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(54) **PLASMA DISPLAY PANEL**

(57) A technique is provided for preventing impurity gas from entering the plasma display panel. A light emitting region 15 is surrounded by a hermetically-sealed part 17 including a metal film tightly adhering to first and second panels 20 and 30, and a sealing part 41 fixing the first and second panels 20 and 30 to each other is located outside the hermetically-sealed part 17. Even when moisture is transmitted through the sealing part 41, the moisture cannot be transmitted through the hermetically-sealed part 17 and does not enter the light emitting region 15. Since the sealing part 41 may transmit the moisture, it can use an ultraviolet curable type resin for improving working efficiency.

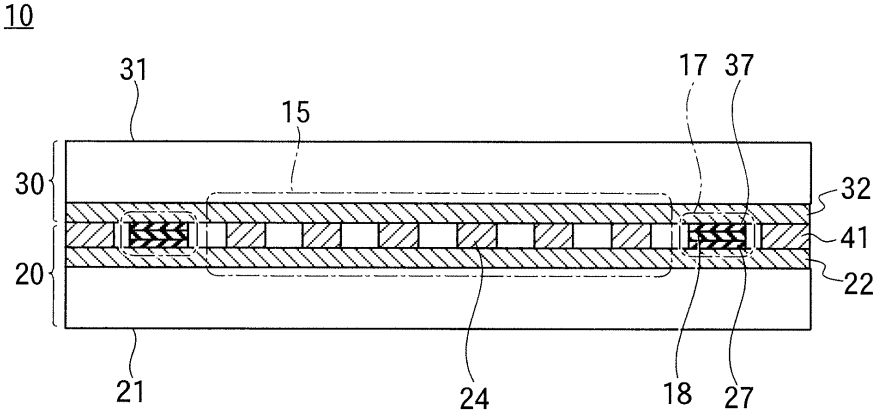

Fig. 1

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Description

Technical Field

[0001] The present invention relates to a technical field of a plasma display panel, and particularly to a technique which prevents impurity gas from entering a plasma display panel.

Background Art

[0002] Conventionally, a PDP has been used widely in the field of the display device, and recently there is required a low cost PDP having a large screen and high quality.

[0003] Currently, a main stream of the PDP is a three electrode surface discharge type panel which is made by adhering together a first panel (back plate) having an address electrode formed on a glass substrate and a second panel (front plate) having a sustain electrode and a scan electrode formed on a glass substrate.

[0004] In Figs. 11(a) and 11(b), reference numeral 110 shows a plasma display panel of conventional art and the plasma display panel 110 has first and second panels 120 and 130. Fig. 11(a) is a plan view for illustrating the inside thereof and Fig. 11(b) is a cross-sectional view thereof.

[0005] The first and second panels 120 and 130 have first and second substrates 121 and 131 made of glass substrates and first and second wiring layers 122 and 132 arranged on the first and second substrates 121 and 131, respectively.

[0006] Partition walls 124 in a projecting bar shape are arranged on the first wiring layer 122, and the first and second panels 120 and 130 are arranged opposite to each other so as to have the partition walls 124 therebetween, with the first and second wiring layers 122 and 132 facing each other.

[0007] A ring-shaped sealing part 141 is disposed in the peripheries of the first and second panels 120 and 130 and the first and second panels 120 and 130 are fixed to each other by the sealing part 141.

[0008] Discharge gas is encapsulated between the first and second panels 120 and 130. Discharge gas plasma is formed by forming plasma at a predetermined position between the partition wall 124 and the partition wall 124 when a voltage is applied across electrodes in the first and second wiring layers 122 and 132. When ultraviolet light emitted from the plasma irradiates a fluorescent layer disposed on the partition wall 124, the fluorescent layer emits light so as to output visible light to the outside. Reference numeral 115 in Figs. 11 (a) and 11 (b) denotes a light emitting region from which the visible light is output to the outside.

[0009] Low melting point glass is used for the sealing material to form the sealing part 141, but the sealing material extricates a lot of impurity gas when heated and solidified because the low melting point glass contains an organic binder.

[0010] Accordingly, degassing is required to be carried out before the sealing and also, long time aging is necessary even after the first and second panels 120 and 130 have been sealed because a lot of gas is extricated in the sealing even if the degassing had been performed. This causes the panel production to have a limited throughput and to require large amounts of electricity.

[0011] Accordingly, resin material has been studied recently to be used for the sealing part 141 in order to reduce the panel production time. By using an ultraviolet curable resin, it becomes possible to form the sealing part 141 in a state of little gas extrication without heating.

[0012] However, when the light emitting region 115 is surrounded by the ring shaped sealing part 141 and the inside of the plasma display panel 110 is isolated from the outside atmosphere by the sealing part 141, impurity gas contained in the outside atmosphere is transmitted through the resin material to enter the panel and the purity of the discharge gas is deteriorated.

[0013] The purity deterioration of the discharge gas causes a discharge voltage to increase.

[0014] Furthermore, also by the decomposition of the resin material when the sealing part 141 is irradiated with the ultraviolet light emitted from the plasma, impurity gas is mixed in between the first and second panels 120 and 130 to deteriorate the purity of the discharge gas, and the adhesive force between the first and second panels 120 and 130 becomes weak.

[0015] For the problem of the sealing pat 141 that impurity gas is generated when the sealing material is cured, an effort to reduce the impurity amount generated in the sealing has been made by carrying out the degassing in advance of curing the resin material composing the sealing part 141. However, the adhesive property of the sealing material is degraded by the degassing process and it becomes difficult to ensure the adhesive force between the first and second panels 120 and 130.

[0016] Furthermore, for solving the above problem, another effort has been made by using a low melting pint metal material such as indium or indium alloy which does not generate the impurity gas as a sealing material for forming the sealing part 141. However, the sealing capability (adhesive force), which is determined by a material property and an adhesion area, so that a large amount of the low melting point metal material is required and particularly indium, which is a rare metal and expensive, causes cost up and a problem that a time required for sealing process becomes longer.

Patent document 1: Japanese Patent Application Laid-Open Publication No. 2002-75197
Patent document 2: Japanese Patent Application Laid-Open Publication No. 2002-156160
Patent document 3: Japanese Patent Application Laid-Open Publication No. 2002-231129
Patent document 4: Japanese Patent Application Laid-Open Publication No. 2001-210258

Disclosure of the Invention

Problems to be Solved by the Invention

[0017] The present invention has been created for solving the above problem of the conventional technique, and aims for providing a technique which prevents impurity gas from entering the plasma display panel.

[0018] The operation principle of the plasma display panel (PDP) utilizes gas discharge in an electric field similarly to that of a fluorescent tube for illumination.

[0019] For the fluorescent tube, it is well known that the start voltage of the fluorescent tube becomes twice when H_2 molecules of the impurity gas are contained in even less than 1% in a discharge gas.

[0020] This is because the H_2 molecules take energy from quasi-stable atoms and electrons relating to light-on. There, it is necessary to apply a higher voltage in order to start the discharge.

[0021] Fromthis, also in the PDP, it is apparent that the impurity gas such as H_2O H_2, O_2, CO, CO_2, and N_2 affects various characteristics of the operation such as a start voltage, an operation voltage, brightness or the like.

[0022] In particular, H_2O sometimes oxidizes a metal electrode of a DC-type PDP or affects the characteristic of an MgO film in an AC-type PDP.

[0023] While He or Ne containing several percent Xe in several tens of thousand Pa is used for the discharge gas of the PDP, it is reported that the impurity gas such as H_2O O_2, CO_2 or N_2 increases the operation voltage of the AC-type PDP when these impurity gasses are contained in 20 ppm or more. Further, there is a problem that some impurity gases deteriorate the material within a PDP cell.

