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(54) **Method for fabricating plasma display panel**

Herstellungsverfahren einer Plasmaanzeigetafel

Procédé de fabrication d'un paneau d'affichage à plasma

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(73) Proprietor: **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**
Kadoma-shi, Osaka-fu, 571 (JP)

(72) Inventors:
- **Funakoshi, Yasutomo**
  Sakai-shi, Osaka-fu 591 (JP)
- **Iwasaki, Takayuki**
  Katano-shi, Osaka-fu 576 (JP)
- **Sekihara, Toshinobu**
  Hirakata-shi, Osaka-fu 573 (JP)
- **Sasaoka, Yasuhiko**
  Kyoto-fu 617 (JP)
- **Akata, Yasuyuki**
  Takatsuki-shi, Osaka-fu 569 (JP)
- **Matsunaga, Koji**
  Katano-shi, Osaka-fu 576 (JP)
- **Miwa, Kiyohito**
  Ikoma-shi, Nara-ken 630-01 (JP)

(74) Representative: **Eisenführ, Speiser & Partner**
Martinistrasse 24
28195 Bremen (DE)

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method for fabricating a plasma display panel wherein the method can produce a fluorescent material layer in a desired shape with stability.

[0002] In recent years, with the development of display devices having high precision and yet fine image quality, such as the high-vision system, display means have also been in demand for larger size and higher definition.

[0003] The CRT display system is capable of providing display tubes with high emission intensities, while they have been available in sizes of 30 to 40 inches. However, the CRT display system has a drawback that it is difficult to upsize beyond 40 inches due to its structural limitations.

[0004] Meanwhile, the liquid crystal display system, although having some advantages including low power consumption and the unit's compactness, has disadvantages that it is incapable of providing high emission intensities, and that it is too complex in structure to upsize except for the projection type.

[0005] In contrast to those systems, the plasma display system has advantages such as the implementation of a display unit comparable in emission intensity to the CRT system, relatively simple structure, the capability to be upsized, and the unit's compactness. From these points of view, the plasma display system has been receiving growing attention as a substitute for the CRT display system or liquid crystal display system.

[0006] The panel of this plasma display system has two substrates, and a large number of cells having such a structure that fluorescent material layers, electrodes, and discharge gas are contained in minute spaces surrounded by partition walls provided on the substrates. When the discharge gas between the electrodes in each cell is excited, ultraviolet rays are generated by the excited discharge gas returning to the ground state, causing the fluorescent materials in the fluorescent material layers to emit light. This is the formation of pixels.

[0007] It has been conventional practice to employ the screen printing process for the fabrication of the fluorescent material layers in this plasma display panel. This process, unfortunately, has limitations in printing precision such that patterns of higher than around 100 μm definitions could hardly be obtained. Besides, in the screen printing process, in order to form a thick film, the printing of the same pattern is repeated many times such that the pattern may shift gradually, making it impossible to obtain a desired pattern as another drawback.

[0008] Recently, however, grinding techniques making use of the sandblasting process or powder beam process have come to be exploited for fine processing, lending themselves to the fabrication of the plasma display panel in combination with the screen printing process.

[0009] In order to fabricate the fluorescent material layers by this process, lower electrodes, an electrode protective layer, and partition walls are first formed on the substrate on the rear surface side. Then, a fluorescent material paste composition composed of high polymer binder, fluorescent material, and solvent or water is filled in desired partition walls by the screen printing process and, as required, a resist pattern having an anti-blast property is provided on the partition walls, followed by blowing fine powder material. Thus, the grinding process is carried out by such a blasting process.

[0010] A paste-state composition with viscosity lower than about 100,000 cP is used as the fluorescent material paste composition. Therefore, by conducting a drying process after the paste-state composition is filled within the partition walls, shrinkage occurs due to its volumetric contraction so that the paste composition results in a mortar-shape. Thus, such a paste composition is suitable for the blasting process involving the blowing of fine powder.

[0011] However, when the grinding process is implemented by the blasting process, there is a possibility that the fluorescent material layers may be finished into various shapes depending on the differences in the filled state of the dried paste or the properties of the fluorescent material powder. In other words, since different colors of the fluorescent material layers involve differences in the hardness and the shape of fluorescent material powder, the filling amount of fluorescent material powder in the paste, and the like, the processed shape of the fluorescent material layer is unstable in shape such that fluorescent material layers of the same shape are difficult to obtain. This largely affects the stability of emission intensity and color balance, causing the issue that constant quality products are difficult to obtain. In particular, lack of uniformity of the electrode exposure area causes functional deteriorations such as intensity variations, creating a significant issue that affects the quality of the plasma display panel.

[0012] Since the processing is performed by the blasting process, it is necessary to select an organic high polymer binder that has good processibility. This leads to another issue of a narrow selective range of binder.

[0013] As yet another issue, the fluorescent material powder scattered in the processing by the blasting process may deposit on upper parts of the partition walls, thus forming bright spots of the plasma display panel, which may result in deteriorated quality.

[0014] JP-A-05 041159 discloses a method of making a PDP, in which partition walls are formed on a substrate and photosensitive liquid is applied.

SUMMARY OF THE INVENTION

[0015] It is therefore an object of the present invention to provide a method for fabricating a plasma display panel, which is capable of overcoming the instability in shape precision of the prior art and improving the stability in the quality of the plasma display panel.

[0016] In accomplishing these and other aspects, according to the present invention, there is provided a method for fabricating a plasma display panel, comprising the steps of:
forming on a substrate an electrode pattern comprising at least one light-impervious first electrode

forming on the substrate a light-transmittable insulating layer covering the electrode pattern so that a portion of the first electrode is not covered by the insulating layer;
providing at least one light-impervious second electrode being an anode or a cathode so as to contact the exposed portion of the first electrode;
providing partition walls on the insulating layer around the second electrodes to define spaces;
inserting a fluorescent-material-containing photosensitive or thermosetting paste for forming a fluorescent material layer containing a photosensitive or thermosetting resin in the spaces between the partition walls by using a screen openings corresponding to the spaces of the partition walls constituting spaces serving as discharge spaces for holding the fluorescent material layer on the substrate
curing the paste from a surface of the substrate opposite to the surface thereof where the partition walls are provided, whereby the paste is cured except for at least one uncured portion shadowed by the first and/or second electrode;
removing the uncured portion of the paste;
forming the fluorescent material layer by drying and then baking the paste; and
providing a cathode if the second electrode is an anode, or providing an anode if the second electrode is a cathode.

[0017] Further advantageous embodiments of the invention are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a partly enlarged perspective view of a plasma display panel obtained by a plasma display panel fabrication method according to a first embodiment of the present invention;
Figs. 2A, 2B, and 2C are sectional schematic views for explaining the procedure of fabricating electrode circuits obtained in the first embodiment;
Fig. 3 is a partial plan view of resistors and electrode circuits obtained in the first embodiment;
Figs. 4A, 4B, 4C, 4D, 4E, and 4F are sectional schematic views for explaining the procedure of fabricating the resistors and an electrode pattern obtained in the first embodiment;
Figs. 5A, 5B, 5C, and 5D are sectional schematic views for explaining the procedure of fabricating insulating layers and anodes obtained in the first embodiment;
Figs. 6A, 6B, and 6C are sectional schematic views for explaining the procedure of fabricating partition walls obtained in the first embodiment;
Figs. 7A, 7B, 7C, and 7D are sectional schematic views for explaining the procedure of fabricating a fluorescent material layer obtained in the first embodiment;
Fig. 8 is a perspective view of a screen used in a second embodiment of the present invention;
Fig. 9 is a partial sectional view showing the sectional configuration of the fluorescent material layer fabricated in the second embodiment;
Fig. 10 is a partial plan view showing the plan configuration of the fluorescent material layer fabricated in the second embodiment;
Fig. 11 is a partial sectional view showing the sectional configuration of the fluorescent material layer fabricated in a comparative example;
Fig. 12 is a partial plan view showing the planar configuration of the fluorescent material layer fabricated in the comparative example;
Fig. 13 is an enlarged sectional view of the fluorescent material layer of a plasma display panel obtained by a third embodiment of the present invention;
Fig. 14 is a partial plan view showing the planar configuration of the fluorescent material layer fabricated by a comparative example;

Fig. 15 is a perspective view of an AC type plasma display panel obtained by a plasma display panel fabrication method according to another embodiment of the present invention;
Fig. 16 is an outlining explanatory view of a DC type plasma display panel;
Fig. 17 is an outlining explanatory view of an AC type plasma display panel; and
Fig. 18 is an outlining explanatory view of an AC type plasma display panel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.
[0020] Fig. 1 is a partial perspective view showing a DC type color PDP (Plasma Display Panel) fabricated according to a first embodiment of the present invention.
[0021] Referring to Fig. 1, the color PDP I comprises a back side panel 2, and a front side panel 3 opposed to the back side panel 2 with a desired interval. The back side panel 2 has a rear side substrate 10, and partition walls 11 formed on the rear side substrate 10 in correspondence to pixels. The intervall between the back side panel 2 and the front side panel 3 is controlled by the partition walls 11.
[0022] The rear side substrate 10 is made of light-transmittable glass. On the rear side substrate 10, island-shaped electrodes 20 arrayed into a matrix, electrode buses 22 for connecting the island electrodes 20 with one another, and resistors 21 for connecting the electrode buses 22 and the island electrodes 20 with each other are formed in pluralities. These island electrodes 20, resistors 21, electrode buses 22, and the like are respectively formed from an electrically conductive composition in which electrically conductive material such as silver or ruthenium oxide is mixed with glass. The electrode buses 22 are ladder-like members branched off to right and left, and are so structured that a pair of right-and-left ladder-like members extending in one direction (vertical direction in Fig. 1) on the rear side substrate 10 are arrayed in a large number in the horizontal direction in Fig. 1 with intervals. Between one pair of electrode buses 22 and another, an auxiliary bus 23 is formed. The island electrodes 20 are each disposed between portions 22a corresponding to the crossbars of the ladder-like members of the electrode buses 22. The resistors 21 are each installed between the island electrode 20 and the crossbar-like portion 22a of the electrode buses 22. Voltages to be applied to the island electrodes 20 depend on the resistors 21.
[0023] On the rear side substrate 10, an insulating layer 15 is formed so as to cover the island electrodes 20, the resistors 21, and the electrode buses 22, including the regions where the auxiliary buses 23 are formed. The insulating layer 15 is made of a dielectric material such as glass, and has through holes 16 formed at portions opposite to the island electrodes 20. At the through holes 16, anodes 13 respectively connected to the island electrodes 20 are formed. The auxiliary buses 23 also have through holes 16a formed at the same pitch as the through holes 16. At the through holes 16a, auxiliary anodes 24 are formed for higher response speed of display.
[0024] The partition walls 11 are formed on the insulating layer 15 and arrayed into a matrix so as to each surround the anode 13. In each partition wall 11, either one of display cells 14_R, 14_G, or 14_B having a fluorescent material layer 17_R, 17_G, or 17_B of one of three colors, red, green, and blue is disposed. In this embodiment, two green display cells 14_G are positioned oblique, and blue and red display cells 14_B and 14_R are positioned oblique so as to cross them. Thus, these four display cells 14_R, 14_G, 14_G, and 14_B make up one pixel.
[0025] The front side panel 3 has a front side substrate 12 made of light-transmittable glass. On a surface of the front side substrate 12 facing the rear side substrate 10, a cathode line 25 extending perpendicularly to the electrode bus 22 is buried at a position facing the anode 13. This cathode line 25 is formed in a way that paste-state electrically conductive ink containing aluminium etc. is filled in a groove formed in the front side substrate 12 by a screen printing process or the like. Further, priming spaces (not shown) for leading charges to the display cells 14_R, 14_G, 14_B are also formed on the front side substrate 12.
[0026] Next, the procedure of fabricating the back side panel 2 of the DC type color PDP adopting the first embodiment of the present invention is explained with reference to Figs. 2 through 7.
[0027] In the first embodiment of the present invention, the conductor circuit for the electrode buses 22, the resistors 21, and the like is first formed on the rear side substrate 10. Then, the insulating layer 15, and the partition walls 11 are stacked thereon one by one. Finally, the fluorescent material layers 17_R, 17_G, 17_B are formed within the partition walls 11, by which the back side panel 2 is fabricated.
[0028] In this fabrication procedure, first, an electrically conductive photosensitive resin film 30 that will result in the rear side substrate 10, the island electrodes 20, the electrode buses 22, and the auxiliary buses 23, an insulating photosensitive resin film 40 that will result in the insulating layer 15, an electrically conductive resin paste 38 that will result in the resistors 21, and a partition wall-forming film 45 that will result in the partition walls 11 are prepared. Besides, a fluorescent-material-containing photosensitive resin paste 50 (50_R, 50_G, 50_B) that will result in the fluorescent material layers 17_R, 17_G, 17_B is also prepared.
[0029] The electrically conductive photosensitive resin film 30 that will result in the electrode buses 22 and the aux-

iliary buses 23 is preferably prepared by mixing a powder including conductive metal powder composed of glass powder and silver, and filler, with a resin composition containing crosslinking or other type organic high polymer binder, photoreaction initiator, and photoreaction accelerator, and then by developing the mixture into a sheet state on a separate film, with the resulting uniform thickness in the range of 5 - 10 µm. The filler may not be contained in the film 30. The insulating photosensitive resin film 40 that will result in the insulating layer 15 is preferably prepared by mixing a powder containing lead-series, zinc-series, or other like glass powder and filler such as boron oxide or silicon dioxide, with a resin composition containing crosslinking or other type of organic high polymer binder, photoreaction initiator, and photoreaction accelerator, and then by developing the mixture into a sheet state on a separate film, with the resulting uniform thickness in the range of 5 - 100 µm. The electrically conductive resin paste 38 that will result in the resistors 21 is preferably a paste prepared by mixing a powder including metal oxide powder containing glass powder and ruthenium oxide, or other which imparts the electrical conductivity with a crosslinking or other type of organic high polymer binder. The partition wall-forming film 45 that will result in the partition walls 11 is preferably prepared by mixing a powder containing lead-series, zinc-series, or other like glass powder and filler such as boron oxide or silicon dioxide, with a crosslinking or other type of organic high polymer binder. The fluorescent-material-containing photosensitive resin paste 50 that will result in the fluorescent material layers 17_R, 17_G, 17_B is preferably a paste prepared by mixing an ultraviolet-ray emission type fluorescent material powder with a resin composition containing crosslinking or other type of organic high polymer binder, photoreaction initiator, and photoreaction accelerator, with the possibly uniform.

