspect of the present invention is a method for manufacturing a deposition mask as described above, this method comprising the steps of forming a first coating covering a region in which said thick portion of said semiconductor substrate is to be formed, using the first coating as an etching mask to etch the semiconductor substrate so as to reduce thickness of the semiconductor substrate and thereby form the opening forming region, forming a second coating in areas other than a predetermined position within the opening forming region, and using the second coating as an etching mask to etch the semiconductor substrate so as to form said at least one opening in the substrate.

[0034] According to another aspect of the present invention, in the deposition mask manufacturing method described above, the first coating is formed on a first side of the semiconductor substrate, and the opening forming region is formed by etching the first side of the semiconductor substrate to reduce thickness of the substrate. Furthermore, the second coating is formed on a second side of the semiconductor substrate, and said at least one opening is formed by etching from the second side until penetrating through the semiconductor substrate.

[0035] According to a further aspect of the present invention, the semiconductor substrate constituting the above deposition mask is composed of silicon. This silicon may be single crystalline or polycrystalline silicon.

[0036] By forming a deposition mask using a semiconductor substrate, such as the above-noted silicon material, according to the present invention as described above, a highly accurate deposition mask in which no deflection occurs can be readily formed. When using such a deposition mask to, for example, evaporate an organic material for forming an emissive layer of an EL display element, deposition the organic material onto an adjacent anode of a different color display pixel can be prevented. This eliminates color blurring and makes possible vivid display of a desired color.

[0037] According to the present invention, the deposition mask is not formed by placing a metal piece for electrodeposition into an electrolyte, as in the case of a conventional metal mask. It is therefore possible to eliminate the problem of deflecting metal surface due to volumetric shrinkage occurring when the metal piece is removed from the electrolyte after electrodeposition.

[0038] Furthermore, the problem of scarring of the glass substrate surface by the projections resulting in the Ni surface when using the electrodeposition technique can be overcome.

[0039] Still further, the thick portion included in the outer periphery region of the deposition mask of the present invention prevents breakage of the deposition mask when mounting the mask on a device onto which deposition is performed or when removing an organic material which became attached to the mask through its repeated use in depositions.

[0040] At the same time, because the opening forming region is sufficiently thin, the step of etching through the semiconductor substrate to form an opening can be completed in a short time, and the opening can be shaped with a high accuracy. Moreover, by making the opening forming region thin, the material supplied from the depositing material source can reach the medium via a short hole (i.e., the opening), allowing the medium to be provided with the depositing material in an efficient manner and with a high positional accuracy.

[0041] Another aspect of the present invention provides a method for manufacturing an electroluminescence display device composed by arranging a plurality of display pixels, each display pixel having an electroluminescence element including at least an emissive layer between first and second electrodes, the method comprising the steps of arranging the above-described deposition mask on a medium having the first electrode formed thereon, and attaching an emissive material from an emissive material source via the opening of the deposition mask to a corresponding display pixel region of the medium, thereby forming an emissive layer for each pixel.

[0042] According to a further aspect of the present invention, in the above method for manufacturing an electroluminescence display device, each element includes between the first and second electrodes at least an emissive layer containing an organic material, and the organic material supplied from the emissive material source is attached via the opening of the deposition mask to a corresponding pixel.

[0043] According to a still further aspect of the present invention, in the above method for manufacturing an electroluminescence display device, each element is formed by including between the first and second electrodes at least an emissive layer containing an organic material corresponding to an emitted color. The deposition mask having the opening formed only in a region corresponding to a pixel for a predetermined color is used to attach the organic material supplied from the emissive material source to a corresponding pixel region.

[0044] According to the present invention, a highly precise deposition mask can be obtained. By using such a mask to attach an organic or other material to an adherend, a material for a predetermined color can accurately be deposited at a predetermined position, realizing an EL display device which achieves vivid color indication.

[0045] The above electroluminescence display device according to the present invention may be an organic EL display device. When depositing each of different organic emissive materials by evaporation onto pixels designated for light emission of a predetermined color, use of the above-described mask of the present invention as an evaporation mask facilitates accurate formation of an organic emissive layer in each pixel.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0046] **FIG. 1** is a diagram for explaining a plan configuration of a region around one display pixel of an organic EL display device.

[0047] **FIG. 2A** is a diagram showing a schematic cross-sectional configuration along line D-D of **FIG. 1**.