[0024] For the main generation source of the impurity gas in the PDP, the impurity gas is sometimes generated from the internal structure material or in the production process, in addition to the case that the impurity gas is originally contained in the discharge gas, and further, the impurity gas is sometimes extricated during light emission or comes from residual gas after exhaust.

Means for Solving the Problems

[0025] In order to prevent the above impurity gas from entering the light emitting region, the present invention provides a plasma display panel including first and second panels having first and second substrates, respectively and arranged to face each other; a light emitting region located between the first and second substrates, a sealing part located outside the light emitting region and including resin which fixes the first and second panels to each other and a hermetically-sealed part including a ring-shaped metal film surrounding the light emitting region, wherein the sealing part is located outside the hermetically-sealed part.

[0026] In addition, the present invention provides the plasma display panel, and the hermetically-sealed part further including first and second metal layers tightly adhering to the first and second panels, respectively; and a low melting point metal layer located between the first and second metal layers and having a melting point lower than those of the first and second metal layers, so as to adhere the first and second metal layers each other.

[0027] In addition, the present invention provides the plasma display panel wherein the resin in the sealing part is a thermosetting resin.

[0028] In addition, the present invention provides the plasma display panel wherein the resin in the sealing part is an ultraviolet curable resin.

[0029] In addition, the present invention provides the plasma display panel wherein the sealing part has a ring shape and surrounds the hermetically-sealed part.

[0030] In addition, the present invention provides the plasma display panel further including an exhaust opening provided between the sealing part and the hermetically-sealed part.

Effect of the Invention

[0031] Since the light emitting region is surrounded by the hermetically-sealed part which is a metal film disposed between the first and second panels, the present invention can prevent both of the impurity gases from entering the light emitting region. The impurity gas which is transmitted through the adhesive sealing material enter the panels and the impurity gas which is extricated from the resin sealing material between the panels during the panel sealing process.

[0032] In addition, since the ultraviolet light generated in the discharge is blocked by the hermetically-sealed part and

does not irradiate the resin in the sealing part, it is possible to protect the resin in the sealing part and prevent the decomposition of the resin material, thereby enabling to prevent the purity deterioration of the discharge gas.

[0033] In addition, since the ultraviolet curable resin can be used for the sealing part, it is possible to reduce the processing time required for the sealing.

[0034] Since the panels are made to adhere to each other with the resin sealing part, it is possible to minimize the amount of the low melting point metal required for the hermetically-sealed part compared to the case of making the panels adhere to each other by use of the hermetically-sealed part.

[0035] Furthermore, since the hermetically-sealed part is provided with metal layers on the respective first and second panels and the metal layers are made to adhere to each other with the low melting point metal layer, it is possible to reduce the amount of the low melting point metal, such as, indium or the like used for the adhesion and hermetic sealing, and since the ultraviolet curable resin can be used for the sealing part, so that it is possible to reduce the processing time required for the sealing.

Brief Description of the Drawings

[0036]

Fig. 1 is a diagram for illustrating an example of a plasma display panel of the present invention.
Fig. 2 is a diagram for illustrating a light emitting region of the plasma display panel of Fig. 1.
Fig. 3 shows an arrangement example of a light emitting region, a hermetically-sealed part, and a sealing part.
Figs. 4(a) and 4(b) are diagrams for illustrating an auxiliary exhaust opening.
Figs. 5(a) to 5(c) are diagrams showing another arrangement example of a light emitting region, a hermetically-sealed part, and a sealing part.
Figs. 6(a) and 6(b) are diagrams showing relationships between a storage time and a discharge voltage of the present invention for (a) and a prior art for (b).
Figs. 7(a) and 7(b) are diagrams showing relationships between an aging time and a discharge voltage of the present invention for (a) and the prior art for (b).
Figs. 8 (a) to 8(c) are diagrams for illustrating a production process of a first panel in a plasma display panel of the present invention.
Figs. 9(a) and 9(b) are diagrams for illustrating a production process of a second panel in the plasma display panel of the present invention.
Fig. 10 is a flowchart for illustrating a production process for the plasma display panel of the present invention.
Figs. 11(a) and 11(b) are diagrams for illustrating a plasma display panel of a conventional art.

Explanation of Reference Numerals

[0037]

10. Plasma display panel
15. Light emitting region
17. Hermetically-sealed part
18. Low melting point metal layer
20. First panel
30. Second panel
21. First substrate
22. Second substrate
28. Exhaust opening
27. First metal layer
37. Second metal layer
41. Sealing part

Best Modes for Carrying Out the Invention

[0038] Fig. 1 is a cross-sectional view for illustrating a sealing state of a plasma display panel of the present invention, and the plasma display panel has first and second panels 20 and 30.

[0039] The first and second panels 20 and 30 have first and second substrates 21 and 31 made of transparent plates such as glass and fist and second wiring layers 22 and 32 arranged on the first and second substrates 21 and 31, respectively.

[0040] The shapes of the first and second substrates are rectangles or squares.

[0041] Partition walls 24 in a projecting bar shape are arranged on the first wiring layer 22, and the first and second panels 20 and 30 are arranged opposite to each other so as to have the partition walls 24 therebetween, with the first and second wiring layers 22 and 32 facing each other. Each of the first and second panels 20 and 30 has a protection film of a SrO-20 mol% CaO evaporated film (thickness: 8,000 Å) formed on the surface thereof by EB evaporation, but the protection film is omitted from the drawing.

[0042] A ring-shaped hermetically-sealed part 17 is disposed in periphery of the first and second panels 20 and 30, and the light emitting region 15 where the partition wall 24 is located is surrounded by the hermetically-sealed part 17. The ring-shaped hermetically-sealed part 17 has only to surround the inside, and the shape thereof includes various ring shapes such as a circular ring shape, rectangular ring shape, and other polygonal ring shape.

[0043] A sealing part 41 is disposed outside the hermetically-sealed part 17, and the first and second panels 20 and 30 are fixed to each other by the sealing part 41.

[0044] The hermetically-sealed part 17 has first and second ring-shaped metal layers 27 and 37 formed at positions facing each other on the first and secondpanels 20 and 30, respectively, and a ring-shaped low melting point metal layer 18 disposed between the first and second metal layers 27 and 37.

[0045] Fig. 2 is a diagram for illustrating the light emitting region 15 where the partition wall 24 is located. This light emitting region 15 is positioned between the first and second substrates 21 and 31, and performs the display of characters, graphics, or the like using the light emission of the plasma.

[0046] As shown in Fig. 2, the first wiring layer 22 has a plurality of address electrodes 23 and an insulating film 26 disposed on the surface thereof.

[0047] The second wiring layer 32 has a plurality of surface discharge electrodes 33 (such as, a scan electrode and a sustain electrode) and an insulating film 36 disposed on the surface of the surface discharge electrode 33.

[0048] Fluorescent material is disposed on the side of the partition wall 24 and between the partition walls 24, and discharge gas is encapsulated in the light emitting region 15.

[0049] The address electrodes 23 and the surface discharge electrodes 33 are arranged in a lattice shape, and when a voltage is applied between the desired address electrode 23 and surface discharge electrode 33, the plasma 51 of the discharge gas is formed in a region sandwiched by the address electrode 23 and the surface discharge electrode 33 so as to emit ultraviolet light. The emitted ultraviolet light irradiates the fluorescent material and visible light 52 is emitted from the fluorescent material. The visible light 52 is transmitted through the second panel 30 and output to the outside.

[0050] The region sandwiched by the address electrode 23 and the surface discharge electrode 33 is called a cell, and the plurality (here, 300) of cells is formed in the plasma display panel 10 of the present invention similar to the plasma display panel 110 of the prior art shown in Figs. 11(a) and 11(b). Each of the cells is configured to emit light individually and characters or graphics are configured to be displayed by the light emission of the cell at a position indicated by the address electrode 23.