[0030] Over the preparation of these materials, the electrode buses 22, the auxiliary buses 23, and the island electrodes 20 are first formed on the rear side substrate 10. As shown in Fig. 2A, the electrically conductive photosensitive resin film 30 is adhered first to the rear side substrate 10. For this adhesion, the separate film, positioned on top, is developed and adhered onto the rear side substrate 10 with a roll or the like. Subsequently, as shown in Fig. 2B, a mask 31 having light-transmitting portions 31a provided at places corresponding to the shapes and positions of the electrode buses 22, the auxiliary buses 23, and the island electrodes 20 is positioned and set above the rear side substrate 10, in which state the electrically conductive photosensitive resin film 30 is exposed to light. Then, as shown in Fig. 2C, through a developing process with a desired developer such as pure water, water solution of sodium carbonate, water solution of tetramethyl ammonium hydroxide, or water solution of sodium hydroxide, for example, exposed portions 30a are cured so that the electrically conductive resin, that will result in the electrode buses 22, the auxiliary buses 23, and the island electrodes 20, is formed. After drying, this is baked with the temperature held at 620 to 650°C for about 0.5 hour as one example, by which organic components or any excess components contained in uncured resin film or cured electrically conductive resin are removed. As a result, the electrode buses 22 each in the form of a ladder-like member, the auxiliary buses 23 each in linear form, and the island electrodes 20 arrayed into a matrix can be obtained at a uniform thickness of 4.8 to 5.2 µm. In this way, by using the electrically conductive photosensitive resin film 30 with uniform thickness in the formation of the conductor circuit of the electrode buses 22 and the like, as compared with their formation performed by the screen printing process variation in electrical resistance value due to time deterioration which is caused by evaporation of ink solvent or the like, as well as variation in electrical resistance value due to deviation of component particles of the mixture within ink can be suppressed. Thus, a stable electrical circuit can be obtained.

[0031] Subsequently, the resistors 21 are formed in such a way that the electrode buses 22 and the island electrodes 20 are connected to each other via the resistors 21. For the formation of the resistors 21, as shown in Fig. 4A, photoresist 35 is applied uniformly to the rear side substrate 10. Then, as shown in Fig. 4B, a mask 36 having light-shielding portions 36b provided at places corresponding to the shapes and positions of the resistors 21 is positioned and set above the rear side substrate 10, in which state the photo-resist 35 is exposed to light. Then, as shown in Fig. 4C, through a developing process with a desired developer such as pure water, water solution of sodium carbonate, water solution of tetramethyl ammonium hydroxide, or water solution of sodium hydroxide, for example, rectangular recessed portions 37 that will result in the pattern of the resistors 21 are formed at unexposed portions 35a, so as to be partly exposed between the electrode buses 22 and the island electrodes 20.

[0032] Now that the recessed portions 37 are formed, as shown in Fig. 4D, an electrically conductive resin paste 38 is filled into the recessed portions 37 and dried. These filling and drying processes of the electrically conductive resin paste 38 are carried out a plurality of times, taking into account the possible contraction due to drying. Upon completion of the filling and drying processes, as shown in Fig. 4E, the surface is ground smooth by a wrapping device 400 and, besides, the filled conductive resin paste 38 is controlled to a specified value of thickness (surface height) (e.g., 10 to 15 µm). Then, through a baking with temperature kept at 600 to 620°C for about 0.5 hour as one example, organic components and the like contained in the photo-resist 35 of unexposed portions or the conductive resin paste 38 are removed, by which the resistors 21 are obtained as shown in Fig. 4F and Fig. 3. The resistors 21 obtained in this way are height-controlled so as to be uniform in thickness. Thus, variation in resistance value is reduced and variation in discharge voltage is less likely to occur. As a result, a successful color PDP with less variation in brightness for each pixel can be obtained.

[0033] After the resistors 21 are formed, the insulating layer 15 is fabricated so as to cover the resistors 21, the island electrodes 20, the electrode buses 22, and the auxiliary buses 23 while the portions where the auxiliary anodes 24 of the auxiliary buses 23 are formed and the portions where the anodes 13 of the island electrodes 20 are formed are exposed. Further, the anodes 13 and the auxiliary anodes 24 are formed by the screen printing process. In the formation of the insulating layer 15, as shown in Fig. 5A, the light-transmittable insulating photosensitive resin film 40 with the separate film up is developed and adhered onto the rear side substrate 10 with a roll or the like. Next, as shown in Fig. 53, a mask 41 having light-shielding portions 41a provided at places corresponding to such shapes and positions that the portions where the anodes 13 of the island electrodes 20 are formed and the portions where the auxiliary anodes 24 of the auxiliary buses 23 are formed are exposed is positioned and set above the rear side substrate 10, in which state the insulating photosensitive resin film 40 is exposed. Through a developing process with a desired developer such as pure water, water solution of sodium carbonate, water solution of tetramethyl ammonium hydroxide, or water solution of sodium hydroxide, as shown in Fig. 5C, the through holes 16 for formation of the anodes 13 and the through holes 16a for formation of the auxiliary anodes 24 are bored, for example, at unexposed portions 40a. Then, through a baking with temperature kept at 550 to 600°C for about 0.5 hour as one example, the insulating layer 15 can be obtained. After the insulating layer 15 has been obtained, the electrically conductive resin paste is filled into the through holes 16, 16a by the screen printing process, and dried and baked, by which the anodes 13 and the auxiliary anodes 24 are obtained as shown in Fig. 5D. In this way, by using the insulating photosensitive resin film 40 with uniform thickness for the formation of the insulating layer 15, the insulating layer 15 can be formed into more smooth, uniform thickness, compared to when it is formed by the screen printing. Therefore, variation in the distance between the anode 13 and the cathode is reduced, so that the variation in discharge gap is reduced.

[0034] With the anodes 13 formed, the partition walls 11 are then formed so as to surround the anodes 13. For the formation of the partition walls 11, as shown in Fig. 6A, the light-transmittable partition wall-forming film 45 with the separate film up is developed and adhered onto the insulating layer 15 of the rear side substrate 10 with a roll or the like. Subsequently, in order that low molecular weight substances contained in the partition wall-forming film 45 are urged to evaporate and that subsequent processing uniformity is obtained, heating is carried out for a certain time, followed by cooling. Then, a photosensitive film 53 with a separate film up is developed and adhered onto the partition wall-forming film with a roll or the like.

[0035] Next, as shown in Fig. 6B, a mask 46 having light-shielding portions 46a provided at places corresponding to the shapes and positions of the partition walls 11 is positioned and set above the rear side substrate 10, in which state the photosensitive film 53 is exposed. Through a developing process with a desired developer such as pure water, water solution of sodium carbonate, water solution of tetramethyl ammonium hydroxide, or water solution of sodium hydroxide, for example unexposed portions 53a are removed and matrix-shaped recessed portions 47 that will be the origin of the partition walls 11 are formed there.

[0036] Subsequently, glass beads etc. are blown onto portions 45a of the partition wall-forming film 45 exposed through the recessed portions 47 via air by using a sandblasting machine. As a result, as shown in Fig. 6C, each of the matrix-shaped recessed portions 48 surrounded by the partition wall 11 having such a shape that the thickness of the lower end portion on its substrate side is larger than that of the upper end portion on its opening side is formed on each of the anodes 13.

[0037] After the partition walls 11 have been formed, the fluorescent material layers 17_R, 17_G, 17_B are formed within the partition walls 11. For the formation of the fluorescent material layers 17_R, 17_G, 17_B, as shown in Fig. 7A, for example, red-fluorescent-material-containing photosensitive resin paste 50_R is dropped from a screen 151 into the partition walls 11 with a squeegee 150 or the like. Next, hot air drying is carried out at about 100°C for 10 minutes as one example, followed by cooling. In this way, the fluorescent material resin paste 50_R is formed within the partition walls 11 as shown in Fig. 7B. Subsequently, as shown in Fig. 7C, the layer of the fluorescent material resin paste 50_R is exposed to light by irradiating ultraviolet rays from below the rear side substrate 10. Then, through a developing process with a desired developer such as pure water, water solution of sodium carbonate, water solution of tetramethyl ammonium hydroxide, or water solution of sodium hydroxide, the fluorescent-material-containing photosensitive resin paste 50_R is left only at, for example, exposed portions 50a as shown in Fig. 7D and then the layer of the red fluorescent-material-containing photosensitive resin paste 50_R is obtained. These processes to the above are repeated similarly by using a green-fluorescent-material-containing photosensitive resin paste 50_G and a blue-fluorescent-material-containing photosensitive resin paste 50_B, by which green and blue fluorescent material layers 17_G and 17_B are obtained sequentially. Then, through a baking with temperature kept at 450 to 520°C for about 0.5 hour as one-example, organic components contained in the fluorescent-material-containing photosensitive resin pastes 50_R, 50_G, 50_B are evaporated with the result that the red fluorescent material layer 17_R is obtained. When the height of the fluorescent material layer obtained in the above fluorescent material layer-forming process is not sufficient, the fluorescent material layer-forming process is repeated desired times to overlap the layer with the previously-formed layer to obtain the fluorescent material layer having a desired height.

[0038] The fluorescent material layers 17_R, 17_G, 17_B obtained in this way are formed in a U-curved shape, or inverted temple bell shape, along the partition walls 11 with the help of the effect of such a configuration of the partition wall 11 that the thickness of the lower end portion is larger than that of the upper end portion. Therefore, the light emitted from the fluorescent material layers 17_R, 17_G, 17_B is irradiated forward with high efficiency. This allows the light emission efficiency to be improved so that a color PDP with high brightness and good contrast can be obtained. Further, since the removed fluorescent materials contained in the fluorescent-material-containing photosensitive resin pastes 50_R, 50_G, 50_B are removed prior to the curing process, it becomes possible to recycle the removed materials. Thus, there is less waste of expensive fluorescent material, as compared with the prior art.

[0039] Once the back side panel 2 is fabricated over these steps, it is bonded together with the front side panel 3 fabricated by a separate process, and inside air is replaced with inert gas such as helium and xenon, or helium and neon. Thus, the display section is completed. Finally, electronic circuits and a chassis are assembled, by which the PDP1 is completed.

[0040] Now, a method for fabricating a plasma display panel according to a second embodiment of the present invention is described with reference to Figs. 1 and Figs. 8 to 10.

[0041] Fig. 1 shows the substrate of a plasma display panel 1, where reference numeral 10 denotes a transparent substrate made of an about 2 mm thick glass substrate as one example; 20 denotes island electrodes formed on the transparent substrate 10 in a matrix in correspondence to pixels; 22 denotes electrode buses for constituting anode buses each extended along one direction of columns of the matrix-shaped island electrodes 20 and each connected to the island electrodes 20; 21 denotes resistors stretched over the connecting portions between the electrode buses 22 and the island electrodes 20; 15 denotes an insulating layer formed on the transparent substrate 10 so that the island electrodes 20 are exposed; 11 denotes partition walls made of glass fine particles etc. which are formed so as to surround the island electrodes 20; 17 (17_R, 17_G, 17_B) denote(s) fluorescent material layers formed within the partition walls 11; and 25 denotes a cathode line for constituting the cathode electrode provided on the partition walls 11 along the other direction of columns of the matrix-shaped island electrodes 20.

[0042] Next described is the molding process of the fluorescent material layers 17_R, 17_G, 17_B. The transparent substrate 10 on which the island electrodes 20, the electrode buses 22, the resistors 21, the insulating layer 15, and the partition walls 11 are formed, as well as a screen (mask) 31 as shown in Fig. 8 are set to a screen printing machine. Then, after the alignment of the position on the transparent substrate 10, where the partition walls 11 are formed, with the screen 31 is carried out, the fluorescent-material-containing photosensitive resin paste for forming the fluorescent material layers 17 is placed on the screen 31 in a necessary amount, and filled within the partition walls 11 of the transparent substrate 10 by using a squeegee. Compositions as shown in Table 1 were used as five Examples of the fluorescent-material-containing photosensitive resin pastes for forming the fluorescent material layers 17.

