US 20040035360A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2004/0035360 A1

Yamazaki et al. (43) Pub. Date: Feb. 26, 2004

(54) MANUFACTURING APPARATUS

(75) Inventors: **Shunpei Yamazaki**, Tokyo (JP); **Masakazu Murakami**, Kanagawa (JP)

Correspondence Address:
NIXON PEABODY, LLP
401 9TH STREET, NW
SUITE 900
WASINGTON, DC 20004-2128 (US)

(73) Assignee: **Semiconductor Energy Laboratory Co., Ltd.**, Atsugi-shi (JP)

(21) Appl. No.: **10/438,194**

(22) Filed: **May 15, 2003**

(30) **Foreign Application Priority Data**

May 17, 2002 (JP) 2002-143803

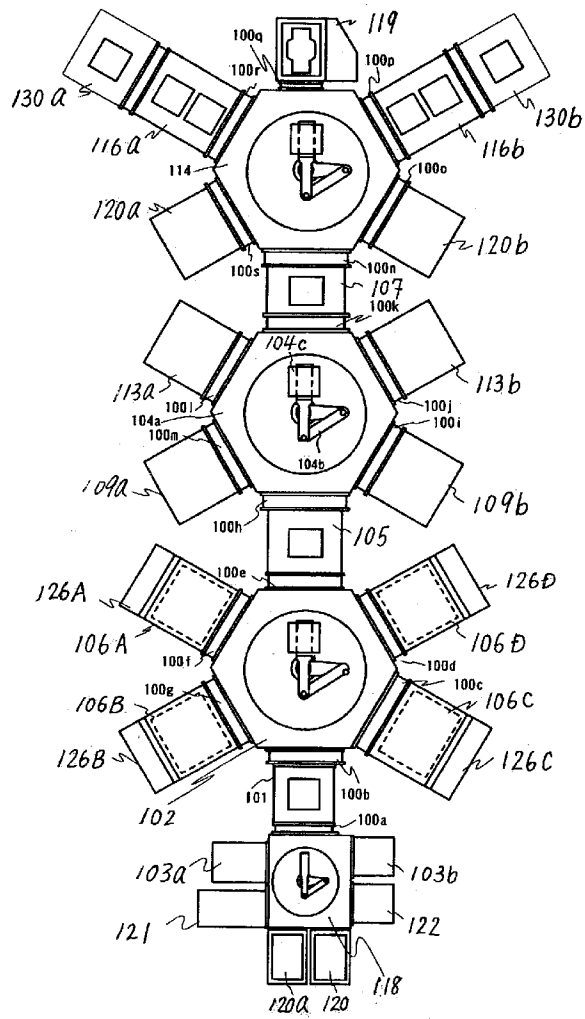
Publication Classification

(51) **Int. Cl.**[7] **H01L 21/306**; C23C 16/00

(52) **U.S. Cl.** **118/715**; 156/345.32

(57) **ABSTRACT**

A manufacturing apparatus is provided, which can improve a utilization efficiency of an evaporation material, reduce manufacturing costs of a light emitting device having an organic light emitting element, and shorten manufacturing time necessary to manufacture a light emitting device. According to the present invention, a multi-chamber manufacturing apparatus having plural film forming chambers includes a first film forming chamber for subjecting a first substrate to evaporation and a second film forming chamber for subjecting a second substrate to evaporation. In each film forming chamber, plural organic compound layers are laminated, thereby improving the throughput. Further, it is possible that the respective substrates in the plural film forming chambers are subjected to evaporation in the same manner in parallel, while another film forming chamber undergoes cleaning.



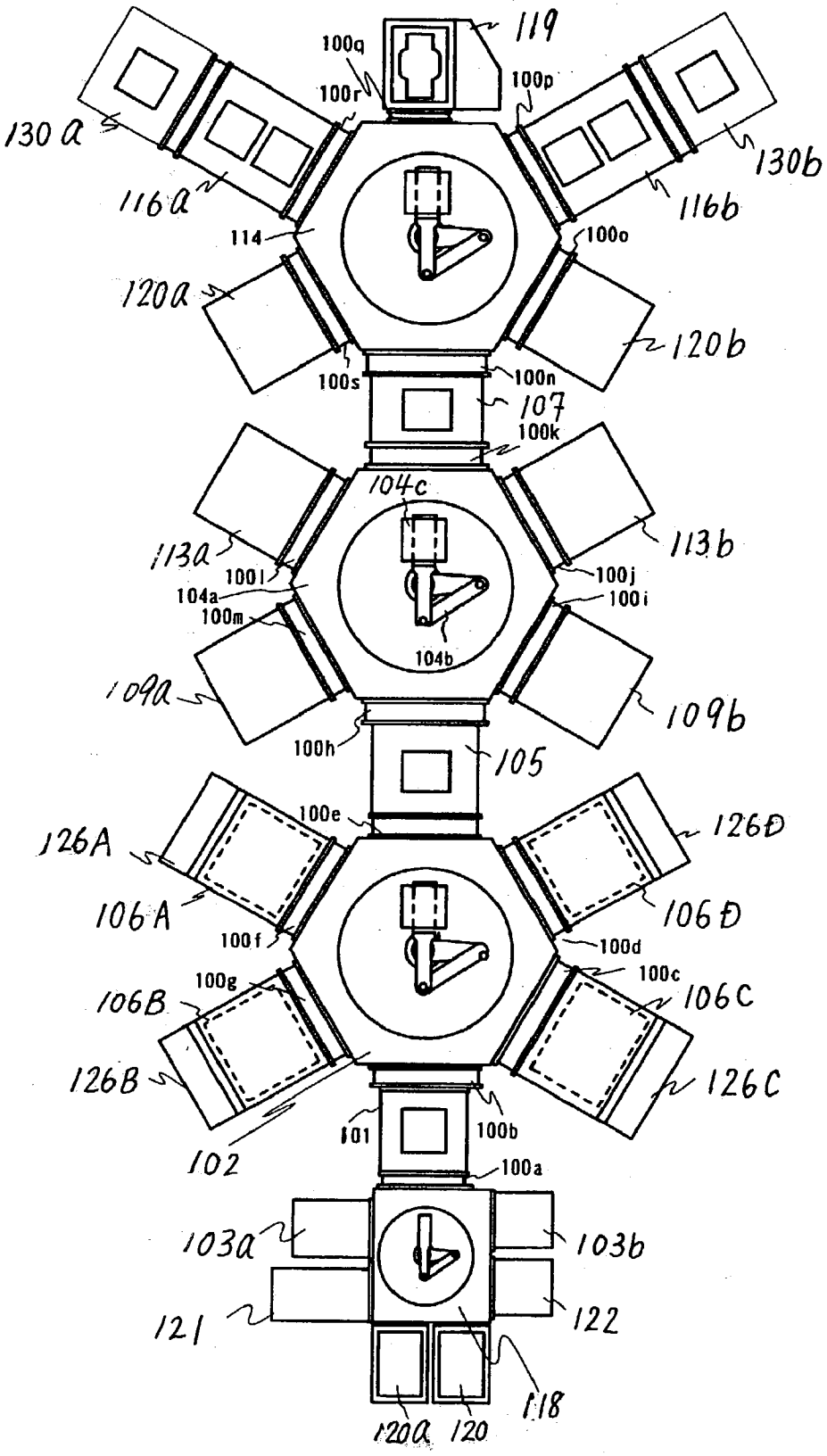

119
100q
100r
100p
130a
130b
116a
116b
114
100o
120a
120b
100s
100n
107
100k
104c
113a
113b
100l
100j
104a
100i
100m
104b
109a
109b
100h
105
100e
126A
126D
106A
106D
100f
100d
100g
100c
106B
106C
126B
126C
101
100b
102
100a
103a
103b
121
122
118
120a
120

Fig. 1

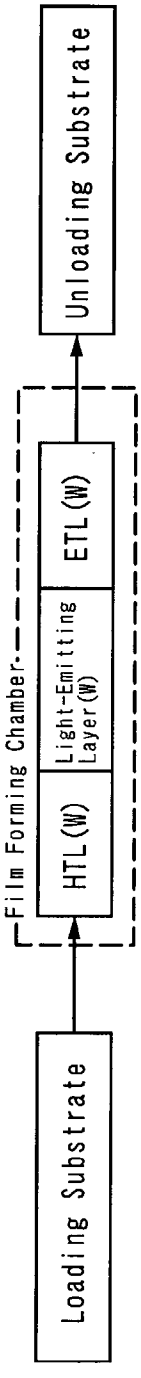

Loading Substrate
Film Forming Chamber
HTL(W)
Light-Emitting Layer(W)
ETL(W)
Unloading Substrate

Fig. 2A

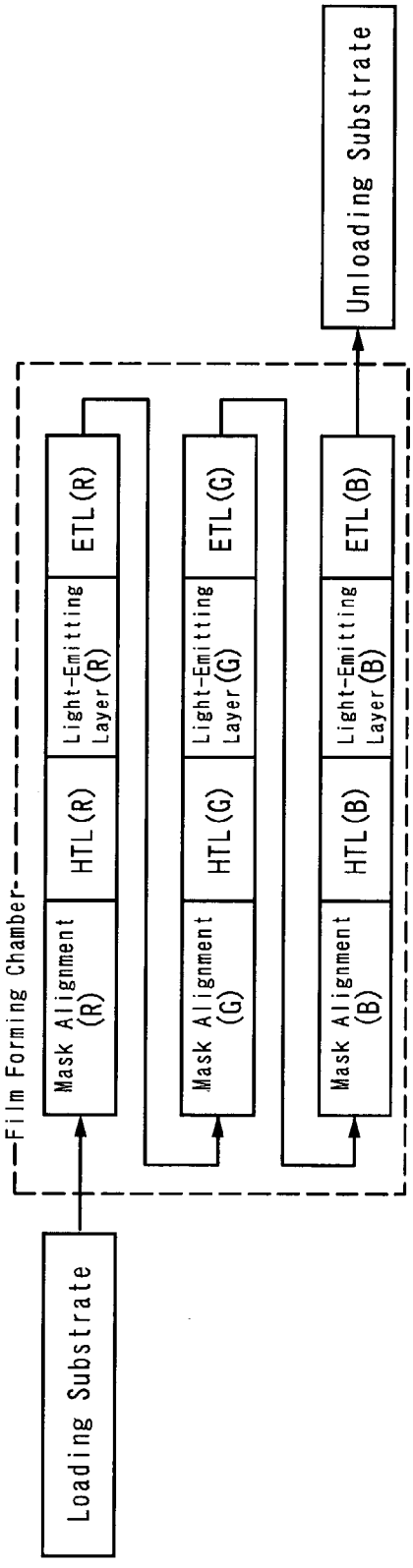

Loading Substrate
Film Forming Chamber
Mask Alignment (R)
HTL(R)
Light-Emitting Layer(R)
ETL(R)
Mask Alignment (G)
HTL(G)
Light-Emitting Layer(G)
ETL(G)
Mask Alignment (B)
HTL(B)
Light-Emitting Layer(B)
ETL(B)
Unloading Substrate

Fig. 2B

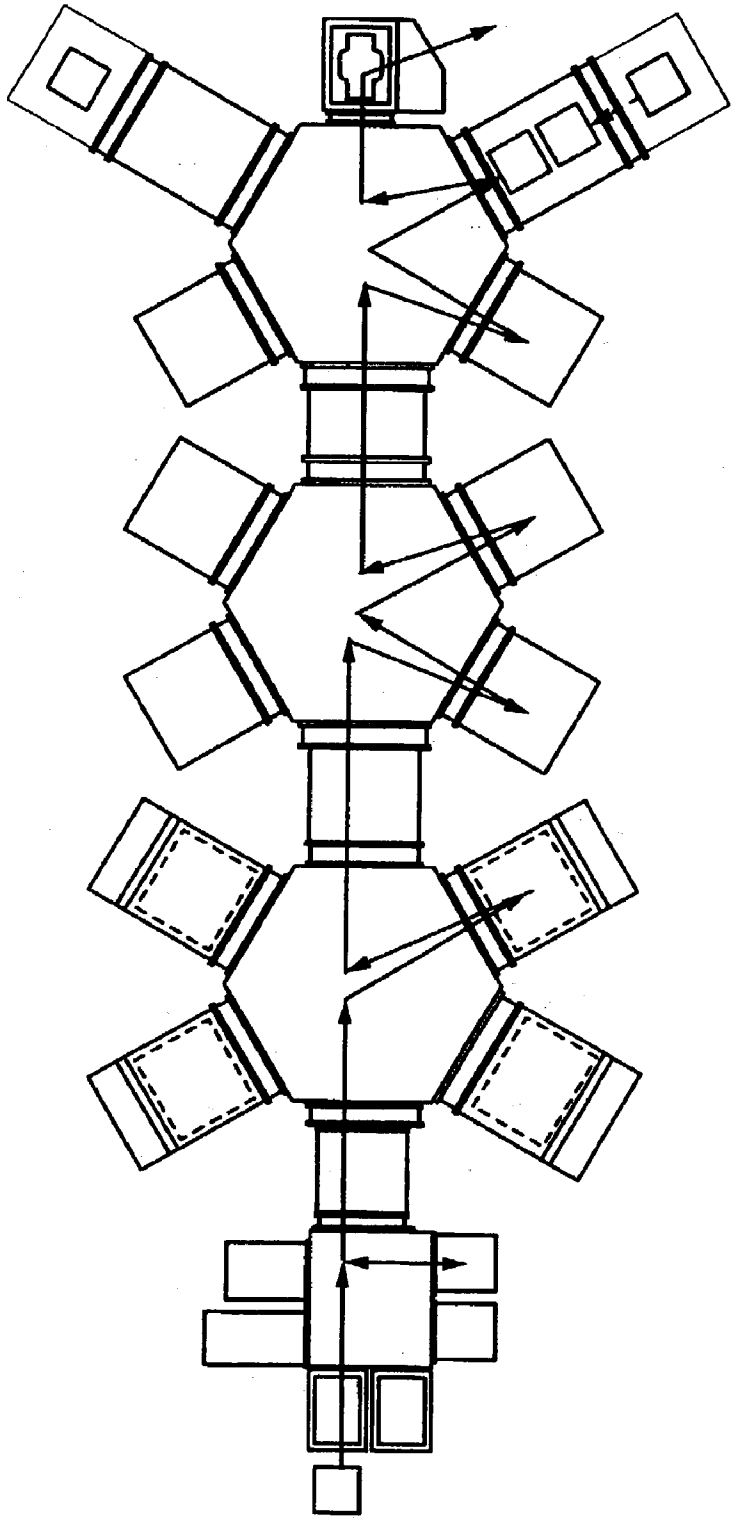


Fig. 3

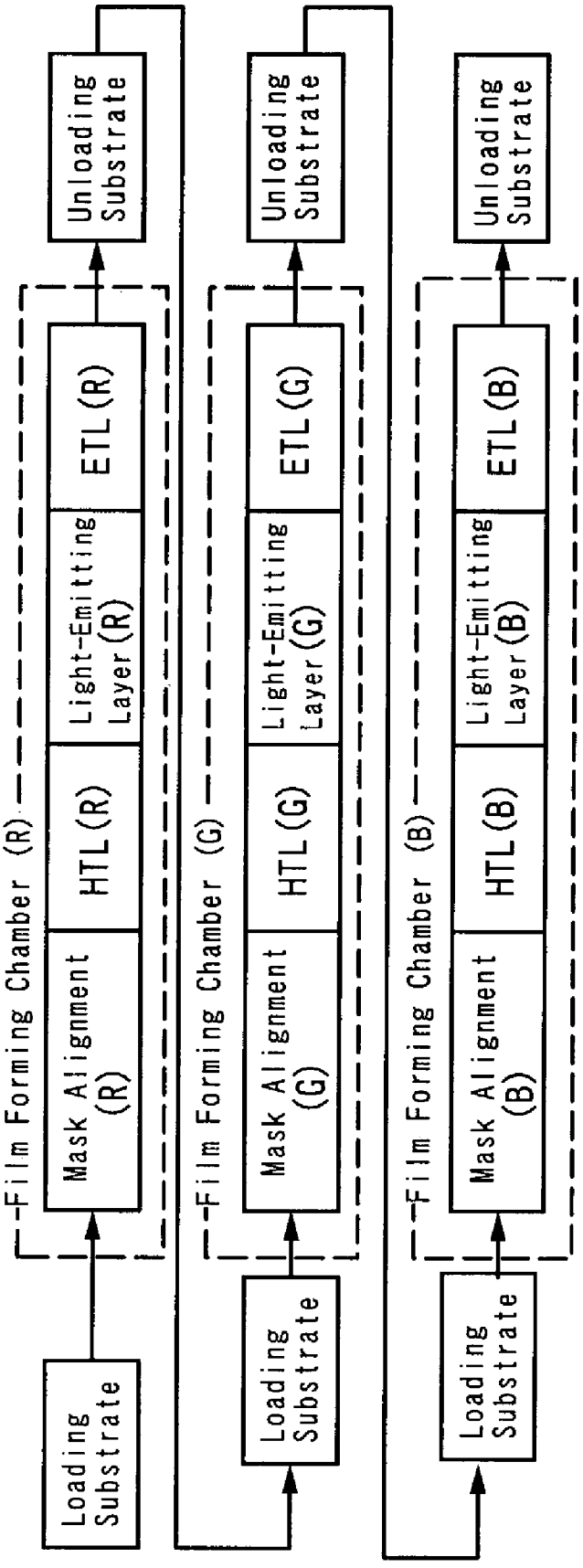

Film Forming Chamber (R)
Loading Substrate
Mask Alignment (R)
HTL (R)
Light-Emitting Layer (R)
ETL (R)
Unloading Substrate
Film Forming Chamber (G)
Loading Substrate
Mask Alignment (G)
HTL (G)
Light-Emitting Layer (G)
ETL (G)
Unloading Substrate
Film Forming Chamber (B)
Loading Substrate
Mask Alignment (B)
HTL (B)
Light-Emitting Layer (B)
ETL (B)
Unloading Substrate

Fig. 4

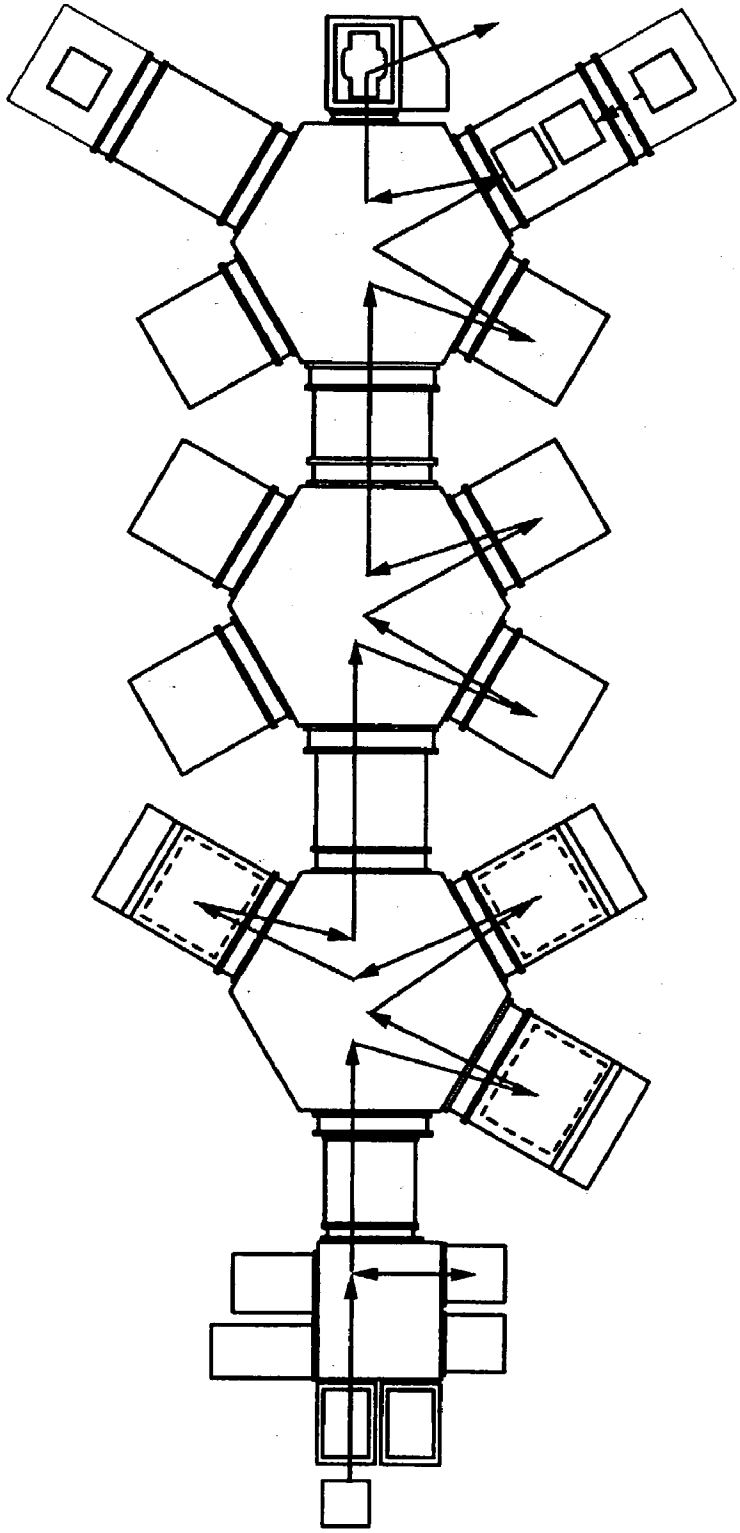


Fig. 5

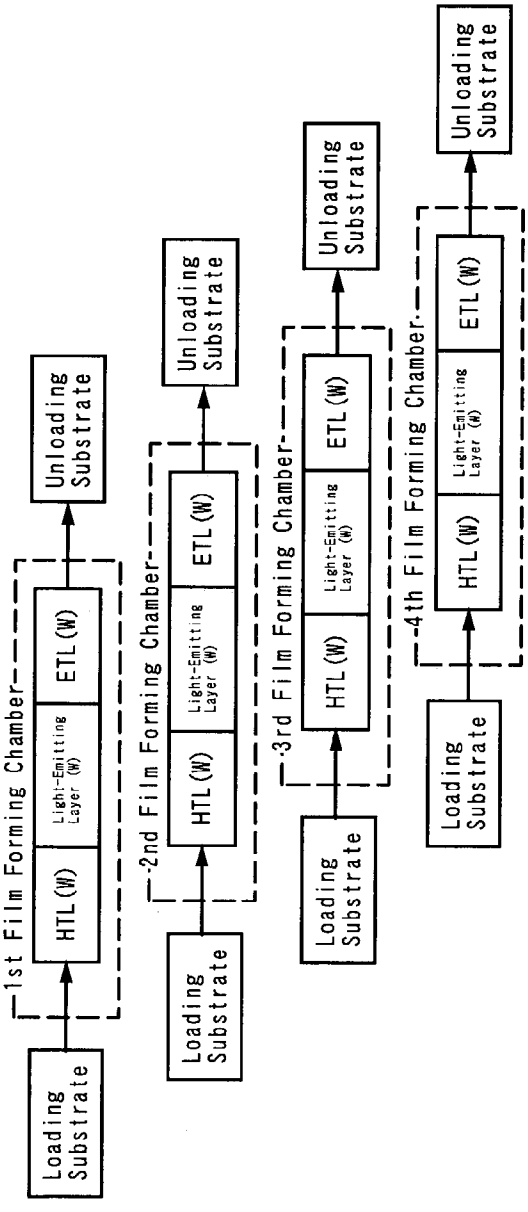

1st Film Forming Chamber
Loading Substrate
HTL(W)
Light-Emitting Layer (W)
ETL(W)
Unloading Substrate
2nd Film Forming Chamber
Loading Substrate
HTL(W)
Light-Emitting Layer (W)
ETL(W)
Unloading Substrate
3rd Film Forming Chamber
Loading Substrate
HTL(W)
Light-Emitting Layer (W)
ETL(W)
Unloading Substrate
4th Film Forming Chamber
Loading Substrate
HTL(W)
Light-Emitting Layer (W)
ETL(W)
Unloading Substrate