[0048] **FIG. 2B** is a diagram showing a schematic cross-sectional configuration along line E-E of **FIG. 1**.

[0049] **FIG. 3** is a diagram conceptually illustrating a layout of display pixels correlated to respective colors of R, G, and B within a panel of an organic EL display device.

[0050] **FIG. 4** is a diagram for explaining an evaporation process of an organic material constituting an emissive layer of the organic EL display device.

[0051] **FIG. 5** is a diagram for explaining a method for using a conventional metal mask employed for evaporation of an organic material.

[0052] **FIGS. 6A and 6B** are diagrams illustrating the configuration and the state of use of a deposition mask according to a first embodiment of the present invention.

[0053] **FIG. 7** is a diagram showing a silicon substrate used for the deposition mask according to the present invention.

[0054] **FIGS. 8A, 8B, 8C, 8D, and 8E** are cross-sectional views explaining a process for manufacturing the deposition mask according to the embodiment of the present invention.

[0055] **FIGS. 9A, 9B, and 9C** are diagrams illustrating the configuration and the state of use of a deposition mask according to a second embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0056] Preferred embodiments of the present invention will be described in further detail with reference to the accompanying drawings.

[0057] A mask used for deposition of a material (hereinafter referred to as a deposition mask) and an organic EL display apparatus manufactured using the deposition mask for evaporation will be described.

[0058] First Embodiment

[0059] **FIGS. 6A and 6B** show a state where an organic material, which is a material to be deposited, is to be evaporated using a deposition mask of the present invention. More specifically, **FIG. 6A** is a perspective view illustrating a deposition mask being in contact with a glass substrate on which an organic material is to be evaporated, and **FIG. 6B** is a cross section taken along line A-A of **FIG. 6A**.

[0060] In actuality, although only the glass substrate **10** is shown in **FIG. 6A**, various films constituting the TFT **40** for driving an organic EL element and the anode **61** are first formed on the glass substrate **10** in the order shown in **FIG. 2B**. Similarly, although only the anodes **61R, 61G, 61B** are shown on the glass substrate **10** in **FIG. 6B**, the TFT **40** and the anodes **61R, 61G, and 61B** are actually disposed in that order on the glass substrate **10**, and the glass substrate **10** functions as a base medium on which a material is to be

deposited. Further, although not shown in **FIGS. 6A and 6B**, the structure of the TFT is the same as that in **FIGS. 2A and 2B**.

[0061] Referring to **FIGS. 6A and 6B**, over the above-described glass substrate **10**, a deposition mask **100** composed of single crystal silicon (Si) and having a thick portion **140** along the outer periphery, which is thicker than an opening forming region at the center of the mask, is disposed so that the substrate **10** and the mask **100** contact with each other. An organic material is then evaporated from a holder **150** holding a material source containing an organic material and disposed at the lower side of the mask **100** in **FIG. 6B**. For convenience of explanation, the deposition mask **100** and the glass substrate **10** are not shown in contact with each other in **FIGS. 6A and 6B**.

[0062] The deposition mask **100** has openings **110**. In the example shown in **FIGS. 6A and 6B**, the openings **110** corresponding to all of the pixels for R, G, B are not formed in a single mask **100**, but they are formed at positions corresponding to pixels for any one color of R, G, and B. More specifically, the mask **100** shown in **FIGS. 6A and 6B** is an example of a mask for R pixels in a case where a set of display pixels **1R, 1G, 1B** are repeatedly provided in that order in the horizontal direction from the left side of the figure as shown in **FIG. 3**.

[0063] In **FIGS. 6A and 6B**, the TFT and the anode are preformed on the substrate, when, similar to the emissive layer, an organic layer in the organic EL element other than the emissive layer, such as a hole transport layer, is also composed of materials different for each color R, G, B. However, when an organic layer such as the hole transport layer is formed by the identical material for all the pixels, the organic hole transport layer has been preformed by evaporation on the anode disposed on the substrate **10** in **FIGS. 6A and 6B**.

[0064] As shown in **FIG. 6B**, when the anodes **61R, 61G, 61B** formed on the display pixels **1R, 1G, 1B** are repeatedly disposed in this order, the openings **110** of the mask **100** for R pixels are formed at positions corresponding to the anodes **61R** formed on the display pixels **1R** for red color. Using this mask **100**, an organic material of red color is evaporated onto the anode **61R** of the red display pixel **1R**.