Table 1:

			(Wt%)
Examples	Fluorescent material powder-filled amount	Resin-filled amount	Crosslinking agent-filled amount
1	59.2	40.7	0.1
2	59.2	40.6	0.2
3	59.1	40.5	0.4
4	58.4	40.1	1.5
5	58.1	39.9	2.0

[0043] After the fluorescent-material-containing photosensitive resin paste filling process was carried out for each color, the transparent substrate 10 was set to an ultraviolet-curing apparatus, and ultraviolet rays were irradiated from the rear side of the transparent substrate 10 at a total quantity of light of 7.2 mW/cm^2 for about 3.5 seconds.

[0044] Next, the transparent substrate 10 over the photo-irradiation was set to a developing machine with the end faces of the partition walls 11 downward. Then, development was carried out for about 1 minute by spraying about 23°C pure water at a pressure of 1 kg/cm^2 as one example.

[0045] Upon completion of the development, the water deposited on the transparent substrate 10 was removed with an air knife (i.e., curtain-like air blow), followed by drying at about 80°C for 30 minutes as one example. Thus, the fluorescent material layers 17 of a DC type plasma display panel each having a configuration as shown in Figs. 9 and 10 were obtained.

[0046] After the drying process, an about 1 hour baking process was carried out in a 520°C air atmosphere oven as one example, followed by cooling. Then, a front side substrate to be paired was combined with the transparent substrate 10, by which the plasma display panel was completed.

[0047] Next, a Comparative Example is described. As in the Examples, with the use of the transparent substrate 10 as shown in Fig. 1 and the screen 31 as shown in Fig. 8, conventional thermo-drying type fluorescent material ink was filled into the partition walls 11 of the transparent substrate 10 as shown in Fig. 1. Subsequently, a drying process was carried out at about 120°C for 10 minutes, followed by cooling. Thereafter, fluorescent material layers formed in the partition walls 11 were processed by the blasting process. Then, foreign matters deposited on the surface of the substrate 10 were removed by air, by which fluorescent material layers 217 as shown in Figs. 11 and 12 were obtained. After that, an about 1 hour baking process was carried out in a 520°C air atmosphere oven, followed by cooling. Then, a front side substrate to be paired was combined with the transparent substrate 10, by which a plasma display panel was completed.

[0048] With regard to the products obtained in the above Examples and Comparative Example, their brightness and electrode-exposure hole precision were evaluated. In more detail, on the basis of the brightness of the product obtained in the Comparative Example (Comparative Example taken as 100), the brightnesses of the products obtained in the Examples were compared relatively. Also, the electrode-exposure hole precision was represented by a circularity characteristic given by a ratio of Y to X, where X is the minor diameter and Y is the major diameter, by measuring the planar configurations of the electrode-exposure holes of the fluorescent material layers 17, 117 formed in the partition walls 11, with a comparison to the Comparative Example. The evaluation results are shown in Table 2:

Table 2

		Relative comparison of brightness (%)	Precision of electrode-exposure hole diameter (Y/X)
Examples	1	115	1.00
	2	107	1.03
	3	100	1.05
	4	90	0.75
	5	87	0.7
Comparative Example		100	1.3

[0049] As apparent from Table 2, Examples 1, 2, and 3 showed superior characteristics over the Comparative Example.

[0050] It is noted that ultraviolet rays have been used as the curing means in the embodiments described above and later, electron beams or other like means may also be used to produce similar advantages.

[0051] According to the method for fabricating the plasma display panel, as apparent from the foregoing description, the fluorescent-material-containing photosensitive resin paste filled in the partition walls is cured in correspondence to the mask pattern by irradiating light from the rear side of the substrate. Therefore, by removing uncured portions thereafter, the fluorescent material layers of the plasma display panel of a specified pattern can be formed with high pattern precision in the partition walls.

[0052] According to the method in the present invention, since the fluorescent-material-containing photosensitive resin paste filled in the partition walls is exposed to light from a surface opposite to the surface on which the electrodes are formed, the electrode-exposure holes to be formed in the fluorescent material layers can be formed into a uniform, stable configuration, while the fluorescent material layers can be formed up to a proximity to the electrode-exposure holes. Therefore, the light emission area of the fluorescent material layers is increased so that the brightness as well as the uniformity of brightness are improved. Besides, the developing process can be accomplished only by removing the uncured portions. Thus, bright spots, a fault of image quality in assembled complete products, can be prevented from occurring due to the deposition of the fluorescent material powder at end portions of the partition walls, as would occur with the conventional mechanical processing technique by the sandblasting process. Further, there can also be eliminated a possibility that no formation of exposure electrode holes due to differences in hardness of fluorescent material layers causes no-lighting spots to be generated, advantageously.

[0053] According to the method in the present invention, the fluorescent-material-containing photosensitive resin paste filled in spaces within the partition walls is cured by irradiating light from the rear side of the substrate. Therefore, the electrode pattern formed on the substrate functions as a mask, so that fluorescent material layers of constant configuration can be formed in the partition walls at constant volume. Besides, the configuration of the electrode-exposure holes becomes uniform so that a functional deterioration due to unstable configuration of the electrode-exposure holes in the blasting process can be prevented. Further, since there is no need of carrying out the exposure process after alignment with the use of an exposure mask, as would be involved in a general exposure process, there occur no variations in the positions where the electrode-exposure holes are formed, which is due to precision variations in the exposure mask alignment. Thus, the electrode-exposure holes can be formed at positions corresponding to the electrodes.

[0054] Next, a plasma display panel and its fabrication method according to a third embodiment of the present invention are described with reference to Figs. 1 and 13.

[0055] Referring to Fig. 1, which is a perspective view showing the construction of an anode-side glass substrate (back side panel) 2 of the plasma display panel, reference numeral 10 denotes an about 2 mm thick glass substrate as one example; 20 denotes an island electrode; 21 denotes resistors for constituting adjustment resistors; 22 denotes electrode buses for constituting primary electrodes to be connected to the island electrodes 20 via the resistors 21; 23 denotes auxiliary buses for constituting auxiliary electrodes for normally applying a voltage close to the excitation voltage so that the electrode buses 22 can excite discharge gas without time delay; 15 denotes a light-transmittable insulating layer formed by screen-printing and baking glass powder paste more than one time so that only the island electrodes 20 are exposed; 13 denotes light-impervious exposed electrode, anode electrodes, formed by inserting and baking electrically conductive paste into the portions where the island electrodes 20 are exposed; and 11 denotes light-transmittable partition walls formed by screen-printing and baking glass powder paste more than one time on the insulating layer 15, where the spaces within the partition walls 11 will result in discharge cells.

Table 3:

(Unit: Wt%)			
Composition	Red paste	Green paste	Blue paste
Fluorescent material powder	48.3	43.4	41.4
Resin	39.1	42.9	44.1
Polymerization initiator	0.08	0.17	0.26
Polymerization promotor	0.16	0.34	0.26
Dispersion stabilizer	0.70	0.43	0.79
Solvent	11.66	12.76	13.19
Paste viscosity [cps]	Approx. 18000	Approx. 14000	Approx. 20000

[0056] Table 3 lists the blending of fluorescent-materlal-containing photosensitive resin pastes containing solvents used as examples in the third embodiment.

[0057] In the application process of the paste, the back side panel 2 as shown in Fig. 1 is set to a printing machine, and the screen is positioned on the back side panel 2 so that screen printing can be effected in the spaces of the partition walls 11. Then, the paste as shown in Table 3 is placed on the screen in a specified amount, and filled into the spaces of the partition walls 11 with the use of a squeegee as indicated by 17a in Fig. 13, followed by drying. This process is carried out for each color of red, green, and blue.

[0058] In this process, the paste 17a as shown in Fig. 13 is formed into a mortar-shape with the central portion recessed down, because the organic solvent or water content used in the paste 17a is dissipated. The degree at which the paste 17a is recessed differs depending on the blending of the paste. In either case where it is recessed to a little degree or to a large degree, the paste 17a is formed into a mortar-shape. However, the anode electrodes 13 are covered with the bottom of the mortar-shaped paste 17a so as not to be exposed.

[0059] In the ultraviolet-ray irradiation process, the back side panel 2 over the application of the paste 17a and drying is set to an ultraviolet curing apparatus, and ultraviolet rays are irradiated from the rear side of the back side panel 2 at a total quantity of light of 7.2 mW/cm^2 for about 3.5 seconds as one example. With this irradiation, since the glass substrate 10 is transparent and both the insulating layer 15 and the partition walls 11 formed by printing and baking glass powder paste more than one time are semitransparent, the ultraviolet rays irradiated from the rear side are transmitted except for upper opaque portions where the island electrodes 20 and the anode electrodes 13 are present, and irregularly reflected and diffused by the semitransparent insulating layer 15 and partition walls 11. In this way, the paste 17a is cured except the shadow portions of the island electrodes 20 and the anode electrodes 13 where the ultraviolet rays are not transmitted. Generally, the diameter of the anode electrodes 13 is slightly larger than that of the island electrodes 20. Accordingly, the paste 17a is cured, outside the island electrodes 20 and the anode electrodes 13, into a mortar-shape as shown in the minute fluorescent material layer 17 of Fig. 13. Also, since the top surface of the partition walls 11 is blackened for better clarity of the screen, the ultraviolet rays will not reach the paste 17a deposited on the top surface of the partition walls 11, so that cured paste 17a will never be deposited on the top surface of the partition walls 11.

[0060] In the cleaning process, the back side panel 2 over the ultraviolet-ray irradiation is set to a cleaning apparatus with the surface having the partition walls 11 positioned down, and about 23°C pure water is sprayed at a pressure of 1 kg/cm^2 as one example. Thus, as shown in Fig. 13, the uncured paste 17a is cleaned away except for the mortar-shaped cured portion.

[0061] In the drying process, water deposited on the cleaned back side panel 2 is removed by an air knife, followed by a 30 minute drying process at 80°C as one example. Thus, a mortar-shaped minute fluorescent material layer 17 as shown in Fig. 13 are obtained.

[0062] In the baking process, the back side panel 2 is baked for about 1 hour in an about 520°C air atmosphere oven as one example.

[0063] In the assembling process, the back side panel 2 and the front side panel 3 having the cathode side glass substrate are combined together, by which a plasma display panel is completed.

[0064] In seven examples of the third embodiment, the plasma display panels were fabricated with the ultraviolet-ray irradiation time varied as 3.5 sec., 10 sec., 30 sec., 60 sec., 90 sec., 120 sec., and 180 sec., as shown in Table 4 below.

[0065] Now, a plasma display panel and its fabrication method according to a fourth embodiment of the present invention are described with reference to Figs. 1 and 13.

[0066] The back side panel 2 of the plasma display panel shown in Fig. 1 has the same construction as in the third embodiment, and so its description is omitted.

[0067] The difference of the fourth embodiment from the third embodiment is that, in the ultraviolet-ray irradiation process, ultraviolet rays are first irradiated from the rear surface of the panel 2 at a total quantity of light of 7.2 mW/cm^2 for about 3.5 seconds as one example, and then with a mask for masking the portions of the anode electrodes 13 positioned on the surface of the back side panel 2, ultraviolet rays are irradiated at a total quantity of light of 7.2 mW/cm^2 for about 3.5 seconds as one example.

[0068] Next, as a comparative example, with the same back side panel 2 as used in the examples of the third and fourth embodiments, conventional thermo-drying type fluorescent material paste 7a is applied into the spaces of the partition walls 11, and dried at about 120°C for 10 minutes, followed by cooling. Then, a grinding process into the configuration of the fluorescent material layer 7a as shown in Fig. 14 is conducted by sandblasting. Foreign matters deposited on the glass substrate 10 are removed by air, and baked in an about 520°C air atmosphere oven for about 1 hour, followed by cooling. Then, the back side panel 2 and the front side panel 3 are combined together, by which a plasma display panel is completed.

[0069] The data of the examples of the third embodiment and the fourth embodiment, and the comparative example are shown in Table 4 below:

Table 4

Item	Ultraviolet-ray irradiation time	Brightness	Height of minute fluorescent material layer	Height of partition wall
Examples of third embodiment	3.5 sec, from rear side of substrate	0.7	50 μm	200 μm
	10 sec, from rear side of substrate	0.98	70 μm	200 μm
	30 sec, from rear side of substrate	1.13	140 μm	200 μm
	60 sec, from rear side of substrate	1.13	145 μm	200 μm
	90 sec, from rear side of substrate	1.15	150 μm	200 μm
	120 sec, from rear side of substrate	1.17	160 μm	200 μm
	180 sec, from rear side of substrate	1.18	170 μm	200 μm

Table 4 (continued)

Item	Ultraviolet-ray irradiation time	Brightness	Height of minute fluorescent material layer	Height of partition wall
Examples of fourth embodiment	3.5 sec, from rear side of substrate 3.5 sec, from front side of substrate	1.2	190 μm	200 μm
Comparative Example	-	1.0	190 μm	200 μm

[0070] As shown in Table 4, by relative comparisons of brightness of the discharge spaces in the plasma display panel with the value of the comparative example taken as 1.0, in the examples of the third embodiment in which ultraviolet rays are irradiated from only the rear sides of the back side panels, the ultraviolet-ray irradiation time and the height of the minute fluorescent material layer are proportional to each other, where if the height of the minute fluorescent material layer is 1/3 or more that of the partition wall, then the brightness becomes equal to that of the comparative example, and if the height of the minute fluorescent material layer is 2/3 or more that of the partition wall, then the brightness is ten odd percent brighter than that of the comparative example. In the example of the fourth embodiment in which ultraviolet rays are irradiated from both rear side and front side of the back side panel, the height of the fluorescent material layer becomes close to that of the partition wall in short time, where the brightness is 20% higher than that of the comparative example.

