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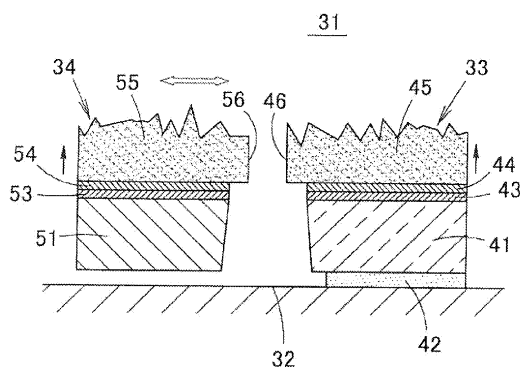
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(54) **Switch and method for manufacturing the same, and relay**

(57) A switch (31) and a relay (31A) in which the contacting surface of a contact is smooth are provided. A side surface of a fixed contact portion (33) and a side surface of a movable contact portion (34) face each other. The fixed contact portion (33) has an insulating layer (43) and a base layer (44) stacked on a fixed contact substrate (41), and a conductive layer (45) formed thereon by electrolytic plating, and the like. The side surface of the conductive layer (45) that faces the movable contact portion (34) becomes the fixed contact (46) (contacting surface). The movable contact portion (34) has an insulating layer (53) and a base layer (54) stacked on the movable contact substrate (51), and a movable contact (56) formed thereon by electrolytic plating and the like. The side surface of the conductive layer (55) that faces the fixed contact portion (33) becomes the movable contact (56) (contacting surface). The fixed contact (46) and the movable contact (56) are surfaces being in contact with the side surfaces of the mold portion in the step of growing the conductive layer (45) and the conductive layer (55) by the electrolytic plating, and the like.

FIG. 3



Description

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

[0001] The present invention relates to a switch and a method for manufacturing the same, and a relay. Specifically, the present invention relates to a switch using a metallic contact and a method for manufacturing the same, and also to a relay that uses the structure of the switch.

2. RELATED ART

[0002] A MEMS switch for bringing into contact with and separating from the metallic contact is, for example, disclosed in Japanese Unexamined Patent Publication No. 2006-526267. As shown in Fig. 1, in a switch 11, an insulating layer 13a is formed on an upper surface of a substrate 12a, a conductive layer 14a made of Al, Cu, or the like is formed thereon, and a plated layer 15a of Au or the like is grown from the upper surface to the end face of the conductive layer 14a to form a movable contact portion 17. Similarly, an insulating layer 13b is formed on an upper surface of a substrate 12b, a conductive layer 14b made of Al, Cu, or the like is formed thereon, and a plated layer 15b of Au or the like is grown from the upper surface to the end face of the conductive layer 14b to form a fixed contact portion 18. A switching operation is carried out between the movable contact portion 17 and the fixed contact portion 18 by moving the movable contact portion 17 in the direction of the arrow, and bringing into contact with or separating from a movable contact 16a that is a projecting region of the plated layer 15a and a fixed contact 16b that is a projecting region of the plated layer 15b.

[0003] An electrostatic relay is disclosed in Japanese Unexamined Patent Publication No. 9-251834 and the like. As shown in Fig. 2, in the electrostatic relay 21, a lever 24a is elastically bent by applying voltage to a movable comb teeth like electrode 22a and a fixed comb teeth like electrode 23a, and at the same time, a lever 24b is elastically bent by applying voltage to a movable comb teeth like electrode 22b and a fixed comb teeth like electrode 23b, so that a movable contact 25a formed at the distal end of the lever 24a and a movable contact 25b formed at the distal end of the lever 24b are in contact with each other thereby closing between the movable contacts 25a, 25b. The movable contacts 25a, 25b are opened and separated by releasing the application voltage between each comb teeth like electrode 22a and 23a and the movable comb teeth like electrode 22b and 23b. In such an electrostatic relay 21, the movable contacts 25a, 25b are formed by forming a metal film on the distal ends of the levers 24a, 24b through vapor deposition, sputtering, and the like.

[0004] In the switch 11 of Japanese Unexamined Pat-

ent Publication No. 2006-526267, a structure of bringing into contact with and separating from the surface of the movable contact 16a formed at the end face of the conductive layer 14a and the surface of the fixed contact 16b formed at the end face of the conductive layer 14b is adopted. Therefore, the movable contact 16a and the fixed contact 16b are in contact with each other at the surfaces (plated surfaces) perpendicular to the growing direction of the plated layer.