[0065] A method of making the deposition mask **100** will be now described.

[0066] **FIG. 7** shows a single crystal silicon wafer to be used as a material of a deposition mask according to the present invention. **FIGS. 8A through 8E** are cross sections taken along line B-B in **FIG. 7** for illustrating a method of making the deposition mask.

[0067] Process Step 1 (**FIG. 8A**):

[0068] On a single crystal Si substrate **100** as shown in **FIG. 7**, an insulating film **101** such as an SiO<sub>2</sub> film is formed using a CVD method or the like. At this time, the thickness of the single crystal Si substrate is approximately 0.5 mm. Further, on the insulating film **101**, a resist **103** is provided and is then removed such that a frame is left along the periphery of the Si substrate **100** such that the center portion of the Si substrate **100** has an opening. The width of the frame-shaped resist **103** left on the insulating film **101** is chosen to be sufficient for maintaining the rigidity of the

mask, and may be, for example, approximately 1-2 mm from the outer edge of the mask, though it depends on the size of the resultant mask **100**, namely the size of the display panel.

[0069] Process Step 2 (FIG. 8B):

[0070] A region of the SiO<sub>2</sub> film **101** which is not covered with the resist **103** is then removed by a dry etching method.

[0071] Process Step 3 (FIG. 8C):

[0072] After removing the resist **103**, a potassium hydroxide (KOH) solution is used as an etchant to etch the Si substrate **100** using the SiO<sub>2</sub> film **101** as a mask. In this case, only the SiO<sub>2</sub> film **101** constitutes a first coating for the mask substrate. However, when the resist **103** is not removed and is used as a mask along with the SiO<sub>2</sub> film **101**, both of the resist **103** and the SiO<sub>2</sub> film **101** serve as the first coating for the mask substrate.

[0073] The Si substrate which is used to form the deposition mask preferably has (100) surface orientation. This is because the etchant KOH etches only a surface with (100) orientation of the Si substrate, and can effectively etch a region for forming a mask in the substrate to uniformly decrease the thickness of that region. For example, the etching rate of 2  $\mu\text{m}$  per minute can be achieved when etching is performed using the above-mentioned KOH.

[0074] When the foregoing etching process is completed, the thickness of the mask Si substrate **100** in the peripheral region where the first coating is formed is substantially maintained to a thickness prior to the etching. The thickness of the mask substrate in a center region where the first coating is not formed, namely an opening forming region M, is 100  $\mu\text{m}$  or less, preferably 50  $\mu\text{m}$  or less, and more preferably 30  $\mu\text{m}$  or less. As the thickness of the region M decreases, the opening **110** of the mask, namely the opening used for deposition, coincides more precisely with the area where an organic material is actually deposited by evaporation through the opening, when the mask is disposed over the glass substrate **10** for used in evaporation. When the mask is too thin, however, there is a danger of damaging the mask. Accordingly, for the mask **100** to secure the minimum rigidity, the lower limit of the thickness of the mask in the region M is approximately 10  $\mu\text{m}$ .

[0075] The thickness of the opening forming region M can be controlled by choice of etchant, temperature, and etching time.

[0076] Process Step 4 (FIG. 8D):

[0077] After the region M with thickness decreased by etching as described above is formed, a resist **104** is applied over the entire region of the rear surface of the Si substrate **100** and is then patterned such that it has openings at positions corresponding to openings **110** which will be formed in the Si substrate **100**. The size of the opening formed in the resist **104** may be determined such that the opening **110** of the deposition mask, which will be formed using the resist **104** as an etching mask as will be described later, is larger than the anode, and such that the organic material to be evaporated using the deposition mask **100** can be evaporated so as to cover the anode and the periphery thereof. The resist **104** having such openings constitutes a second coating for the deposition mask **100**.

[0078] Process Step 5 (FIG. 8E):

[0079] Using the above-mentioned resist pattern **104** as a mask, dry etching is performed by applying an etching gas SF<sub>6</sub> from above the Si substrate **100** in FIG. 8D to etch the Si substrate **100** and form the deposition openings **110** in the substrate **100**. Then, the resist pattern **104** is removed.