[0051] The first and second metal layers 27 and 37 are made to tightly adhere to the insulating films 26 and 36 on the first and second panels 20 and 30, respectively, and the first and second metal layers 27 and 37 are connected to each other with a low melting point metal layer 18 which is formed by melting and solidification.

[0052] Accordingly, there are no gaps between the first panel 20 and the first metal layer 27, between the first metal layer 27 and the low melting point metal layer 18, between the low melting point metal layer 18 and the second metal layer 37, and between the second metal layer 37 and the second panel 30, thereby, the plasma display panel 10 is configured such that gas or moisture of atmosphere outside the plasma display panel 10 may not enter the light emitting region 15.

[0053] The production process of the plasma display panel 10 will be described as follows using the flowchart of Fig. 10 and the process charts of Figs. 8(a) to 8(c) and Figs. 9(a) and 9 (b) . That is, as shown in Fig. 8(a), the first wiring layer 22 and the partition wall 24 are formed on the first panel 20 (Step R_1 in Fig. 10), Cr vapor and Ag vapor are evaporated sequentially in this order from an evaporation source where Cr is applied and an evaporation source where Ag is applied, with a metal mask being placed onto the surface of the first panel 20, by the vacuum evaporation method so that the first metal layer 27 which is composed of a Cr thin film and an Ag thin film is formed as shown in Fig. 8(b) (Step R_2). The film formation conditions of the Cr thin film and the Ag thin film are shown in the following Table 1.

Table 1: Formation condition of Cr thin film and Ag thin film

Film forming material	Cr	Ag
Attained pressure (Pa)	5.0×10^{-4}	1.3×10^{-4}
Substrate heating temperature (°C)	250	250
EB output power (kw)	0.3	0.5

(continued)

Film forming material	Cr	Ag
Pressure during evaporation (Pa)	1.3×10^{-4}	6.0×10^{-4}
Film forming rate (nm/s)	1	10

[0054] Here, the thickness of the Cr thin film is 50 nm and the thickness of the Ag thin film is 1, 000 nm. The first metal layer 27 may be formed by a printing method using Ag paste.

[0055] The Cr thin film is made to tightly adhere to the first substrate 21 and the Ag thin film is exposed on the surface of the first metal layer 27.

[0056] Next, as shown in Fig. 8(c), the ring-shaped low melting point metal 16 is disposed on the surface of the first metal layer 27 (Step R_3). For the low melting point metal 16, it is possible to use a metal or an alloy having a melting point of 250°C or lower (such as, In (melting point: 157°C), In 50%-Sn 50% alloy (melting point: 120°C), Sn 96.5%-Ag 3%-Cu 0.5% alloy (melting point 210°C), Sn 96.5%-Ag 3.5% alloy (melting point: 220°C) and Sn 100% (melting point: 232°C), or the like).

[0057] The low melting point metal 16 may be formed by screen printing, or a wire having a diameter of about 0.5 to 1 mm may be disposed on the surface of the first metal layer 27.

[0058] Next, the first panel 20 is carried into a vacuum heating chamber, and vacuum exhaust and degassing are carried out (StepR_4). Here, the sealing material is an ultraviolet curable type epoxy resin.

[0059] For the second panel 30, as shown in Fig. 9(a), the second wiring layer 32 is formed on the second substrate 31 (Step S_1) ; a metal mask is placed on the second panel 30, a ring-shaped Cr thin film and Ag thin film are accumulated sequentially in this order by the evaporation method similar to the first panel 20, and then, the second metal layer 37 composed of the Cr thin film and Ag thin film is formed as shown in Fig. 9(b) (Step S_2). The first metal layer 27, the low melting point metal 16, and the second metal layer 37 have the same size ring shapes and are configured to overlap with each other.

[0060] The second panel 30 after the formation of the second metal layer 37 is carried into a degassing chamber and heated in a vacuum ambience to be degassed (Step S_3) .

[0061] Next, a protection film, such as, Sr-CaO or MgO is formed on a region inside the second metal layer 37 on the second panel 30 by EB evaporation (Step S_4), and the second panel 30 is carried into the vacuum heating chamber in which the first panel 20 has been carried. The surfaces thereof where the first and second metal layers 27 and 37 are formed are made to face each other, and the first and second panels 20 and 30 are overlapped with each other by alignment so as to position the second metal layer 37 onto the low melting point metal 16 on the first panel 20.

[0062] In this state, the first and second metal layers 27 and 37 face each other sandwiching the low melting point metal 16 and the first and second metal layers 27 and 37 are in close contact with the low melting point metal 16.

[0063] The first and second panels 20 and 30 are pressurized in a vacuum ambience while the first and second panels 20 and 30 are heated at a part where the first and second metal layers 27 and 37 are disposed.

[0064] The low melting point metal 16 is composed of a metal (either single metal or alloy) having a melting point lower than the melting points of the first and second metal layers 27 and 37. The surfaces of the first and second metal layers 27 and 37 and the melted low melting point metal 16 have a good wettability, and when the low melting point metal 16 is melted, the melted material spreads over the first and second metal layers 27 and 37 and is solidified to form the low melting point metal layer 18.

[0065] When the melted material is solidified by cooling, the first and second metal layers 27 and 37 are made to adhere to each other by the low melting point metal layer 18. In this state, the ring-shaped hermetically-sealed part 17 is formed by a metal film (accumulated film) accumulated with the first and second metal layers 27 and 37 and the low melting point metal layer 18, each of which has a ring shape, and the light emitting region 15 is surrounded by the hermetically-sealed part 17. The first and second metal layers 27 and 37 are fixed to the first and second panels 20 and 30, respectively.

[0066] The formation condition of the hermetically-sealed part is shown in the following Table 2.

Table 2: Formation condition of hermetically-sealed part

Attained pressure (Pa)	5.0×10^{-4}
Panel temperature increasing rate (°C/min)	20
Panel sealing temperature (°C)	175
Pressure at sealing (Pa)	5.0×10^{-4}

(continued)

Sealing time (min)	1.0
Panel temperature decreasing rate(°C/min)	20
Take-out temperature (°C)	50

[0067] After the formation of the hermetically-sealed part 17, the first and second panels 20 and 30 are carried into a sealing chamber and the sealing material is applied.

[0068] In the state after the formation of the hermetically-sealed part 17, the sealing material is in contact with both of the first and second panels 20 and 30, and when the sealing material is irradiated with ultraviolet light and solidified to form the ring-shaped sealing part 41 outside the hermetically-sealed part 17, the first and second panels 20 and 30 are fixed to each other with a sufficient strength by the sealing part 41 (Step T_1).

[0069] In this state, the light emitting region 15 is surrounded by the hermetically-sealed part 17 and the light emitting region 15 has a vacuum ambience.

[0070] Reference numeral 20a of Fig. 3 shows an example of the arrangement state of the light emitting region 15, the hermetically-sealed part 17, and the sealing part 41 on the first substrate 21.

[0071] In the above example, the sealing part 41 has a ring shape and the hermetically-sealed part 17 and the light emitting region 15 are disposed within the sealing part 41. However, the first and second panels 20 and 30 may be fixed to each other by a plurality of sealing parts 41_1 to 41_4 separated from each other as shown by reference numerals 20c and 20d in Figs. 5(a) and 5(b).

[0072] In this case, the spacing between the plurality of sealing parts 41_1 to 41_4 may be disposed at a corner part of the first substrate 21 as shown by reference numeral 20c in Fig. 5(a), or may be disposed in a side part as shown by reference numeral 20d in Fig. 5(b).

[0073] Further, many dot-like sealing parts 41n may be disposed around the hermetically-sealed part 17 as shown by reference numeral 20e in Fig. 5(c).