Fig. 6A

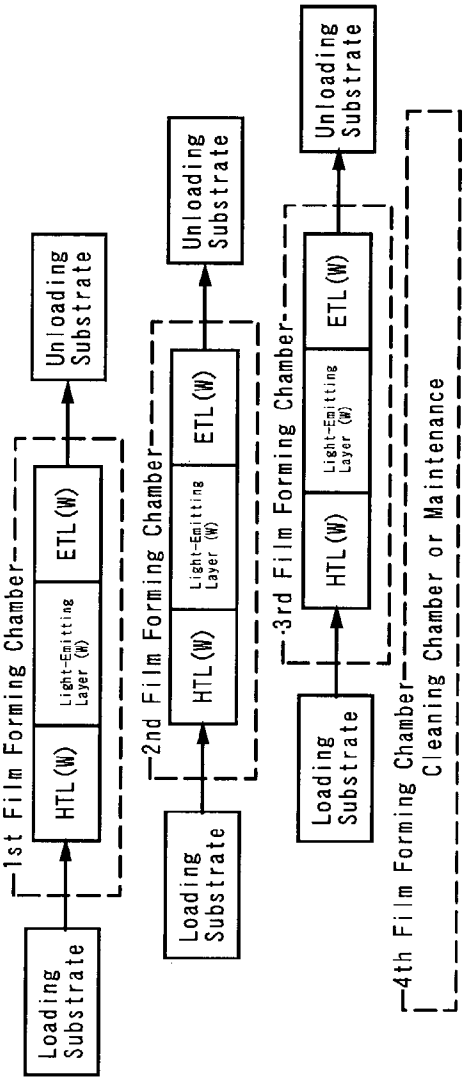

1st Film Forming Chamber
Loading Substrate
HTL(W)
Light-Emitting Layer (W)
ETL(W)
Unloading Substrate
2nd Film Forming Chamber
Loading Substrate
HTL(W)
Light-Emitting Layer (W)
ETL(W)
Unloading Substrate
3rd Film Forming Chamber
Loading Substrate
HTL(W)
Light-Emitting Layer (W)
ETL(W)
Unloading Substrate
4th Film Forming Chamber
Cleaning Chamber or Maintenance

Fig. 6B

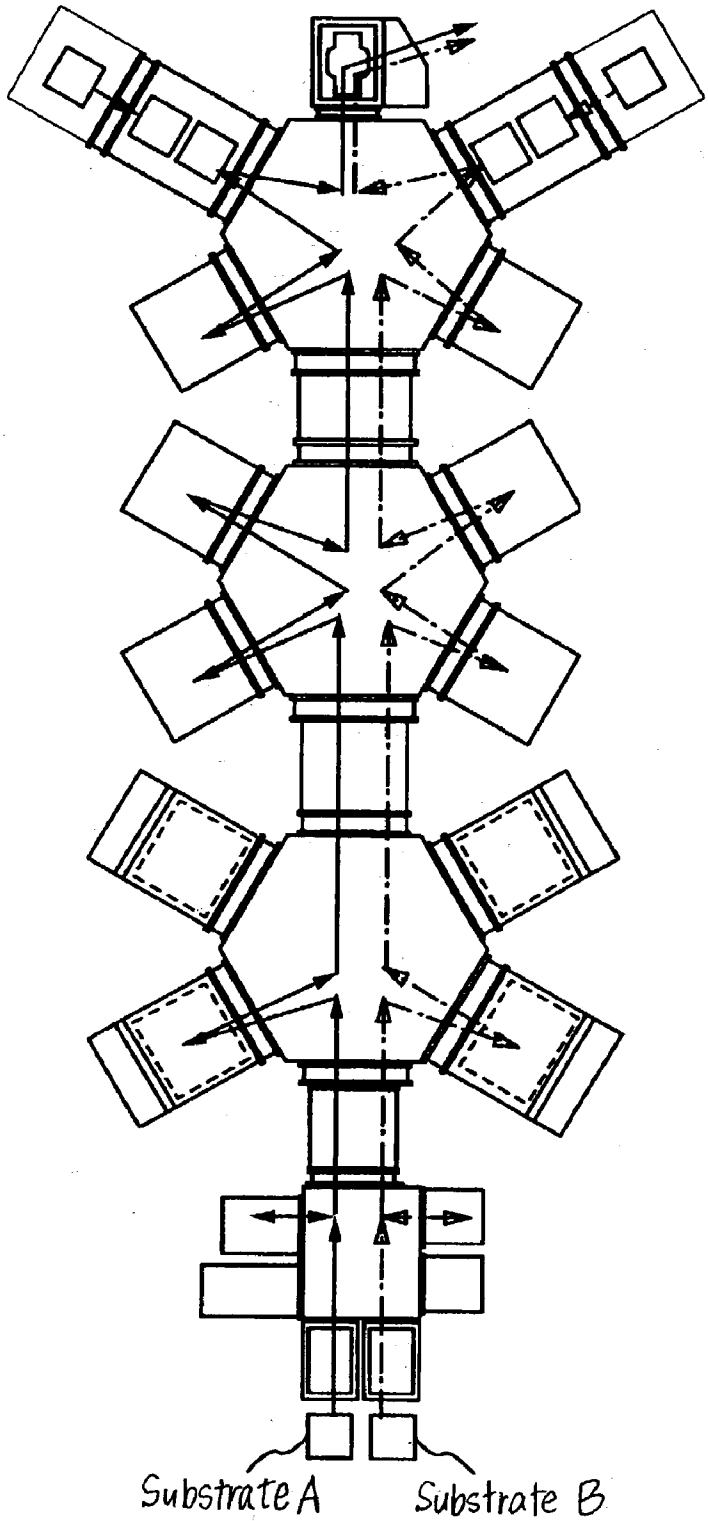


Fig. 7

Fig. 8 A X-direction Cross Section

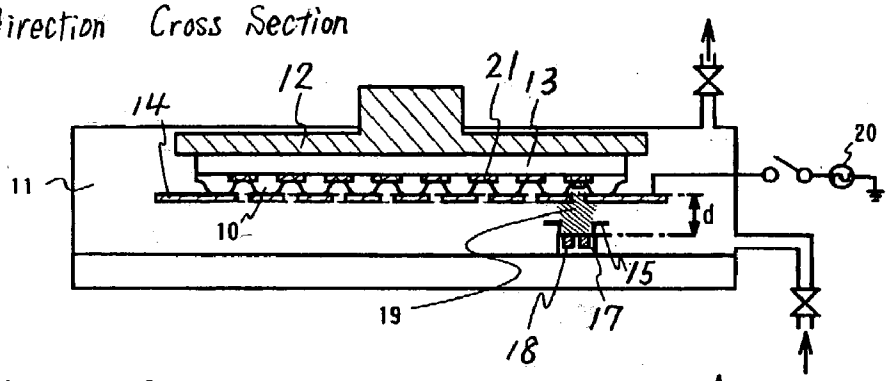


Fig. 8 B Y-direction Cross Section

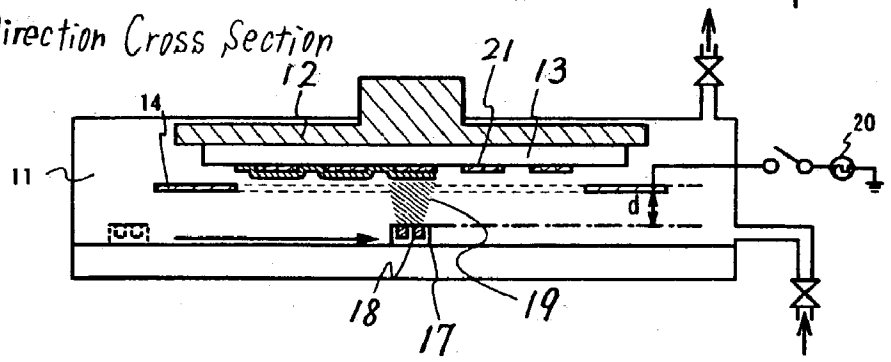


Fig. 8 C Plane View 1,1

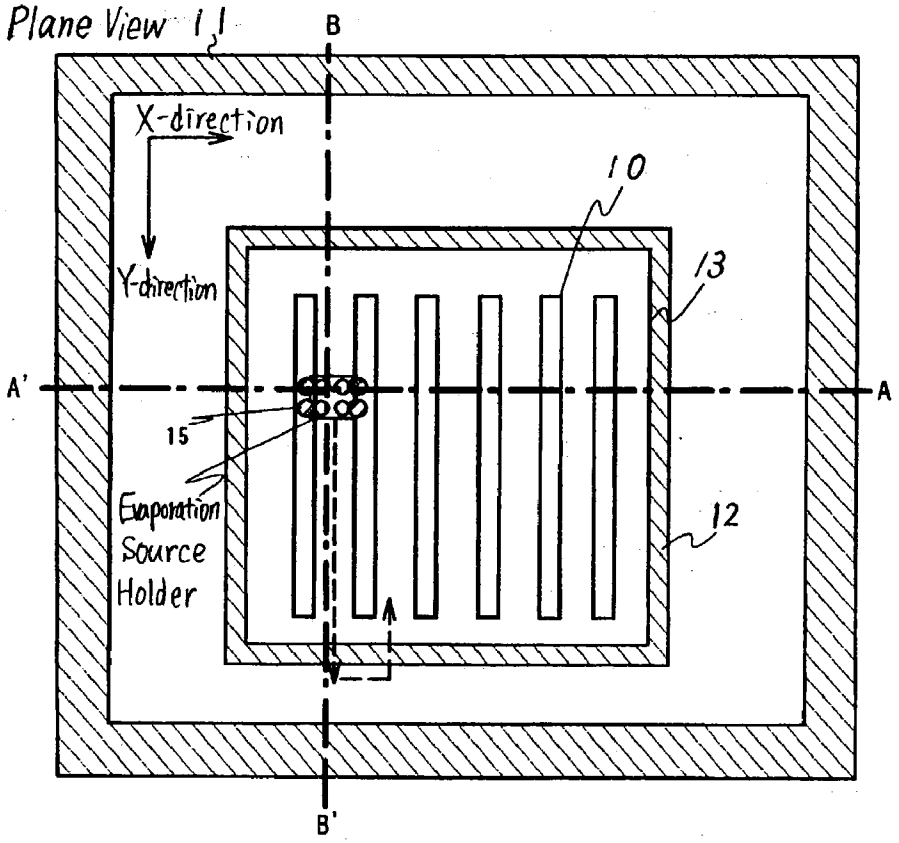


Fig. 9A

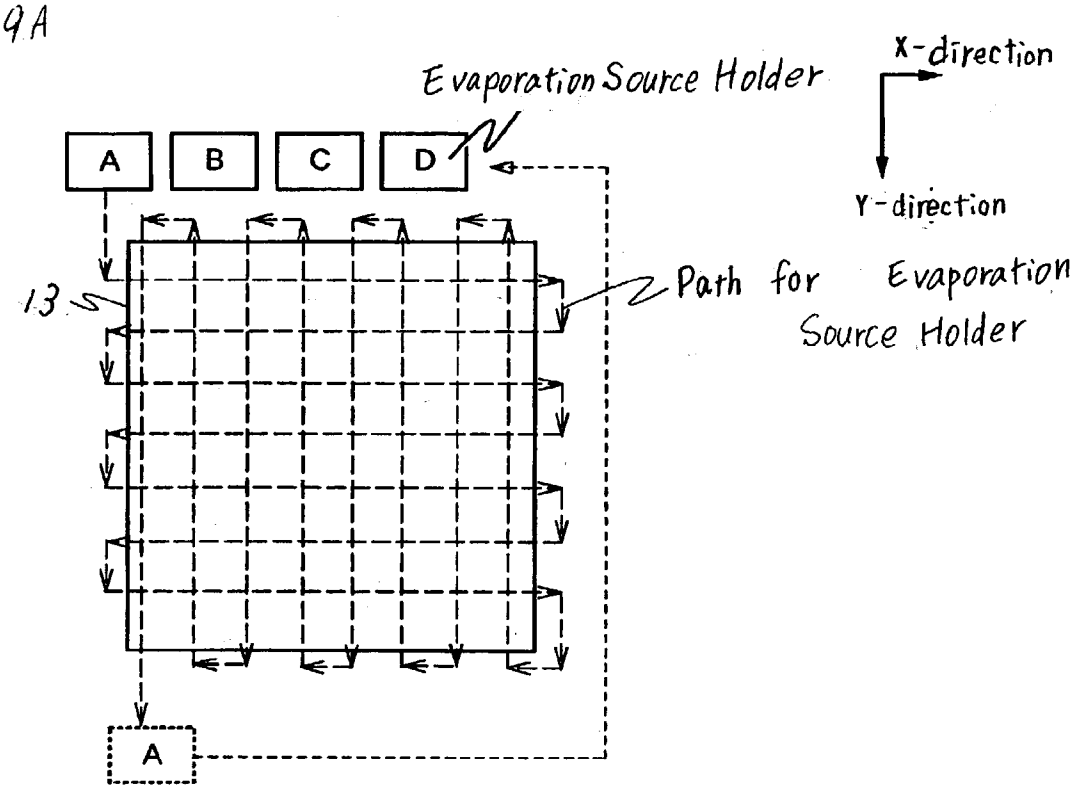

Evaporation Source Holder
X-direction
Y-direction
A
B
C
D
13
Path for Evaporation Source Holder
A