[0005] In the electrostatic relay 21 of Japanese Unexamined Patent Publication No. 9-251834 as well, a structure of bringing into contact with and separating from the surfaces of the movable contacts 25a, 25b formed at the end faces of the levers 24a, 24b is adopted. Therefore, in the electrostatic relay 21 as well, the movable contacts 25a, 25b come into contact with each other at the surfaces perpendicular to the growing direction of the vapor deposition film and the like.

[0006] However, the surfaces (surfaces of contacts) perpendicular to the growing direction of such contacts are considerably rough when viewed microscopically, and have irregular microscopic bumps. The contacting area of the contacts is thus small when seen microscopically, and the contact resistance in the case where the contacts are closed is large. Furthermore, the contact resistance between the contacts tends to become unnecessarily large since the parallelism of the surfaces of the opposing contacts is difficult to obtain.

[0007] When performing a plating process, the growing speed of the contact is large since the electric field intensity is high at the end face of the conductive layer in the switch 11 as well as the end face of the lever in the electrostatic relay 21, and hence, the gap distance between the contacts is difficult to control. Thus, the distance between the contacts becomes difficult to narrow.

[0008] A method of smoothing the surface of the contact by polishing and the like is known to resolve such drawbacks, but this increases the polishing step of the contact and becomes a factor in increase in cost of the switch and the relay.

SUMMARY

[0009] The present invention has been devised to solve the problems described above, and an object thereof is to provide a switch capable of smoothly forming a contacting surface of a contact without performing polishing, and the like and a method for manufacturing the same, as well as, a relay that uses the structure of the switch.

[0010] In accordance with one aspect of the present invention, a switch according to the present invention relates to a switch including a plurality of contacts that bring into contact with or separate from each other, wherein a surface parallel to a growing direction when forming a conductive layer for forming the contacts is a contacting surface of the contacts.

[0011] In the present invention, the contacting surface

of the contact can be formed smooth without performing polishing and the like of the contact since the contacting surfaces of the contacts are surfaces parallel to the growing direction of the conductive layer. The contact resistance in the case where the contacts come into contact with each other thus becomes small. If the contacting surfaces of the contacts are smooth, the contacts come into contact with each other evenly, and hence the contact contacting portion is less likely to break. As a result, the open/dose lifespan of the switch becomes longer, and the distance between the contacts can be narrowed.

[0012] In the one aspect of the switch according to the present invention, the contacting surface of the contact is a surface contacting a mold portion for defining a forming region of the conductive layer when growing the conductive layer. According to such an aspect, the contacting surface of the contact can be formed smooth since the contacting surface of the contact can be formed using the surface of the mold portion.

[0013] In accordance with another aspect of the present invention, a method for manufacturing a switch according to the present invention relates to a method for manufacturing a switch including a plurality of contacts that bring into contact with or separate from each other, the method comprising the steps of forming a mold portion of a predetermined pattern on an upper side of a substrate, growing a conductive layer in a thickness direction of the substrate in a plurality of regions excluding a region formed with the mold portion at the upper side of the substrate, removing the mold portion and having a surface contacting a side surface of the mold portion of the conductive layer as contacting surfaces of the contacts, and dividing the substrate into plurals in accordance with the plurality of regions formed with the conductive layer.

[0014] According to the method for manufacturing the switch of the present invention, the contacting surface of the contact can be formed smooth without performing the polishing and the like of the contact since the contacting surface of the contact can be molded by the side surface of the mold portion when forming the conductive layer. The contact resistance in the case where the contacts come into contact with each other thus becomes small. As the contacting surfaces of the contacts become smooth, the contacting positions of the contacts are dispersed, and the contact contacting portion becomes less likely to break. As a result, the open/dose lifespan of the switch becomes longer, and the distance between the contacts can be narrowed.

[0015] In one aspect of the method for manufacturing the switch according to the present invention, both side surfaces of the mold portion for forming the opposing contacts are formed parallel to each other. According to such an aspect, the contacting surfaces of the contacts can be made parallel to each other.

[0016] In the method for manufacturing the switch according to the present invention, the conductive layer may be grown on the upper side of the substrate through

an electrolytic plating or a non-electrolytic plating, or may be grown on the upper side of the substrate through a deposition method such as vapor deposition and sputtering. In the case of the deposition method, the material of the conductive layer deposited on the mold portion can be removed with the mold portion in the step of removing the mold portion.

[0017] A relay according to the present invention includes the switch according to the present invention, and an actuator for moving one part of the contact in a direction perpendicular to the contacting surfaces of the contacts to bring into contact with or separate from the contacts each other. In the relay of the present invention, the contact resistance in the case where the contacts come into contacts with each other can be reduced since the contacting surfaces of the contacts can be formed smooth. If the contacting surfaces of the contacts are smooth, the contacts come into contact with each other evenly, and hence the contact contacting portion is less likely to break. As a result, the lifespan of the relay becomes longer.