[0074] After the formation of the sealing part 41, the discharge gas is introduced into the light emitting region 15. A gas introduction opening is provided passing through the first panel 20 in the thickness direction at a position inside the hermetically-sealed part 17 in the first panel 20. Thedischarge gas enters a region surrounded by the hermetically-sealed part 17 from the gas introduction opening, and the light emitting region 15 is filled with the discharge gas.

[0075] When the gas introduction opening is blocked after the discharge gas introduction, the light emitting region is hermetically sealed by the first and second panels 20 and 30 and the hermetically-sealed part 17 so that the light emitting region is isolated from the outside atmosphere while being filled with the discharge gas. Then, the plasma display panel 10 of Fig. 1 is obtained (Step T_2). After hermetically sealed, the plasma display panel 10 is carried outside the sealing chamber.

[0076] In addition, as shown by reference numeral 20b in the plan view of Fig. 4(a) and the cross-sectional view thereof in Fig. 4(b), an auxiliary exhaust opening 28 is provided passing through the first or second panel 20 or 30 in the thickness direction at a position between the hermetically-sealed part 17 and the sealing part 41 in either one of or both of the first and second panels 20 and 30, so that the portion between the hermetically-sealed part 17 and the sealing part 41 is not provided with an increased pressure or reduced pressure by the change of atmosphere temperature.

Example 1

[0077] A plasma display panel 10 of the present invention prepared by using Ne-4%Xe gas as a discharge gas introduced in the light emitting region 15 at 400 Torr and being sealed, is carried into a constant temperature-and-humidity chamber at 85 degrees Celsius and 95% humidity and the storage change of the discharge voltage is measured. A relationship between the storage time and the discharge voltage is shown in Fig. 6(a).

[0078] For comparison, the discharge voltage of the conventional plasma display panel 110 (Fig. 11), which does not have the hermetically-sealed part 17 and has the light emitting region isolated from the outside atmosphere by use of the resin material sealing part, was measured under the same condition. A relationship between the storage time and the discharge voltage is shown in Fig. 6(b).

[0079] The final cell light-on voltage is a drive voltage required for starting the discharge of all the cells. Further, the first cell light-off voltage is a voltage at which the first cell puts the light off when the drive voltage is reduced gradually from the state of the light-on in all the cells.

[0080] While the drive voltage is constant even in a long storage time for the plasma display panel 10 of the present invention, both of the final cell light-on voltage and the first cell light-off voltage increase considerably in a short time storage for the plasma display panel 110 of the conventional art. This is supposedly because moisture in the constant temperature-and-humidity chamber was transmitted through the sealing part 141 to enter between the first and second

panels 120 and 130 and the purity of the discharge gas was deteriorated.

[0081] In the plasma display panel 10 of the present invention, the voltage change is within 5 V even when the storage time is increased, and it is apparent that the impurity gas (moisture) transmitted through the sealing part 41 was prevented from entering the light emitting region 15 by the hermetically-sealed part 17.

[0082] Note that the conventional plasma display panel 110 as well as the plasma display panel of the present invention was processed within the vacuum ambience without being taken out to the air atmosphere from the protection film formation to the discharge gas introduction and sealing.

Example 2

[0083] Next, the plasma display panel 10 of the present invention was carried into the constant temperature-and-humidity chamber at 50°C and 50% humidity and stored in the state that the light was emitted by the voltage application to the electrode, and the discharge voltage was measured. A relationship between a time of voltage application to the electrode (aging time) and the discharge voltage is shown in Fig. 7(a).

[0084] For comparison, the discharge voltage of the conventional plasma display panel 110 (Fig. 11), which does not have the hermetically-sealed part 17 and has the light emitting region isolated from the outside atmosphere by use of the resin material sealing part, was measured under the same condition. A relationship between the aging time and the discharge voltage is shown in Fig. 7(b).

[0085] In the plasma display panel 10 of the present invention, the voltage increase is 10 V or smaller even when the aging time reaches 2,000 hours. This is supposedly because the ultraviolet light emitted from the plasma was blocked by the hermetically-sealed part 17 not to irradiate the sealing part 41 so that the sealing part 41 was not decomposed, and the impurity gas was prevented from being extricated.

[0086] In the conventional plasma display panel 10, the discharge voltage increases along with the increase of the aging time and the final cell light-on voltage increases by about 30 V after an aging time of 2,000 hours. This is supposedly because the ultraviolet light generated by the PDP discharge irradiated into the sealing material for long hours to decompose the resin material contained in the sealing material, and the impurity gas of the CH-series was extricated into the PDP to deteriorate the purity of the discharge gas.

[0087] Note that, while the ultraviolet curable type epoxy resin was used for the sealing material in the above examples, another resin may be used. Further, not limited to the ultraviolet curable type, thermosetting type may be used.

[0088] Moreover, while the first and second substrates 21 and 31 were glass substrates in the above examples, the present invention is not limited thereto and another material can be used as far as the second substrate 31 is transparent.

Industrial Applicability

[0089] The present invention can be applied to the PDP production process using MgO protection film which includes an air atmosphere process, in addition to a PDP production process by vacuum consecutive processing equipment. Furthermore, the present invention can be utilized for the sealing methods of FED (Field Emission Display) and SED (Surface-Conduction Electron-Emitter Display).

Claims

1. A plasma display panel, comprising:

first and second panels having first and second substrates, respectively, and arranged to face each other;
a light emitting region located between the first and second substrates;
a sealing part located outside the light emitting region and including resin which fixes the first and second panels to each other; and
a hermetically-sealed part including a ring-shaped metal film surrounding the light emitting region,
wherein the sealing part is located outside the hermetically-sealed part.

2. The plasma display panel according to claim 1, the hermetically-sealed part further comprising:

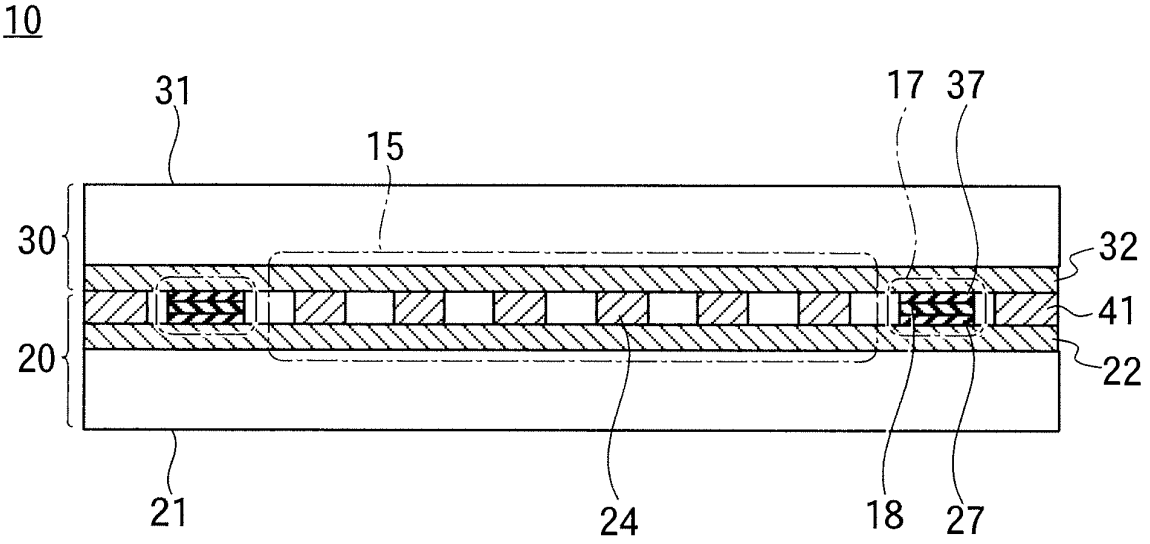
first and second metal layers tightly adhering to the first and second panels, respectively; and
a low melting point metal layer located between the first and second metal layers and having a melting point lower than those of the first and second metal layers so as to adhere the first and second metal layers each other.