Fig. 9B

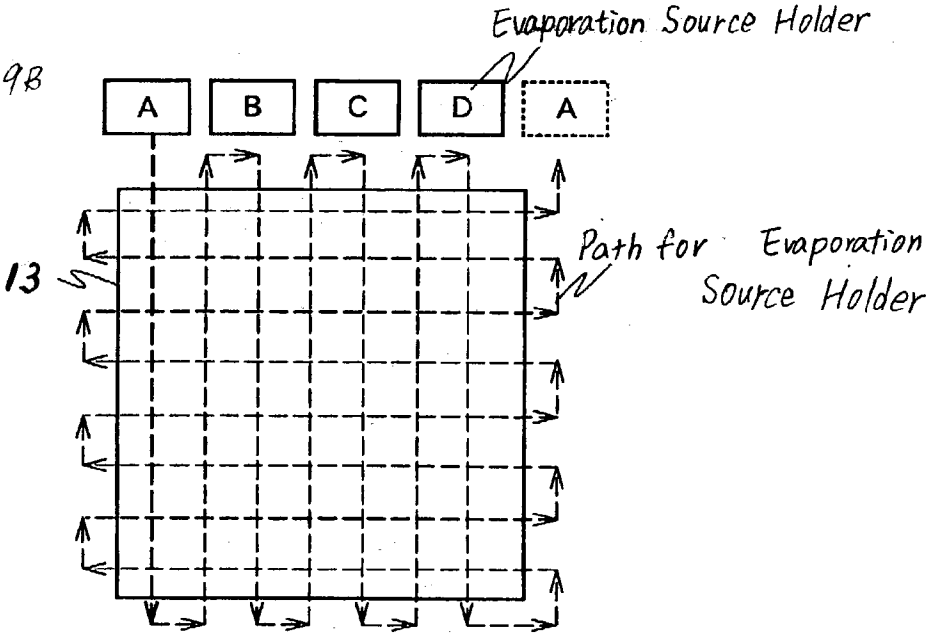

Evaporation Source Holder
A
B
C
D
A
13
Path for Evaporation Source Holder

Fig. 10A

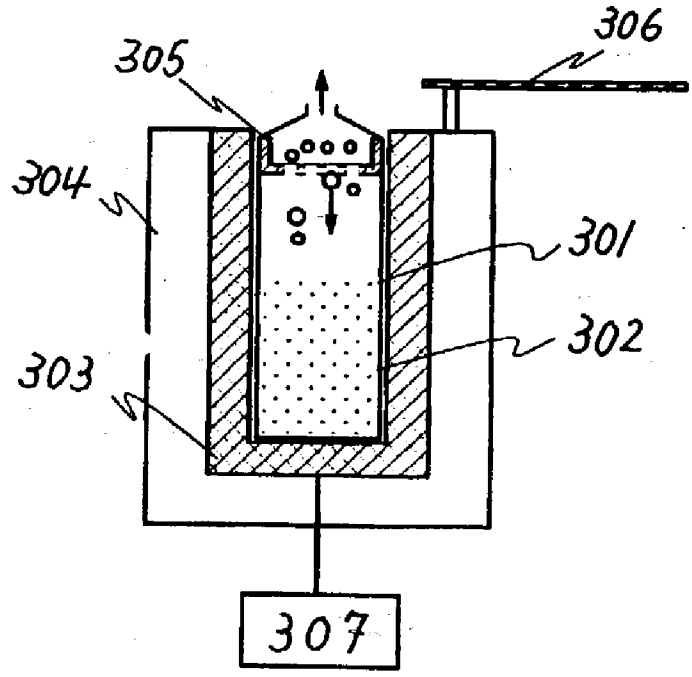


Fig. 10B

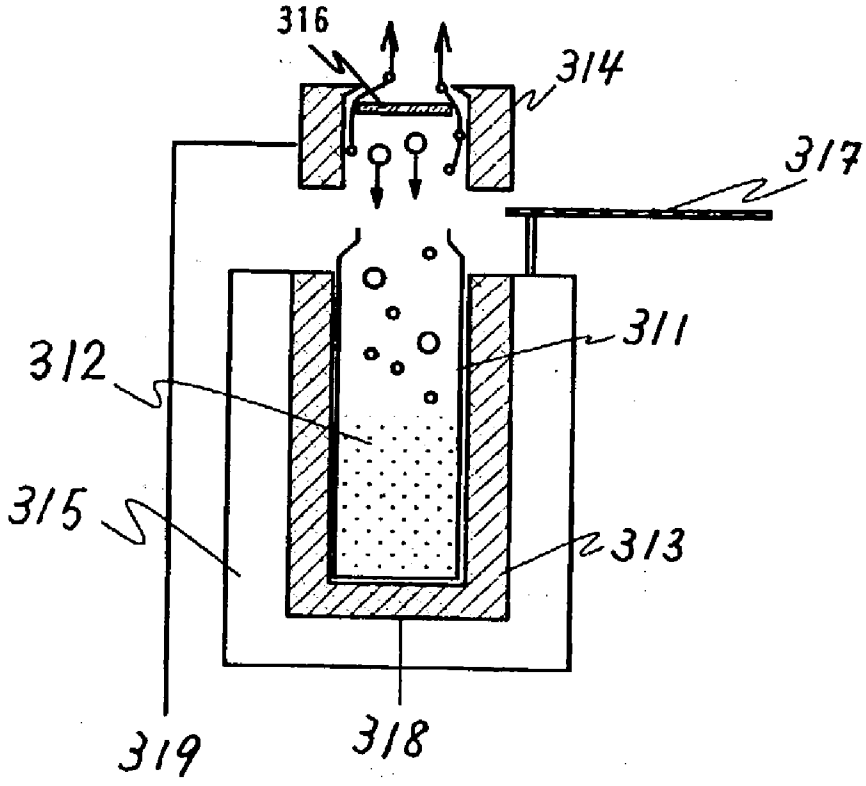


Fig. 11 A

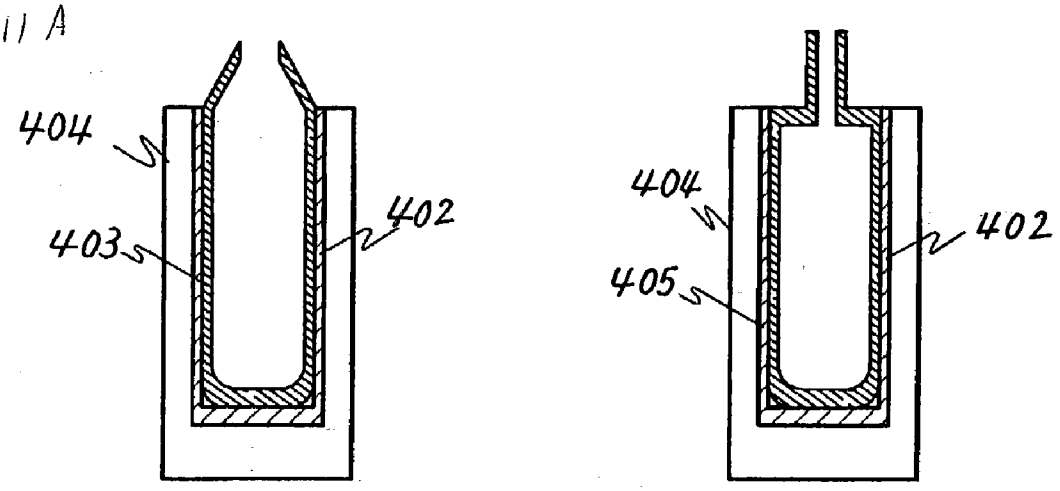


Fig. 11 B

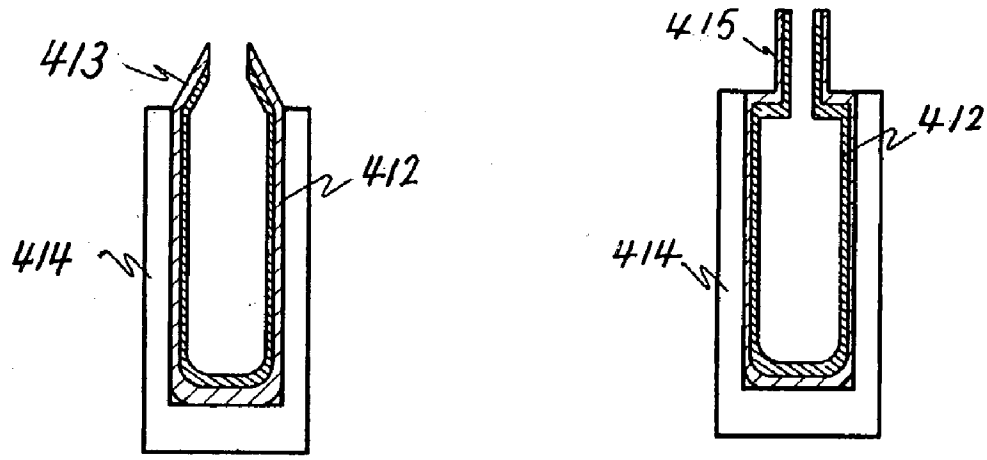


Fig. 12A

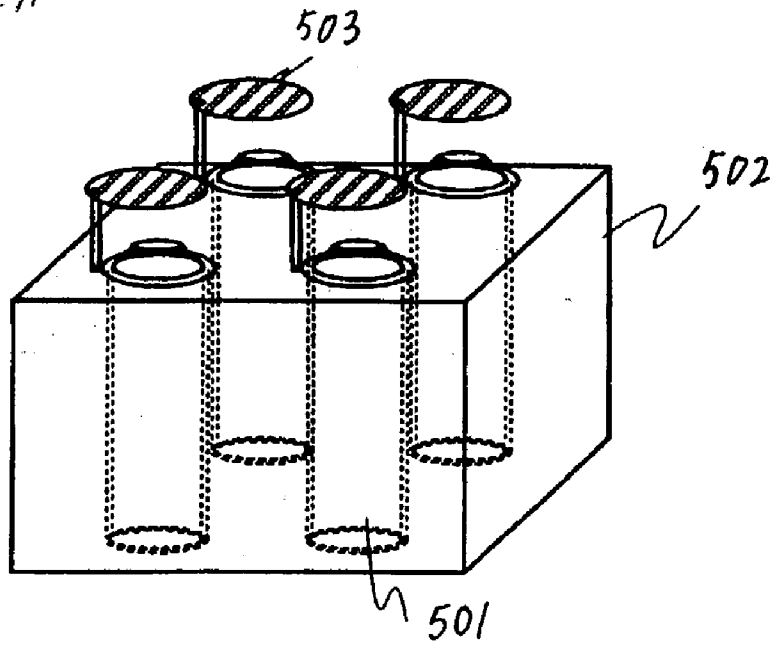
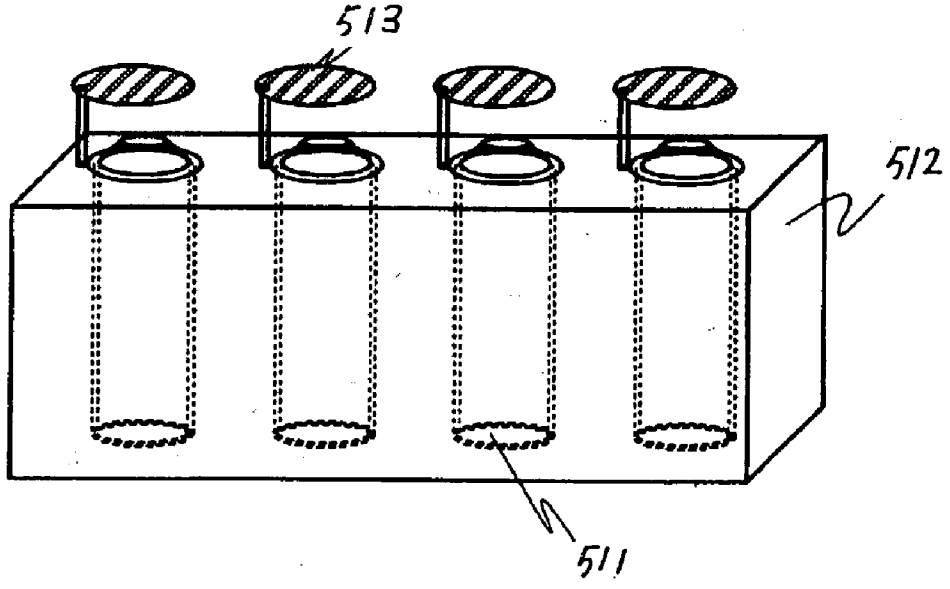


Fig. 12B



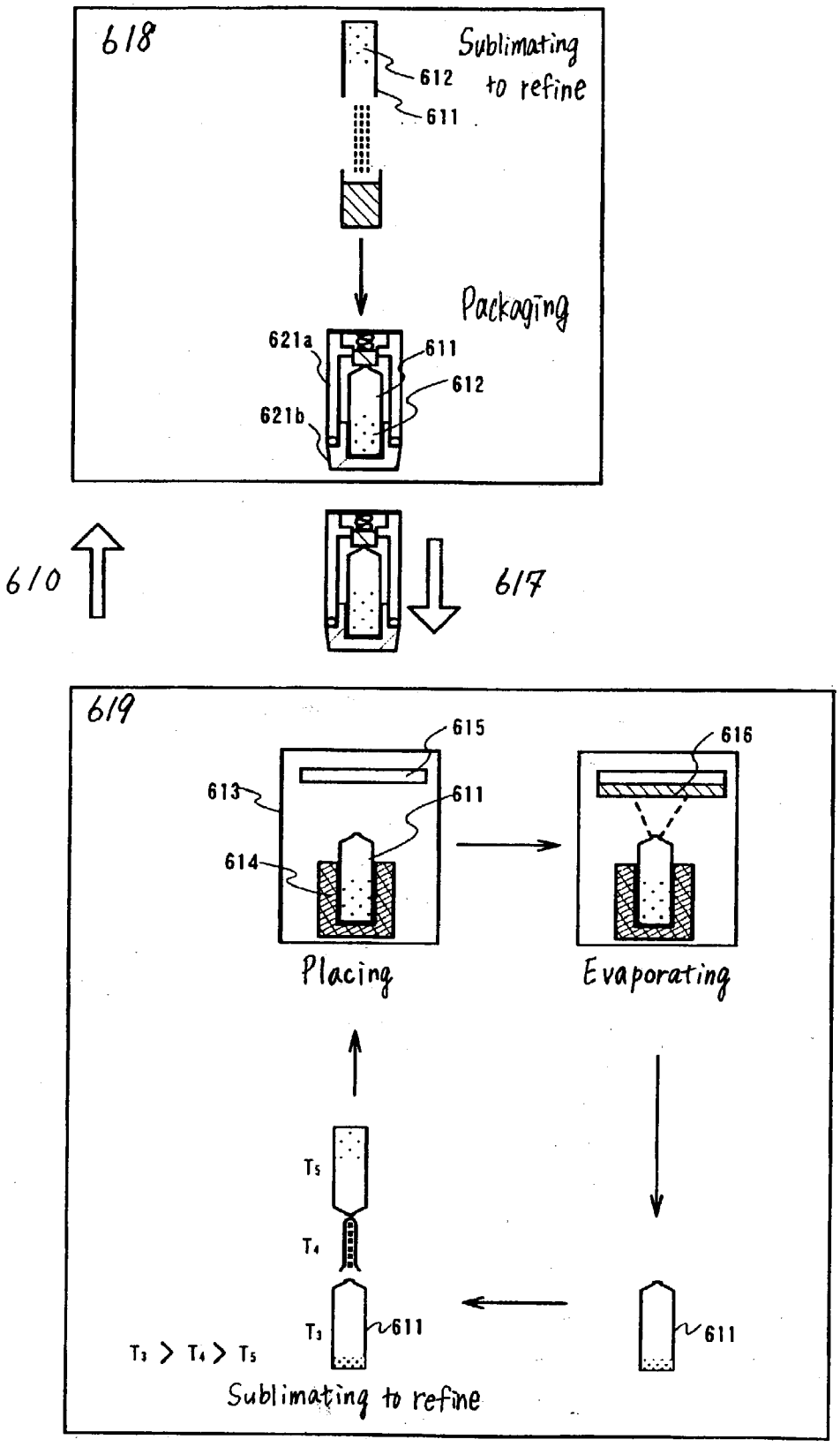

618
Sublimating to refine
612
611
Packaging
621a
611
612
621b
610
617
619
615
616
613
611
614
Placing
Evaporating
T5
T4
T3
611
611
T3 > T4 > T5
Sublimating to refine

Fig. 13

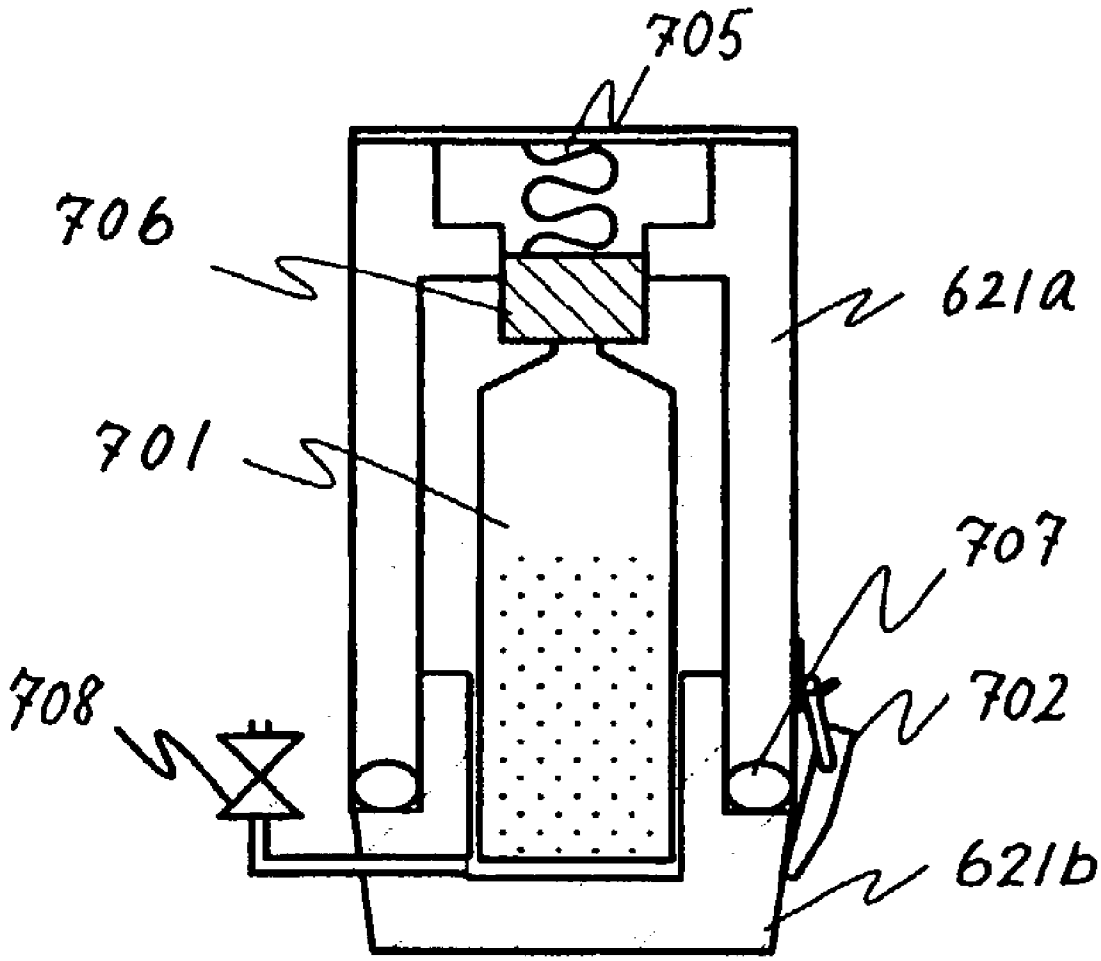


Fig. 14

Fig. 15A Plane View

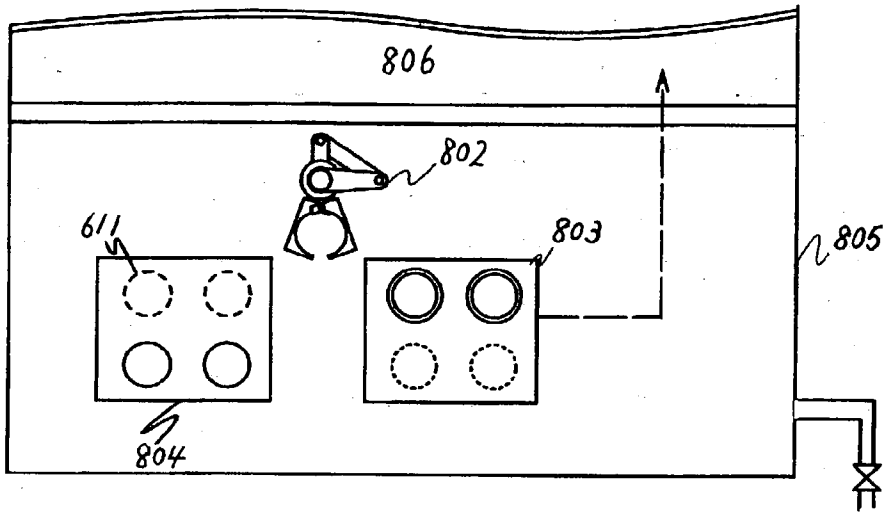


Fig. 15B Perspective View

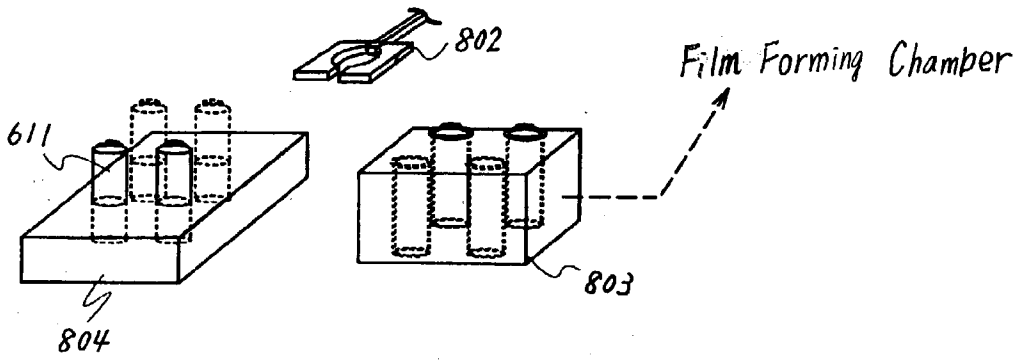


Fig.16A
Plane View

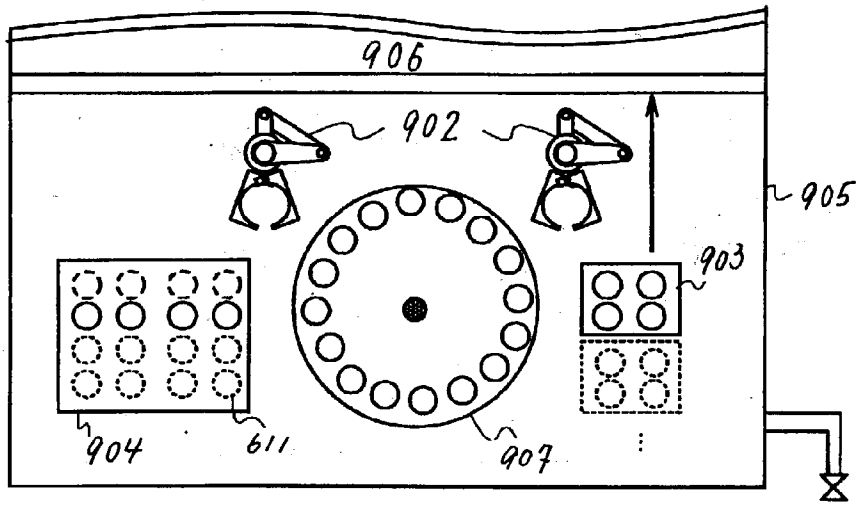


Fig.16B
Perspective View

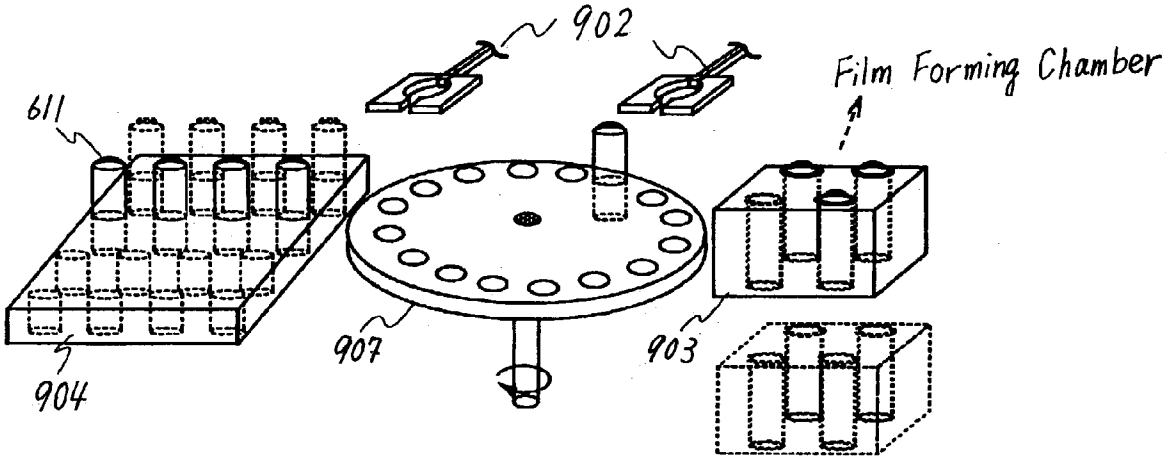


Fig. 17A

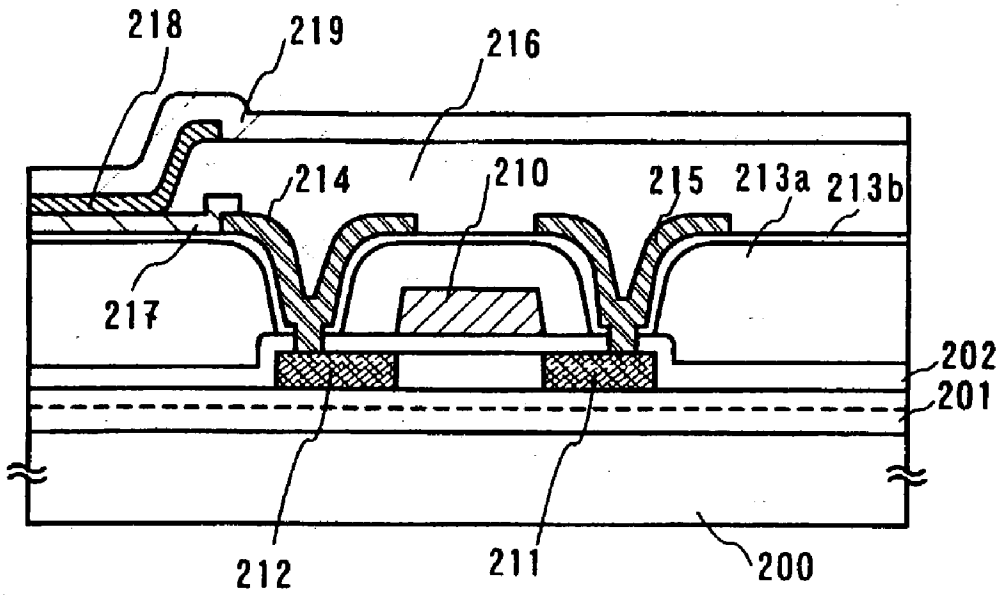
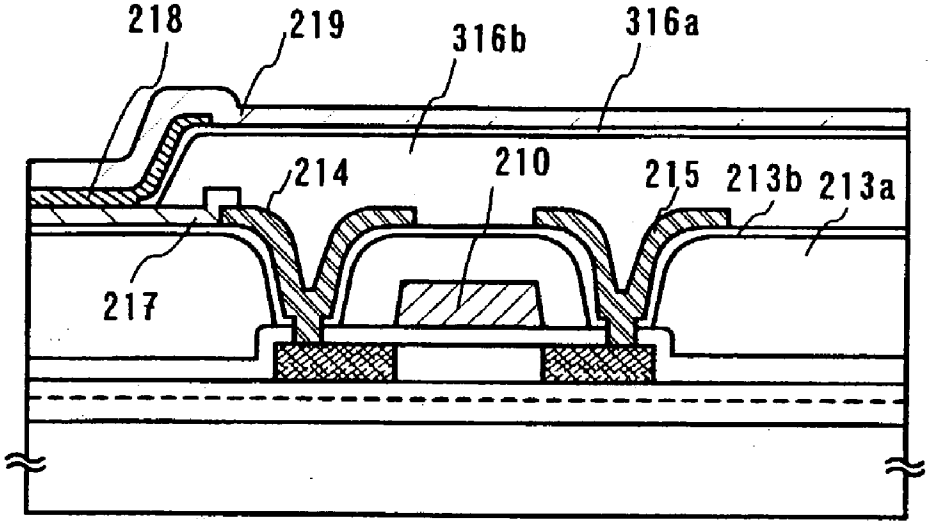