[0018] The means for solving the problems in the present invention have characteristics in which the configuring elements described above are appropriately combined, where the present invention includes a great number of variations obtained by combining the configuring elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is an enlarged cross sectional view of a switch disclosed in Japanese Unexamined Patent Publication No. 2006-526267;

Fig. 2 is a perspective view of an electrostatic relay disclosed in Japanese Unexamined Patent Publication No. 9-251834;

Fig. 3 is a cross-sectional view showing a structure of a switch according to a first embodiment of the present invention;

Figs. 4A to 4D are schematic cross-sectional views describing the method for manufacturing the switch of the first embodiment;

Figs. 5A to 5D are schematic cross sectional views describing another method for manufacturing the switch of the first embodiment;

Fig. 6 is a plan view showing an electrostatic relay according to a second embodiment of the present invention;

Fig. 7 is a perspective view showing area A of Fig. 6 in an enlarged manner; and

Fig. 8 is a schematic cross-sectional view taken along line B-B of Fig. 6.

DETAILED DESCRIPTION

[0020] Hereinafter, preferred embodiments of the

present invention will be described with reference to the drawings. The present invention is not limited to the following embodiments, and various design changes can be made within a scope not departing from the gist of the present invention.

[First embodiment]

(Structure)

[0021] Fig. 3 is a cross-sectional view showing a structure of a switch according to a first embodiment of the present invention. The switch 31 includes a fixed contact portion 33 and a movable contact portion 34. The fixed contact portion 33 is fixed to an upper surface of a base substrate 32 through an insulating film 42, and the movable contact portion 34 moves in a direction (direction indicated with outlined arrow) parallel to the upper surface of the base substrate 32 by a drive mechanism or an actuator. For instance, the switch of the present invention can be used in a MEMS switch having the structure disclosed in Japanese Unexamined Patent Publication No. 2006-526267.

[0022] The fixed contact portion 33 is obtained by forming an insulating 43 and a base layer 44 on the upper surface of a fixed contact substrate 41, and forming a conductive layer 45 thereon. The movable contact portion 34 is obtained by forming an insulating 53 and a base layer 54 on the upper surface of a movable contact substrate 51, and forming a conductive layer 55 thereon. The conductive layers 45, 55 are formed by growing a conductive material in the thickness direction (direction of arrow in Fig. 3) through electrolytic plating and non-electrolytic plating, vapor deposition, sputtering and the like, where the respective opposing side surfaces become a fixed contact 46 (electrical contacting surface) and a movable contact 56 (electrical contacting surfaces). The material of the conductive layers 45, 55 may be Pt, Au, Pd, Ir, Ru, Rh, Re, Ta, Pt alloy, Au alloy and the like. The fixed contact 46 and the movable contact 56 are smoothly formed parallel to each other. Therefore, when the movable contact portion 34 is parallel moved so that the fixed contact 46 and the movable contact 56 bring into contact with each other to close the contacts 46, 56, the contacts 46, 56 are in contact with over substantially the entire surface.

[0023] The opposing portions of the conductive layer 45 and the conductive layer 55 respectively project out from the end face of the fixed contact substrate 41 and the movable contact substrate 51, and the opposing surfaces of the fixed contact substrate 41 and the movable contact substrate 51 are both inclined to retreat toward the lower surface side. Therefore, when moving the movable contact portion 34 to bring contact the movable contact 56 into contact with the fixed contact 46, the fixed contact substrate 41 and the movable contact substrate 51 are not in contact with each other thereby inhibiting the contact of the movable contact 56 and the fixed con-

tact 46.