3. The plasma display panel according to claim 1, wherein the resin in the sealing part is a thermosetting resin.

4. The plasma display panel according to claim 1, wherein the resin in the sealing part is an ultraviolet curable resin.

5. The plasma display panel according to claim 1, wherein the sealing part has a ring shape and surrounds the hermetically-sealed part.

6. The plasma display panel according to claim 4, further comprising
an exhaust opening provided between the sealing part and the hermetically-sealed part.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18
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Fig. 1

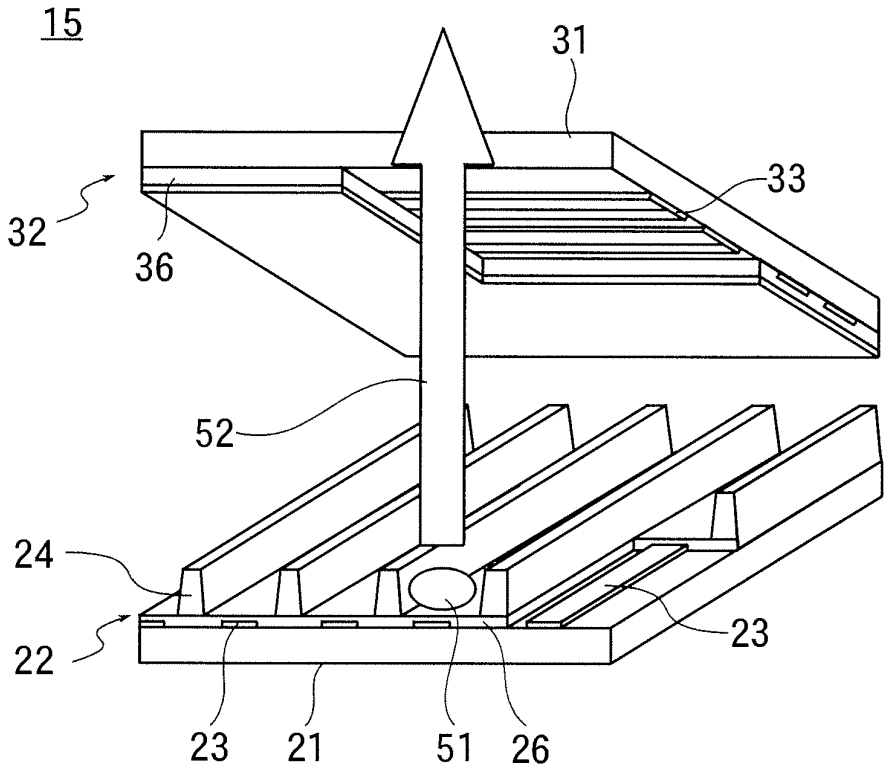
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Fig. 2

Fig. 3

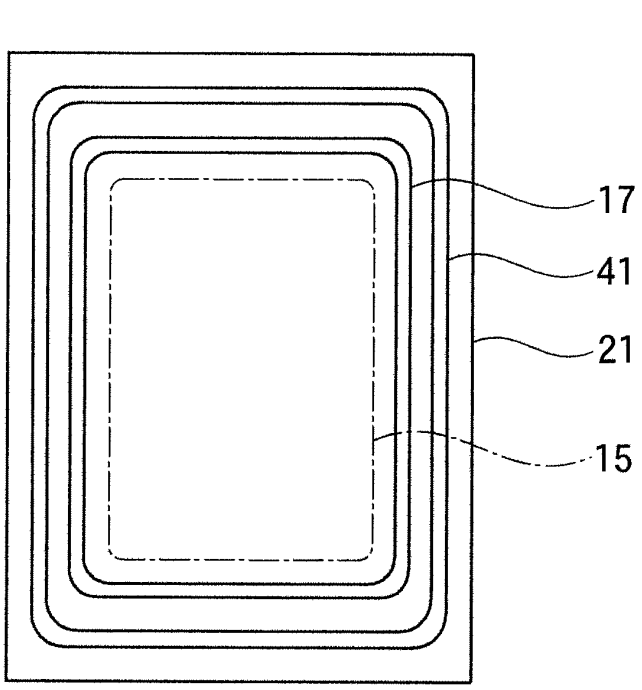


Fig. 4 (a)

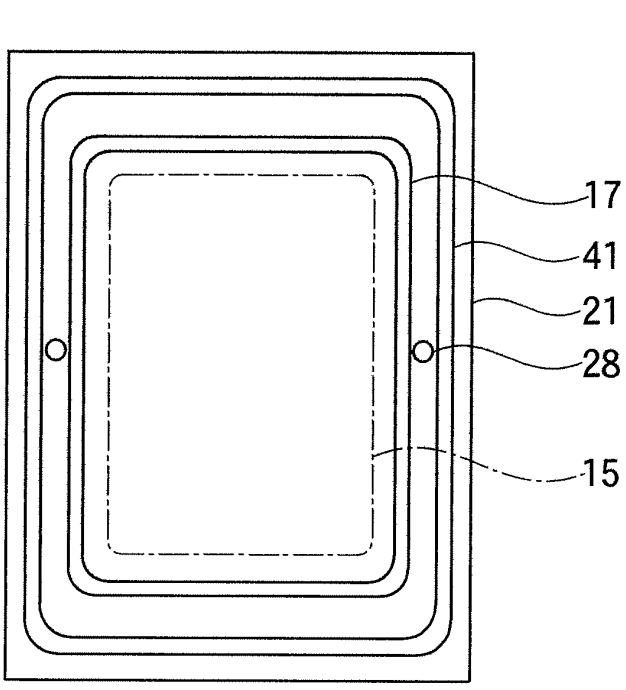
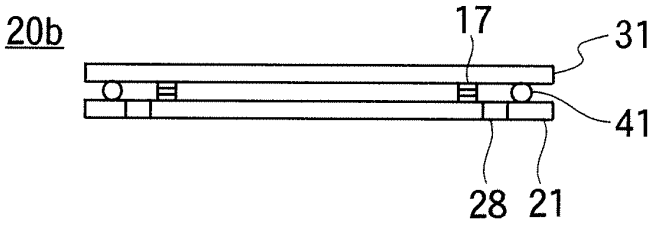


Fig. 4 (b)



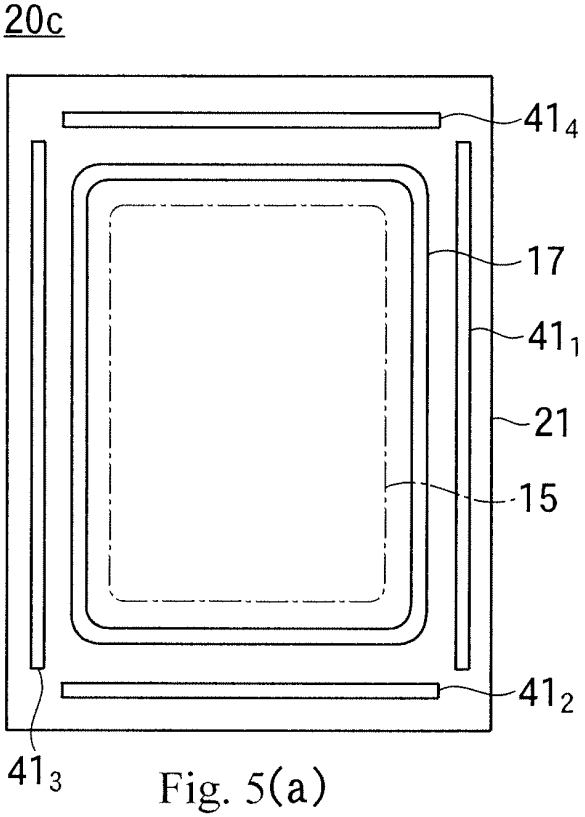


Fig. 5(a)