Fig. 17B



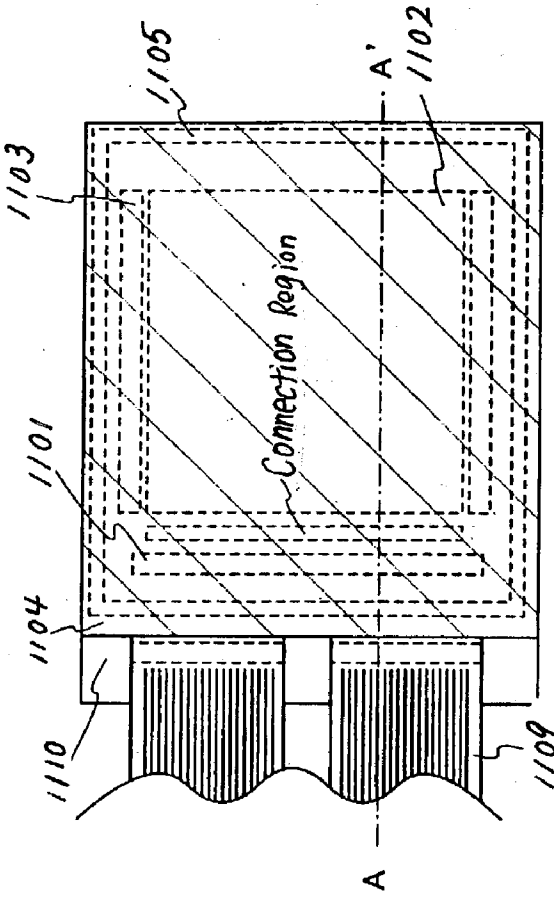


Fig. 18A

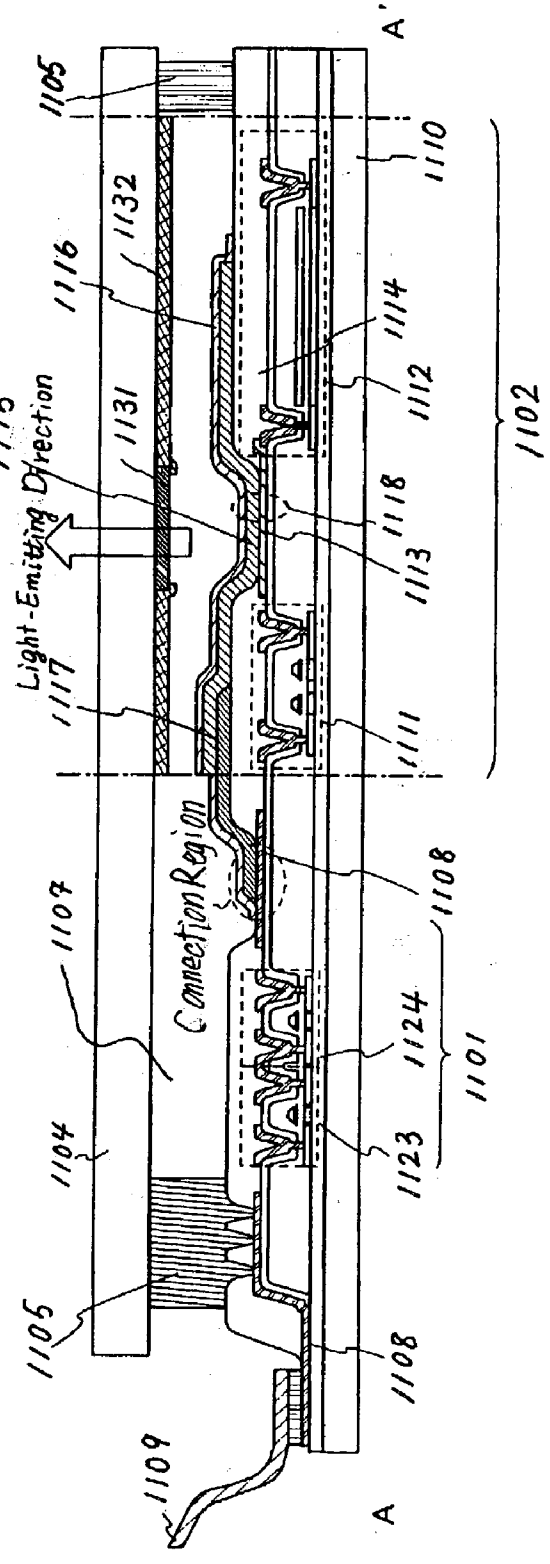


Fig. 18B

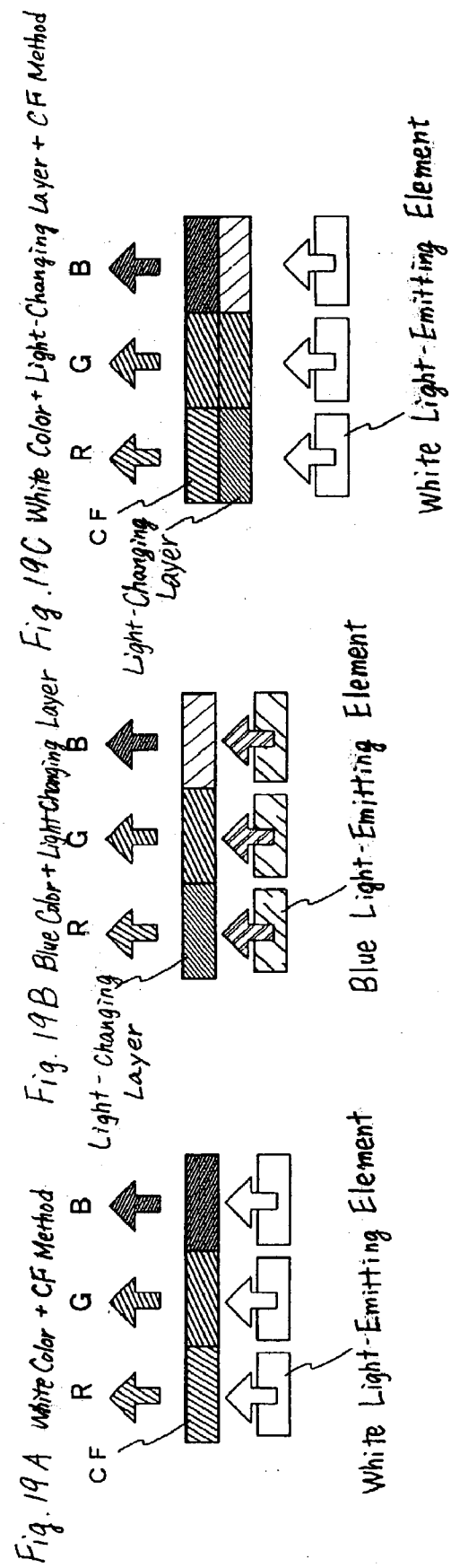


Fig. 19A White Color + CF Method

Fig. 19B Blue Color + Light-Changing Layer

Fig. 19C White Color + Light-Changing Layer + CF Method

Fig. 20A

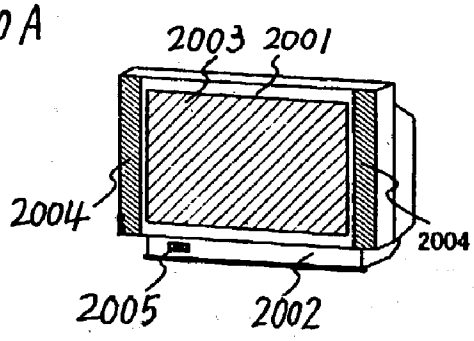


Fig. 20B

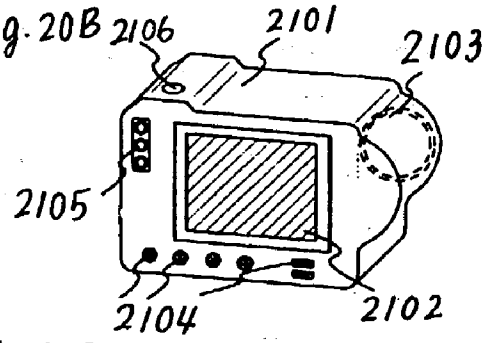


Fig. 20C

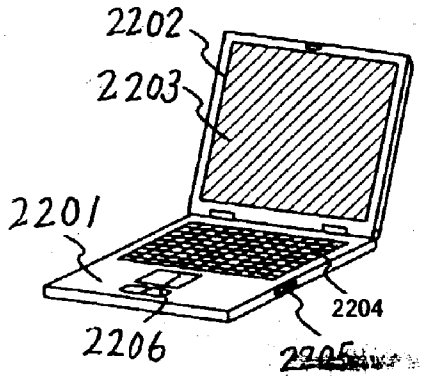


Fig. 20D

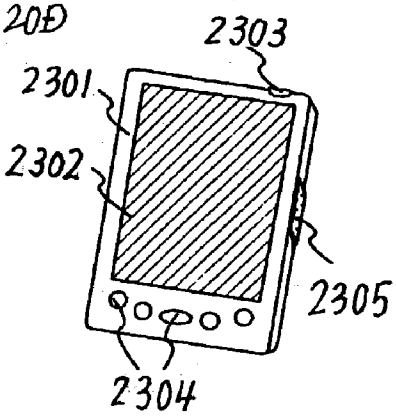


Fig. 20E

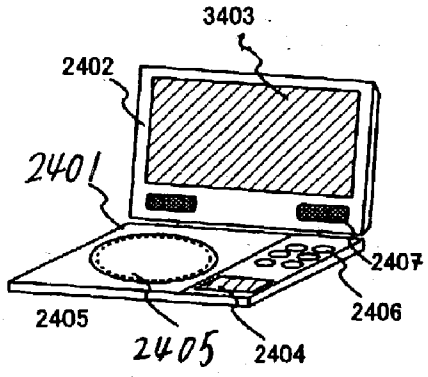


Fig. 20F

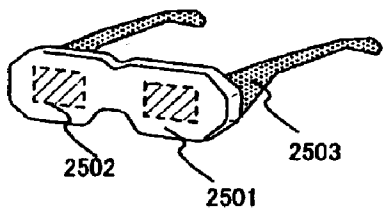


Fig. 20G

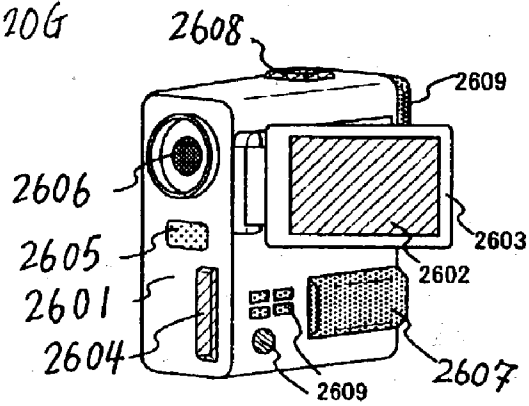
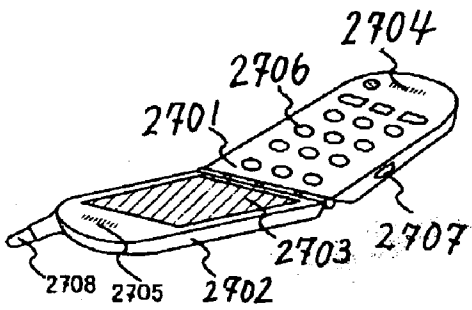


Fig. 20H



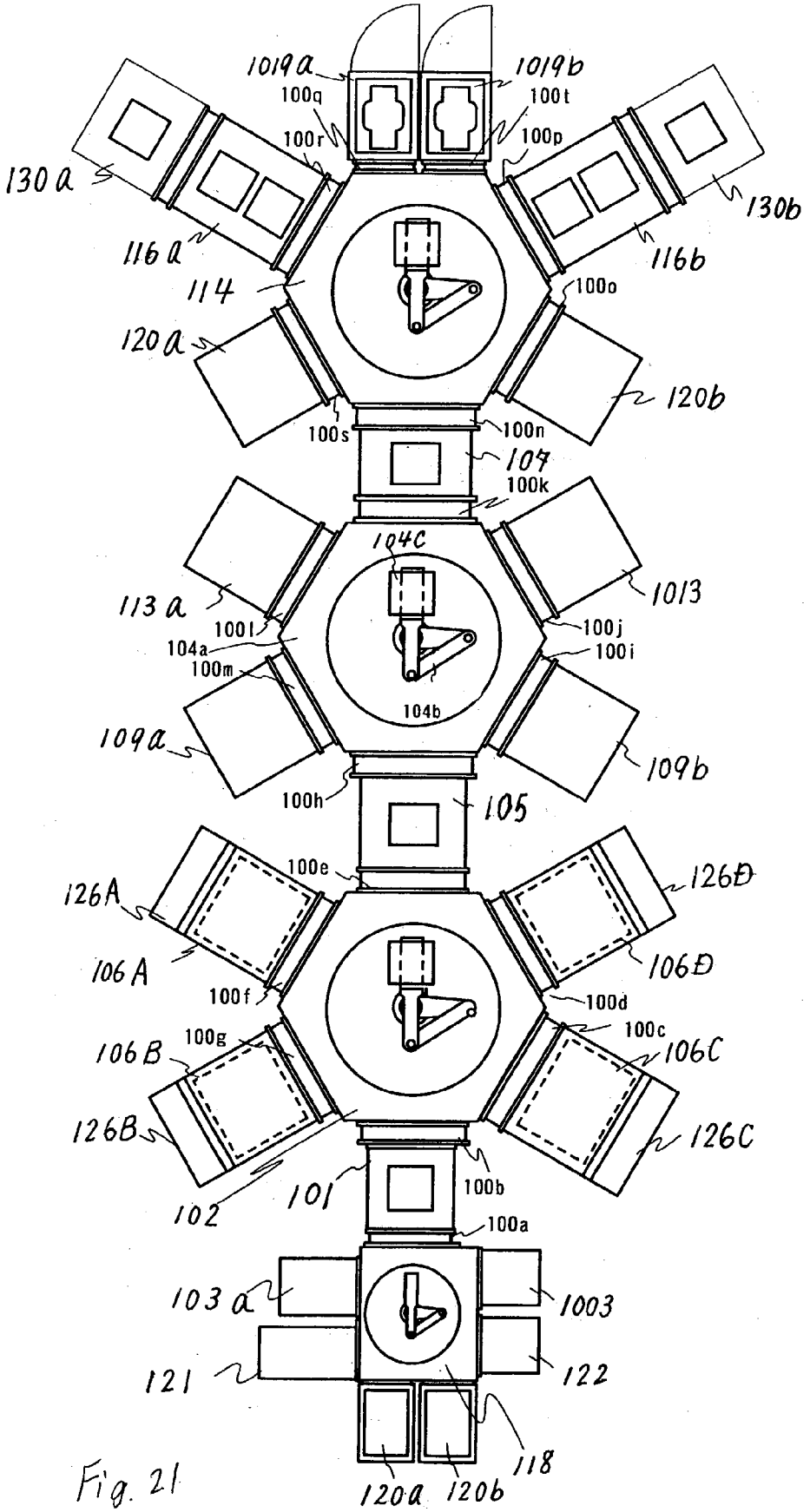

1019a
1019b
100q
100t
100r
100p
130a
130b
116a
116b
114
100o
120a
120b
100s
100n
107
100k
104C
113a
1013
100l
100j
104a
100i
100m
104b
109a
109b
100h
105
100e
126A
126D
106A
106D
100f
100d
100c
100g
106B
106C
126B
126C
100b
101
102
100a
103a
1003
121
122
118
120a
120b

Fig. 21

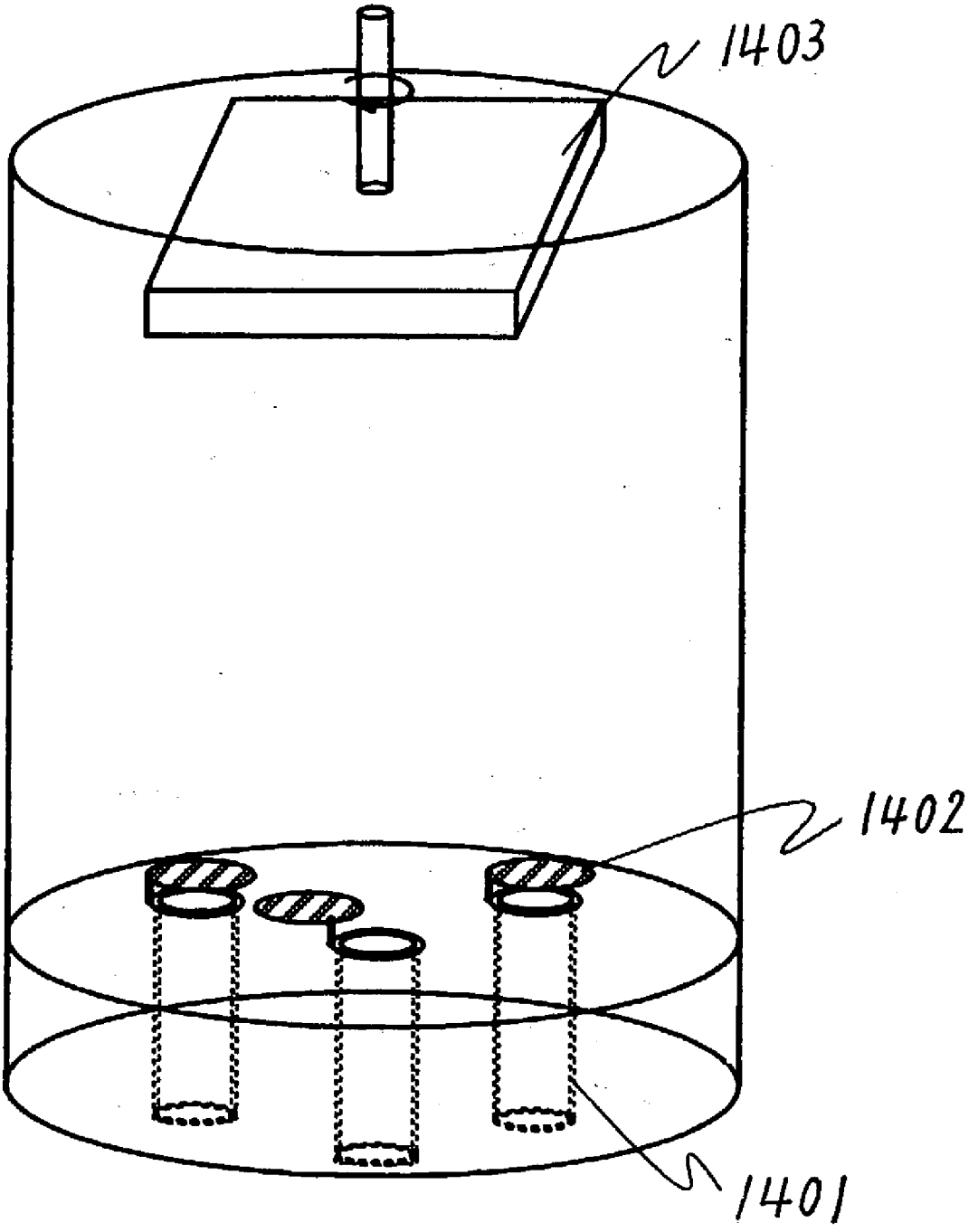


Fig. 22

MANUFACTURING APPARATUS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a manufacturing apparatus used for film formation of a material that can be formed into a film by evaporation (hereinafter referred to as evaporation material) and a manufacturing method of a light emitting device typified by an EL element. In particular, the present invention relates to a technique using an organic material as the evaporation material and being effective when manufacturing a light emitting device. Note that the term "light emitting device" in this specification refers to an image display device, a light emitting device, or a light source (including illuminating devices). Also included in the definition of the light emitting device are: a module in which a connector such as an FPC (flexible printed circuit), a TAB (tape automated bonding) tape, or a TCP (tape carrier package) is attached to a light emitting device; a module in which a printed wiring board is provided on the tip of a TAB tape or a TCP; and a module in which an IC (integrated circuit) is mounted directly to a light emitting element by a COG (chip on glass) method.

[0003] 2. Description of the Related Art

[0004] In recent years, the research of light emitting devices using an EL element as a self-luminous element has become active. In particular, light emitting devices using an organic material as an EL material are attracting more attention. The light emitting devices are called organic EL displays (OELD) or organic light emitting diodes (OLED).

[0005] Note that an EL element has a layer (hereinafter referred to as EL layer) containing an organic compound in which luminescence developed by applying an electric field (electroluminescence) is obtained, an anode, and a cathode. The types of the organic compound luminescence includes light emission when returning from a singlet excitation state to a ground state (fluorescence) and light emission when returning from a triplet excitation state to a ground state (phosphorescence). Both types of light emission can be applied to a light emitting device produced by a film forming apparatus and a film formation method according to the present invention.

[0006] Unlike liquid crystal display devices, light emitting devices are of a self-luminous type, thereby causing no problem of a view angle. More specifically, the light emitting devices are more suitable as a display used outside than the liquid crystal displays. Thus, the use of the light emitting devices in various forms has been proposed.

[0007] An EL element has a structure in which an EL layer is sandwiched between a pair of electrodes, and the EL layer normally has a laminate structure. A typical example of the laminate structure is one composed of "a hole transporting layer/a light emitting layer/and an electron transporting layer". Most of the light emitting devices currently under research and development adopt the structure due to its extremely high light emitting efficiency.

[0008] Alternatively, another laminate structure may be used in which: a hole injecting layer, a hole transporting layer, a light emitting layer, and an electron transporting layer are laminated onto an anode in the stated order; or a hole injecting layer, a hole transporting layer, a light emitting layer, an electron transporting layer, and an electron injecting layer are laminated onto an anode in the stated order. Fluorescent pigments and the like may also be doped into the light emitting layers. Further, all of the above layers may be formed using only low-molecular weight materials, or may be formed using only high-molecular weight materials.