[0080] Referring back to FIG. 7, the single crystal Si wafer having a circular shape is then cut into a shape in accordance with the shape of the substrate (display panel) **10** on which evaporation is to be performed. In this example, the wafer is cut into a rectangular shape, as indicated by dashed line in FIG. 7. If the mask is of a circular shape including unnecessary circular arc portions b in the periphery, there is a problem that, when the mask is mounted to an evaporation apparatus or the like for evaporation of an organic material, an mounting area must be increased and a large evaporation apparatus is required. Therefore, the circular arc portions b, which are not essential from a viewpoint of masking regions of the substrate **10** except necessary portions, are removed.

[0081] According to the foregoing process steps, a deposition mask **100** is completed.

[0082] In this embodiment, the thick portion **140** is provided along the outer periphery of the Si substrate. However, to thereby further enhance the rigidity of the mask the thick portion **140** may also be formed between the openings **110** in the region M.

[0083] As described above, with the configuration of the present embodiment, a highly accurate deposition mask can be formed using a photolithography technique. In particular, using the photolithography technique, a mask which is accurate in size, position, and dimension between the openings can be obtained. Further, since the mask is composed of a silicon substrate, the rigidity of the mask is improved compared to a metal mask having similar thickness. Accordingly, when evaporation is performed using this deposition mask, it is possible to prevent an organic material for forming an emissive layer of an organic EL element from being incorrectly evaporated on an anode of a display pixel for a wrong color which is adjacent to the target color display pixel. Thus, an organic EL display apparatus capable of clearly displaying desired colors without color mixture can be provided.

[0084] Further, even when an organic material is adhered to the deposition mask after repeated use, the organic material can be easily removed using a solvent. Since a mask composed of silicon is not easily attacked by such a solution for solving an organic material, the mask can be reused a plurality of times, leading to saving the cost. Also, since the mask has high rigidity due to the thick portion serving as an outer frame, it will not be broken easily when an organic material adhered to the mask is removed, and can be repeatedly used, thereby reducing the cost.

[0085] In particular, the workability of the mask is very high due to use of Si, as described above, and therefore the deposition openings as well as the opening forming region M (mask forming region M) can be formed easily and accurately.

**[0086]** Second Embodiment

**[0087]** A second preferred embodiment of the present invention will next be described.

**[0088]** FIG. 9A shows, in a perspective view, a state where an organic material is to be evaporated onto a glass substrate using a deposition mask according to the second embodiment of the present invention. FIG. 9B is a cross sectional view taken along line C-C of FIG. 9A.

**[0089]** The deposition mask according to the second embodiment shown in FIGS. 9A and 9B differs from that in the first embodiment in that it is a large deposition mask used when performing evaporation onto a large size glass substrate, and in that such a large mask is reinforced so as to improve the rigidity. Specifically, when a plurality of opening forming regions M are provided in a single mask substrate, a thick portion 140 is formed at each gap between adjoining regions M, in addition to along the outer frame portion of the mask 100. In the example shown in FIGS. 9A and 9B, four of the regions M are provided in the mask 100, and the thick portion 140 is formed along the rectangular frame portion and in a cross-shaped pattern inside the frame. Further unlike the first embodiment, the deposition mask of the second embodiment is composed of polycrystalline silicon.

**[0090]** The polycrystalline Si substrate 100 used may be, for example, of a rectangular shape of 400 mm×400 mm, as indicated by dashed line a in FIG. 7, when the peripheral region is removed. The original shape of the substrate 100 is not limited to a circular shape as indicated, and may originally be of a rectangular shape of minimum size.

**[0091]** In this embodiment, as shown in FIG. 9A the thick portion 140 is formed in the center part of the mask 100, in addition to along the periphery (frame portion) of the mask 100. In other words, the thick portion 140 is provided along the entire surroundings of each region M. Thus, the deposition mask composed of Si (p-Si) can be reinforced due to the thick portion 140 additionally formed in the center part thereof, and therefore even a mask of large size will not be easily damaged.

**[0092]** Referring to FIG. 9B, the mask 100 is disposed such that the deposition openings 110 are located at positions corresponding to the anodes 61R of the display pixels for red color of the display pixels of R, G, B colors. The thick portion 140 formed in the center part of the mask 100 may have a width which is smaller than a gap between one anode 61R and an adjacent anode 61R.