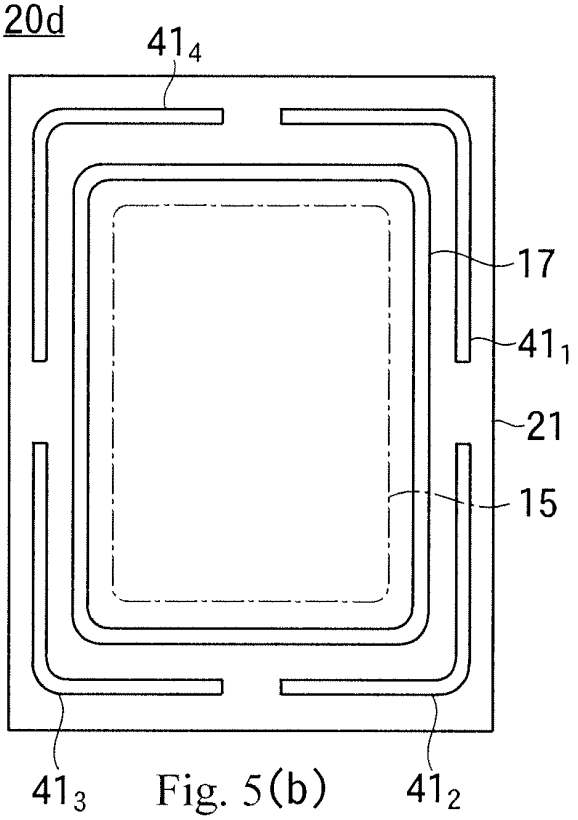


Fig. 5(b)

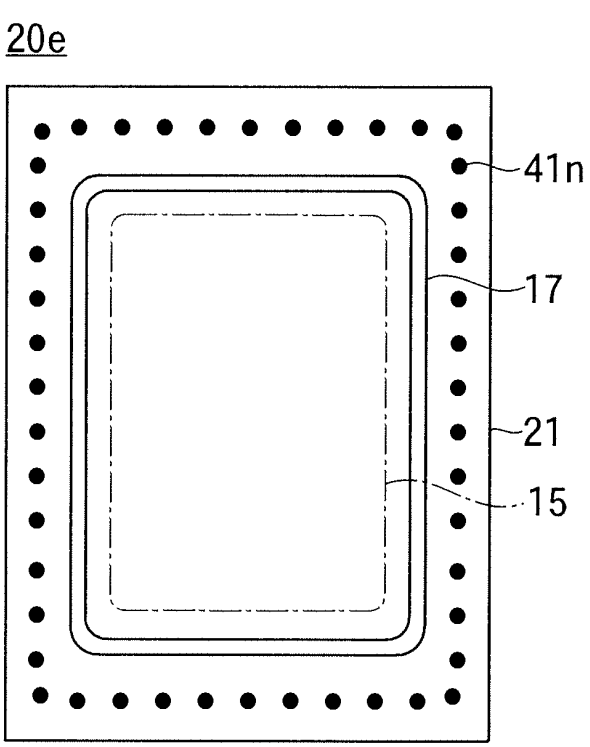


Fig. 5(c)

Fig. 6(a)

Relationship between strage time and discharge voltaeg in PDP of the present invention

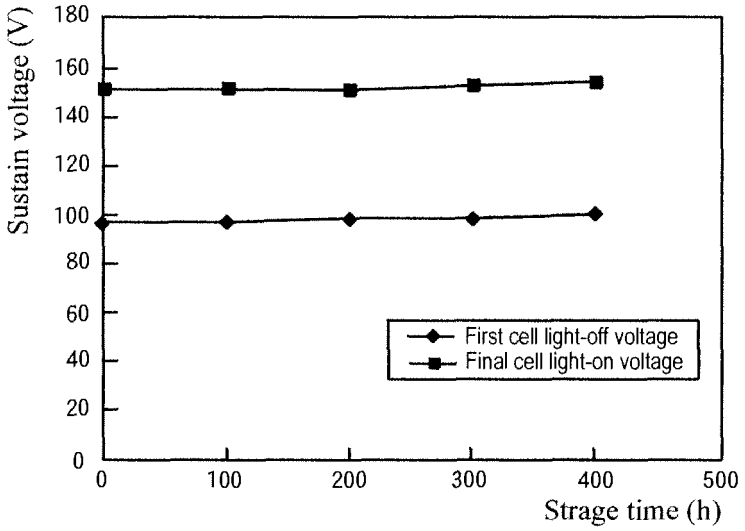


Fig. 6(b)

Relationship between strage time and discharge voltaeg in PDP of the conventional art

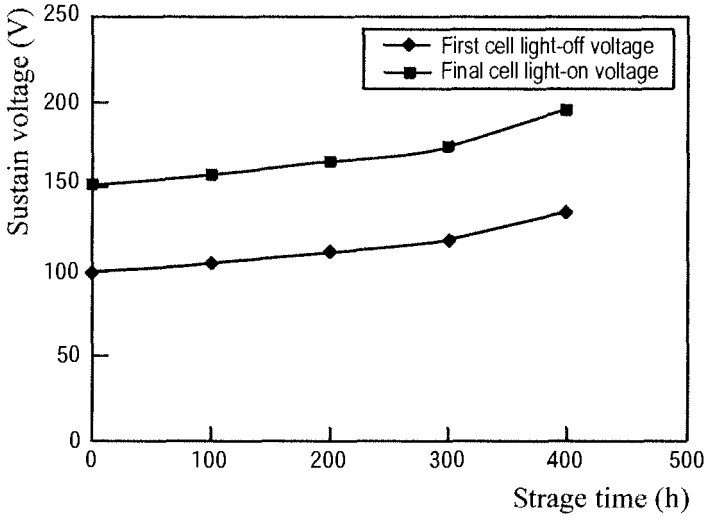


Fig. 7(a)

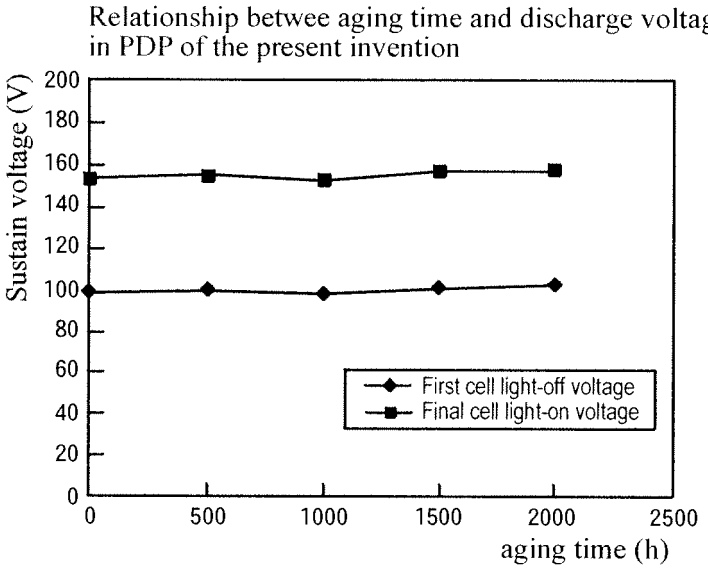

Relationship betwee aging time and discharge voltage in PDP of the present invention
Sustain voltage (V)
200
180
160
140
120
100
80
60
40
20
0
0
500
1000
1500
2000
2500
aging time (h)
First cell light-off voltage
Final cell light-on voltage

Fig. 7(b)