[0071] The reason of this can be inferred as follows. That is, each minute fluorescent material layer 7 of the comparative example is formed Into a cylindrical shape adjoined to the inner side face of the partition wall 11 as shown in Fig. 14, with the result of low light emission efficiency. In contrast, the minute fluorescent material layer 17 in each example of the third and fourth embodiments is formed into a mortar-shape as shown in Fig. 13, in which case the mortar-shape is good at light emission efficiency.

[0072] The reason that the minute fluorescent material layer 17 is mortar-shaped could be inferred as follows.

[0073] Examples of paste 17a, each of which is blended as shown in Table 3, contains a solvent. Therefore, when it is filled into the spaces of the partition walls 11 and then dried, the solvent contained therein is dissipated, so that the central portion is recessed. The degree of this recess differs depending on the blending of the paste, where it can be controlled to slight to large recesses depending on the blending of the paste. If the blending is controlled so that the recess over the processes of filling the paste into the spaces of the partition walls 11 and drying it becomes as shown by the paste 17a of Fig. 13, and if ultraviolet rays are irradiated from only the rear side of the back side panel 2, then the ultraviolet rays reach within the paste 17a except the portions shadowed by the opaque anode electrodes 13. In this case, the ultraviolet rays decay soon in the paste 17a, and are transmitted and diffused by the semitransparent insulating layer 15 and partition walls 11, which have been made by baking glass powder paste. Therefore, the ultraviolet rays that reach within the paste 17a result in a superimposition of ultraviolet rays passing the insulating layer 15 upward and ultraviolet rays diffusing from the partition walls 11 transverse. As a result, the vicinity of the anode electrodes 13, which is originally poor in the paste 17a and low in amount of ultraviolet rays, is cured in such a way that the bottom of the mortar-shape is formed with the anode electrodes 13 exposed. Meanwhile, the vicinity of the partition wall 11, which is rich in the paste 17a and high in amount of ultraviolet rays, forms the top of the mortar-shape.

[0074] Other than the above characteristic comparisons, fabrication process can be compared as below.

[0075] In the comparative example, the anode electrodes are exposed by using the sandblasting process. Therefore, the degree of exposure is affected by many factors such as differences in the grinding effect of sandblasting, differences in hardness of the fluorescent material layers, and differences in the configuration of the applied and dried fluorescent material layers, each with instability. In the present embodiment, ultraviolet rays are irradiated from the rear side of the back side panel, so that the fluorescent-material-containing photosensitive resin paste is cured except for the portions shadowed by the island electrodes and the anode electrodes. Then, uncured portions are cleaned and removed. In this way, the anode electrodes can be appropriately and securely exposed with simplicity.

[0076] In the comparative example, the grinding process is accomplished by sandblasting. Therefore, the back side panel is overlaid and assembled as the ground fluorescent material particles remain deposited on the top surfaces of the partition walls 11. Thus, there is a possibility that those fluorescent material particles form bright spots, causing a deterioration in the quality of the plasma display panel. The present invention is free from this issue.

[0077] As the light that cures the fluorescent-material-containing photosensitive resin paste, ultraviolet rays are of good efficiency and easy to handle. However, other types of light or radioactive rays may be applied without the limitation to ultraviolet rays.

[0078] According to the fabrication method, a fluorescent-material-containing photosensitive resin paste containing a solvent is used, and ultraviolet or other light or radioactive ravs are irradiated from the rear side of the back side panel, so that the paste is cured except for the portions where the light or radioactive ravs are shadowed by the island electrodes and/or the anode electrodes. Then, uncured portions are cleaned and removed. As a result, the anode electrodes can be appropriately and securely exposed with simplicity. Besides, the shape precision of the minute fluorescent material layers is excellent and stable, so that the characteristics such as brightness uniformity and color balance are excellent, advantageously.

[0079] With an additional process of irradiating, from the partition wall side of the back side panel, light or radioactive rays serving for curing the fluorescent-material-containing photosensitive resin paste containing a solvent by using a mask that masks upper part of the anode electrodes and/or the island electrodes, minute fluorescent material layers with larger height can be formed in short time irradiation of light or radioactive rays, and a bright plasma display panel can be obtained, advantageously.

[0080] If the height of each of the minute fluorescent material layers is 1/3 or more that of each of the partition walls, then a bright plasma display panel can be obtained, advantageously.

[0081] If ultraviolet rays are used as the light, the workability is good advantageously. For the formation of minute fluorescent material layers, a fluorescent-material-containing photosensitive resin paste containing a solvent is first filled in the spaces where the discharge cells are formed. Then, the contained solvent is dissipated away, so that the central portion of the surface is recessed down, with the paste cured into a mortar-shape. In this state, the anode electrodes are covered with the paste.

[0082] Next, light or radioactive rays that cure the paste are irradiated from the rear side of the back side panel. In this case, the glass substrate that constitutes the back side panel is transparent, while the insulating layer and the partition walls, which are prepared by applying and overlaying glass powder paste on a glass substrate and baking them, are semitransparent so as to transmit the light or radioactive rays and diffuse part of them. As a result, the light or radioactive rays will not reach the portions shadowed by the opaque anode electrodes and/or the island electrodes, while the paste present at the other portions is cured.

[0083] Subsequently, the paste of the uncured portions is cleaned and removed. Thus, mortar-shaped minute fluorescent material layers with the anode electrodes exposed are formed. The minute fluorescent material layers of the mortar-shape are good at light emission efficiency due to discharge.

[0084] In this way, without troublesome burdens of the control for various types of fabrication conditions under which the minute fluorescent material layers are fabricated, there can be provided a plasma display panel having a stable configuration precision of the mortar-shape of the minute fluorescent material layers, an appropriate exposure of the anode electrodes, and superior characteristics of brightness uniformity, and color balance.

[0085] In the embodiments, the screen (mask) may also be a mesh screen, as well as a screen made from a metal plate having openings formed at the same pitch precision as those of the partition walls.

[0086] The term, "solvent," in the specification and claims refers to a liquid to be removed from the paste during the drying process, including water as well as organic solvents. The fluorescent-material-containing photosensitive resin paste refers to at least one which contains monomer, polymerization initiator, and fluorescent material. The paste further contains polymer, contains solvent, or contains photosensitizer or polymerization inhibitor, as needed.

[0087] The means for curing the paste may be light including ultraviolet rays or electron beams, radioactive rays, or heat, or the like.

[0088] The first to fourth embodiments have been described with the use of the DC type plasma display panel. However, the invention may also be applied to an AC type plasma display panel as shown in Fig. 15. In this AC type plasma display panel, as shown in Fig. 15, the back side panel has a large number of strip-shaped, parallel address electrodes 120 formed on a glass substrate 110. Partition walls 111 are formed parallel between the address electrodes. The spaces between the adjacent partition walls 111 are in a string like a gutter, and the address electrodes 120 do not need to be exposed. Accordingly, the AC type plasma display panel largely differs from the DC type plasma display panel in which the exposed anode electrodes 13 are surrounded by the partition walls 11. In the AC plasma display panel, the fluorescent material layer 117 has a gutter-like cross section of a generally C shape. Meanwhile, two parallel write electrodes 125 are disposed on a glass substrate 103 of the front side panel. Accordingly, as shown in Fig. 17, in the AC type plasma display panel, discharge occurs first between one of the two write electrodes 125 and the address electrode 120, and thereafter the discharge is continuously effected between the two write electrodes 125. Thus, the fluorescent material layer 117 emits light as shown by an arrow 200.

[0089] In contrast to this, in the DC type plasma display panel, as shown in Fig. 16, discharge occurs between the cathode lines 25 of the front side panel substrate 12 and anodes 13 of the back side panel substrate 10, by which the fluorescent material layer 17 emits light as shown by an arrow 201. Thus, the anodes 13 need to be exposed.

[0090] In the DC type plasma display panel, photosetting is preferable from the viewpoint of the need for making electrodes exposed in the back side panel. Meanwhile, in the AC type plasma display panel as shown in Fig. 15, the electrodes do no need to be exposed in the back side panel, so that thermosetting may be applied as well as photosetting. In this case, the thermosetting can be accomplished by various means such as blowing hot air to a fluorescent-material-containing thermosetting resin paste, or putting the rear side panel having the paste into a high-temperature oven. The thermosetting is capable of reliably thermo-curing the paste up to its interior, so that the portions to be cured can be cured more reliably than the photosetting.

[0091] Further, when the back side panel having the paste is put Into an oven that can be accurately controlled in temperature, it becomes possible to first conduct a curing process with the temperature controlled to one necessary for the paste to be cured, and over the curing process, to subsequently conduct a baking process with the temperature elevated to a high necessary for baking. In this case, the curing process and the baking process of the paste can be conducted in succession, so that the fabrication efficiency can be enhanced.

[0092] Although the AC type plasma display panel has no insulating layer, an insulating layer 115 may be provided on the address electrodes 120 and the glass substrate 110 and the partition walls 111 may be provided on the insulating layer 115 as shown in Fig. 18.

[0093] The sectional shape of each partition wall 11, 111 is not limited to such a shape that its side surface is a flat surface with the thicknesses of the whole portions from its substrate side to its opening side being the same as each other, but may be of such a shape that its side surface is curved so as to outwardly widen from the portion on its substrate side to the portion on its opening side with the thickness of the substrate side-portion being larger than that of the opening side-portion so as to easily form the mortar-shape or gutter shape, as shown in Fig. 9.

[0094] In the DC type and AC type plasma display panels, the arrangement of the anodes and cathodes can be replaced with each other. That is, the electrodes 13, 120 arranged on the anode-side in the panels may function as the electrodes 13, 120 on the cathode-side while the electrodes 25, 125 arranged on the cathode-side in the panels may function as the electrodes 25, 125 on the anode-side.

Claims

1. A method for fabricating a plasma display panel, comprising the steps of:

forming on a substrate (10; 110) an electrode pattern (20, 21, 22, 23; 120) comprising at least one light-impervious first electrode (20; 120)
forming on the substrate (10; 110) a light-transmittable insulating layer (15; 115) covering the electrode pattern so that a portion of the first electrode (20; 120) is not covered by the insulating layer (15; 115);
providing at least one light-impervious second electrode (1 3) being an anode or a cathode so as to contact the exposed portion of the first electrode (20; 120);
providing partition walls (11; 111) on the insulating layer (15; 115) around the second electrodes to define spaces;
inserting a fluorescent-material-containing photosensitive or thermosetting paste for forming a fluorescent material layer (17; 117) containing a photosensitive or thermosetting resin in the spaces between the partition walls (11; 111) by using a screen (31; 151) having openings corresponding to the spaces of the partition walls (11; 111) constituting spaces serving as discharge spaces for holding the fluorescent material layer (17; 117) on the substrate (10; 110);
curing the paste from a surface of the substrate (10; 110) opposite to the surface thereof where the partition walls (11; 111) are provided, whereby the paste is cured except for at least one uncured portion shadowed by the first and/or second electrode (20; 13);
removing the uncured portion of the paste;
forming the fluorescent material layer (17; 117) by drying and then baking the paste; and
providing a cathode (25) if the second electrode is an anode, or providing an anode if the second electrode is a cathode.

2. The method according to claim 1, wherein the paste contains a solvent, monomer, polymerization initiator, and fluorescent material, and the substrate (10; 110) and the partition walls (11; 111) are light-transmittable.

3. The method according to claim 2, wherein the electrode pattern (20, 21, 22, 23) comprises an electrode bus (22) and the first electrode (20) is an island electrode, so as to constitute a DC type plasma display panel (1).

4. The method according to claim 3, wherein the solvent in the paste is filled in the spaces serving as the discharge cells is dried and then the paste is formed in a shape of a mortar, the paste is cured except a portion shadowed by the anode or cathode (13) or the first electrode (20), and uncured portions of the paste are cleaned and removed, and whereby the fluorescent material layer having the mortar-shape is obtained with the anode or cathode exposed.

5. The method according to claim 2, wherein the electrode pattern (120) has address electrodes (120) which are formed on the substrate (110) and are parallel with each other, so as to constitute an AC type plasma display panel.

6. The method according to claim 5, wherein the solvent in the paste filled in the spaces serving as the discharge spaces is dried and then the paste is formed in a shape of a gutter and is cured except for portions shadowed by the address electrodes (120), and uncured portions of the paste are cleaned and removed, whereby the fluorescent material layer having the gutter-shape is obtained with the address electrodes (120) exposed.