**[0093]** A method of forming a mask according to this embodiment differs from the method described above for the first embodiment in that, rather than etching the opening forming region M using KOH as an etchant, the region M of the Si substrate is preformed to a significant degree using a grinder or the like, and the region M is completed by performing dry etching is then performed using an etching gas of SF<sub>6</sub>.

**[0094]** It has been described that the thick portion 140 is also formed between a plurality of opening forming regions M in a single deposition mask 100. When a plurality of display panel regions are simultaneously formed in a single large substrate (a mother substrate) 10, namely in a simultaneous multi-panel forming method, the plurality of the

regions M formed in one mask 100 respectively correspond to the display panel regions. Because the gap between the display panel regions is usually larger than the gap between pixels for the same color within one panel, the thick portion 140 can be easily formed as a sufficiently wide portion at a region corresponding to the above-mentioned gap between panel regions. In addition, such a wide thick portion 140 improves the reinforcing effect. It is preferable that the deposition mask 100 as shown in FIGS. 9A and 9B is used also when a single display panel is formed in a single large substrate 10. In such a case, the thick portion 140 formed in the center part of a single mask 100 is located between desired pixels in the center of the display panel. In this case, each region partitioned by this thick portion 140 corresponds to each of the region M shown in FIG. 9B.

**[0095]** Further, the pattern of the thick portion 140 formed in the deposition mask 100 is not limited to that shown in FIGS. 9A and 9B. For example, as shown in FIG. 9C, the thick portion 140 may be formed along the outer frame (outer periphery) of the mask 100 and also in a grid pattern within a region enclosed by this frame. The thick portion 140 may also be formed in another pattern, such as a mesh pattern.

**[0096]** Various patterns can be adopted for the thick portion 140 according to the size and rigidity of the large deposition mask 100 and the layout, size, and pixel pitch of a display panel to be formed using this mask 100.

**[0097]** In the foregoing embodiments, a deposition mask used for evaporating an organic material of red color onto a display pixel which emits red light among display pixels displaying R, G, and B colors was described. However, the mask is not limited to that for displaying red color, and a mask used for any other color can be formed in a similar manner by providing a deposition opening at a position corresponding to the anode of the display pixel displaying that color. Further, rather than manufacturing and using separate masks for different colors, it is also possible to use a single mask to perform evaporation of organic materials emitting all the R, G, or B colors, by shifting the mask in one direction so as to displace the openings correspondingly.

**[0098]** Further, although the foregoing embodiments have described a stripe pixel arrangement where the display pixels are arranged such that the pixels displaying the same color are aligned in the column direction to form a stripe pattern, the mask of the present invention is not limited to application to such pixel arrangement, and is also applicable to a so-called delta arrangement, or to a case where the display pixels for the same color are disposed diagonally from upper left to lower right. In these cases, the deposition openings of the mask are formed at positions corresponding to anodes of the display pixels for the same color.

**[0099]** As described above, the accuracy of a mask can be improved even for the deposition mask used in depositing a material to a large display device. Also, the rigidity of the mask is further increased by providing the thick portion in the center part of the mask as well.

**[0100]** Although only several openings of the deposition mask are shown for convenience of explanation in the foregoing embodiments, the number of mask openings actually corresponds to the number of pixels in each display apparatus, such as 852×222.



[0101] Further, when a polycrystalline silicon substrate is used to form a large deposition mask **100** as described above, a large substrate can be manufactured at a lower cost than when single crystal silicon is used and therefore an increase in a manufacturing cost resulting from increase in a mask size can be minimized.

[0102] While 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 deposition mask for placing between a depositing material and a medium on which deposition is performed, including a pattern for allowing said depositing material to be selectively attached to a desired position on said medium, wherein

said mask is composed of a semiconductor substrate.

2. A deposition mask as defined in claim 1, wherein

said semiconductor substrate is composed of silicon.

3. A deposition mask for placing between a depositing material and a medium on which deposition is performed, comprising:

a semiconductor substrate including an opening forming region having a reduced thickness provided with at least one opening for allowing said depositing material to be selectively attached to a desired position on said medium, and a thick portion formed in at least one portion of an outer periphery region of said mask.

4. A deposition mask as defined in claim 3, wherein

said semiconductor substrate is composed of silicon.

5. A deposition mask as defined in claim 3, wherein

said semiconductor substrate is composed of single crystalline or polycrystalline silicon.