[0009] Further, EL materials used to form an EL layer are broadly divided into low-molecular weight (monomer-based) materials and high-molecular weight (polymer-based) materials, while the low-molecular weight materials are formed into films mainly by evaporation.

[0010] The EL material is extremely likely to deteriorate, because the EL material is easily oxidized due to presence of oxygen or moisture. Thus, a photolithography step cannot be performed after film formation. In order to form a pattern, it is necessary to use a mask (hereinafter referred to as evaporation mask) having an opening portion to separate out the pattern region at the same time of the film formation. Therefore, most of the sublimated organic EL materials are adhered to an inner wall of a film forming chamber or an adhesion proof shield (protective plate for preventing an evaporation material from adhering to the inner wall of the film forming chamber). As a result, an evaporation apparatus needs regular maintenance such as a cleaning process for removing adhered substances from the inner wall of the film forming chamber and the adhesion proof shield, thereby making it inevitable to temporarily stop a manufacturing line for mass production during the maintenance.

[0011] In order to improve uniformity of a film thickness, conventional evaporation apparatuses have a larger interval between a substrate and an evaporation source, so that the apparatuses per se have a larger size. Also, the conventional evaporation apparatuses have a structure, as shown in **FIG. 22**, in which the interval between a substrate and an evaporation source is set to 1 m or more and the substrate is rotated to obtain a film having a uniform thickness. Further, the evaporation apparatuses have such a structure as to rotate the substrate, so that there is a limitation on an evaporation apparatus for attaining a large-area substrate. Also, the interval between a substrate and an evaporation source is large, so that a speed of film formation is reduced and a longer time is necessary to exhaust a film forming chamber, thereby reducing the throughput.

[0012] In addition, in the conventional evaporation apparatuses, the utilization efficiency of an expensive EL material is as extremely low as approximately 1% or low. Thus, the manufacturing costs of a light emitting device are extremely high.

[0013] An EL material is extremely expensive and costs higher per gram than gold costs per gram. Therefore it is desired to use an EL material as efficiently as possible. However, in the conventional evaporation apparatuses, the utilization efficiency of the expensive EL material is low.

SUMMARY OF THE INVENTION

[0014] The present invention has been made in view of the above, and therefore has an object to provide an evaporation apparatus and a manufacturing apparatus, which are capable of improving a utilization efficiency of an EL material, excellent in uniformity, and excellent in throughput.

[0015] Due to evaporation being performed in vacuum, it takes a long time to set an inside of a film forming chamber to vacuum and a time necessary for each step differs in every film forming chamber. Thus, it is difficult to design manufacturing processes as automated steps, thereby putting a limitation on improvement in productivity. In particular, it takes a long time to deposit and laminate layers containing an organic compound by evaporation, so that there is a limitation on reduction in a processing time per substrate. In view of the above, the present invention has another object to reduce a processing time per substrate.

[0016] Further, another object of the present invention is to provide a manufacturing apparatus capable of maintenance of a film forming chamber without temporarily stopping a manufacturing line.

[0017] Further, according to the present invention, there is provided a method of depositing an EL material by evaporation efficiently on a large-area substrate having a size such as 320 mm×400 mm, 370 mm×470 mm, 550 mm×650 mm, 600 mm×720 mm, 680 mm×880 mm, 1000 mm×1200 mm, 1100 mm×1250 mm, or 1150 mm×1300 mm.

[0018] Further, according to the present invention, there is provided a manufacturing system capable of preventing impurities from mixing into an EL material.

[0019] According to the present invention, there is provided a multi-chamber manufacturing apparatus having plural film forming chambers, including a first film forming chamber for subjecting a first substrate to evaporation and a second film forming chamber for subjecting a second substrate to evaporation, characterized in that plural organic compound layers are laminated in respective film forming chambers in parallel, thereby reducing a processing time per substrate. More specifically, after the first substrate is loaded from a transfer chamber into the first film forming chamber, a surface of the first substrate is subjected to evaporation, while after the second substrate is loaded from the transfer chamber into the second film forming chamber, a surface of the second substrate is also subjected to evaporation. In **FIG. 1**, four film forming chambers are connected to a transfer chamber **102**. Therefore, as shown in **FIG. 6A** showing an example of a sequence from loading of substrates to unloading of the substrates, it is possible that four substrates are loaded into the respective film forming chambers and sequentially subjected to evaporation in parallel.

[0020] According to the present invention, in order to maintain uniform cycle times during mass production, plural chambers are provided at least as evaporation chambers and heating chambers, and a single chamber may be provided as another chamber having a relatively short processing time. Accordingly, the present invention allows efficient mass production.

[0021] According to a first structure of the present invention disclosed in this specification, there is provided a manufacturing apparatus, including:

[0022] a load chamber;

[0023] a transfer chamber that is connected to the load chamber; and

[0024] plural film forming chambers that are connected to the transfer chamber, wherein:

[0025] the plural film forming chambers are each connected to a vacuum-exhaust process chamber for setting an inside of the film forming chamber to vacuum, and each include: alignment means for performing position alignment of a mask and a substrate; an evaporation source; and means for heating the evaporation source; and

[0026] in at least two of the plural film forming chambers, surfaces of substrates loaded into the respective film forming chambers are subjected to evaporation in parallel.

[0027] Further, not only the film forming chambers in which an organic compound layer is formed but also the film forming chambers, sealing chambers, and pretreatment chambers in which electrodes (cathodes or anodes) are formed on the organic compound layer may be provided in plural number, respectively, and the respective forming processes may be performed in parallel similarly. Therefore, according to a second structure of the present invention disclosed in this specification, there is provided a manufacturing apparatus, including:

[0028] a load chamber;

[0029] a transfer chamber that is connected to the load chamber;

[0030] plural film forming chambers that are connected to the transfer chamber, and

[0031] plural sealing chambers, wherein:

[0032] the plural film forming chambers are each connected to a vacuum-exhaust process chamber for setting an inside of the film forming chamber to vacuum, and each include: alignment means for performing position alignment of a mask and a substrate; an evaporation source; and means for heating the evaporation source;

[0033] in at least two of the plural film forming chambers, surfaces of substrates loaded into the respective film forming chambers are subjected to evaporation in parallel; and

[0034] each substrate is assigned to one of the plural sealing chambers to be sealed therein.

[0035] Further, according to the present invention, even though the processing number of substrates is slightly reduced, the effective evaporation process can be realized. For example, as shown in **FIG. 6B** showing an example of a sequence from loading of substrates to unloading of the substrates, even when a fourth film forming chamber is undergoing the maintenance, evaporation can be performed in first to third film forming chambers sequentially without temporarily stopping the production line. Therefore, according to a third structure of the present invention disclosed in this specification, there is provided a manufacturing apparatus, including:

[0036] a load chamber;

[0037] a transfer chamber that is connected to the load chamber; and

[0038] plural film forming chambers that are connected to the transfer chamber, wherein:

[0039] the plural film forming chambers are each connected to a vacuum-exhaust process chamber for setting an inside of the film forming chamber to vacuum, and each include: alignment means for performing position alignment of a mask and a substrate; an evaporation source; and means for heating the evaporation source; and

[0040] in at least two of the plural film forming chambers, surfaces of substrates loaded into the respective film forming chambers are subjected to evaporation in parallel, and in at least one of the plural film forming chambers, the inside of the film forming chamber undergoes cleaning.

[0041] Further, in the case of forming a single-color light emitting device, as shown in **FIG. 2A** showing a sequence from loading of substrates to unloading of the substrates, a hole transporting layer (referred to as HTL), a light emitting layer, and an electron transporting layer (referred to as ETL) are continuously laminated in the same film forming chamber, thereby improving the throughput. When the hole transporting layer, the light emitting layer, and the electron transporting layer are continuously laminated in the same film forming chamber, as shown in **FIGS. 9A and 9B**, plural evaporation source holders (evaporation source holders each moving in the direction X or in the direction Y) may be provided in one film forming chamber. By using an evaporation apparatus in **FIGS. 9A and 9B**, a utilization efficiency of an evaporation material can be improved.

[0042] The respective structures described above are characterized in that in at least two of the plural film forming chambers, evaporation processes of layers containing the same organic compound are performed in parallel.

[0043] Further, as shown in **FIG. 6A** showing an example of a sequence from loading of substrates to unloading of the substrates, a transfer path for a substrate is divided into the same number of paths as that of the film forming chambers arranged in connection to each transfer chamber, so that film formation can be efficiently performed in order. Note that an example of the path for one substrate from loading of substrates to unloading of the substrates is shown by the arrows in **FIG. 3**. Therefore, according to a fourth structure of the present invention disclosed in this specification, there is provided a manufacturing apparatus, including:

[0044] a load chamber;

[0045] a transfer chamber that is connected to the load chamber; and

[0046] plural film forming chambers that are connected to the transfer chamber, wherein:

[0047] the plural film forming chambers are each connected to a vacuum-exhaust process chamber for setting an inside of the film forming chamber to vacuum, and each include: alignment means for performing position alignment of a mask and a substrate; an evaporation source; and means for heating the evaporation source; and

[0048] plural substrates loaded into the load chamber are each assigned to one of the plural film forming chambers in the transfer chamber to be loaded thereinto, and each substrate undergoes processes along one of different paths whose number is the same as that of the film forming chambers.

[0049] Further, in the case of forming a full-color light emitting device, as shown in **FIG. 2B, a** hole transporting layer, a light emitting layer, and an electron transporting layer may preferably be continuously laminated in the same film forming chamber. When the hole transporting layer, the light emitting layer, and the electron transporting layer are continuously laminated in the same film forming chamber, there may be used such a film forming apparatus as shown in **FIGS. 9A and 9B**, that is, an evaporation apparatus provided with plural, at least three or more, evaporation source holders (evaporation source holders each moving in the direction X or in the direction Y) in one film forming chamber. Note that as shown in **FIG. 4** showing a sequence from loading of substrates to unloading of the substrates, all the necessary organic layers, for example, the hole transporting layer, the light emitting layer, and the electron transporting layer may continuously be laminated in different three film forming chambers (a film forming chamber for a red light emitting element, a film forming chamber for a blue light emitting element, and a film forming chamber for a green light emitting element). For example, the hole transporting layer, the light emitting layer, and the electron transporting layer which are to compose a red light emitting element are selectively laminated by using an evaporation mask (R) in a first chamber; the hole transporting layer, the light emitting layer, and the electron transporting layer which are to compose a blue light emitting element are selectively laminated by using an evaporation mask (B) in a second chamber; and the hole transporting layer, the light emitting layer, and the electron transporting layer which are to compose a green light emitting element are selectively laminated by using an evaporation mask (G) in a third chamber, thereby realizing full-color display. Note that in **FIG. 4**, mask alignment is performed before evaporation in each chamber to perform film formation in a predetermined region.

[0050] Further, in the case where the hole transporting layer, the light emitting layer, and the electron transporting layer are laminated in one chamber, in order to realize the full-color display, for example, materials (organic materials to become the hole transporting layer and the electron transporting layer) optimum for a given color (R, G, or B) can be selected appropriately. The feature of the present invention also resides in that the film thicknesses of those layers can be changed in accordance with colors. Therefore, different materials can be used for all the nine types of layers in total: the hole transporting layer, the light emitting layer, and the electron transporting layer for R; the hole transporting layer, the light emitting layer, and the electron transporting layer for G; and the hole transporting layer, the light emitting layer, and the electron transporting layer for B. Note that organic materials to become the hole transporting layer or the electron transporting layer may be used as the common materials.

[0051] Further, in the case where the hole transporting layers, the light emitting layers, and the electron transporting layers for R, G, and B are laminated in the different three film forming chambers, an example of the path for one

substrate is shown simply by the arrows in **FIG. 5**. For example, after a first substrate is loaded into a first film forming chamber, a layer containing an organic compound for red light emission is formed into a laminate film, and then the first substrate is unloaded. Subsequently, after the first substrate is loaded into a second film forming chamber, a layer containing an organic compound for green light emission is formed into a laminate film, while after a second substrate is loaded into the first film forming chamber, a layer containing an organic compound for red light emission may be laminated to the second substrate to form a film. Lastly, after the first substrate is loaded into a third film forming chamber, a layer containing an organic compound for blue light emission is formed into a laminate film, while after the second substrate is loaded into the second film forming chamber, a third substrate is loaded into the first film forming chamber, and layers may sequentially be laminated to the respective substrates.

[**0052**] Further, the present invention is not limited to the structure in which the hole transporting layer, the light emitting layer, and the electron transporting layer are continuously laminated in the same chamber. However, the hole transporting layer, the light emitting layer, and the electron transporting layer may be laminated in plural chambers connected to each other. For example, the hole transporting layer to compose a green light emitting element is formed into a film in the first chamber, the light emitting layer to compose the green light emitting element is formed into a film in the second chamber, and the electron transporting layer to compose the green light emitting element is formed into a film in the third chamber. Accordingly, the layers containing an organic compound for green light emission may be formed into laminate films.

[**0053**] Further, in the above description, as the typical example of layers containing an organic compound arranged in a position between a cathode and an anode, the laminate structure of the three layers consisting of the hole transporting layer, the light emitting layer, and the electron transporting layer. However, there is no particular limitation thereon. Another laminate structure may be used in which: a hole injecting layer, a hole transporting layer, a light emitting layer, and an electron transporting layer are laminated onto an anode in the stated order; or a hole injecting layer, a hole transporting layer, a light emitting layer, an electron transporting layer, and an electron injecting layer are laminated onto an anode in the stated order. Alternatively, a double layer structure or a single layer structure may be used. Fluorescent pigments and the like may also be doped into the light emitting layers. Also, examples of the light emitting layers include a light emitting layer having hole transportability and a light emitting layer having electron transportability. Further, all of the above layers may be formed using only low-molecular weight materials, or one or several layers of the above layers may be formed using high-molecular weight materials. Note that in this specification, the layers provided between the cathode and the anode are generically referred to as a layer (EL layer) containing an organic compound. Therefore, the hole injecting layer, the hole transporting layer, the light emitting layer, the electron transporting layer, and the electron injecting layer which are described above are all included in the EL layers. In addition, the layer (EL layer) containing an organic compound may also contain an inorganic material such as silicon.

[**0054**] Note that a light emitting element (EL element) has a layer (hereinafter referred to as EL layer) containing an organic compound in which luminescence developed by applying an electric field (electroluminescence) is obtained, an anode, and a cathode. The types of the organic compound luminescence includes light emission when returning from a singlet excitation state to a ground state (fluorescence) and light emission when returning from a triplet excitation state to a ground state (phosphorescence). Both types of light emission can be applied to a light emitting device produced according to the present invention.

[**0055**] Further, in the light emitting device according to the present invention, there is no particular limitation on a drive method for screen display. For example, a dot-sequential drive method, a line-sequential drive method, a plane-sequential drive method, and the like are used. Typically, the line-sequential drive method is used, and a time-division gray scale drive method and an area gray scale drive method may also be used appropriately. Also, a picture signal inputted to a source line of the light emitting device may be an analog signal or may be a digital signal, so that drive circuits and the like may be designed appropriately in accordance with picture signals.

BRIEF DESCRIPTION OF THE DRAWINGS

[**0056**] In the accompanying drawings:

[**0057**] **FIG. 1** shows an example of a manufacturing apparatus according to Embodiment 1 of the present invention;

[**0058**] **FIGS. 2A and 2B** each show an example of a sequence for the manufacturing apparatus according to Embodiment 1;

[**0059**] **FIG. 3** shows an example of a transfer path for a substrate according to Embodiment 1;

[**0060**] **FIG. 4** shows another example of the sequence for the manufacturing apparatus according to Embodiment 1;

[**0061**] **FIG. 5** shows an example of the transfer path for a substrate according to Embodiment 1;

[**0062**] **FIGS. 6A and 6B** each show another example of the sequence for the manufacturing apparatus according to Embodiment 1;

[**0063**] **FIG. 7** shows an example of a transfer path for two substrates according to Embodiment 1;

[**0064**] **FIGS. 8A** to **8**C show an evaporation apparatus according to Embodiment 2 of the present invention;

[**0065**] **FIGS. 9A and 9B** show the evaporation apparatus according to Embodiment 2 of the present invention;

[**0066**] **FIGS. 10A and 10B** show examples of a container according to Embodiment 3 of the present invention;

[**0067**] **FIGS. 11A and 11B** show other examples of the container according to Embodiment 3 of the present invention;

[**0068**] **FIGS. 12A and 12B** show examples of an evaporation source holder according to Embodiment 3 of the present invention;

[**0069**] **FIG. 13** shows a manufacturing system according to Embodiment 4 of the present invention;

[0070] **FIG. 14** shows a transfer container according to Embodiment 4 of the present invention;

[0071] **FIGS. 15A and 15B** show an evaporation apparatus according to Embodiment 4 of the present invention;

[0072] **FIGS. 16A and 16B** show the evaporation apparatus according to Embodiment 4 of the present invention;

[0073] **FIGS. 17A and 17B** show a light emitting device according to Example 1 of the present invention;

[0074] **FIGS. 18A and 18B** show the light emitting device according to Example 1 of the present invention;

[0075] **FIGS. 19A** to **19**C show the light emitting device according to Example 1 of the present invention;

[0076] **FIGS. 20A** to **20**H each show an example of electronic equipment using the present invention;

[0077] **FIG. 21** shows another example of the manufacturing apparatus according to Embodiment 1 of the present invention; and

[0078] **FIG. 22** shows a conventional evaporation apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EXAMPLES

[0079] Hereinafter, embodiments of the present invention will be described.

[0080] [Embodiment 1]

[0081] **FIG. 1** shows an example of a manufacturing apparatus of a multi-chamber system in which all production processes are automated from a process of forming a first electrode to a sealing process.

[0082] The multi-chamber manufacturing apparatus shown in **FIG. 1** includes: gates **100***a* to **100***s*; a take-out chamber **119**; transfer chambers **104***a*, **102**, **114**, and **118**; handing-over chambers **105** and **107**; a preparation chamber **101**; a first film forming chamber **106**A; a second film forming chamber **106**B; a third film forming chamber **106**C; a fourth film forming chamber **106**D; other film forming chambers **109***a*, **109***b*, **113***a*, and **113***b*; process chambers **120***a* and **120***b*; setting chambers **126**A, **126**B, **126**C, and **126**D for installing an evaporation source; pre-treatment chambers **103***a* and **103***b*; a first sealing chamber **116***a*; a second sealing chamber **116***b*; a first stock chamber **130***a*; a second stock chamber **130***b*; cassette chambers **120***a* and **120***b*; a tray putting stage **121**; and a washing chamber **122**.

[0083] Hereinafter, a description will be made of a procedure for producing a light emitting device after a substrate to which a thin-film transistor, an anode (first electrode), and an insulator covering an end portion of the anode are formed in advance is loaded into the manufacturing apparatus shown in **FIG. 1**.

[0084] First, the above-mentioned substrate is set in the cassette chamber **120***a* or **120***b*. If the substrate has a large size (for example, 300 mm×360 mm), the substrate is set in the cassette chamber **120***a* or **120***b*. If the substrate has a normal size (for example, 127 mm×127 mm), the substrate is transferred to the tray putting stage **121** and plural substrates are set in a tray (having a size of, for example, 300 mm×360 mm).

[0085] Next, the plural substrates each formed with the thin-film transistor, the anode, and the insulator covering an end portion of the anode are transferred to the transfer chamber **118**, and then further transferred to the washing chamber **122** to remove impurities (such as fine particles) from the substrate surfaces by using a solution. If the substrates are washed in the washing chamber **122**, the substrates are set with the surfaces to be formed with a film facing downward at the atmospheric pressure.

[0086] Also, before forming a film containing an organic compound, in order to remove moisture and gas from within the substrates, it is preferable to perform annealing for degasification in vacuum. Therefore, the substrates may be transferred to the pretreatment chambers **103***a* and **103***b* each connected to the transfer chamber **118**, to be subjected to annealing therein. Also, if a film containing an organic compound formed to an unnecessary portion is to be removed, the substrates are transferred to the pretreatment chambers **103***a* and **103***b* to selectively remove a laminate of organic compound film layers. The pretreatment chambers **103***a* and **103***b* each have plasma generating means, and generate plasma by exciting one or plural kinds of gas selected from the group consisting of Ar, H, F, and O, to thereby perform dry etching. Here, it is shown as an example that the two pretreatment chambers **103***a* and **103***b* are provided to allow treatment on the two substrates substantially in parallel with each other.

[0087] Next, the substrates are transferred from the transfer chamber **118** provided with a substrate transferring mechanism to the preparation chamber **101**. In the manufacturing apparatus of this embodiment, the preparation chamber **101** has a substrate inverting mechanism and can invert the substrates appropriately. The preparation chamber **101** is connected to a vacuum-exhaust process chamber and preferably set to the atmospheric pressure by introducing inert gas into the chamber after the chamber is vacuum-exhausted.

[0088] Next, the substrates are transferred to the transfer chamber **102** connected to the preparation chamber **101**. It is preferable that the transfer chamber **102** be vacuum-exhausted in advance and maintain vacuum so as to contain as little moisture and oxygen as possible.

[0089] The above-mentioned vacuum-exhaust process chamber is provided with a magnetic levitation turbomolecular pump, a cryopump, or a dry pump. The pump makes it possible for the transfer chamber connected to the preparation chamber to reach a vacuum level of 10^{-5} to 10^{-6} Pa. In addition, reverse diffusion of impurities from the pump side and the exhaust system can be controlled. In order not to let impurities enter the interior of the device, inert gas such as nitrogen or rare gas is introduced. Used as the gas introduced into the device is one that is refined to have a high purity by a gas refining machine prior to introduction to the device interior. Thus, it is necessary to provide a gas refining machine such that the gas is refined to have a high purity and, after that, introduced into an evaporation apparatus. Accordingly, oxygen, water, and other impurities are removed from within the gas in advance, thereby making it possible to prevent those impurities from entering the device interior.