7. The method according to claim 4 or 6, wherein the partition wall (11; 111) has such a shape that its side surface is curved so as to outwardly widen from a portion on its substrate side to a portion on its opening side with a thickness of the portion on the substrate side being larger than that of the portion on the opening side.

8. The method according to any one of claims 1 to 7, wherein in the curing step, light, electron beams, or radioactive rays for curing the paste is irradiated from the surface of the substrate opposite to the surface thereof where the partition walls (11; 111) are formed.

9. The method according to claim 8, wherein irradiation of light, electron beams, or radioactive rays for curing the fluorescent-material-containing photosensitive resin paste is conducted also from the surface of the substrate (10) where the partition walls are formed by using a mask for masking an upper part of the anode or cathode (13) of the first electrode (20).

10. The method according to claim 8 or 9, wherein the light is ultraviolet ray.

11. The method according to any one of claims 8 to 10, wherein an amount of the paste filled in the spaces serving as the discharge spaces, or an amount of the solvent contained in the paste is controlled, and an amount of light, electron beams, or radioactive rays is controlled, so that a height of the fluorescent material layer (17; 117) is 1/3 or more that of the partition wall (11; 111).

Patentansprüche

1. Verfahren zum Herstellen einer Plasmaanzeigetafel, enthaltend die folgenden Schritte:

Bilden eines Elektrodenmusters (20, 21, 22, 23; 120) auf einem Substrat (10; 110), welches zumindest eine erste lichtdichte Elektrode (20; 120) enthält,
Bilden einer zum Übertragen von Licht fähigen Isolierschicht (15; 115) auf dem Substrat (10; 110), die das Elektrodenmuster in der Weise bedeckt, daß ein Abschnitt der ersten Elektrode (20; 120) nicht durch die Isolierschicht (15; 115) bedeckt ist,
Bereitstellen zumindest einer zweiten lichtdichten Elektrode (13), welche eine Anode oder eine Kathode ist, um in Kontakt mit dem freigelegten Abschnitt der ersten Elektrode (20; 120) zu gelangen,
Bereitstellen von Trennwänden (11, 111) auf der Isolierschicht (15; 115) um die zweiten Elektroden, um Räume zu bilden,
Einbringen einer ein fluoreszierendes Material enthaltenden, photosensitiven oder thermofixierbaren Paste zum Bilden einer Fluoreszenzmaterialschicht (17; 117), welche ein photosensitives oder thermofixierbares Harz aufweist, in die Räume zwischen den Trennwänden (11; 111) durch Verwenden eines Schirmes (31; 151), welcher Öffnungen in Übereinstimmung zu den Räumen der Trennwände (11; 111) aufweist, die Räume bilden, welche als Entladeräume zum Halten der Fluoreszenzmaterialschicht (17; 117) auf dem Substrat (10; 110) dienen,
Härten der Paste von einer Oberfläche des Substrats (10; 110), die der Oberfläche gegenüber liegt, welche die Trennwände (11; 111) aufweist, wodurch die Paste bis auf zumindest einen nichtgehärteten Abschnitt härtet, der durch die erste und/oder zweite Elektrode (20; 13) abgedeckt wird,
Entfernen des nichtgehärteten Teils der Paste,
Bilden der Fluoreszenzmaterialschicht (17; 117) durch Trocknen und anschließendem Backen der Paste, und Bereitstellen einer Kathode (25), wenn die zweite Elektrode eine Anode ist, oder Bereitstellen einer Anode, wenn die zweite Elektrode eine Kathode ist.

2. Verfahren nach Anspruch 1,
bei dem die Paste eine monomere Polymerisationsinitiatorlösung sowie Fluoreszenzmaterial enthält und bei dem

das Substrat (10; 110) sowie die Trennwände (11; 111) in der Lage sind, Licht zu übertragen.

3. Verfahren nach Anspruch 2,
bei dem das Elektrodenmuster (20, 21, 22, 23) einen Elektrodenbus (22) aufweist und die erste Elektrode (20) eine Inselelektrode ist, um eine Gleichstrom-Plasmaanzeigetafel (1) zu bilden.

4. Verfahren nach Anspruch 3,
bei dem das Lösungsmittel in der Paste, die in die Räume eingefüllt ist, welche als Entladezellen dienen, getrocknet wird und anschließend die Paste in die Form eines Mörsers gebracht wird, bei dem die Paste mit Ausnahme eines Abschnittes gehärtet wird, der durch die Anode oder Kathode (13) oder die erste Elektrode (20) abgedeckt wird, und bei dem die nicht ausgehärteten Abschnitte der Paste gereinigt und entfernt werden, wodurch die Fluoreszenzmaterialschicht, die die Mörserform besitzt, erhalten wird, wobei die Anode oder die Kathode freigelegt ist.

5. Verfahren nach Anspruch 2,
bei dem das Elektrodenmuster (120) Addressenelektroden (120) besitzt, welche auf dem Substrat (110) ausgebildet und parallel zueinander angeordnet sind, um eine Wechselstrom-Plasmaanzeigetafel zu bilden.

6. Verfahren nach Anspruch 5,
bei dem das Lösungsmittel in der Paste, die in die Räume eingefüllt ist, welche als Entladeräume dienen, getrocknet wird und anschließend die Paste in die Form eines Abflußbeckens gebracht und mit Ausnahme der Abschnitte gehärtet wird, die durch die Addressenelektroden (120) abgedeckt sind, und bei dem die ungehärteten Teile der Paste gereinigt und entfernt werden, wodurch die Fluoresenzmaterialschicht, die die Abflußbeckenform besitzt, erhalten wird, wobei die Adressenelektroden (120) freigelegt sind.

7. Verfahren nach Anspruch 4 oder 6,
bei dem die Trennwand (11; 111) eine solche Form besitzt, das ihre Seitenfläche in der Weise gekrümmt ist, daß sie sich von einem Abschnitt auf ihrer Substratseite zu einem Abschnitt an ihrer Öffnungsseite nach außen verbreitert, wobei die Dicke des Abschnittes auf der Substratseite größer als die Dicke des Abschnitts an der Öffnungsseite ist.

8. Verfahren nach einem der Ansprüche 1 bis 7,
bei dem in dem Härteschritt Licht, Elektronenstrahlen oder radioaktive Strahlen zum Härten der Paste von der Oberfläche des Substrats aus verwendet wird, die der Oberfläche des Substrats gegenüberliegt, auf welcher die Trennwände (11; 111) ausgebildet sind.

9. Verfahren nach Anspruch 8,
bei dem das Abstrahlen von Licht, von Elektronenstrahlen oder radioaktiven Strahlen zum Härten der das Fluoreszenzmaterial enthaltenden, photosensitiven Harzpaste ebenfalls von der Oberfläche des Substrats (10) aus, auf der die Trennwände ausgebildet sind, unter Verwendung einer Maske zum Masking eines oberen Teils der Anode oder Kathode (13) der ersten Elektrode (20) ausgeführt wird.

10. Verfahren nach Anspruch 8 oder 9,
bei dem das Licht ultraviolette Strahlen sind.

11. Verfahren nach einem der Ansprüche 8 bis 10,
bei dem eine Menge der Paste, die in die Räume gefüllt ist, welche als Entladeräume dienen, oder eine Menge des Lösungsmittels, welches in der Paste enthalten ist, und eine Menge des Lichtes, der Elektrodenstrahl oder der radioaktiven Strahlen so eingestellt wird, daß die Höhe der Fluoreszenzmaterialschicht (17; 117) 1/3 oder mehr der Höhe der Trennwand (11; 111) entspricht.

Revendications

1. Procédé de fabrication d'un panneau d'affichage à plasma comprenant les étapes consistant à :

former sur un substrat (10 ; 110) un motif d'électrode (20, 21, 22, 23 ; 120) comprenant au moins une première électrode étanche à la lumière (20 ; 120),
former sur le substrat (10 ; 110) une couche isolante pouvant transmettre la lumière (15 ; 115) recouvrant le

motif d'électrode de sorte qu'une partie de la première électrode 20; 120) ne soit pas recouverte par la couche isolante (15 ; 115),
fournir au moins une seconde électrode étanche à la lumière (13) qui constitue une anode ou une cathode de façon à entrer en contact avec la partie exposée de la première électrode (20 ; 120),
fournir des parois de séparation (11 ; 111) sur la couche isolante (15 ; 115) autour des secondes électrodes pour définir des espaces,
insérer une pâte photosensible ou thermodurcissable contenant un matériau fluorescent afin de former une couche de matériau fluorescent (17 ; 117) contenant une résine photosensible ou thermodurcissable dans les espaces entre les parois de séparation (11 ; 111) en utilisant un écran (31 ; 151) comportant des ouvertures correspondant aux espaces des parois de séparation (11 ; 111) constituant les espaces servant d'espaces de décharge pour contenir la couche de matériau fluorescent (17 ; 117) sur le substrat (10 ; 110),
polymériser la pâte à partir d'une surface du substrat (10 ; 110) opposée à la surface de celui-ci où les parois de séparation (11 ; 111) sont disposées, d'où il résulte que la pâte est polymérisée à l'exception d'au moins une partie non polymérisée masquée par la première et/ou la seconde électrode (20 ; 13),
éliminer la partie non polymérisée de la pâte,
former la couche de matériau fluorescent (17 ; 117) par séchage et ensuite cuisson de la pâte, et
fournir une cathode (25) si la seconde électrode est une anode, ou fournir une anode si la seconde électrode est une cathode.

2. Procédé selon la revendication 1, dans lequel la pâte contient un solvant, un monomère, un initiateur de polymérisation, et un matériau fluorescent, et le substrat (10 ; 110) ainsi que les parois de séparation (11 ; 111) peuvent transmettre la lumière.

3. Procédé selon la revendication 2, dans lequel le motif d'électrode (20, 21, 22, 23) comprend un bus d'électrode (22) et la première électrode (20) est une électrode en îlot, de façon à constituer un panneau d'affichage à plasma du type à courant continu (1).

4. Procédé selon la revendication 3, dans lequel le solvant dans la pâte versée dans les espaces servant de cellules de décharge, est séché et ensuite la pâte est formée en une forme de mortier, la pâte est polymérisée à l'exception d'une partie masquée par l'anode ou la cathode (13) ou la première électrode (20), et les parties non polymérisées de la pâte sont nettoyées et éliminées, et d'où il résulte que la couche de matériau fluorescent présentant la forme de mortier est obtenue avec l'anode ou la cathode exposée.

5. Procédé selon la revendication 2, dans lequel le motif d'électrode (120) comporte des électrodes d'adressage (120) qui sont formées sur le substrat (110) et sont parallèles l'une à l'autre, de façon à constituer un panneau d'affichage à plasma du type à courant alternatif.

6. Procédé selon la revendication 5, dans lequel le solvant dans la pâte versée dans les espaces servant d'espaces de décharge est séché et ensuite la pâte est formée en une forme de gouttière et est polymérisée à l'exception de parties masquées par les électrodes d'adressage (120) et les parties non polymérisées de la pâte sont nettoyées et éliminées, d'où il résulte que la couche de matériau fluorescent présentant la forme de gouttière est obtenue avec les électrodes d'adressage (120) exposées.

7. Procédé selon la revendication 4 ou 6, dans lequel la paroi de séparation (11 ; 111) présente une forme telle que sa surface latérale est incurvée de manière à s'élargir vers l'extérieur depuis une partie sur son côté de substrat jusqu'à une partie sur son côté d'ouverture, l'épaisseur de la partie sur le côté de substrat étant plus grande que celle de la partie sur le côté d'ouverture.

8. Procédé selon l'une quelconque des revencications 1 à 7, dans lequel, dans l'étape de polymérisation, la lumière, les faisceaux d'électrons, ou les rayons radioactifs destinés à polymériser la pâte rayonnent à partir de la surface du substrat à l'opposé de la surface de celui-ci où les parois de séparation (11 ; 111) sont formées.

9. Procédé selon la revendication 8, dans lequel le rayonnement de la lumière, des faisceaux d'électrons, ou des rayons radioactifs destinés à polymériser la pâte de résine photosensible contenant un matériau fluorescent est exécuté également depuis la surface du substrat (10) où les parois de séparation sont formées en utilisant un masque destiné à masquer une partie supérieure de l'anode ou de la cathode (13), de la première électrode (20).

10. Procédé selon la revendication 8 ou 9, dans lequel la lumière est un rayon ultraviolet.

11. Procédé selon l'une quelconque des revendications 8 à 10, dans lequel une quantité de la pâte remplissant les espaces servant d'espaces de décharge, ou bien une quantité du solvant contenu dans la pâte est commandée, et une quantité de lumière, de faisceaux d'électrons, ou de rayons radioactifs est commandée, de sorte qu'une hauteur de la couche de matériau fluorescent (17 ; 117) soit de 1/3 ou plus de celle de la paroi de séparation (11 ; 111).