[0024] (First manufacturing method) The switch 31 is formed using a MEMS (Micro Electrical-Mechanical Systems) technique. The manufacturing method shown in Fig. 4A to Fig. 4D forms the conductive layers 45, 55 by electrolytic plating. Fig. 4A shows that in which an insulating layer A3 such as SiO_2 and a plated base layer A4 are formed on a substrate A1 made of Si, and a mould portion A2 is formed on the plated base layer A4. The plated base layer A4 becomes a plated electrode and has two-layer structure including the lower layer Cr / upper layer Au, and has the function of enhancing the adhesiveness (stripping strength) of the insulating layer A3 and the conductive layer A5. The mold portion A2 uses a material that has resistance to plating solution and that is selectively etching removed without corroding the conductive layer A5 in the subsequent mold portion removing step. For instance, the mold portion A2 may be formed by exposing a photoresist applied on the upper surface of the plated base layer A4 through an exposure mask, and patterning by etching. Alternatively, the mold portion A2 may be obtained by forming an oxide film (SiO_2), a nitride film (SiN), an alumina film (Al_2O_3), and a metal film of a type different from the conductive layers 45 and 55 on the upper surface of the plated base layer A4, and then patterning such films using the photolithography technique. The mold portion A2 is thus formed in the region other than the region to form the conductive layers 45, 55, and both side surfaces of the mold portion A2 patterned between the regions to form the conductive layers 45, 55 become parallel to each other and also smooth. Although not shown in Fig. 4A, the entire lower surface of the substrate A1 is fixed to the upper surface of the base substrate 32 including an Si substrate, a glass substrate, or the like through the insulating film 42 such as the SiO_2 .

[0025] The substrate A1 is then immersed in a plating bath and electrolytic plating is carried out with the plated base layer A4 as the plating electrode, so that the plating metal particles such as Pt gradually precipitate on the surface of the plated base layer A4 and the conductive layer A5 grows in the thickness direction of the substrate A1, as shown in Fig. 4B. The plating metal particles do not precipitate at the region covered by the mold portion A2. The non-electrolytic plating (chemical plating) may be performed instead of the electrolytic plating.

[0026] After cleaning the substrate A1 taken out from the plating bath with water, the mold portion A2 is removed by etching, so that a cavity A6 forms at the area where the mold portion A2 existed between the regions to form the conductive layers 45, 55, as shown in Fig. 4C. One conductive layer A5 separated by the cavity A6 becomes the conductive layer 55, and the side surface facing the cavity A6 becomes the movable contact 56. The other conductive layer A5 separated by the cavity A6 becomes the conductive layer 45, and the side surface facing the cavity A6 becomes the fixed contact 46.

[0027] Then, as shown in Fig. 4D, etchant is infiltrated

from the cavity A6 to sequentially divide the plated base layer A4 and the insulating layer A3 into two. Furthermore, the substrate A1 is etched from the lower surface side or etched from the cavity A6 side to divide into two, where one becomes the base layer 54, the insulating layer, 53 and the movable contact substrate 51 and the other becomes the base layer 44, the insulating layer 43, and the fixed contact substrate 41.

[0028] One of the blocks thus becomes the fixed contact portion 33 where the fixed contact substrate 41, the insulating layer 43, the base layer 44, and the conductive layer 45 are stacked. The fixed contact portion 33 is fixed to the upper surface of the base substrate 32 through the insulating film 42. The other block becomes the movable contact portion 34 where the movable contact substrate 51, the insulating layer 53, the base layer 54, and the conductive layer 55 are stacked. The movable contact portion 34 is separated from the base substrate 32 by lastly removing the insulating film at the lower surface through etching, whereby the switch 31 (MEMS switch) is formed.

(Second manufacturing method)

[0029] The switch 31 may be formed through steps shown in Figs. 5A to 5D. This manufacturing method forms the conductive layers 45, 55 by vapor deposition, sputtering, and the like. Fig. 5A is a step corresponding to Fig. 4A, but a adhesion layer A7 (e.g., two-layer structure of lower layer Cr / upper layer Au) for enhancing the adhesion strength (stripping strength) of the insulating layer A3 and the conductive layer A5 is formed in place of the plated base layer A4 on the insulating layer A3. In the step of Fig. 5B, the metal material such as Pt is deposited on the adhesion layer A7 through vapor deposition, sputtering, and the like. The conductive layer A5 is also deposited on the mold portion A2 as shown in Fig. 5B according to the deposition method through vapor deposition, sputtering, and the like, but the conductive layer A5 on the mold portion A2 is simultaneously removed when removing the mold portion A2 through etching if the mold portion A2 has sufficient height (lift off method).

[0030] The cavity A6 forms after the mold portion A2 is removed as shown in Fig. 5C, and the conductive layer A5 is separated to the conductive layer 55 and the conductive layer 45, which is the same as the step of Fig. 4C. Furthermore, as shown in Fig. 5D, the etchant is infiltrated from the cavity A6 to sequentially divide the adhesion layer A7 and the insulating layer A3 into two, and furthermore, the substrate A1 is divided into two, where one becomes the base layer 54, the insulating layer, 53 and the movable contact substrate 51 and the other becomes the base layer 44, the insulating layer 43, and the fixed contact substrate 41, which is the same as the step of Fig. 4D.