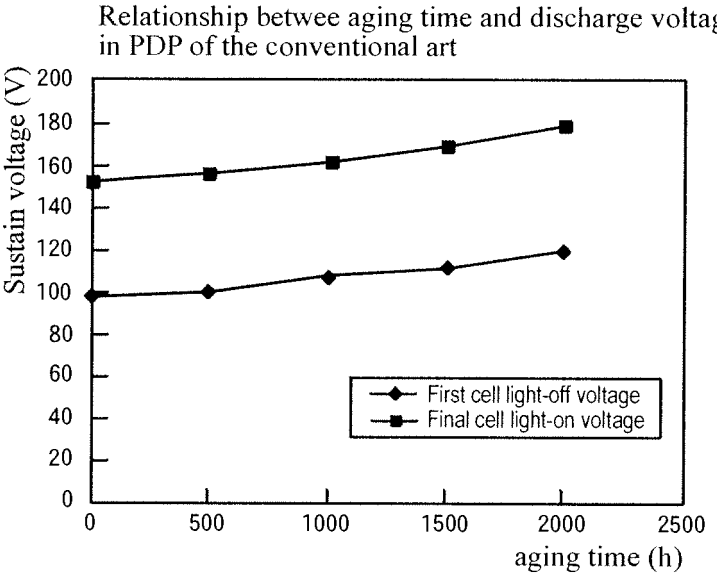

Relationship betwee aging time and discharge voltage in PDP of the conventional art
Sustain voltage (V)
200
180
160
140
120
100
80
60
40
20
0
0
500
1000
1500
2000
2500
aging time (h)
First cell light-off voltage
Final cell light-on voltage

Fig. 8(a)

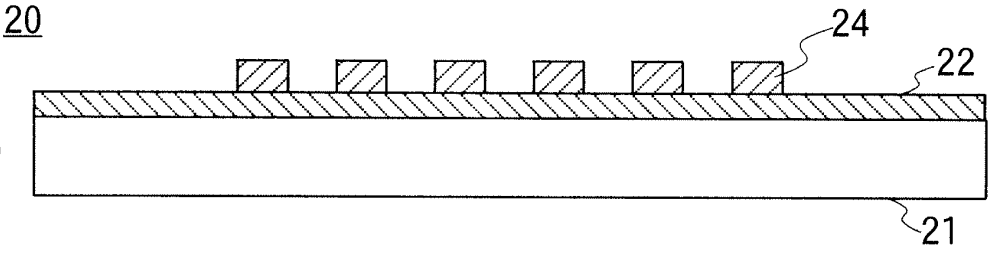


Fig. 8(b)

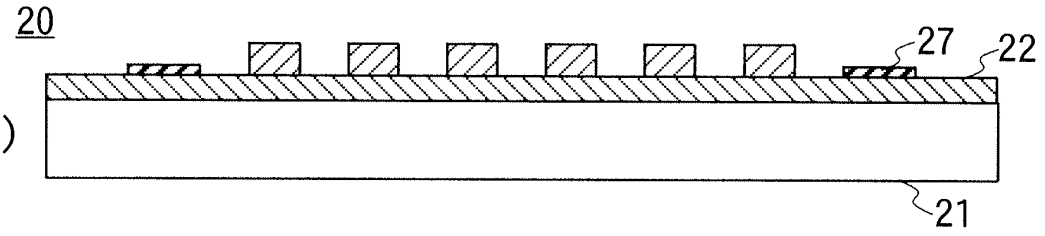


Fig. 8(c)

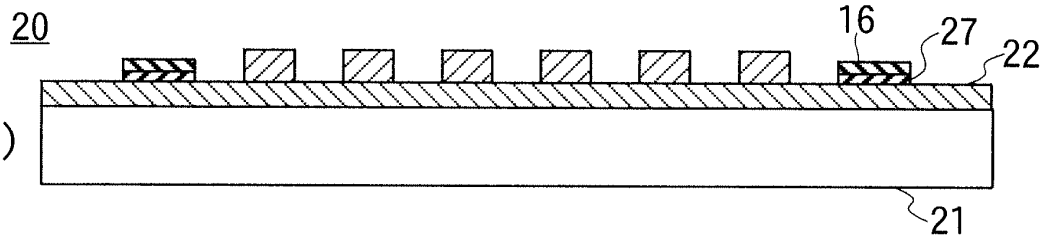


Fig. 9(a)

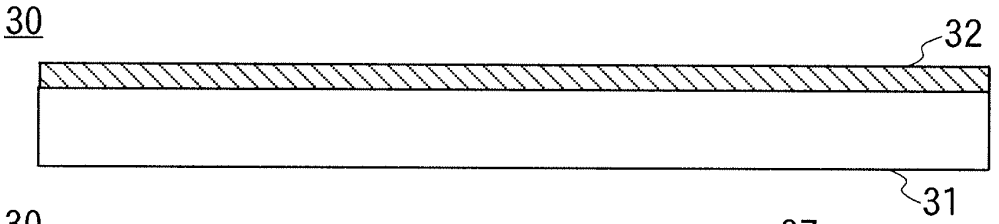


Fig. 9(b)

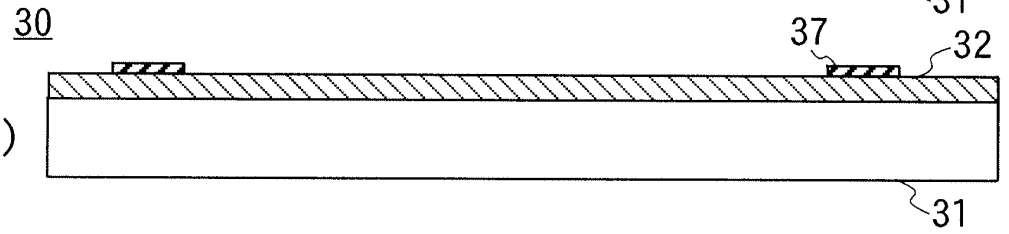
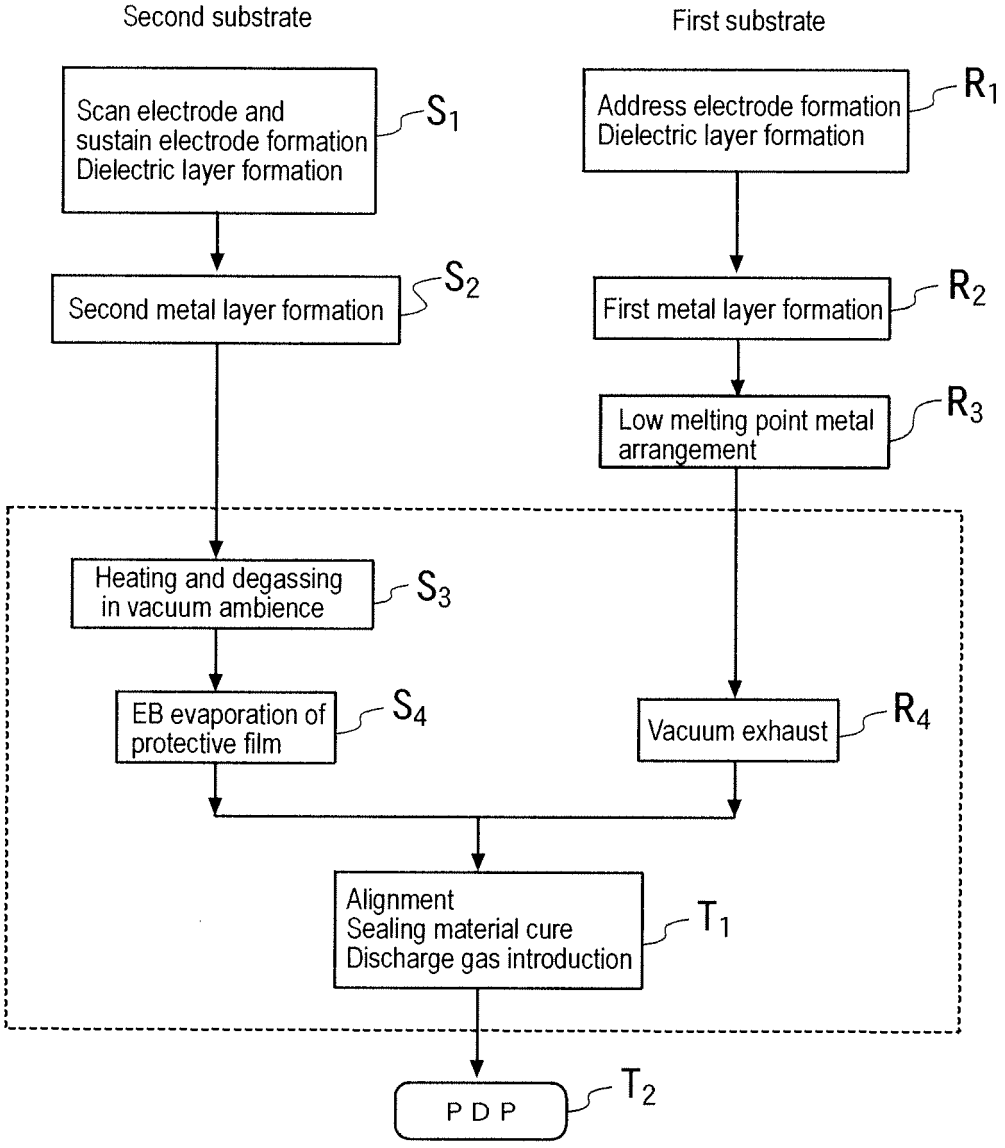