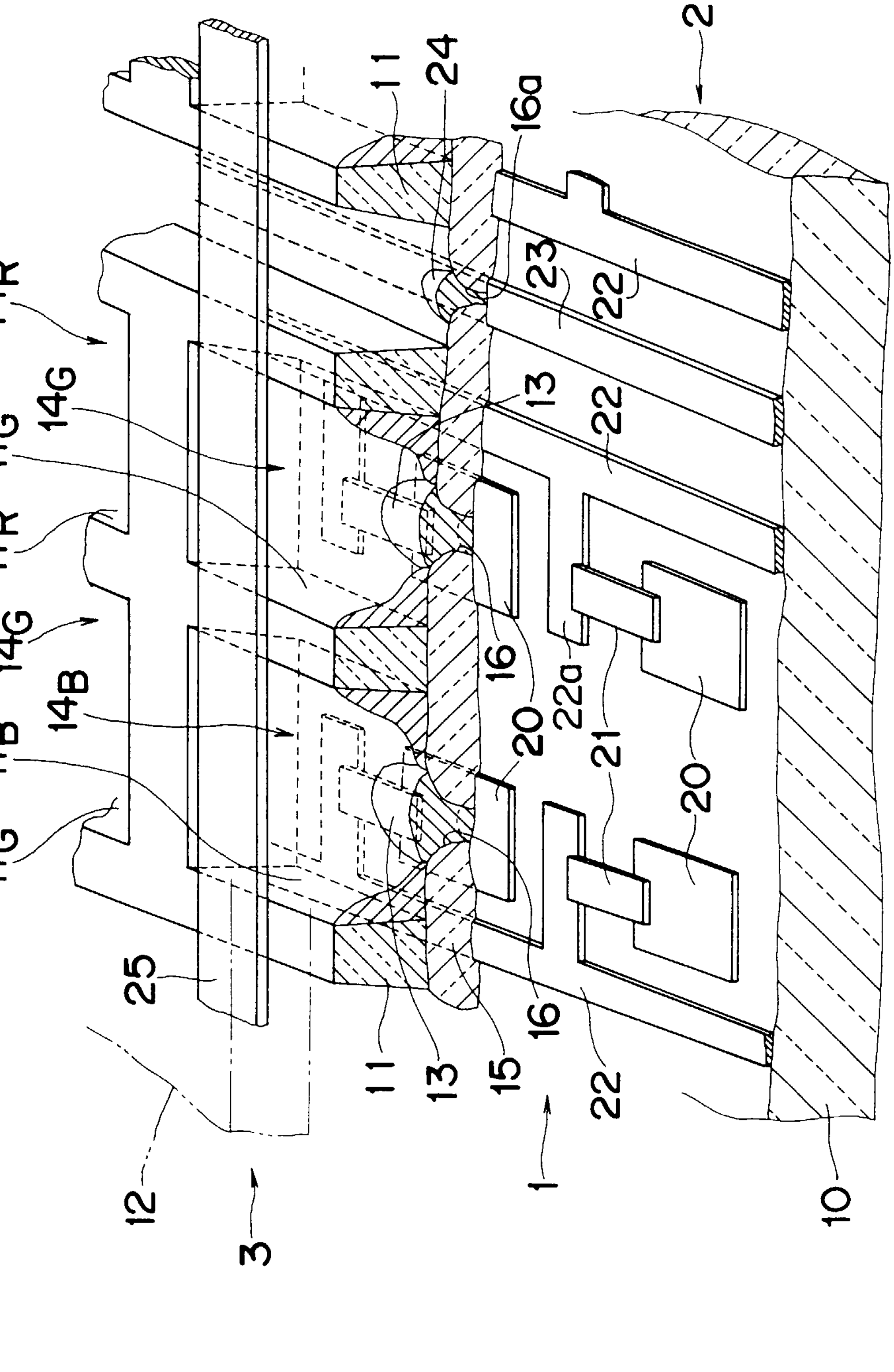
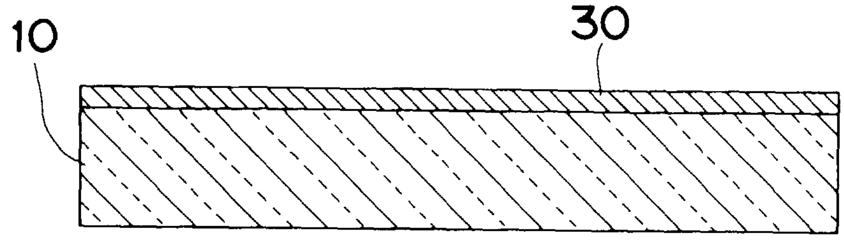
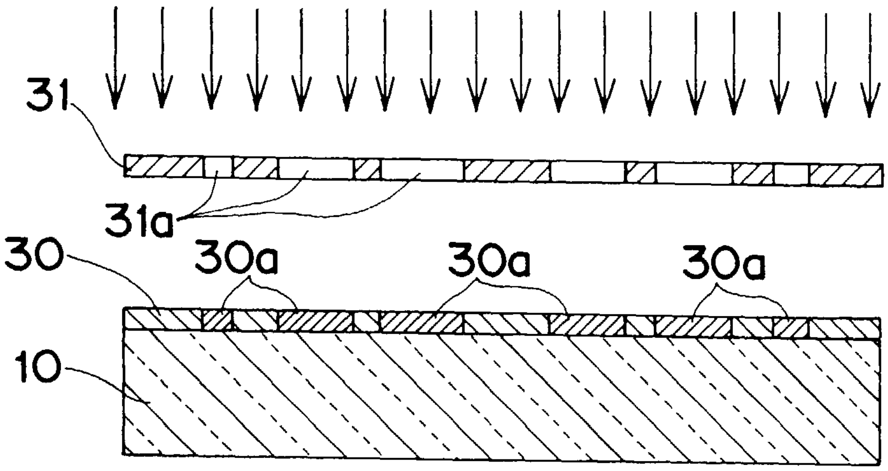

2
24
11
16a
23
22
22
14R
14G
13
22
17G
17R
16
14G
20
22a
21
20
14B
17B
20
21
20
17G
25
11
13
15
16
22
12
3
1
10

Fig. 1

F i g. 2A



F i g. 2B



F i g. 2C

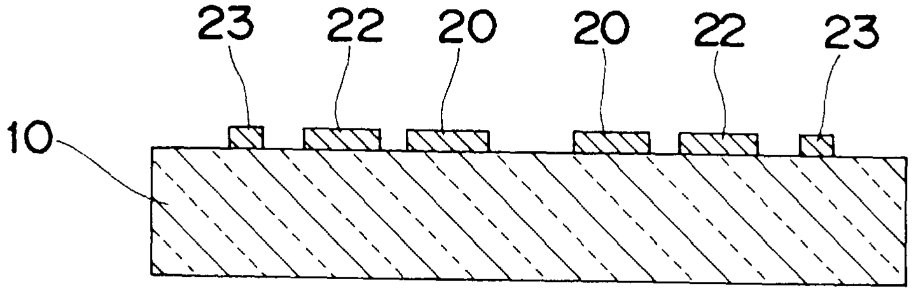


Fig. 3

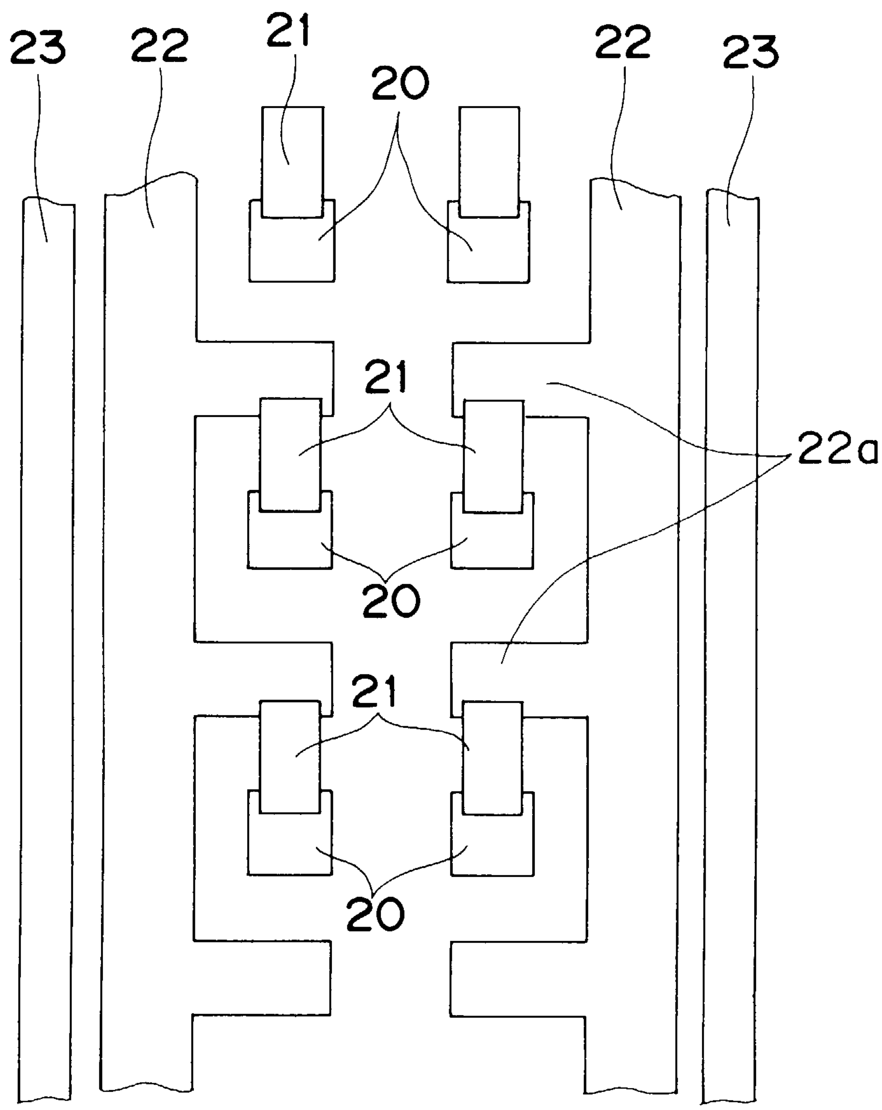


Fig. 4A

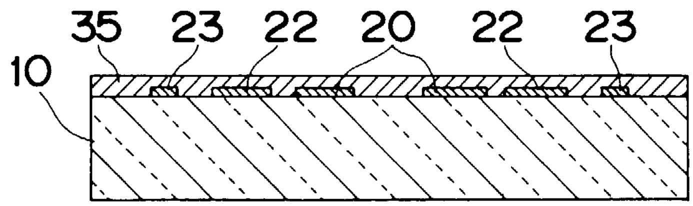


Fig. 4B

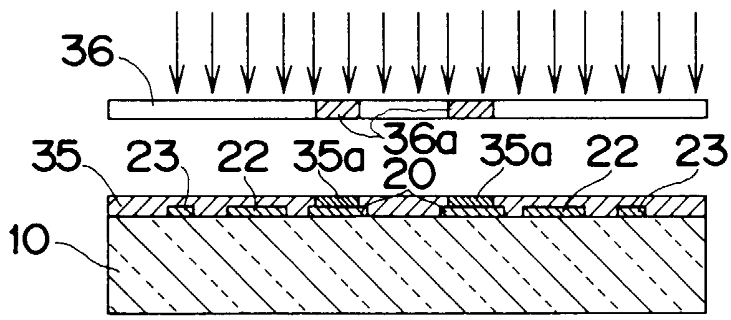


Fig. 4C

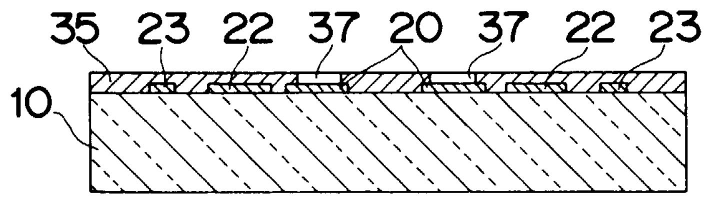


Fig. 4D

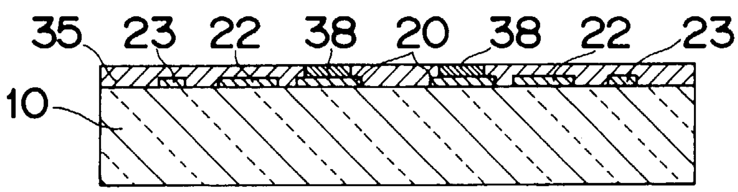


Fig. 4E

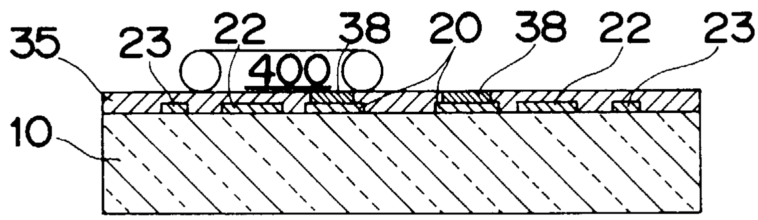
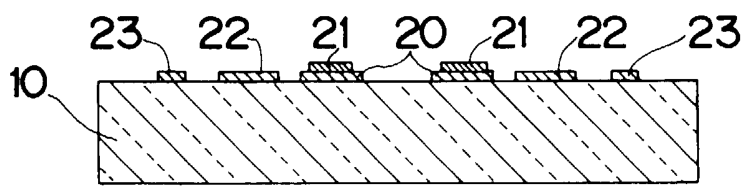
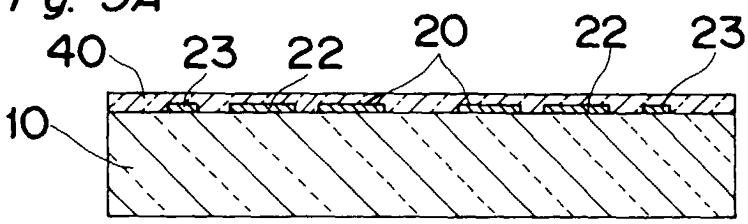