(Effects)

[0031] In the switch 31 of the present invention, the contacting surface can be smoothly molded with the side surface of the mold portion without performing polishing and the like since the contacting surface of the fixed contact 46 and the contacting surface of the movable contact 56 are parallel in the growing direction of the conductive layer A5. The parallelism of the contacting surfaces of the contacts 46, 56 can be enhanced. The contact resistance in the case where the contacts 46, 56 are in contact with each other thus becomes small.

[0032] Since the accuracy of the gap distance between the contacts 46, 56 can be enhanced while reducing variance, the gap distance between the contacts can be narrowed and the movement distance of the movable contact 56 by the actuator can be reduced. Furthermore, the contacting positions of the contacts are dispersed since the surfaces of the fixed contact 46 and the movable contact 56 are smooth, and hence the contact contacting portion is less likely to break and the open/close lifespan of the switch 31 becomes longer.

[Second embodiment]

[0033] The structure of the electrostatic relay 31A for high frequency according to a second embodiment of the present invention will now be described. Fig. 6 is a plan view showing the structure of the electrostatic relay 31A. Fig. 7 is a perspective view showing area A of Fig. 6 in an enlarged manner. Fig. 8 is a schematic cross-sectional view taken along line B-B of Fig. 6.

[0034] The electrostatic relay 31A has the fixed contact portion 33, the movable contact portion 34, a fixed electrode portion 35, a movable electrode portion 36 for supporting the movable contact portion 34, an elastic spring 37, and a supporting portion 38 for supporting the elastic spring 37 arranged on the upper surface of the base substrate 32 including the Si substrate, the glass substrate, or the like.

[0035] As shown in Fig. 8, the fixed contact portion 33 has the lower surface of the fixed contact substrate 41 made of Si fixed to the upper surface of the base substrate 32 by the insulating film 42 (SiO_2). The insulating layer 43 including an oxide film (SiO_2), a nitride film (SiN), or the like is formed on the upper surface of the fixed contact substrate 41, the base layer 44 including the lower layer Cr / upper layer Au is formed on the upper surface thereof, and the conductive layers 45a, 45b of Pt and the like are formed on the base layer 44.

[0036] As shown in Fig. 6 and Fig. 7, the fixed contact substrate 41 extends in the width direction (X direction) at the end on the upper surface of the base substrate 32, where a bulging-out portion 41a projecting out towards the movable contact portion 34 side is formed at the central part and pad supporting portions 41b, 41b are formed at both ends. The conductive layers 45a, 45b are wired along the upper surface of the fixed contact point sub-

strate 41, where one of the ends of the conductive layers 45a, 45b are arranged parallel to each other on the upper surface of the bulging-out portion 41 a, and the distal end faces of the portion projecting out from the end face of the bulging-out portion 41a are positioned within the same plane to become the fixed contacts 46a, 46b (electrical contacting surface), respectively. The other ends of the conductive layers 45a, 45b have metal pad portions 47a, 47b formed on the upper surface of the pad supporting portions 41 b, 41 b.

[0037] The movable contact portion 34 is arranged at a position facing the bulging-out portion 41a. As shown in Fig. 8, the movable contact portion 34 has the insulating layer 53 including the oxide film (SiO_2), the nitride film (SiN), or the like formed on the upper surface of the movable contact substrate 51 made of Si, the base layer 54 including the lower layer Cr / upper layer Au formed on the upper surface thereof, and the conductive layer 55 of Pt and the like formed on the base layer 54.

The end face of the conductive layer 55 facing the conductive layers 45a, 45b projects out from the front surface of the movable contact substrate 41 and is formed parallel to the fixed contact 46a, 46b, whereby the relevant end face becomes the movable contact 56 (electrical contacting surface). The movable contact 56 has a width substantially equal to the distance from the edge on the outer side of the fixed contact 46a to the edge on the outer side of the fixed contact 46b.

[0038] The movable contact substrate 51 is supported in a cantilever manner by a supporting beam 57 projecting out from the movable electrode portion 36. The lower surfaces of the movable contact substrate 51 and the supporting beam 57 are floating from the upper surface of the base substrate 32, and can move parallel to the length direction (Y direction) of the base substrate 32 with the movable electrode portion 36.

[0039] In the electrostatic relay 31A, a main circuit (not shown) is connected to the metal pad portions 47a, 47b of the fixed contact portion 33, where the main circuit can be closed by bringing the movable contact 56 into contact with the fixed contacts 46a, 46b, and the main circuit can be opened by separating the movable contact 56 from the fixed contacts 46a, 46b. The opposing surfaces of the bulging-out portion 41a and the movable contact substrate 51 are inclined to retreat towards the lower side, and the fixed contacts 46a, 46b are projected out than the bulging-out portion 41 a and the movable contact 56 is also projected out from the movable contact substrate 51, and hence the bulging-out portion 41 a and the movable contact substrate 51 are not in contact when closing the contacts thereby preventing the movable contact 56 and the fixed contacts 46a, 46b from causing contact failure.