[0090] Next, the substrates are transferred from the transfer chamber **102** to the first forming chamber **106**A, the

second film forming chamber **106**B, the third film forming chamber **106**C, and the fourth film forming chamber **106**D. Then, low-molecular weight organic compound layers are formed which serve as hole injecting layers, hole transporting layers, and light emitting layers.

[**0091**] As overall light emitting elements, organic compound layers exhibiting single-color (specifically white) light emission or full-color (specifically red, green, and blue) light emission can be formed. Here, an example will be described in which the organic compound layers exhibiting white light emission are formed in the respective film forming chambers **106**A, **106**B, **106**C, and **106**D at the same time (each film forming process is performed approximately in parallel).

[**0092**] Note that in the case where the organic compound layers exhibiting white light emission are a laminate of light emitting layers having different light emission colors, the organic compound layers are broadly divided into two types: a three wavelength type that includes the primary colors of red, green, and blue and a two wavelength type that utilizes the relationship between complementary colors of blue and yellow or blue-green and orange. Here, an example will be described in which a white light emitting element is obtained using the three wavelength type.

[**0093**] First, the respective film forming chambers **106**A, **106**B, **106**C, and **106**D will be described. The film forming chambers **106**A, **106**B, **106**C, and **106**D each have movable evaporation source holders, which are prepared in plural numbers. In each of the film forming chambers, five evaporation source holders are set in the following states: a first evaporation source holder has aromatic diamine (referred to as TPD) for forming a white light emitting layer sealed therein; a second evaporation source holder has p-EtTAZ for forming a white light emitting layer sealed therein; a third evaporation source holder has Alq_3 for forming a white light emitting layer sealed therein; a fourth evaporation source holder has an EL material sealed therein which is obtained by doping Alq_3 for forming a white light emitting layer with Nile Red that is a red light emitting pigment; and a fifth evaporation source holder has Alq_3 sealed therein.

[**0094**] It is preferable that EL materials be set in the above film forming chambers by using the following manufacturing system. That is, it is preferable that a container (typically a melting pot) in which an EL material is stored in advance by a material manufacturer be used to form a film. In addition, it is preferable that the container be set without being exposed to the atmosphere. Thus, it is preferable that the melting pot be sealed in a second container when being shipped from the material manufacturer, and then be loaded into a film forming chamber while maintaining the sealed state. It is desirable that the setting chambers **126**A, **126**B, **126**C, and **126**D each having vacuum-exhaust means and connected to the film forming chambers **106**A, **106**B, **106**C, and **106**D, respectively, be set to vacuum or an inert gas atmosphere, and melting pots be taken out of second containers in the setting chambers and then be set in the film forming chambers. As a result, a melting pot and an EL material stored in the melting pot can be protected from contamination. Note that metal masks may be stocked in the setting chambers **126**A, **126**B, **126**C, and **126**D.

[**0095**] Next, film forming steps will be described. In the film forming chamber **106**A, a mask is transferred from the setting chamber described above and set as the need arises. Then, the first to fifth evaporation source holders start to move sequentially to perform evaporation to the substrate. More specifically, TPD from the first evaporation source holder is sublimated by heating and is deposited by evaporation on the entire surface of the substrate. After that, p-EtTAZ from the second evaporation source holder is sublimated, Alq_3 from the third evaporation source holder is sublimated, Alq_3:Nile Red from the fourth evaporation source holder is sublimated, and Alq_3 from the fifth evaporation source holder is sublimated, which are all deposited by evaporation on the entire surface of the substrate.

[**0096**] In the case of using an evaporation method, it is preferable to perform evaporation in the film forming chamber that is vacuum-exhausted to reach a vacuum level of 5×10^{-3} Torr (0.665 Pa) or lower, preferably, 10^{-4} to 10^{-6} Pa.

[**0097**] Note that the above-mentioned evaporation source holders with the EL materials set therein are provided in the respective film forming chambers, and also in the respective film forming chambers **106**B to **106**D, evaporation is performed in the same manner. In other words, the same film forming process can be performed to four substrates approximately in parallel. **FIG. 7** shows a simple example of the path along which two of the four substrates are processed. As a result, even if a given film forming chamber is undergoing maintenance or cleaning, the film forming process is possible in the rest of the film forming chambers, thereby reducing the cycle time for the film formation. Accordingly, the throughput of the light emitting device can be improved.

[**0098**] Next, the substrate is transferred from the transfer chamber **102** to the handing-over chamber **105**, and further transferred from the handing-over chamber **105** to the transfer chamber **104***a* without being exposed to the atmosphere.

[**0099**] Next, a transfer mechanism set in the transfer chamber **104***a* is used to transfer the substrate to the film forming chamber **109***a* or the film forming chamber **109***b*, and then a cathode is formed to the substrate. The cathode may be formed by laminating two cathodes (lower layer and upper layer). The cathode (lower layer) is formed of an extremely thin metal film (MgAg, MgIn, AlLi, CaN, or like other alloy film, or a film formed by co-evaporation of aluminum and an element that belongs to Group 1 or 2 in the periodic table) formed by evaporation using resistance heating. The cathode (upper layer) is formed of a transparent conductive film (an indium tin oxide alloy (ITO) film, an indium oxide-zinc oxide alloy (In_2O_3—ZnO) film a zinc oxide (ZnO) film, or the like) formed by sputtering. Therefore, it is preferable that a film forming chamber for forming a thin metal film be arranged in the manufacturing apparatus.

[**0100**] Through the above steps, a light emitting element having a laminate structure as shown in **FIGS. 17A and 17B** is formed.

[**0101**] Next, without being exposed to the atmosphere, the substrate is transferred from the transfer chamber **104***a* to the film forming chamber **113***a* or **113***b*, and then a protective film consisting of a silicon nitride film or a silicon nitroxide film is formed to the substrate. Here, the film forming chambers **113***a* and **113***b* each include a silicon target, a silicon oxide target, or a silicon nitride target. For example, a silicon nitride film can be formed by using the

silicon target and setting the atmosphere in the film forming chamber to a nitrogen atmosphere or an atmosphere containing nitrogen and argon. **FIG. 1** shows an example system provided with the two film forming chambers **113***a* and **113***b* such that a protective film can be formed to two substrates approximately in parallel.

[**0102**] Next, without being exposed to the atmosphere, the substrate formed with a light emitting device is transferred from the transfer chamber **104***a* to the handing-over chamber **107**, and further transferred from the handing-over chamber **107** to the transfer chamber **114**. Then, the substrate formed with a light emitting device is transferred from the transfer chamber **114** to the first sealing chamber **116***a* or the second sealing chamber **116***b*. Note that in the first sealing chamber **116***a* and the second sealing chamber **116***b*, *a* sealing member for bonding substrates to each other later or for sealing a substrate is formed. **FIG. 1** shows an example system provided with the two sealing chambers **116***a* and **116***b* such that a bonding process can be performed to two substrates approximately in parallel.

[**0103**] A sealing substrate is set in the first stock chamber **130***a* or the second stock chamber **130***b* from the outside for preparation. Note that in order to remove moisture and other impurities, it is preferable that the sealing substrate be subjected to annealing in vacuum in advance, for example, within the first stock chamber **130***a* or the second stock chamber **130***b*. If the sealing member for bonding the sealing substrate and the substrate on which the light emitting element is formed is formed on the sealing substrate, the sealing member is formed in the first stock chamber **130***a* or the second stock chamber **130***b*, and the sealing substrate on which the sealing member is formed is then transferred to the first sealing chamber **116***a* or the second sealing chamber **116***b*. Note that the sealing substrate may be provided with a desiccant in the first sealing chamber **116***a* or the second sealing chamber **116***b*. Also, the first sealing chamber **130***a* and the second sealing chamber **130***b* may be stocked with an evaporation mask to be used at the time of evaporation.

[**0104**] Next, in order to perform degasification to the substrate provided with the light emitting device, after performing annealing in vacuum or in an inert gas atmosphere, the sealing substrate provided with the sealing member and the substrate formed with the light emitting device are bonded to each other. Also, an enclosed space is filled with nitrogen or inert gas. Note that here, the example of forming the sealing member on the sealing substrate is shown. However, there is no particular limitation and the sealing member may be formed on the substrate formed with the light emitting element.

[**0105**] Next, the pair of bonded substrates are irradiated with UV light by a UV ray irradiation mechanism provided in the sealing chamber **116***a*, **116***b* to thereby cure the sealing member. Note that a UV-curable and thermoset resin is used here as the sealing member. However, there is no particular limitation as long as an adhesive is used as the sealing member, and such a resin as one curable by only a UV ray may be used.

[**0106**] Further, instead of filling the enclosed space with inert gas, a resin may be filled therein. In the case of a downward emission type, no light transmits through the cathode, so that the material for the resin to be filled are not particularly limited and the UV-curable resin or an opaque resin may be used. However, in the case of an upward emission type, a UV ray transmits through the cathode to cause damage to the EL layer, so that the UV-curable resin cannot be used. Thus, in the case of an upward emission type, it is preferable to use a transparent thermoset resin as the resin to be filled.

[**0107**] Next, the pair of bonded substrates are transferred from the sealing chamber **116***a*, **116***b* to the transfer chamber **114**, and then transferred from the transfer chamber **114** to the take-out chamber **119** to be taken out thereof.

[**0108**] Further, after being taken out of the take-out chamber **119**, the sealing member is cured by heat treatment. In the case of using the upward emission type and filling the enclosed space with the thermoset resin, the thermoset resin can be cured simultaneously with the heat treatment for curing the sealing member.

[**0109**] As described above, the use of the manufacturing apparatus shown in **FIG. 1** prevents a light emitting element from being exposed to the atmosphere before the light emitting element is completely sealed in an enclosed space. As a result, a light emitting device having high reliability can be produced. Note that the transfer chamber **114** alternates between vacuum and a nitrogen atmosphere at the atmospheric pressure. However, it is desirable that the transfer chambers **102**, **104***a*, and **108** maintain vacuum all the time.

[**0110**] Note that, although not shown in the figures, a control drive unit is provided which controls the path along which substrates are moved to individual process chambers, to thereby realize a fully automatic system.

[**0111**] Also, it is possible to load a substrate formed with a transparent conductive film as the anode into the manufacturing apparatus shown in **FIG. 1**, and form a light emitting element (having a structure in which light emission caused in a layer containing an organic compound is taken out from the transparent anode toward a TFT; hereinafter referred to as downward emission structure) that emits light in the direction opposite to that of the laminate structure described above.

[**0112**] In the case where both the anode and the cathode are composed of a transparent or translucent material, it is also possible to form a structure in which light emission caused in the layer containing the organic compound is taken out toward both the upper surface and the lower surface (hereinafter referred to as double-sided emission structure).

[**0113**] Further, **FIG. 21** shows an example of a manufacturing apparatus provided with two take-out chambers because plural take-out chambers become necessary in the case where elements are produced by simultaneously processing two substrates in different sizes in parallel. A mask stock chamber and a coating chamber are also provided in **FIG. 21**. Note that in **FIG. 21**, the same reference numerals as those in **FIG. 1** are used.

[**0114**] In **FIG. 21**, reference numeral **100***t* denotes a gate, **1003** the coating chamber, **1013** the mask stock chamber, and reference numerals **1019***a* and **1019***b* denote the take-out chambers.

[**0115**] Note that the mask stock chamber **1013** is stocked with evaporation masks to be used at the time of evaporation. The evaporation masks are appropriately transferred to

each film forming chamber when performing evaporation, and then set therein. In particular, it is difficult to stock the mask having a large area in the setting chamber, so that it is preferable to separately provide the mask stock chamber as shown in **FIG. 21**. Also, the mask stock chamber **1013** may be stocked with not only the evaporation masks but also, for example, substrates.

[**0116**] Further, in the coating chamber **1003**, a layer containing a high-molecular weight material may be formed by an ink jet method or a spin coating method. For example, an aqueous solution of poly(ethylene dioxythiophene)/poly-(styrene sulfonic acid) (PEDOT/PSS) acting as a hole injecting layer (an anode buffer layer), an aqueous solution of polyaniline/camphor sulfonic acid (PANI/CSA), PTPDES, Et-PTPDEK, PPBA or the like may be coated over the entire surface of the first electrode (anode) and then subjected to baking.

[**0117**] Further, the PEDOT/PSS film formed by the spin coating method covers the entire surface. Accordingly, it is preferable to selectively remove portions of the film that cover end surfaces and perimeter of the substrate, a terminal portion, a region where a cathode and a lower wiring are connected to each other, and the like. For example, it is preferable that the removal is performed by O_2 ashing or the like using a mask in the pretreatment chamber **103***a*.

[**0118**] [Embodiment 2]

[**0119**] **FIGS. 8A** to **8**C show a film forming system featured in moving a substrate and an evaporation source relative to each other. **FIG. 8A** is a sectional view in X direction (a section taken along a dotted line A-A'), **FIG. 8B** is a sectional view in Y direction (a section taken along a dotted line B-B') and **FIG. 8C** is a top view. Further, **FIGS. 8A, 8B** and **8**C show the evaporation system in the midst of evaporation.

[**0120**] The film forming system shown in **FIGS. 8A** to **8**C is characterized in that in an evaporation system, an evaporation source holder installed with a container filled with an evaporation material is moved by a certain pitch relative to a substrate or the substrate is moved by a certain pitch relative to the evaporation source. Further, it is preferable to move the evaporation source holder by a certain pitch to overlap ends (skirts) of a sublimated evaporation material.

[**0121**] Although a single or a plurality of the evaporation source holders may be constituted, when the evaporation source holders are provided for respective laminated films of EL layers, evaporation can be carried out efficiently and continuously. Further, a single or a plurality of containers may be installed at the evaporation source holder and a plurality of containers filled with the same evaporation material may be installed. Further, when containers having different evaporation materials are arranged, a film can be formed at a substrate in a state of mixing the sublimated evaporation materials (this is referred to as common evaporation).

[**0122**] In **FIGS. 8A** to **8**C, a film forming chamber **11** includes a substrate holder **12**, an evaporation source holder **17** installed with an evaporation shutter **15**, means for moving the evaporation source holder (not illustrated) and means for producing a low pressure atmosphere. Further, the film forming chamber **11** is installed with a substrate **13** and an evaporation mask **14**. Further, alignment of the evaporation mask may be confirmed by using a CCD camera (not illustrated). The evaporation source holder **17** is installed with a container filled with an evaporation material **18**. The film forming chamber **11** is vacuumed to a vacuum degree of 5×10^{-3} Torr (0.665 Pa) or lower, preferably, 10^{-4} through 10^{-6} Pa by the means for producing the low pressure atmosphere.

[**0123**] Further, in evaporation, the evaporation material is previously sublimated (vaporized) by resistance heating and scattered in a direction of the substrate **13** by opening the shutter **15** in evaporation. An evaporated evaporation material **19** is scattered in an upward direction and is selectively vapor-deposited on the substrate **13** by passing an opening portion provided at the evaporation mask **14**. Further, preferably, a speed of film formation, a moving speed of the evaporation holder and opening and closing of the shutter are controlled by a control unit such as a personal computer. The evaporation rate of the evaporation source holder can be controlled by the moving speed.

[**0124**] Further, although not illustrated, evaporation can be carried out while measuring a film thickness of a deposited film by a quartz oscillator provided at the film forming chamber **11**. When the film thickness of the deposited film is measured by using the quartz oscillator, a change in mass of a film deposited to the quartz oscillator can be measured as a change in the resonance frequency.

[**0125**] In the evaporation system shown in **FIGS. 8A** to **8**C, in evaporation, a distance d of an interval between the substrate **13** and the evaporation source holder **17** can be reduced to, representatively, 30 cm or smaller, preferably, 20 cm or smaller, further preferably, 5 cm through 15 cm to thereby significantly promote an efficiency of utilizing the evaporation material and throughput.

[**0126**] In the evaporation system, the evaporation source holder **17** is constituted by a container (representatively, crucible), a heater arranged on an outer side of the container via a uniformly heating member, an insulating layer provided on an outer side of the heater, an outer cylinder containing these, a cooling pipe wound around an outer side of the outer cylinder and the evaporation shutter **15** for opening and closing an opening portion of the outer cylinder including an opening portion of a crucible. Further, the evaporation source holder **17** may be a container capable of being carried in a state of fixing the heater to the container. Further, the container is formed by a material of a sintered body of BN, a composite sintered body of BN and AlN, quartz or a graphite capable of withstanding high temperature, high pressure and low pressure.

[**0127**] Further, the evaporation source holder **17** is provided with a mechanism movable in X direction or Y direction at inside of the film forming chamber **11** while maintaining a horizontal state. In this case, the evaporation source holder **17** is made to move in zigzag on a two-dimensional plane as shown by **FIG. 9A** or **FIG. 9B**. Further, a pitch of moving the evaporation source holder **17** may pertinently be matched to an interval between insulators. Further, insulators **10** are arranged in a stripe shape to cover end portions of first electrodes **21**.

[**0128**] Further, in **FIGS. 9A and 9B**, timings of starting to move the evaporation source holders A, B, C and D may be after stopping or before stopping preceding ones of the

evaporation source holders. For example, with setting an organic material capable of hole transporting at the evaporation holder A, an organic material serving as an light emitting layer at the evaporation holder B, an organic material capable of electron transporting at the evaporation holder C and a material serving as a cathode buffer at the evaporation holder D, it is possible to continuously laminate these material layers in a same chamber. Further, when a succeeding one of the evaporation source holder starts moving before solidifying a vapor-deposited film, in an EL layer having a laminated layers structure, a region mixed with evaporation materials (mixed region) may be formed at an interface of respective films.

[0129] According to the invention of moving the substrate and the evaporation source holders A, B, C and D relative to each other in this way, small-sized formation of the device can be achieved without needing to prolong a distance between the substrate and the evaporation source holder. Further, since the evaporation system is small-sized, adherence of the sublimated evaporation material to the inner wall or the adherence preventive shield at inside of the film forming chamber is reduced and the evaporation material can be utilized without waste. Further, according to the evaporation method of the invention, it is not necessary to rotate the substrate and therefore, the evaporation system capable of dealing with a large area substrate can be provided. Further, according to the invention of moving the evaporation source holder in the X axis direction and the Y axis direction relative to the substrate, the vapor-deposited film can uniformly be formed.

[0130] Further, it is not necessarily needed that an organic compound provided at the evaporation source holder is one or one kind thereof but may be a plurality of kinds thereof. For example, other than one kind of a material provided as a luminescent organic compound at the evaporation source holder, other organic compound which can be a dopant (dopant material) may be provided along therewith. It is preferable to design an organic compound layer to be vapor-deposited to constitute by a host material and a luminescent material (dopant material) having excitation energy lower than that of the host material such that the excitation energy of the dopant becomes lower than excitation energy of a hole transporting region and excitation energy of an electron transporting layer. Thereby, diffusion of a molecular exciter of the dopant can be prevented and the dopant can effectively be made to emit light. Further, when the dopant is a material of a carrier trap type, an efficiency of recombining carriers can also be promoted. Further, the invention includes a case in which a material capable of converting triplet excitation energy to luminescence is added to a mixing region as a dopant. Further, in forming the mixing region, a concentration gradient may be provided to the mixing region.

[0131] Further, when a plurality of organic compounds are provided at a single evaporation source holder, it is preferable for evaporating directions to be skew to intersect at a position of an object to be deposited such that the organic compounds are mixed together. Further, in order to carry out common evaporation, the evaporation source holder may be provided with four kinds of evaporation materials (for example, two kinds of host materials as evaporation material A, two kinds of dopant materials as evaporation material b). Further, when a pixel size is small (or, an interval between respective insulators is narrow), a film can finely be formed by dividing inside of a container in four and carrying out common evaporation for subjecting respective pertinently to evaporation.

[0132] Further, since the interval distance d between the substrate **13** and the evaporation source holder **17** is narrowed to, representatively, 30 cm or smaller, preferably, 5 cm through 15 cm, there is a concern of heating also the evaporation mask **14**. Therefore, it is preferable for the evaporation mask **14** to use a metal material having a low thermal expansion rate which is difficult to deform by heat (for example, a high melting point metal such as tungsten, tantalum, chromium, nickel or molybdenum or an alloy including these elements, a material such as stainless steel, inconel, Hastelloy). For example, a low thermal expansion alloy having 42% of nickel and 58% of iron or the like is pointed out. Further, in order to cool the evaporation mask to be heated, the evaporation mask may be provided with a mechanism of circulating a cooling medium (cooling water, cooling gas).

[0133] Further, in order to clean a deposited substance adhered to the mask, it is preferable to generate a plasma at inside of the film forming chamber by plasma generating means to vaporize the deposited substance adhered to the mask to vent the vapor to outside of the film forming chamber. For that purpose, a mask is separately provided with an electrode and a high frequency power source **20** is connected to either one of them.

[0134] Further, the film forming chamber includes gas introducing means for introducing one kind or a plurality of kinds of gases selected from the group consisting of Ar, H, F, NF_3, and O and venting means for venting the deposited substance vaporized. By the above-described constitution, inside of the film forming chamber can be cleaned without being in contact with the atmosphere in maintenance.

[0135] Cleaning can be performed as follows, the atmosphere in a chamber is substituted by nitrogen, and is vacuum exhausted, and a high frequency power supply (13.56 MHz) can be connected with either the mask or the electrode so that a plasma is generated the mask and the electrode (a substrate shutter, not illustrated). Then, argon and hydrogen are introduced to the chamber in respective flow rate of 30 sccm, and the atmosphere in the chamber are stabilized, an RF electric power of 800W is applied to generate a plasma, thereby the mask and inner wall of the chamber can be cleaned.

[0136] Further, the film forming chamber **11** is connected with a vacuuming chamber for vacuuming inside of the film forming chamber. The vacuum processing chamber is provided with a turbo-molecular pump of a magnetic levitation type, a cryopump or a dry pump. Thereby, the ultimate vacuum degree of the film forming chamber **11** can be made to be 10^{-5} through 10^{-6} Pa and inverse diffusion of an impurity from a pump side and an venting system can be controlled. In order to prevent an impurity from being introduced into the film forming chamber **11**, as a gas to be introduced, an inert gas of nitrogen or rare gas is used. There are used the gases to be introduced which are highly purified by a gas refiner before being introduced into the device. Therefore, it is necessary to provide the gas refiner such that the gas is highly purified and thereafter introduced into the film forming chamber **11**. Thereby, an impurity of oxygen,

water or the like included in the gas can previously be removed and therefore, the impurities can be prevented from being introduced into the film forming chamber **11**.