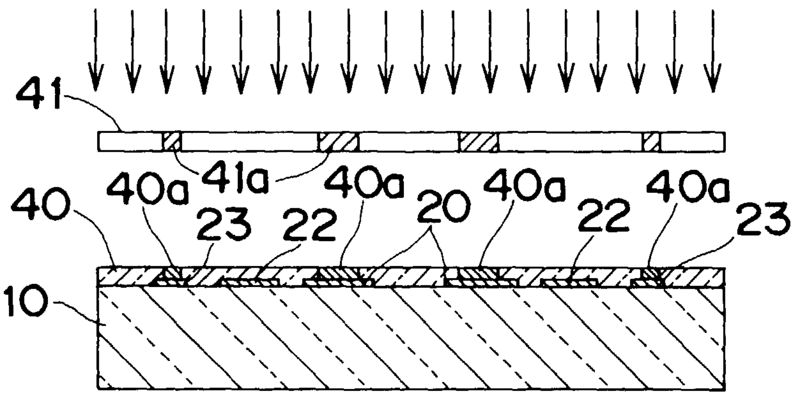
Fig. 4F



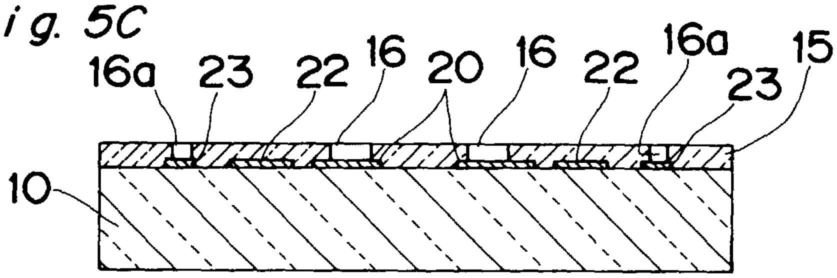
F i g. 5A



F i g. 5B



F i g. 5C



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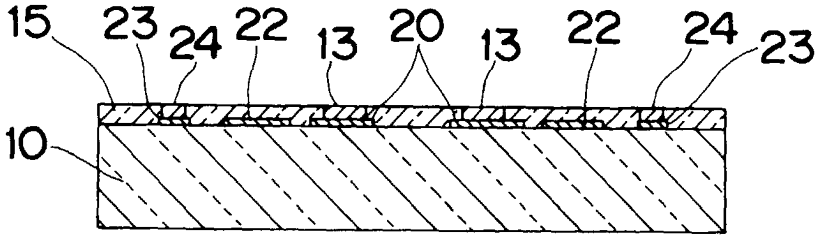
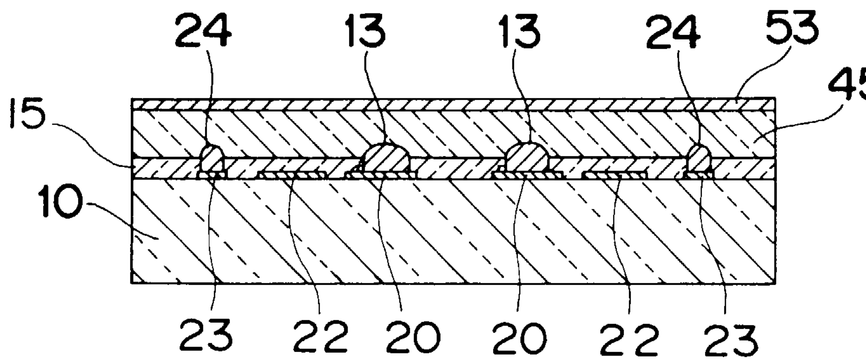
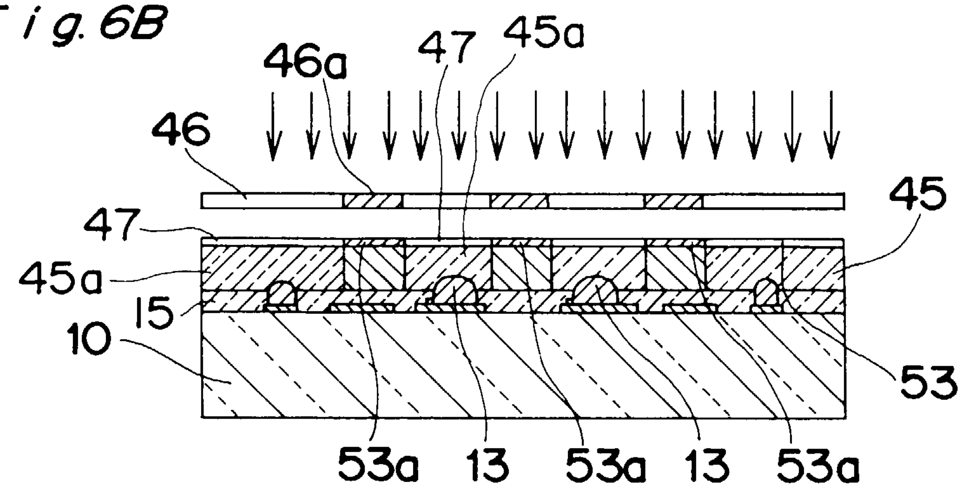


F i g. 6A



F i g. 6B



F i g. 6C

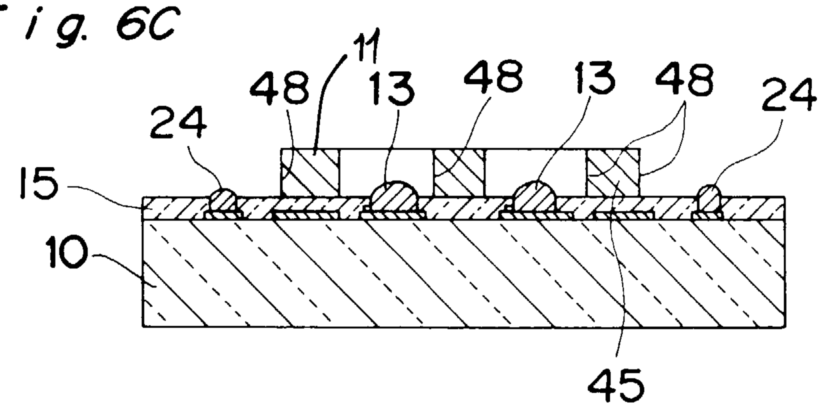


Fig. 7A

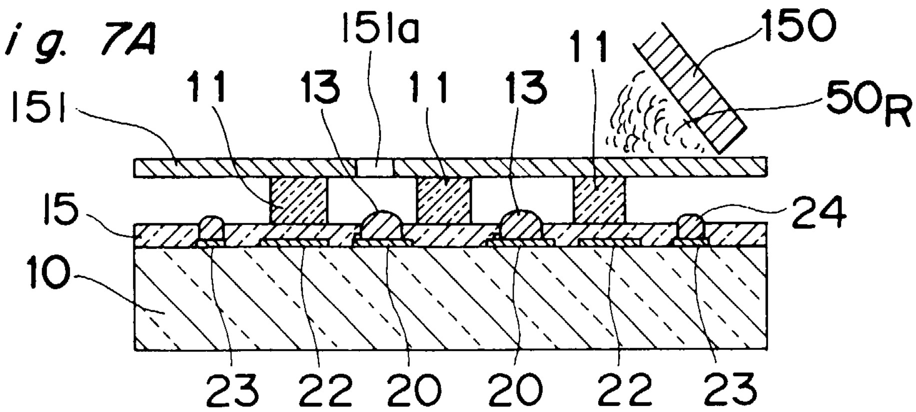


Fig. 7B

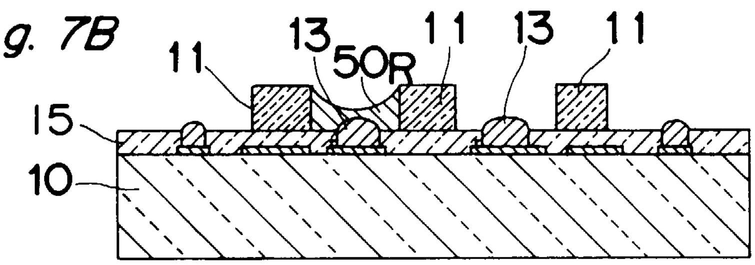


Fig. 7C

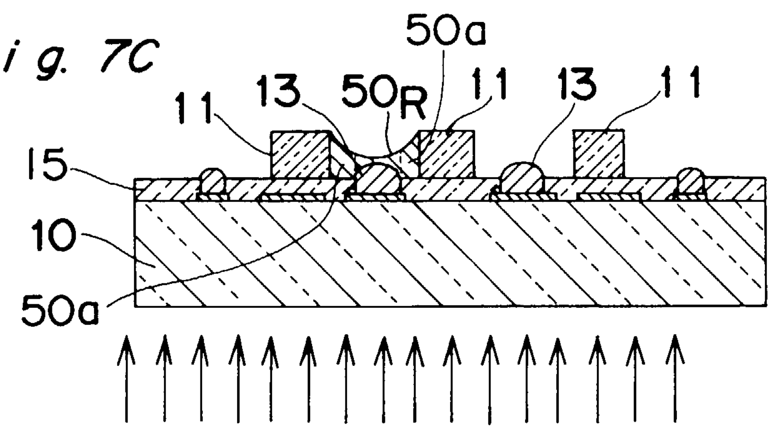


Fig. 7D

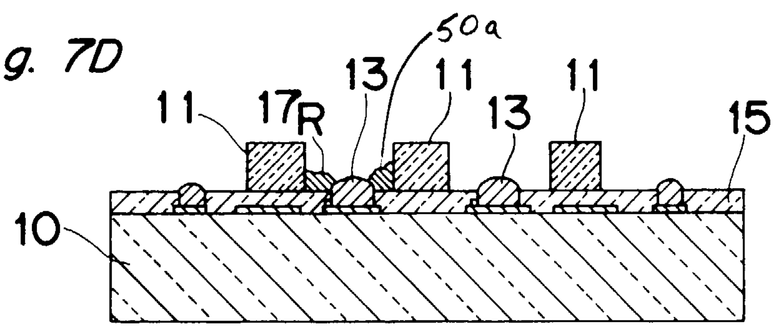


Fig. 8

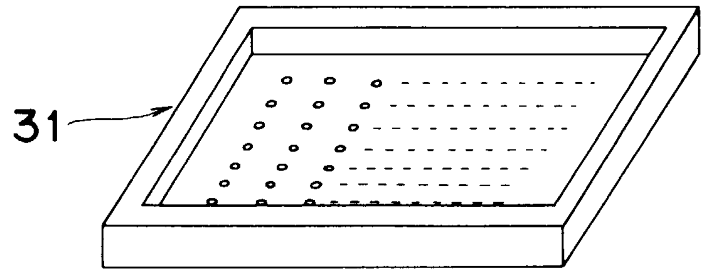


Fig. 9

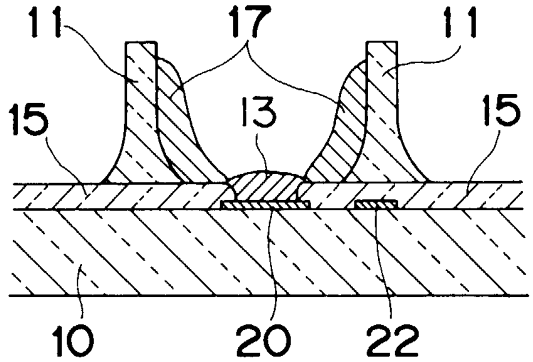
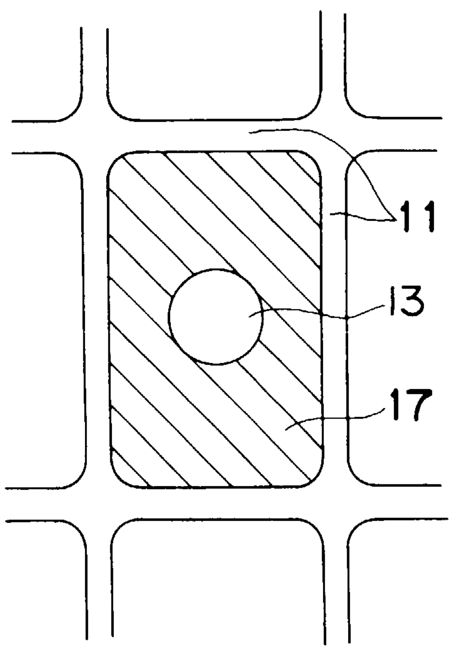
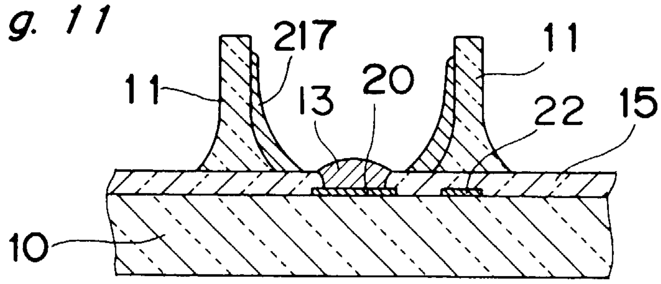