[0040] The actuator for moving the movable contact portion 34 is configured by the fixed electrode portion 35, the movable electrode portion 36, the elastic spring 37, and the supporting portion 38.

[0041] As shown in Fig. 6, a plurality of fixed electrode

portions 35 is arranged in parallel to each other on the upper surface of the base substrate 32. In plan view, the fixed electrode portion 35 has a branch-like electrode part 67 of a branch-shape extending in the Y direction from both surfaces of a rectangular pad portion 66. The branch-like electrode part 67 has a branch portion 68 projecting out so as to be symmetrical to each other, the branch portion 68 is lined at a constant pitch in the Y-direction.

[0042] As shown in Fig. 8, the lower surface of the fixed electrode substrate 61 is fixed to the upper surface of the base substrate 32 by the insulating film 62 in the fixed electrode portion 35. In the pad portion 66, the fixed electrode 63 is formed by Cu, Al, and the like on the upper surface of the fixed electrode substrate 61, and an electrode pad layer 65 is arranged above the fixed electrode 63.

[0043] As shown in Fig. 6, the movable electrode portion 36 is formed to surround each fixed electrode portion 35. The movable electrode portion 36 includes a comb teeth like electrode portion 74 formed so as to sandwich each fixed electrode portion 35 from both sides (branch-shape by a pair of comb teeth like electrode portions 74 between the fixed electrode portions 35). The comb teeth like electrode portion 74 is symmetric with each fixed electrode portion 35 as the center, where a comb teeth part 75 extends from each comb teeth like electrode portion 74 to a clearance between the branch portions 68. Furthermore, each comb teeth part 75 has the distance with the branch portion 68 positioned on the side close to the movable contact portion 34 adjacent to the comb teeth part 75 shorter than the distance with the branch portion 68 positioned on the side distant from the movable contact portion 34 adjacent to the comb teeth part 75.

[0044] The movable electrode portion 36 includes a movable electrode substrate 71 of Si, where the lower surface of the movable electrode substrate 71 is floating from the upper surface of the base substrate 32. The supporting beam 57 is arranged in a projecting manner at the center of the end face on the movable contact side of the movable electrode portion 36, and the movable contact portion 34 is held at the distal end of the supporting beam 57.

[0045] The supporting portion 38 is made of Si, and extends long in the X direction at the other end of the base substrate 32. The lower surface of the supporting portion 38 is fixed to the upper surface of the base substrate 32 by the insulating film 39. Both ends of the supporting portion 38 and the movable electrode portion 36 (movable electrode substrate 71) are connected by a pair of elastic springs 37 formed symmetrically by Si, where the movable electrode portion 36 is horizontally supported by the supporting portion 38 by way of the elastic spring 37. The movable electrode portion 36 is movable in the Y direction by elastically deforming the elastic spring 37.

[0046] In the electrostatic relay 31A having the above structure, a DC voltage source is connected between the

fixed electrode portion 35 and the movable electrode portion 36, and the DC voltage is turned ON and OFF by the control circuit and the like. In the fixed electrode portion 35, one terminal of the DC voltage source is connected to the electrode pad layer 65. The other terminal of the DC voltage source is connected to the supporting portion 38. The supporting portion 38 and the elastic spring 37 have conductivity, and the supporting portion 38, the elastic spring 37, and the movable electrode substrate 71 are electrically conducted, and hence the voltage applied to the supporting portion 38 will be applied to the movable electrode substrate 71.

[0047] When the DC voltage is applied between the fixed electrode portion 35 and the movable electrode portion 36 by the DC voltage source, an electrostatic attractive force is generated between the branch portion 68 of the branch like electrode part 67 and the comb teeth part 75 of the comb teeth like electrode portion 74. However, the electrostatic attractive force in the X direction acting on the movable electrode portion 36 becomes balanced since the structure of the fixed electrode portion 35 and the movable electrode portion 36 is formed symmetric with respect to the center line of each fixed electrode portion 35, whereby the moveable electrode portion 36 does not move in the X direction. Since the distance with the branch portion 68 positioned on the side close to the movable contact portion 34 adjacent to the comb teeth part 75 is shorter than the distance with the branch portion 68 positioned on the side distant from the movable contact portion 34 adjacent to the comb teeth part 75, each comb teeth part 75 is attracted to the movable contact portion side, and the movable electrode portion 36 moves in the Y direction while bending the elastic spring 37. As a result, the movable contact portion 34 moves to the fixed contact portion 33 side, and the movable contact 56 come into contact with the fixed contacts 46a, 46b thereby electrically closing the fixed contact 46a and the fixed contact 46b (main circuit).