Fig. 10


Second substrate
First substrate
Scan electrode and sustain electrode formation Dielectric layer formation
S1
Address electrode formation Dielectric layer formation
R1
Second metal layer formation
S2
First metal layer formation
R2
Low melting point metal arrangement
R3
Heating and degassing in vacuum ambience
S3
EB evaporation of protective film
S4
Vacuum exhaust
R4
Alignment Sealing material cure Discharge gas introduction
T1
PDP
T2

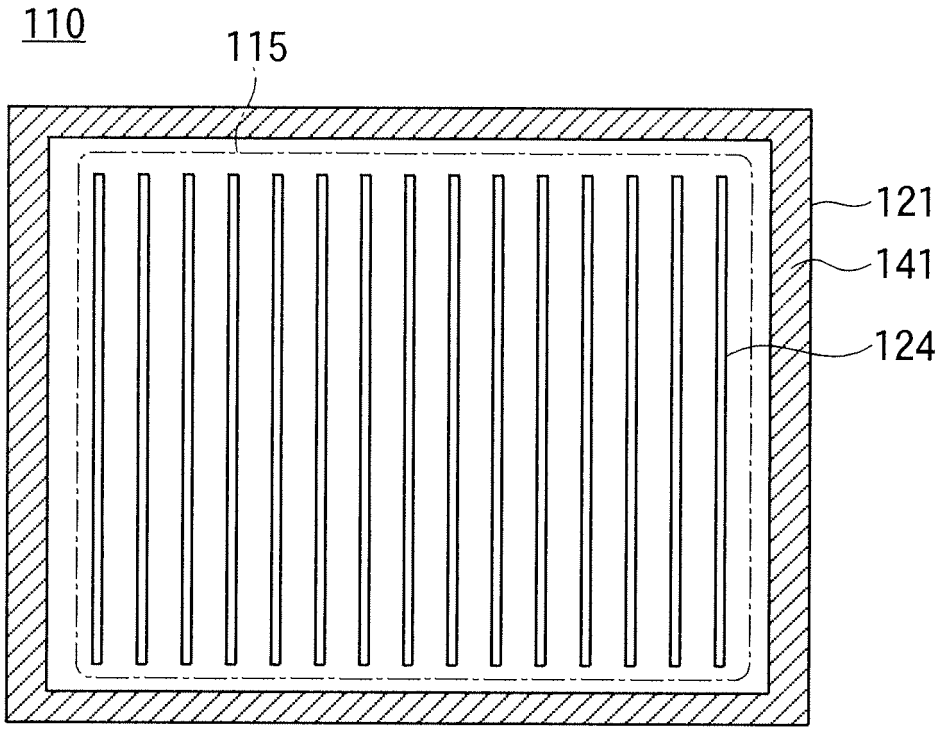


Fig. 11 (a)

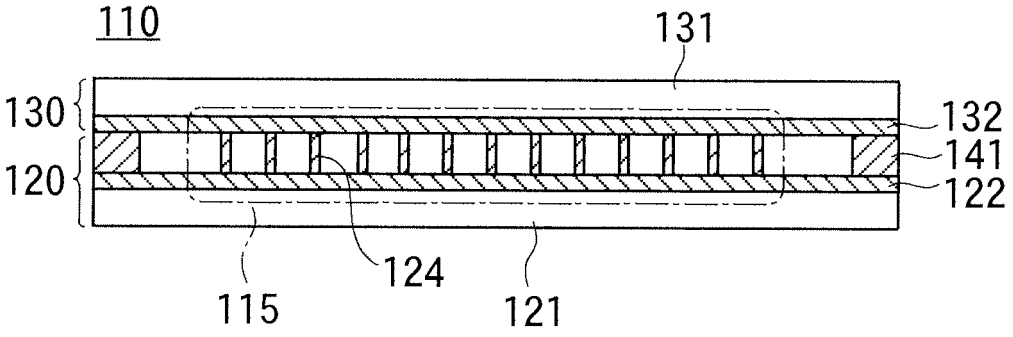


Fig. 11(b)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/054350

A. CLASSIFICATION OF SUBJECT MATTER
H01J11/02(2006.01)i, *H01J29/86*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01J11/00-17/64

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2008
Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2006-324026 A (Matsushita Electric Industrial Co., Ltd.), 30 November, 2006 (30.11.06), Par. Nos. [0036] to [0054]; Fig. 4 (Family: none)	1,3-6 2
X A	WO 2006/019032 A1 (Matsushita Electric Industrial Co., Ltd.), 23 February, 2006 (23.02.06), Figs. 15 to 19; Par. Nos. [0098] to [0114] (Family: none)	1,3-5 2
A	JP 2002-163977 A (Sony Corp.), 07 June, 2002 (07.06.02), Figs. 1 to 3; Par. Nos. [0020] to [0040] (Family: none)	1-6

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 May, 2008 (19.05.08)	27 May, 2008 (27.05.08)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/054350

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/054350

Continuation of Box No.III of continuation of first sheet(2)

For the reasons stated below, this international application is considered to contain two inventions which do not satisfy the requirement of unity of invention.

Main Invention: claims 1-5
Second Invention: claim 6

The international search has revealed that the invention of claim 1 is not novel or does not involve an inventive step in view of the following document 2.

Document 2: WO 2006/019032 A1 (Matsushita Electric Industrial Co., Ltd.), 23 February, 2006 (23.02.06), Figs. 15-19, paragraphs 0098-0114, (no patent family members)

Consequently, the technical feature of claim 1 cannot be considered as a "special technical feature" within the meaning of PCT Rule 13.2, second sentence.

There is therefore no technical relationship between the main invention and the second invention involving one or more of the same or corresponding special technical features.

Incidentally, since the invention of claims 3-5 is not novel or does not involve an inventive step in view of the document 2, it is considered to fall under the same group of inventions as the invention of claim 1.

Form PCT/ISA/210 (extra sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2002075197 A **[0016]**
- JP 2002156160 A **[0016]**
- JP 2002231129 A **[0016]**
- JP 2001210258 A **[0016]**