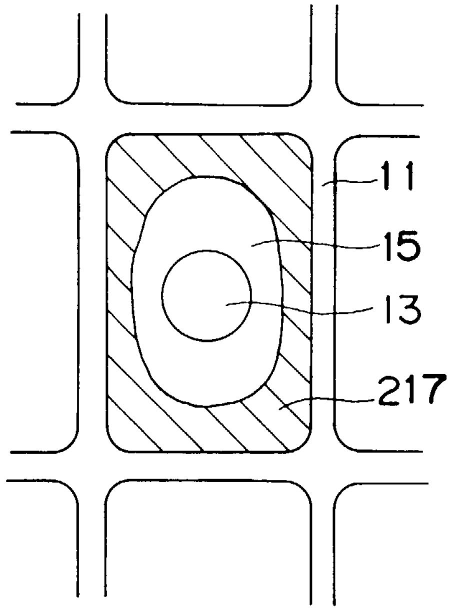
Fig. 10



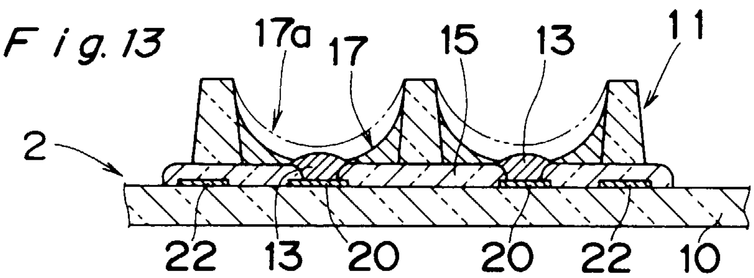
F i g. 11



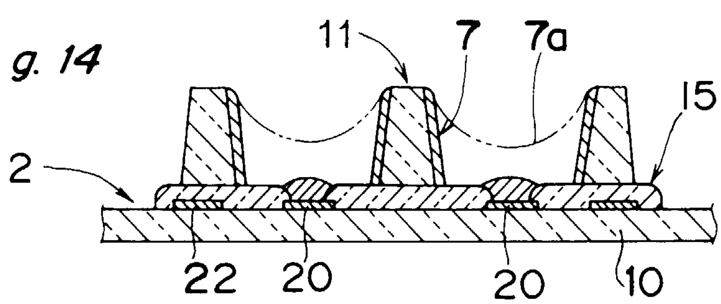
F i g. 12



F i g. 13



F i g. 14



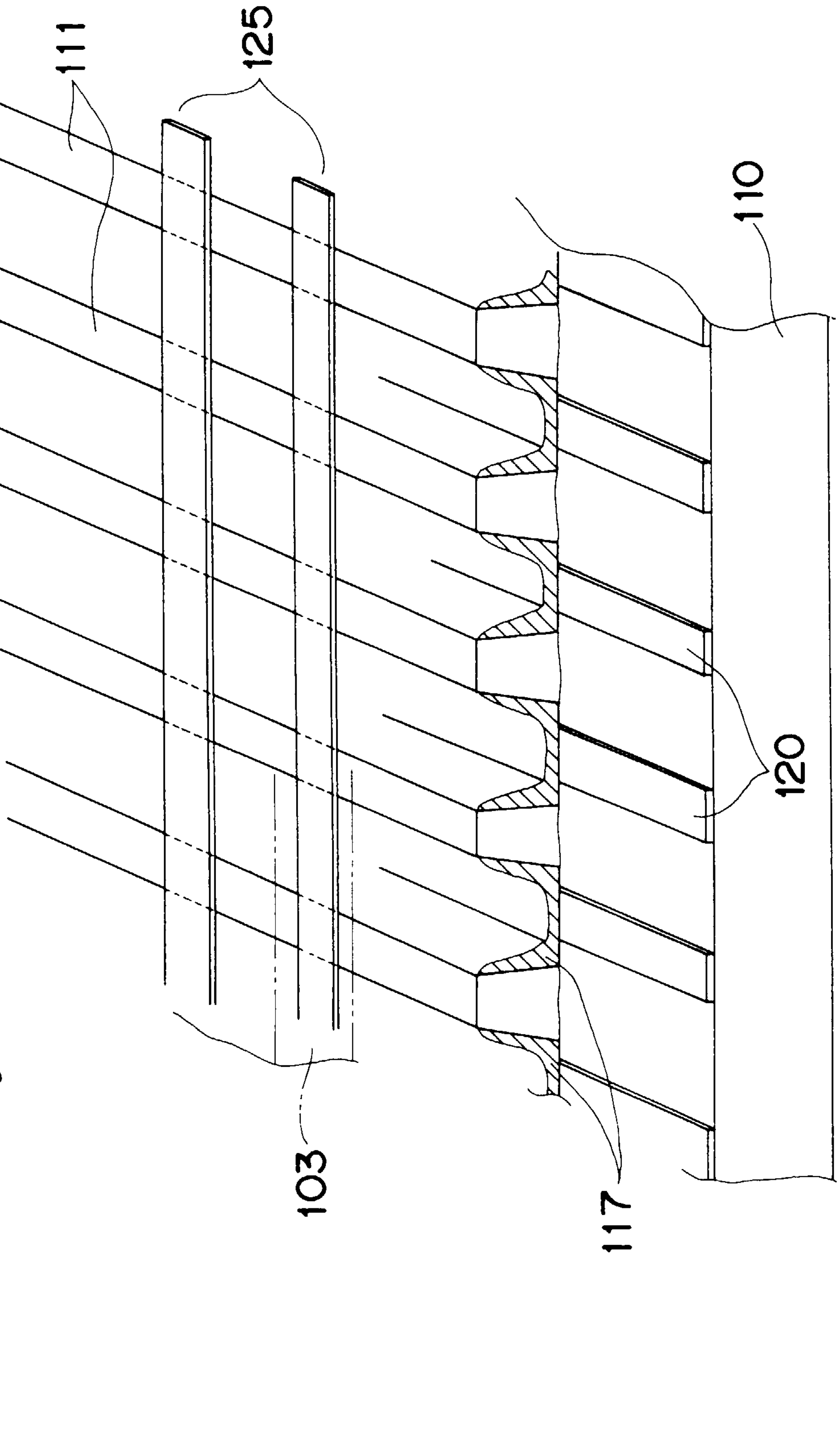


Fig. 15

Fig. 16

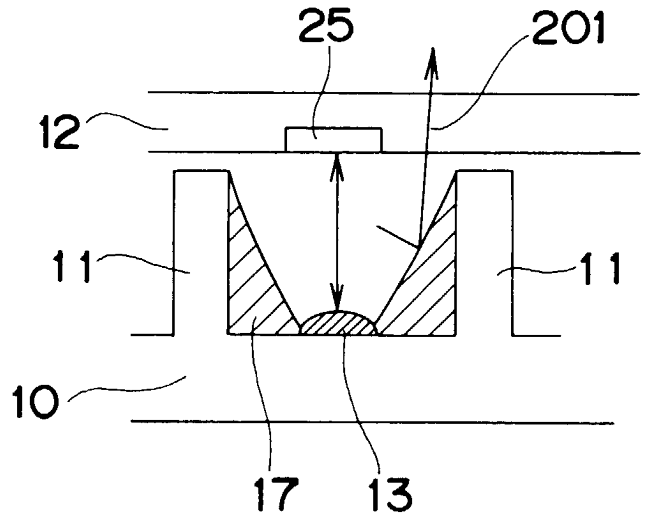
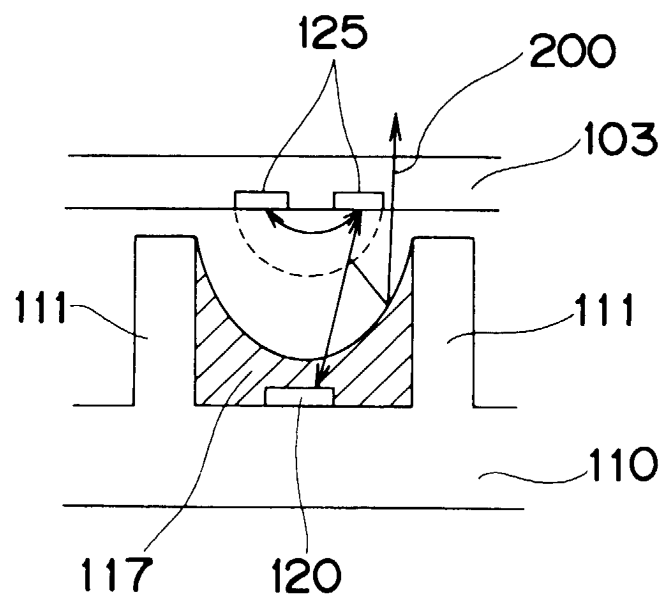


Fig. 17



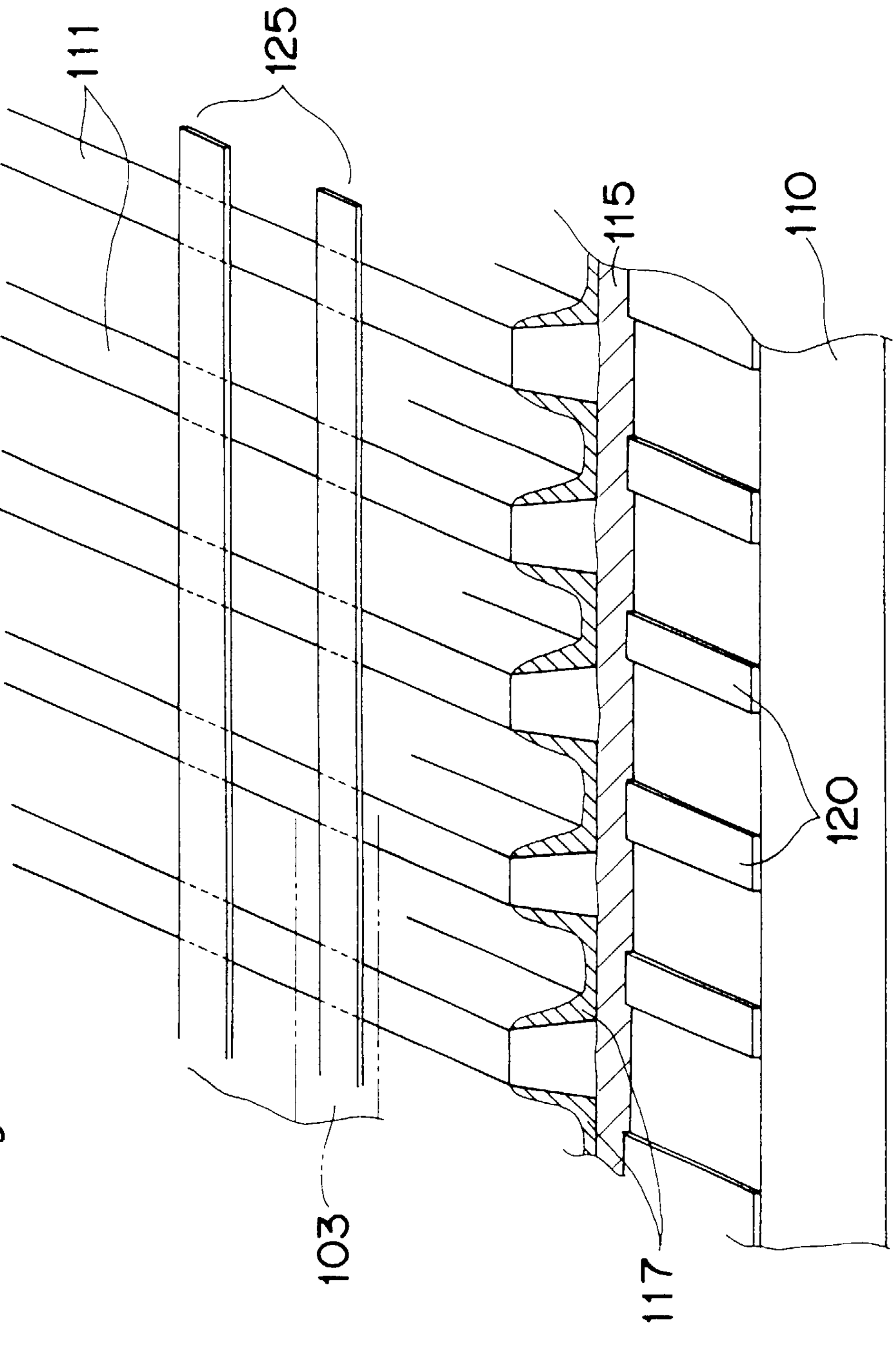


Fig. 18