[0048] When the DC voltage applied between the fixed electrode portion 35 and the movable electrode portion 36 is released, the electrostatic attractive force between the branch portion 68 and the comb teeth part 35 disappears, whereby the movable electrode portion 36 moves backward in the Y direction by the elastic returning force of the elastic spring 47 thereby separating the movable contact 56 from the fixed contacts 46a, 46b and opening the fixed contact 46a and the fixed contact 46b (main circuit).

[0049] Such electrostatic relay 31A is formed through the following steps. First, the Si substrate (another Si wafer having conductivity) is joined to the upper surface of the base substrate 32 (Si wafer, SOI wafer, etc.) having the entire surface covered with the insulating film, and the metal material is vapor deposited on the upper surface of the Si substrate to form the electrode film. The electrode film is then patterned by the photolithography technique, and the fixed electrode 63 is formed on the upper surface of the fixed electrode substrate 61 at the

pad portion 66 by the electrode film.

[0050] Thereafter, the insulating layer, the base layer, and the conductive layer are stacked on the upper surface of the Si substrate from above the electrode film. The conductive layer is then patterned to form the conductive layers 45a, 45b of the fixed contact portion 33, the conductive layer 55 of the movable contact portion 34, and the electrode pad layer 65 of the fixed electrode portion 35. The conductive layers 45a, 45b and the conductive layer 55 are removed through etching leaving the base layer and the insulating layer at the lower surface, where the base layers 44, 54 are formed by the remaining base layer and the insulating layers 43, 53 are formed by the remaining insulating layer.

[0051] The fixed electrode 63, the conductive layers 45a, 45b, and the conductive layer 55 may be simultaneously formed through procedures different from the above.

[0052] Thereafter, a photoresist is applied on the conductive layer 45a, the conductive layer 55, the fixed electrode 63, and the like to form a resist mask, the Si substrate is etched through the resist mask, and the fixed contact substrate 41 of the fixed contact portion 33, the movable contact substrate 51 of the movable contact portion 34, the fixed electrode substrate 61 of the fixed electrode portion 35, the movable electrode substrate 71 of the movable electrode portion 36, the elastic spring 37, and the supporting portion 38 are formed from the Si substrate remaining in each region.

[0053] Lastly, the insulating film of the region exposed from the Si substrate and the insulating film at the lower surfaces of the movable contact portion 34 and the movable electrode portion 36 are removed through etching, and then cut to individual electrostatic relay 31A.

[0054] In the manufacturing step of the electrostatic relay 31A, the movable contact portion 34 and the fixed electrode portion 35 are formed through steps similar to the steps shown in Fig. 4 or Fig. 5, and hence the fixed contacts 46a, 46b of the fixed contact portion 33 and the movable contact 56 of the movable contact portion 34 become side surfaces parallel to the growing direction of the conductive layer, and a contact having satisfactory smoothness and parallelism can be obtained without performing polishing and the like. Effects similar to the switch 31 of the first embodiment thus can be obtained in the electrostatic relay 31A as well.

Claims

1. A switch (31) including a plurality of contacts that bring into contact with or separate from each other, **characterized in that:**

a surface parallel to a growing direction when forming a conductive layer (45, 45a, 45b, 55) for forming the contacts is a contacting surface of the contacts.

2. The switch (31) according to claim 1, **characterized in that:**

the contacting surface of the contact is a surface contacting a mold portion for defining a forming region of the conductive layer (45, 45a, 45b, 55) when growing the conductive layer (45, 45a, 45b, 55)

5

3. A method for manufacturing a switch including a plurality of contacts that bring into contact with or separate from each other, the method being **characterized by** comprising the steps of:

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forming a mold portion of a predetermined pattern on an upper side of a substrate, growing a conductive layer (45, 45a, 45b, 55) in a thickness direction of the substrate in a plurality of regions excluding a region formed with the mold portion at the upper side of the substrate, removing the mold portion and having a surface contacting a side surface of the mold portion of the conductive layer (45, 45a, 45b, 55) as contacting surfaces of the contacts, and dividing the substrate into plurals in accordance with the plurality of regions formed with the conductive layer (45, 45a, 45b, 55).