[**0137**] Further, the substrate holder **12** is provided with a permanent magnet for fixing the evaporation mask comprising a metal with the magnetic force and also fixing the substrate **13** interposed therebetween. Although an example of bringing the evaporation mask into close contact with the substrate **13** is shown here, a substrate holder or an evaporation mask holder fixed with an interval to some degree therebetween may pertinently be provided.

[**0138**] According to the film forming chamber having the mechanism of moving the evaporation source holder as described above, it is not necessary to prolong the distance between the substrate and the evaporation source holder and the evaporation film can uniformly be formed.

[**0139**] [Embodiment 3]

[**0140**] Here, a detailed description will be given of constitutions of a container for filling an evaporation material and an evaporation source holder at a surrounding thereof in reference to **FIGS. 10A and 10B** as follows. Further, **FIGS. 10A and 10B** show a state of an open shutter.

[**0141**] **FIG. 10A** shows a sectional view of a surrounding of one container installed at an evaporation source holder **304** illustrated with heating means **303** provided at the evaporation source holder, a power source **307** of the heating means, an evaporation material **302** of the container, a filter **305** provided at inside of the container and a shutter **306** arranged above an opening portion provided at an upper portion of the container. As the heating means **303**, resistance heating, high frequency or laser may be used, specifically, an electric coil may be used.

[**0142**] Further, the evaporation material **302** heated by the heating means **303** is sublimated and the sublimated material **302** rises upwardly from the opening portion of the container. At this occasion, the sublimated material having a size equal to or larger than a certain constant amount (mesh of filter) cannot pass the filter **305** provided at inside of the container, returns into the container and is sublimated again. Further, the filter **305** may be formed by a highly conductive material and heated by heating means (not illustrated). By the heating, the evaporation material can be prevented from being solidified and adhered to the filter.

[**0143**] By the container having the constitution provided with such a filter, the evaporation material having an even size is vapor-deposited and therefore, a speed of film formation can be controlled and a uniform film thickness can be provided and uniform evaporation without nonuniformity can be carried out. Naturally, when uniform evaporation without nonuniformity can be carried out, it is not necessarily needed to provide a filter. Further, a shape of the container is not limited to that in **FIG. 10A**.

[**0144**] Next, an explanation will be given of a container filled with an evaporation material having a constitution different from that of **FIG. 10A** in reference to **FIG. 10B**.

[**0145**] **FIG. 10B** is illustrated with a container **311** installed at an evaporation holder, an evaporation material **312** at inside of the container, first heating means **313** provided at the evaporation source holder, a power source **318** of the first heating means, a shutter **317** arranged above an opening portion of the container, a plate **316** provided above the opening portion, second heating means **314** provided to surround the filter and a power source **319** of second heating means.

[**0146**] Further, the evaporation material **312** heated by the first heating means **313** is sublimated and the sublimated evaporation material rises upwardly from the opening portion of the container **311**. At this occasion, the sublimated material having a size equal to or larger than a certain constant amount cannot pass an interval between the plate **316** provided above the opening portion of the container and the second heating means **314**, impinges on the plate **316** and returns to inside of the container. Further, since the plate **316** is heated by the second heating means **314**, the evaporation material can be prevented from solidifying and adhering to the plate **316**. Further, it is preferable to form the plate **316** by a highly conductive material. Further, a filter may be provided in place of the plate.

[**0147**] Further, as heating temperature (T_1) by the first heating means **313**, a temperature higher than a sublimating temperature (T_A) of the evaporation material is applied, a heating temperature (T_2) by the second heating means **314** may be lower than that of the first heating means. This is because once sublimated evaporation material is easy to sublimate and therefore, the evaporation material is sublimated without applying the actual sublimating temperature. That is, respective heating temperatures may establish $T_1 >> T_2 > T_A$.

[**0148**] By such a container having a constitution of providing the heating means around the plate, the evaporation material having an even size is sublimated, further, the sublimated material passes a vicinity of the heating means and therefore, adherence of the evaporation material to the plate is reduced, further, the speed of film formation can be controlled and therefore a uniform film thickness can be provided and uniform evaporation without nonuniformity can be carried out. Naturally, when the uniform evaporation without nonuniformity can be carried out, it is not necessarily needed to provide the plate. Further, the shape of the container is not limited to those in **FIGS. 10A and 10B** but, for example, the container may be provided with shapes as shown by **FIGS. 11A and 11B**.

[**0149**] **FIG. 11A** shows an example of providing heating means **402** at an evaporation source holder **404** illustrating sectional views of examples of shapes of containers **403** and **405** in each of which an opening portion of the container is narrowed toward an upper side thereof. Further, after filling a refined evaporation material in a container having a wide opening portion, the shapes of the container **403** or **405** shown in **FIG. 11A** may be constituted by using a lid or the like. Further, when a diameter of the opening portion of the container narrowed toward the upper side is constituted by the size of the evaporation material intended to form, an effect similar to that of a filter can be achieved.

[**0150**] Further, **FIG. 11B** shows examples of providing heating means **412** at containers. Although shapes of the containers **413** and **415** are similar to those of **FIG. 11A**, the heating means **412** are provided at the containers per se. Further, power sources of the heating means may be designed to be brought into an ON state at a stage of being installed to evaporation source holders. By such a constitution of providing the heating means at the container per se,

heat can be applied sufficiently to an evaporation material even in the case of a container having an opening portion in a shape which is difficult to heat.

[0151] Next, a specific constitution of an evaporation source holder will be explained in reference to **FIGS. 12A and 12B**. **FIGS. 12A and 12B** show enlarged views of evaporation source holders.

[0152] **FIG. 12A** shows a constitution example of providing four containers **501** filled with an evaporation material to an evaporation source holder **502** in a shape of a lattice and providing shutters **503** above the respective containers and **FIG. 12B** shows a constitution example of providing four containers **511** filled with an evaporation material to an evaporation source holder **512** in a linear shape and providing shutters **513** above the respective containers.

[0153] A plurality of the containers **501** or **511** filled with the same material may be installed at the evaporation source holder **502** or **512** illustrated in **FIG. 12A** or 12B or a single one of the container may be installed at the evaporation source holder. Further, common evaporation may be carried out by installing containers filled with different evaporation materials (for example, host material and guest material). Further, as described above, the evaporation material is sublimated by heating the container and a film is formed at the substrate.

[0154] Further, as shown by **FIG. 12A** or 12B, it may be controlled whether the film is formed by the sublimated evaporation material by providing the shutter **503** or **513** above each container. Further, only a single one of the shutter may be provided above all of the containers. Further, by the shutter, it can be reduced to sublimate and scatter an unnecessary evaporation material without stopping to heat the evaporation source holder which does not form the film, that is, the evaporation source holder being at standby. Further, the constitution of the evaporation source holder is not limited to those of **FIGS. 12A and 12B** but may pertinently be designed by a person for embodying the invention.

[0155] By the above-described evaporation source holder and container, the evaporation material can efficiently be sublimated, further, the film is formed in a state in which the size of the evaporation material is even and therefore, a uniform evaporation film without nonuniformity is formed. Further, a plurality of evaporation materials can be installed at the evaporation source holder and therefore, common evaporation can easily be carried out. Further, an aimed EL layer can be formed in one operation without moving the film forming chamber for each film of the EL layer.

[0156] [Embodiment 4]

[0157] An explanation will be given, with reference to **FIG. 13**, of a system of a fabricating method of filling a refined evaporation material in the above-described container, carrying the container and thereafter installing the container directly at an evaporation system which is a film forming device, to carry out evaporation.

[0158] **FIG. 13** illustrates a manufacturer, representatively, a material manufacturer **618** (representatively, material manufacturer) for producing and refining an organic compound material which is an evaporation material and a manufacturer (representatively, production factory) **619** of a luminescent device which is a manufacturer of a luminescent device having an evaporation system.

[0159] First, an order **610** is carried out from the luminescent device manufacturer **619** to the material manufacturer **618**. Based on the order **610**, the material manufacturer **618** refines to sublimate an evaporation material and fills an evaporation material **612** in a shape of a powder refined in high purity to a first container **611**. Thereafter, the material manufacturer **618** isolates the first container from the atmosphere such that an extra impurity is not adhered to inside or outside thereof, and contains the first container **611** in second containers **621***a* and **621***b* to hermetically seal for preventing the first container **611** from being contaminated at inside of the clean environment chamber. In hermetically sealing the second containers **621***a* and **621***b*, at inside of the containers it is preferable to be vacuum or to be filled with an inert gas of nitrogen or the like. Further, it is preferable to clean the first container **611** and the second containers **621***a* and **621***b* before refining or containing the evaporation material **612** with an ultra high purity. Further, although the second containers **621***a* and **621***b* may be package films having barrier performance for blocking oxygen or moisture from mixing thereinto, in order to be able to take out the containers automatically, it is preferable that the second containers are constituted by stout containers having light blocking performance in a shape of a cylinder or a shape of a box.

[0160] Thereafter, the first container **611** is carried (**617**) from the material manufacturer **618** to the luminescent device manufacturer **619** in a state of being hermetically sealed by the second containers **621***a* and **621***b*.

[0161] At the luminescent device manufacturer **619**, the first container **611** is directly introduced into a vacuumable processing chamber **613** in a state of being hermetically sealed in the second containers **621***a* and **621***b*. Further, the processing chamber **613** is an evaporation system installed with heating means **614** and substrate holding means (not illustrated) at inside thereof.

[0162] Thereafter, inside of the processing chamber **613** is vacuumed to bring about a clean state in which oxygen or moisture is reduced as less as possible, thereafter, without breaking the vacuum, the first container **611** is taken out from the second containers **621***a* and **621***b*, the first container **611** is installed in contact with the heating means **614** and an evaporation source can be prepared. Further, an object to be deposited (here, substrate) **615** is installed at the processing chamber **613** to be opposed to the first container **611**.

[0163] Successively, an evaporation film **616** is formed on a surface of the object to be deposited **615** by applying heat to the evaporation material by the heating means **614**. The evaporation film **616** provided in this way does not include an impurity and when a luminescent element is finished by using the evaporation film **616**, high reliability and high brightness can be realized.

[0164] Further, after forming the film, the evaporation material remaining at the first container **611** may be sublimated to refine at the luminescent device manufacturer **619**. After forming the film, the first container **611** is installed at the second containers **621***a* and **621***b*, taken out from the processing chamber **613** and carried to a refining chamber

for sublimating to refine the evaporation material. There, the remaining evaporation material is sublimated to refine and the evaporation material in a shape of a powder refined at high purity is filled into a separate container. Thereafter, in a state of being hermetically sealed in the second container, the evaporation material is carried to the processing chamber **613** to carry out evaporation processing. At this occasion, it is preferable that a relationship among temperature (T3) for refining the remaining evaporation material, temperature (T4) elevated at a surrounding of the evaporation material and temperature (T5) at a surrounding of the evaporation material which is sublimated to refine satisfy T3>T4>T5. That is, in the case of sublimating to refine the material, when temperature is lowered toward a side of the container for filling the evaporation material to be sublimated to refine, convection is brought about and the material can be sublimated to refine efficiently. Further, the refining chamber for sublimating to refine the evaporation material may be provided in contact with the processing chamber **613** and the evaporation material which has been sublimated to refine may be carried without using the second container for hermetically sealing the evaporation material.

[**0165**] As described above, the first container **611** is installed in the evaporation chamber which is the processing chamber **613** without being brought into contact with the atmosphere at all to enable to carry out evaporation while maintaining the purity at the stage of containing the evaporation material **612** by the material manufacturer. Therefore, according to the invention, a fully automated fabricating system promoting the throughput can be realized and an integrated closed system capable of avoiding the impurity from mixing to the evaporation material **812** refined at the material manufacturer **618** can be realized. Further, the evaporation material **612** is directly contained in the first container **611** by the material mater based on the order and therefore, only a necessary amount thereof is provided to the luminescent device manufacturer and the comparatively expensive evaporation material can efficiently be used. Further, the first container and the second container can be reutilized to amount to a reduction in cost.

[**0166**] A specific explanation will be given of a mode of the container to be carried in reference to **FIG. 14** as follows. A second container divided into an upper portion (**621***a*) and a lower portion (**621***b*) used for transportation includes fixing means **706** provided at an upper portion of the second container for fixing a first container, a spring **705** for pressing the fixing means, a gas introducing port **708** provided at a lower portion of the second container for constituting a gas path for maintaining the second container being depressurized, an O ring **707** for fixing the upper container **621***a* and the lower container **621***b* and a retaining piece **702**. The first container **611** filled with the refined evaporation material is installed in the second container. Further, the second container may be formed by a material including stainless steel and the first container may be formed by a material including titanium.

[**0167**] At the material manufacturer, the refined evaporation material is filled in the first container **611**. Further, the upper portion **621***a* and the lower portion **621***b* of the second container are matched via the O ring **707**, the upper container **621***a* and the lower container **621***b* are fixed by the retaining piece **702**, and the first container **611** is hermetically sealed at inside of the second container. Thereafter, inside of the second container is depressurized via the gas introducing port **708** and is replaced by a nitrogen atmosphere and the first container **611** is fixed by the fixing means **706** by adjusting the spring **705**. A desiccant may be installed at inside of the second container. When inside of the second container is maintained in vacuum, in a low pressure or in nitrogen atmosphere in this way, even a small amount of oxygen or water can be prevented from adhering to the evaporation material.

[**0168**] The first container **611** is carried to the luminescent device manufacturer **619** under the state and is directly installed to the processing chamber **613**. Thereafter, the evaporation material is sublimated by heating and the evaporation film **616** is formed.

[**0169**] Next, an explanation will be given of a mechanism of installing the first container **611** which is carried by being hermetically sealed in the second container to a film forming chamber **806** in reference to **FIGS. 15A and 15B** and **FIGS. 16A and 16B**. Further, **FIGS. 15A and 15B** and **FIGS. 16A and 16B** show the first container in the midst of transportation.

[**0170**] **FIG. 15A** illustrates to a top view of an installing chamber **805** including a base **804** for mounting the first container or the second container, an evaporation source holder **803**, and carrying means **802** for carrying the base **804**, the evaporation source holder **803** and the first container, and **FIG. 15B** illustrates a perspective view of the installing chamber. Further, the installing chamber **805** is arranged to be contiguous to the film forming chamber **806** and the atmosphere of the installing chamber can be controlled by means for controlling the atmosphere via a gas introducing port. Further, the carrying means of the invention is not limited to a constitution of pinching a side face of the first container to carry as illustrated in **FIGS. 15A and 15B** but may be constructed by a constitution of pinching (picking) the first container at upper part thereof to carry.

[**0171**] The second container is arranged to such an installing chamber **805** above the base **804** in a state of disengaging the retaining piece **702**. Successively, inside of the installing chamber **805** is brought into a decompressed state by means for controlling the atmosphere. When pressure at inside of the installing chamber and pressure at inside of the second container become equal to each other, there is brought about a state of being capable of opening the second container easily. Further, the upper portion **621***a* of the second container is removed and the first container **611** is installed in the evaporation source holder **803** by the carrying means **802**. Further, although not illustrated, a portion for installing the removed upper portion **621***a* is pertinently provided. Further, the evaporation source holder **803** is moved from the installing chamber **805** to the film forming chamber **806**.

[**0172**] Thereafter, by heating means provided at the evaporation source holder **803**, the evaporation material is sublimated and the film starts to be formed. In forming the film, when a shutter (not illustrated) provided at the evaporation source holder **803** is opened, the sublimated evaporation material is scattered to the direction of the substrate and the vapor-deposited onto the substrate to form the luminescent layer (including hole transporting layer, hole injecting layer, electron transporting layer and electron injecting layer).

[0173] Further, after finishing evaporation, the evaporation source holder **803** returns to the installing chamber **805** and the first container **611** installed at the evaporation source holder **803** by the carrying means **802** is transferred to the lower container (not illustrated) of the second container installed at the base **804** and is hermetically sealed by the upper container **621***a*. At this occasion, it is preferable that the first container, the upper container **621***a* and the lower container are hermetically sealed by a combination by which the containers have been carried. Under the state, the installing chamber **805** is brought under the atmospheric pressure and the second container is taken out from the installing chamber, fixed with the retaining piece **702** and is carried to the material manufacturer **618**.

[0174] Next, an explanation will be given of a mechanism of installing a plurality of first containers carried by being hermetically sealed by the second containers to a plurality of the evaporation source holders, which is different from those of **FIGS. 15A and 15B** in reference to **FIGS. 16A and 16B**.

[0175] **FIG. 16A** illustrates a top view of an installing chamber **905** including a base **904** for mounting the first container or the second container, a plurality of evaporation source holders **903**, a plurality of carrying means **902** for carrying the first containers and a rotating base **907** and **FIG. 16B** illustrates a perspective view of the installing chamber **905**. Further, the installing chamber **905** is arranged to be contiguous to a film forming chamber **906** and the atmosphere of the installing chamber can be controlled by means for controlling the atmosphere via a gas introducing port.

[0176] By the rotating base **907** and the plurality of carrying means **902**, operation of installing the plurality of first containers **611** to the plurality of evaporation source holders **903** and transferring the plurality of first containers **611** from the plurality of evaporation source holders finished with film formation to the base **904** can efficiently be carried out. At this occasion, it is preferable to install the first container **611** to the second container which has been carried.

[0177] Further, in order to carry the evaporation source holder for starting evaporation and the evaporation source holder finished with evaporation efficiently, the rotating base **907** may be provided with a rotating function. In addition, the structure of the rotating base **907** is not limited to the above one, as far as the rotating base **907** has a function of moving to the right and lift directions, when the rotating base approaches to the evaporation holders arranged in the film forming chamber **906**, a plurality of the first containers may be provided at the evaporation holders by the carrying means **902**

[0178] According to an evaporation film formed by the above-described evaporation system, an impurity can be reduced to an extreme and when a luminescent element is finished by using the evaporation film, high reliability and brightness can be realized. Further, by such a fabricating system, the container filled by the material manufacturer can be installed directly to the evaporation system and therefore, oxygen or water can be prevented from adhering to the evaporation material and further ultrahigh purity formation of the luminescent element in the future can be dealt with. Further, by refining the container having the remaining evaporation material again, waste of the material can be eliminated. Further, the first container and the second container can be reutilized and the low cost formation can be realized.

[0179] The present invention constituted by the above structure will be described in more detail with examples shown below.

EXAMPLES

[0180] Examples of the present invention are described thereinafter based on the drawings. In addition, in all drawings used for the description of the examples, same portions are given common symbols, and the repetitive descriptions thereof are omitted.

Example 1

[0181] In this example, an example of forming TFT on a substrate having an insulating surface and forming an EL element (light emitting element) is shown in **FIG. 17**. A cross-sectional view of one TFT that is connected to an EL element in a pixel portion is shown in this example.

[0182] A base insulating film **201** is formed by a lamination of insulating films such as a silicon oxide film, a silicon nitride film or a silicon oxynitride film on a substrate **200** having an insulating surface. Although the base insulating film **201** herein uses a two-layer structure, it may use a structure having a single layer or two layers or more of the insulating films. The first layer of the base insulating film is a silicon oxynitride film formed to have a thickness of 10 to 200 nm (preferably 50 to 100 nm) by plasma CVD using a reaction gas of SiH_4, NH_3 and N_2O. Herein, a silicon oxynitride film is formed (composition ratio: Si=32%, O=27%, N=24% and H=17%) having a film thickness of 50 nm. The second layer of the base insulating film is a silicon oxynitride film formed to have a thickness 50 to 200 nm (preferably 100 to 150 nm) by plasma CVD using a reaction gas of SiH_4 and N_2O. Herein, a silicon oxynitride film is formed (composition ratio: Si=32%, O=59%, N=7% and H=2%) having a film thickness of 100 nm.

[0183] Subsequently, a semiconductor layer is formed on the base insulating film **201**. The semiconductor layer is formed as follows: an amorphous semiconductor film is formed by known means (a sputtering, an LPCVD, a plasma CVD, or the like), then, the film is crystallized by a known crystallization method (a laser crystallization method, a thermal crystallization method or a thermal crystallization method using a catalyst such as nickel), and then, the crystalline semiconductor film is patterned into a desired form. This semiconductor layer is formed in a thickness of 25 to 80 nm (preferably 30 to 60 nm). The material of the crystalline semiconductor film, although not limited in material, is preferably formed of silicon or a silicon-germanium alloy.

[0184] In the case of forming a crystalline semiconductor film by a laser crystallizing process, it is possible to use an excimer laser of a pulse-oscillation or continuous-oscillation type, a YAG laser, or an YVO_4 laser. In the case of using such laser, preferably used is a method that the laser light emitted from a laser oscillator is condensed by an optical system into a linear form to be irradiated onto the semiconductor film. The condition of crystallization is to be appropriately selected by those who implement the invention. In

the case of using an excimer laser, pulse oscillation frequency is 30 Hz and laser energy density is 100 to 400 mJ/cm^2 (typically 200 to 300 mJ/cm^2). Meanwhile, in the case of using a YAG laser, preferably its second harmonic is used and pulse oscillation frequency is 1 to 10 kHz and laser energy density is 300 to 600 mJ/cm^2 (typically 350 to 500 mJ/cm^2). The laser light focused linear to a width of 100 to 1000 μm, e.g. 400 μm, is irradiated throughout the substrate entirety, whereupon the overlap ratio of linear laser beam may be taken 50 to 98%.

[0185] Then, the surface of the semiconductor layer is cleaned by an etchant containing a hydrogen fluoride, to form a gate insulating film **202** covering the semiconductor layer. The gate insulating film **202** is formed by an insulating film containing silicon having a thickness of 40 to 150 nm by the use of plasma CVD or sputtering. In this example, a silicon oxynitride film is formed (composition ratio: Si=32%, O=59%, N=7% and H=2%) to have a thickness of 115 nm by plasma CVD. Of course, the gate insulating film **202** is not limited to a silicon oxynitride film but may be made in a single layer or a lamination of layers of insulating films containing other form of silicon.