6. A method for manufacturing a deposition mask, wherein

said deposition mask for placing between a depositing material and a medium on which deposition is performed comprises a semiconductor substrate including an opening forming region having a reduced thickness provided with at least one opening for allowing said depositing material to be selectively attached to a desired position on said medium, and a thick portion formed in at least one portion of a mask outer periphery region of said semiconductor substrate,

said method comprising the steps of:

forming a first coating covering a region in which said thick portion of said semiconductor substrate is to be formed;

using said first coating as an etching mask to etch said semiconductor substrate so as to reduce thickness of said semiconductor substrate and thereby form said opening forming region;

forming a second coating in areas other than a predetermined position within said opening forming region; and

using said second coating as an etching mask to etch said semiconductor substrate so as to form said at least one opening in said predetermined position.

7. A deposition mask as defined in claim 6, wherein

said semiconductor substrate is composed of silicon.

8. A deposition mask manufacturing method as defined in claim 6, wherein

said first coating is formed on a first side of said semiconductor substrate;

said opening forming region is formed by etching said first side of said semiconductor substrate to reduce thickness of said substrate;

said second coating is formed on a second side of said semiconductor substrate; and

said at least one opening is formed by etching from said second side until penetrating through said semiconductor substrate.

9. A method for manufacturing an electroluminescence display device composed by arranging a plurality of display pixels, each display pixel having an electroluminescence element including at least an emissive layer between first and second electrodes, said method comprising the steps of:

arranging a deposition mask on a medium having said first electrode formed thereon; and

attaching an emissive material from an emissive material source via an opening in said deposition mask to a corresponding display pixel region of said medium, thereby forming an emissive layer for each pixel; wherein

said deposition mask for placing between a depositing material and said medium on which deposition is performed comprises a semiconductor substrate including an opening forming region having a reduced thickness provided with at least one opening for allowing said depositing material to be selectively attached to a desired position on said medium, and a thick portion formed in at least one portion of a mask outer periphery region of said semiconductor substrate; and

said deposition mask is obtained through the steps of:

forming a first coating covering a region in which said thick portion of said semiconductor substrate is to be formed;

using said first coating as an etching mask to etch said semiconductor substrate so as to reduce thickness of said semiconductor substrate and thereby form said opening forming region;

forming a second coating in areas other than a predetermined position within said opening forming region; and

using said second coating as an etching mask to etch said semiconductor substrate so as to form said at least one opening in said predetermined position.

10. A method for manufacturing an electroluminescence display device as defined in claim 9, wherein

each of said elements includes between said first and second electrodes at least an emissive layer containing an organic material; and

said organic material supplied from said emissive material source is attached via said opening of said deposition mask to a corresponding pixel.

**11.** A method for manufacturing an electroluminescence display device as defined in claim 9, wherein

each of said elements is composed by including between said first and second electrodes at least an emissive layer containing an organic material corresponding to an emitted color; and

said deposition mask having said opening formed only in a region corresponding to a pixel for a predetermined color is used to attach said organic material supplied from said emissive material source to a corresponding pixel region.

**12.** An electroluminescence display device formed using the manufacturing method defined in claim 9.

**13.** A color organic electroluminescence display device formed using the manufacturing method defined in claim 9.

\* \* \* \* \*

专利名称(译)	沉积掩模及其制造方法，电致发光显示装置及其制造方法		
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#### 摘要(译)

形成单晶或多晶硅衬底(100)作为半导体衬底。使用抗蚀剂(103)，在基板(100)的外周的至少一部分上形成SiO<sub>2</sub>膜(101)作为第一涂层。在使用该SiO<sub>2</sub>膜(101)作为掩模的同时，使用KOH等从第一表面侧蚀刻基板(100)。因此，基板的厚度减小，从而形成开口形成区域M，而不蚀刻被第一涂层覆盖的基板区域，从而形成厚部分140。然后，在基板的第二表面上(100)，通过在基板的区域上施加抗蚀剂(104)而不是在区域M中形成开口来形成第二涂层。然后使用第二涂层作为掩模蚀刻基板以形成孔，如开口(110)，在未被第二涂层覆盖的区域。通过使用由此获得的沉积掩模(100)作为用于蒸发的掩模，可以高精度地将材料沉积到期望的位置。