[0186] After cleaning the surface of the gate insulating film **202**, a gate electrode **210** is formed.

[0187] Then, a p-type providing impurity element (such as B), herein, adequate amounts of boron is added to the semiconductor to form a source region **211** and a drain region **212**. After the addition of the impurity element, heating process, intense light radiation or laser irradiation is made in order to activate the impurity element. Simultaneously with activation, restoration is possible from the plasma damage to the gate insulating film or from the plasma damage at the interface between the gate insulating film and the semiconductor layer. Particularly, it is extremely effective to irradiate the second harmonic of a YAG laser at a main or back surface thereby activating the impurity element in an atmosphere at room temperature to 300° C. YAG laser is preferable activating means since it requires a few maintenances.

[0188] In the subsequent process, after hydrogenation is carried out, an insulator **213***a* made from an organic or inorganic material (for example, from a photosensitive organic resin) is formed, then, an aluminum nitride film, an aluminum oxynitride film shown as AlN_xO_y, or a first protection film **213***b* made from a silicon nitride film are formed. The film shown as AlN_xO_y is formed by introducing oxygen, nitrogen, or rear gas from the gas inlet system by RF sputtering using a target made of AlN or Al. The content of nitrogen in the AlN_xO_y film may be in the range of at least several atom %, or 2.5 to 47.5 atom %, and the content of oxygen may be in the range of at most 47.5 atom %, preferably, less than 0.01 to 20 atom %. A contact hole is formed therein reaching the source region **211** or drain region **212**. Next, a source electrode (wiring) **215** and a drain electrode **214** are formed to complete a TFT (p-channel TFT). This TFT will control the current that is supplied to OLED (Organic Light Emitting Device).

[0189] Also, the present invention is not limited to the TFT structure of this example, but, if required, may be in a lightly doped drain (LDD) structure having an LDD region between the channel region and the drain region (or source region). This structure is formed with a region an impurity element is added with light concentration between the channel formation region and the source or drain region formed by adding an impurity element with high concentration, which is called an LDD region. Furthermore, it may be in, what is called, a GOLD (Gate-drain Overlapped LDD) structure arranging an LDD region overlapped with a gate electrode through a gate insulating film. It is preferable that the gate electrode is formed in a lamination structure and etched to have a different taper angle of an upper gate electrode and a lower gate electrode to form an LDD region and a GOLD region in a self-aligning manner using the gate electrode as a mask.

[0190] Meanwhile, although explanation herein was by using the p-channel TFT, it is needless to say that an n-channel TFT can be formed by using an n-type impurity element (P, As, etc.) in place of the p-type impurity element.

[0191] Though a top gate TFT is described as an example in this example, the present invention can be applied irrespective of TFT's structure. For example, the present invention can be applied to a bottom gate (reverse stagger) TFT and a forward stagger TFT.

[0192] Subsequently, in the pixel portion, a first electrode **217** in contact with a connecting electrode in contact with the drain region is arranged in matrix shape. This first electrode **217** serves as an anode or a cathode of the light-emitting element. Then, an insulator (generally referred to as a bank, a partition, a barrier, a mound, or the like) **216** that covers the end portion of the first electrode **217** is formed. For the insulator **216**, a photosensitive organic resin is used. In the case of using a negative type photosensitive acrylic resin is used as a material of the insulator **216**, for example, the insulator **216** may be preferably prepared such that the upper end portion of the insulator **216** has a curved surface having a first curvature radius and the lower end portion of the insulator has a curved surface having a second curvature radius. Each of the first and second curvature radiuses may be preferably in the range of 0.2 μm to 3 μm. Furthermore, a layer **218** containing an organic compound is formed in the pixel portion, and a second electrode **219** is then formed thereon to complete an EL element. This second electrode **219** serves as a cathode or an anode of the EL element.

[0193] The insulator **216** that covers the end portion of the first electrode **217** may be covered with a second protective film formed of an aluminum nitride film, an aluminum nitride oxide film, or a silicon nitride film.

[0194] For instance, an example of using a positive type photosensitive acrylic resin as a material of the insulator **216** is shown in **FIG. 17B**. The insulator **316***a* has a curved surface having a curvature radius only the upper end thereof. Furthermore, the insulator **316***a* is covered with a second protective film **316***b* formed of an aluminum nitride film, an aluminum nitride oxide film, or a silicon nitride film.

[0195] For instance, when the first electrode **217** is used as an anode, the material of the first electrode **217** may be a metal (i.e., Pt, Cr, W, Ni, Zn, Sn, or In) having a large work function. The end portion of such an electrode **217** is covered with the insulator (generally referred to as a bank, a partition, a barrier, a mound, or the like) **216** or **316**, then, a vacuum-evaporation is carried out moving an evaporation source along with the insulator **216** or **316** by using the

evaporation system shown in Embodiments 1 to 3. For example, a film forming chamber is vacuum-exhausted until the degree of vacuum reaches 5×10^{-3} Torr (0.665 Pa) or less, preferably 10^{-4} to 10^{-6} Pa, for vacuum-evaporation. Prior to vacuum-evaporation, the organic compound is vaporized by resistance heating. The vaporized organic compound is scattered on the substrate as the shutter is opened for vacuum-evaporation. The vaporized organic compound is scattered upward, then, deposited on the substrate through an opening formed in a metal mask. A light emitting layer (including a hole transporting layer, a hole injection layer, an electron transporting layer, and an electron injection layer) is formed.

[0196] In the case that a layer containing an organic compound is formed that emits white luminescence in its entirety by vacuum-evaporation, it can be formed by depositing each light emitting layer. For instance, an Alq_3 film, an Alq_3 film partially doped with Nile red which is a red light emitting pigment, a p-EtTAZ film, and a TPD (aromatic diamine) film are layered in this order to obtain white light.

[0197] In case of using vacuum-evaporation, as shown in Embodiment 3, a container (typically a melting pot) in which an EL material that a vacuum-evaporation material is stored in advance by a material manufacturer is set in a film forming chamber. Preferably, the melting pot is set in the film forming chamber while avoiding contact with the air. The melting pot shipped from a material manufacturer is preferably sealed in a second container during shipment and is introduced into a film forming chamber in that state. Desirably, a chamber having vacuum exhaust means is connected to the film forming chamber, the melting pot is taken out of the second container in vacuum or in an inert gas atmosphere in this chamber, and then the melting pot is set in the film forming chamber. In this way, the melting pot and the EL material stored in the melting pot are protected from contamination.

[0198] The second electrode **219** comprises a laminate structure of a metal (e.g., Li, Mg, or Cs) having a small work function; and a transparent conductive film (made of an indium tin oxide (ITO) alloy, an indium zinc oxide alloy (In_2O_3—ZnO), zinc oxide (ZnO), or the like) on the thin film. For attaining a low-resistance cathode, an auxiliary electrode may be provided on the insulator **216** or **316**. The light-emitting element thus obtained emits white luminescence. Here, the example in which the layer **218** containing the organic compound is formed by vacuum-evaporation has been described. According to the present invention, however, it is not limited to a specific method and the layer **218** may be formed using a coating method (a spin coating method, an ink jet method).

[0199] In this example, an example of depositing layers made from low molecular material as an organic compound layer is described though, both high molecular materials and low molecular materials may also be deposited.

[0200] It can be thought that there are two types of structures of an active matrix light emitting device having TFT in terms of radiating direction of luminescence. One is a structure that luminescence generated in a light emitting element can be observed passing through the second electrode, and can be manufactured using the above-mentioned steps.

[0201] Another structure is that luminescence generated in the light emitting element is irradiated into the eyes of the observer after passing through the first electrode, it is preferable that the first electrode **217** may be prepared using a material having a translucency. For instance, when the first electrode **217** is provided as an anode, a transparent conductive film (made of an indium tin oxide (ITO) alloy, an indium zinc oxide alloy (In_2O_3—ZnO), zinc oxide (ZnO), or the like) is used for a material of the first electrode **217** and the end portion thereof is covered with the insulator (generally referred to as a bank, a partition, a barrier, a mound, or the like) **216**, followed by forming the layer **218** containing an organic compound. On this layer, furthermore, a second electrode **219** formed of a metal film (i.e., an alloy of MgAg, MgIn, AlLi, CaF_2, CaN, or the like, or a film formed by a co-vacuum-evaporation of an element of Group I and Group II in the periodic table and aluminum) is formed as a cathode. Here, a resistive heating method using vacuum-evaporation is used for the formation of a cathode, so that the cathode can be selectively formed using a vacuum-evaporation mask.

[0202] After forming the second electrode **219** by the steps described above, a seal substrate is laminated using a sealing material to encapsulate the light-emitting element formed on the substrate **200**.

[0203] Here, an appearance view of an active matrix type light-emitting device is described with reference to **FIGS. 18A and 18B**. Further, **FIG. 18A** is a top view showing the light emitting apparatus and **FIG. 18B** is a sectional view constituted by cutting **FIG. 18A** by a line A-A'. A source signal side driving circuit **1101**, a pixel portion **1102**, and a gate signal line driving circuit **1103** are formed on a substrate **1110**. An inner side surrounded by a seal substrate **1104**, the sealing material **1105**, and the substrate **1110** constitutes a space **1107**.

[0204] Further, a wiring **1108** for transmitting signals inputted to the source signal side driving circuit **1101** and the gate signal side driving circuit **1103** receives a video signal or a clock signal from FPC (flexible printed circuit) **1109** for constituting an external input terminal. Although only FPC is illustrated here, the FPC may be attached with a printed wiring substrate (PWB). The light emitting apparatus in the specification includes not only a main body of the light emitting apparatus but also a state in which FPC or PWB is attached thereto.

[0205] Next, a sectional structure will be explained in reference to **FIG. 18B**. Driver circuits and the pixel portion are formed over a substrate **1110** and here, the source signal line driving circuit **1101** as the driver circuit and the pixel portion **1102** are shown.

[0206] Further, the source signal line driving circuit **1101** is formed with a CMOS circuit combined with an n-channel type TFT **1123** and a p-channel type TFT **1124**. Further, TFT for forming the driver circuit may be formed by a publicly-known CMOS circuit, PMOS circuit or NMOS circuit. Further, although according to this example, a driver integrated type formed with the driver circuits over the substrate is shown, the driver integrated type is not necessarily be needed and the driver circuits can be formed not over the substrate but at outside thereof.

[0207] Further, the pixel portion **1102** is formed of a plurality of pixels each including a switching TFT **1111**, a current controlling TFT **1112**, and a first electrode (anode) **1113** electrically connected to a drain of the current controlling TFT **1112**.

[0208] Further, an insulating layer **1114** is formed at both ends of the first electrode (anode) **1113** and an organic compound layer **1115** is formed on the first electrode (anode) **1113**. The organic compound layer **1115** is formed by moving an evaporation source along with the insulating film **1114** by using the device shown in Embodiments 1 and 2. Further, a second electrode (cathode) **1116** is formed over the organic compound layer **1115**. As a result, a light-emitting element **1118** comprising the first electrode (anode) **1112**, the organic compound layer **1115** and the second electrode (cathode) **1116** is formed. Here, the light-emitting element **1118** shows an example of white color luminescence and therefore, provided with the color filter comprising a coloring layer **1131** and a light-shielding layer **1132** (for simplification, overcoat layer is not illustrated here).

[0209] In **FIGS. 19A** to **19**C, a color filter is formed at the side of a seal substrate **1104** since it is the structure that light emitted from a light emitting element is observed through the second electrode, however, in case of the structure that light emitted from a light emitting element is observed through the first electrode, a color filter is formed at the side of the substrate **1110**.

[0210] The second electrode (cathode) **1116** functions also as a wiring common to all the pixels and electrically connected to FPC **1109** via the connection wiring **1108**. The third electrode (auxiliary electrode) **1117** is formed on the insulating layer **1114** to realize to make the second electrode have a low resistance.

[0211] Further, in order to encapsulate the light-emitting element **1118** formed over the substrate **1110**, the seal substrate **1104** is pasted by the sealing material **1105**. Further, a spacer comprising a resin film may be provided for ensuring an interval between the seal substrate **1104** and the light-emitting element **1118**. Further, the space **1107** on the inner side of the sealing material **1105** is filled with an inert gas of nitrogen or the like. Further, it is preferable to use epoxy species resin for the sealing material **1105**. Further, it is preferable that the sealing material **1105** is a material for permeating moisture or oxygen as less as possible. Further, the inner portion of the space **1107** may be included with the substance having an effect of absorbing oxygen or moisture.

[0212] Further, according to the example, as a material for constituting the seal substrate **1104**, other than glass substrate or quartz substrate, a plastic substrate comprising FRP (Fiberglass-Reinforced Plastics), PVF (polyvinyl fluoride), Mylar, polyester or acrylic resin can be used. Further, it is possible to adhere the seal substrate **1104** by using the sealing material **1105** and thereafter seal to cover a side face (exposed face) by a sealing material.

[0213] By encapsulating the light-emitting element as described above, the light-emitting element can completely be blocked from outside and a substance for expediting to deteriorate the organic compound layer such as moisture or oxygen can be prevented from invading from outside. Therefore, the highly reliable light-emitting device can be provided.

[0214] Further, this example can be freely combined with Embodiments 1 to 4.

Example 2

[0215] Given as examples of electronic apparatuses that employ the light emitting device manufactured in accordance with the present invention are video cameras, digital cameras, goggle type displays (head mounted displays), navigation systems, audio reproducing devices (such as car audio and audio components), laptop computers, game machines, portable information terminals (such as mobile computers, cellular phones, portable game machines, and electronic books), and image reproducing devices equipped with recording media (specifically, devices with a display device that can reproduce data in a recording medium such as a digital versatile disk (DVD) to display an image of the data). A wide viewing angle is important particularly for portable information terminals because their screens are often slanted when they are looked at. Therefore it is preferable for portable information terminals to employ the light emitting device using the light emitting element. Specific examples of these electronic apparatuses are shown in **FIGS. 20A** to **20**H.

[0216] **FIG. 20A** shows a light emitting device including a case **2001**, a support base **2002**, a display unit **2003**, speaker units **2004**, a video input terminal **2005**, etc. The light emitting device manufactured in accordance with the present invention can be applied to the display unit **2003**. In addition, the light emitting device shown in **FIG. 20A** can be completed by the present invention. Since the light emitting device having the light emitting element is of self-luminous type, the device does not need a backlight and can make a thinner display unit than that of a liquid crystal display device. The light emitting device refers to all light emitting devices for displaying information, including ones for personal computers, for TV broadcasting reception, and for advertisement.

[0217] **FIG. 20B** shows a digital still camera including a main body **2101**, a display unit **2102**, an image receiving unit **2103**, operation keys **2104**, an external connection port **2105**, a shutter **2106**, etc. The light emitting device manufactured in accordance with the present invention can be applied to the display unit **2102**. The digital camera shown in **FIG. 16B** can be completed by the present invention.

[0218] **FIG. 20C** shows a laptop computer including a main body **2201**, a case **2202**, a display unit **2203**, a keyboard **2204**, an external connection port **2205**, a pointing mouse **2206**, etc. The light emitting device manufactured in accordance with the present invention can be applied to the display unit **2203**. The laptop computer shown in **FIG. 20C** can be completed by the present invention.

[0219] **FIG. 20D** shows a mobile computer including a main body **2301**, a display unit **2302**, a switch **2303**, operation keys **2304**, an infrared port **2305**, etc. The light emitting device manufactured in accordance with the present invention can be applied to the display unit **2302**. The mobile computer shown in **FIG. 20D** can be completed by the present invention.

[0220] **FIG. 20E** shows a portable image reproducing device equipped with a recording medium (a DVD player, to be specific). The device includes a main body **2401**, a case **2402**, a display unit A **2403**, a display unit B **2404**, a recording medium (DVD or the like) reading unit **2405**, operation keys **2406**, speaker units **2407**, etc. The display unit A **2403** mainly displays image information whereas the display unit B **2404** mainly displays text information. The light emitting device manufactured in accordance with the present invention can be applied to the display units A **2403**

and B **2404**. The image reproducing device equipped with a recording medium also includes home-video game machines. The DVD player shown in **FIG. 20E** can be completed by the present invention.

[**0221**] **FIG. 20F** shows a goggle type display (head mounted display) including a main body **2501**, display units **2502**, and arm units **2503**. The light emitting device manufactured in accordance with the present invention can be applied to the display units **2502**. The goggle type display shown in **FIG. 20F** can be completed by the present invention.

[**0222**] **FIG. 20G** shows a video camera including a main body **2601**, a display unit **2602**, a case **2603**, an external connection port **2604**, a remote control receiving unit **2605**, an image receiving unit **2606**, a battery **2607**, an audio input unit **2608**, operation keys **2609** etc. The light emitting device manufactured in accordance with the present invention can be applied to the display unit **2602**. The video camera shown in **FIG. 20G** can be completed by the present invention.

[**0223**] **FIG. 20H** shows a cellular phone including a main body **2701**, a case **2702**, a display unit **2703**, an audio input unit **2704**, an audio output unit **2705**, operation keys **2706**, an external connection port **2707**, an antenna **2708**, etc. The light emitting device manufactured in accordance with the present invention can be applied to the display unit **2703**. If the display unit **2703** displays white letters on a black background, the cellular phone consumes less power. The cellular phone shown in **FIG. 20H** can be completed by the present invention.

[**0224**] If a brighter luminance of luminescence materials becomes valuable in the future, the light emitting device can be used in front or rear projectors by enlarging outputted light that contains image information through a lens or the like and projecting the light.

[**0225**] These electronic apparatuses now display with increasing frequency information sent through electronic communication lines such as the Internet and CATV (cable television), especially, animation information. Since the luminescence materials have very fast response speed, the light emitting device is suitable for moving images.

[**0226**] According to the present invention, there can be provided a manufacturing apparatus including the plural film forming chambers for performing the evaporation process, which are arranged in a row. Accordingly, the film forming processes are performed in the plural film forming chambers approximately in parallel, thereby improving the throughput of the light emitting device and allowing the reduction of a processing time per substrate.

[**0227**] Further, according to the present invention, even though the processing number of substrates is slightly reduced, the maintenance of one or plural film forming chambers is possible without temporarily stopping the production line.

What is claimed is:

1. A manufacturing apparatus comprising:

a load chamber;

a transfer chamber that is connected to the load chamber; and

plural film forming chambers that are connected to the transfer chamber,

wherein the plural film forming chambers are each connected to a vacuum-exhaust process chamber for setting an inside of the film forming chamber to vacuum,

wherein each of the plural film forming chambers includes alignment means for performing position alignment of a mask and a substrate, an evaporation source, and means for heating the evaporation source, and

wherein in at least two of the plural film forming chambers, surfaces of substrates loaded into the respective film forming chambers are subjected to evaporation in parallel.

2. A manufacturing apparatus comprising:

a load chamber;

a transfer chamber that is connected to the load chamber;

plural film forming chambers that are connected to the transfer chamber; and

plural sealing chambers,

wherein the plural film forming chambers are each connected to a vacuum-exhaust process chamber for setting an inside of the film forming chamber to vacuum,

wherein each of the plural film forming chambers includes alignment means for performing position alignment of a mask and a substrate, an evaporation source, and means for heating the evaporation source,

wherein in at least two of the plural film forming chambers, surfaces of substrates loaded into the respective film forming chambers are subjected to evaporation in parallel, and

wherein each substrate is assigned to one of the plural sealing chambers to be sealed therein.

3. A manufacturing apparatus comprising:

a load chamber;

a transfer chamber that is connected to the load chamber; and

plural film forming chambers that are connected to the transfer chamber,

wherein the plural film forming chambers are each connected to a vacuum-exhaust process chamber for setting an inside of the film forming chamber to vacuum,

wherein each of the plural the film forming chambers includes alignment means for performing position alignment of a mask and a substrate, an evaporation source, and means for heating the evaporation source, and

wherein in at least two of the plural film forming chambers, surfaces of substrates loaded into the respective film forming chambers are subjected to evaporation in parallel, and in at least one of the plural film forming chambers, the inside of the film forming chamber undergoes cleaning.

4. A manufacturing apparatus according to any one of claims 1 to 3, wherein in at least two of the plural film

forming chambers, evaporation processes of layers containing the same organic compound are performed in parallel.

5. A manufacturing apparatus comprising:

a load chamber;

a transfer chamber that is connected to the load chamber; and

plural film forming chambers that are connected to the transfer chamber,

wherein the plural film forming chambers are each connected to a vacuum-exhaust process chamber for setting an inside of the film forming chamber to vacuum,

wherein each of the plural film forming chambers includes alignment means for performing position alignment of a mask and a substrate, an evaporation source, and means for heating the evaporation source, and

wherein plural substrates loaded into the load chamber are each assigned to one of the plural film forming chambers in the transfer chamber to be loaded thereinto, and each substrate undergoes processes along one of different paths whose number is the same as that of the film forming chambers.

6. A method of fabricating a light emitting device by using an evaporation system including a plurality of first deposition chambers for forming a film of an organic compound layer and a plurality of second deposition chambers for forming a conductive film, said method comprising the steps of:

forming the organic compound layer in parallel in the plurality of first deposition chambers;

moving the organic compound layer from the first deposition chamber to the second deposition chamber by using carrying means without being exposed to an atmosphere; and

forming the conductive film in contact with the organic compound layer in the second deposition chamber.

7. A method of fabricating a light emitting device by using an evaporation system including a first through a fourth deposition chamber for forming a film of an organic compound layer above a substrate, a fifth deposition chamber for forming a conductive film, a sixth deposition chamber for forming a protective film and a seventh deposition chamber for pasting together the substrate and a sealing substrate, said method comprising the step of:

simultaneously forming the organic compound layer above the substrate in the first through the fourth deposition chambers and moving the substrate from any one of the first through the fourth deposition chambers to the fifth forming chamber without being exposed to an atmosphere; and

forming the conductive film above the organic compound layer in the fifth deposition chamber;

moving the substrate from the fifth deposition chamber to the sixth deposition chamber without being exposed to the atmosphere;

forming the protective film above the conductive film in the sixth deposition chamber;

moving the substrate from the sixth chamber to the seventh deposition chamber without being exposed to the atmosphere; and

pasting together the substrate and the sealing substrate formed with a sealing member in the seventh deposition chamber.

* * * * *