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4. The method for manufacturing the switch (31) according to claim 3, **characterized in that:**

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both side surfaces of the mold portion for forming the opposing contacts are formed parallel to each other.

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5. The method for manufacturing the switch (31) according to claim 3, **characterized in that:**

the conductive layer (45, 45a, 45b, 55) is grown on the upper side of the substrate through an electrolytic plating or a non-electrolytic plating.

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6. The method for manufacturing the switch (31) according to claim 3, **characterized in that:**

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the conductive layer (45, 45a, 45b, 55) is grown on the upper side of the substrate through a deposition method such as vapor deposition and sputtering.

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7. The method for manufacturing the switch (31) according to claim 6, **characterized in that:**

the material of the conductive layer (45, 45a, 45b, 55) deposited on the mold portion is removed with the mold portion in the step of removing the mold portion.

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8. A relay (31A) being **characterized by** comprising:

the switch (31) according to claim 1, and an actuator for moving one part of the contact in a direction perpendicular to the contacting surfaces of the contacts to bring into contact with or separate from the contacts each other.

FIG. 1

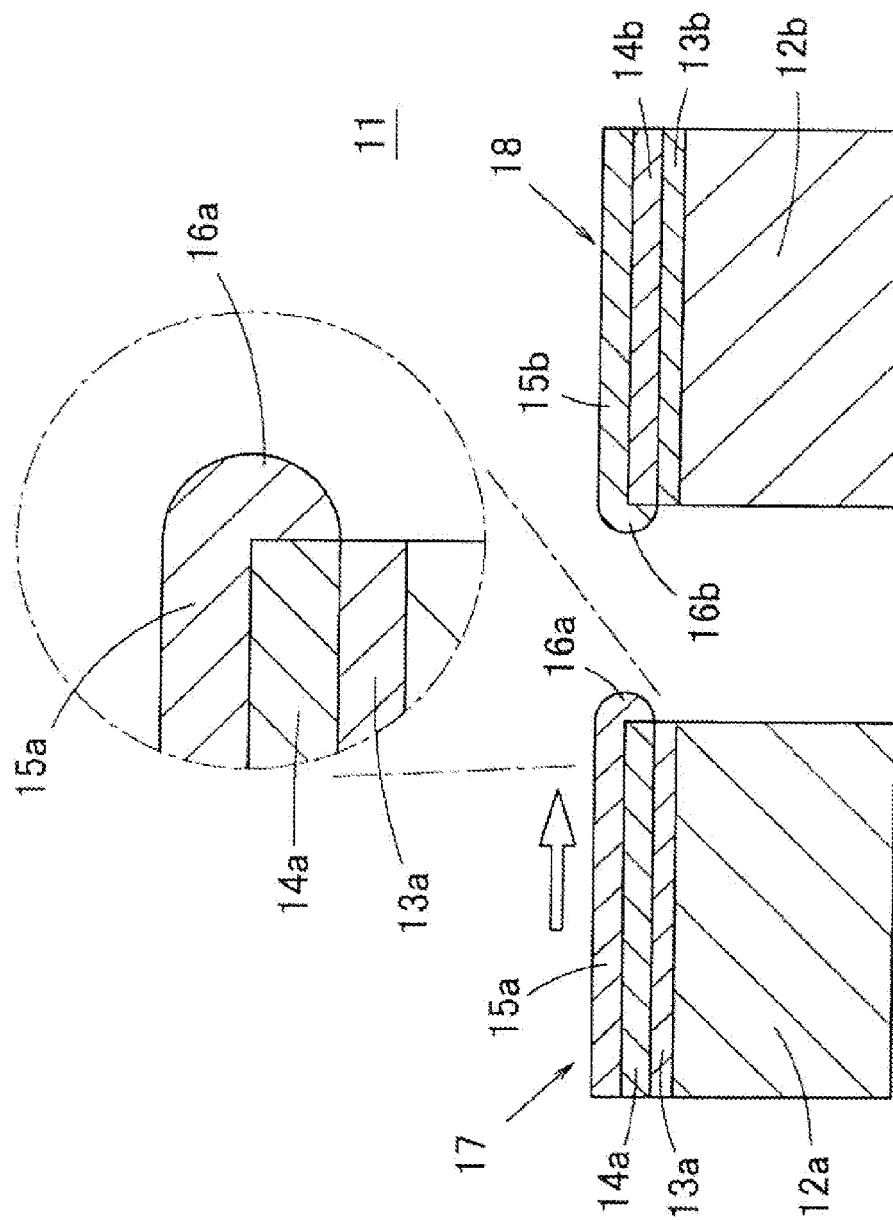


FIG. 2

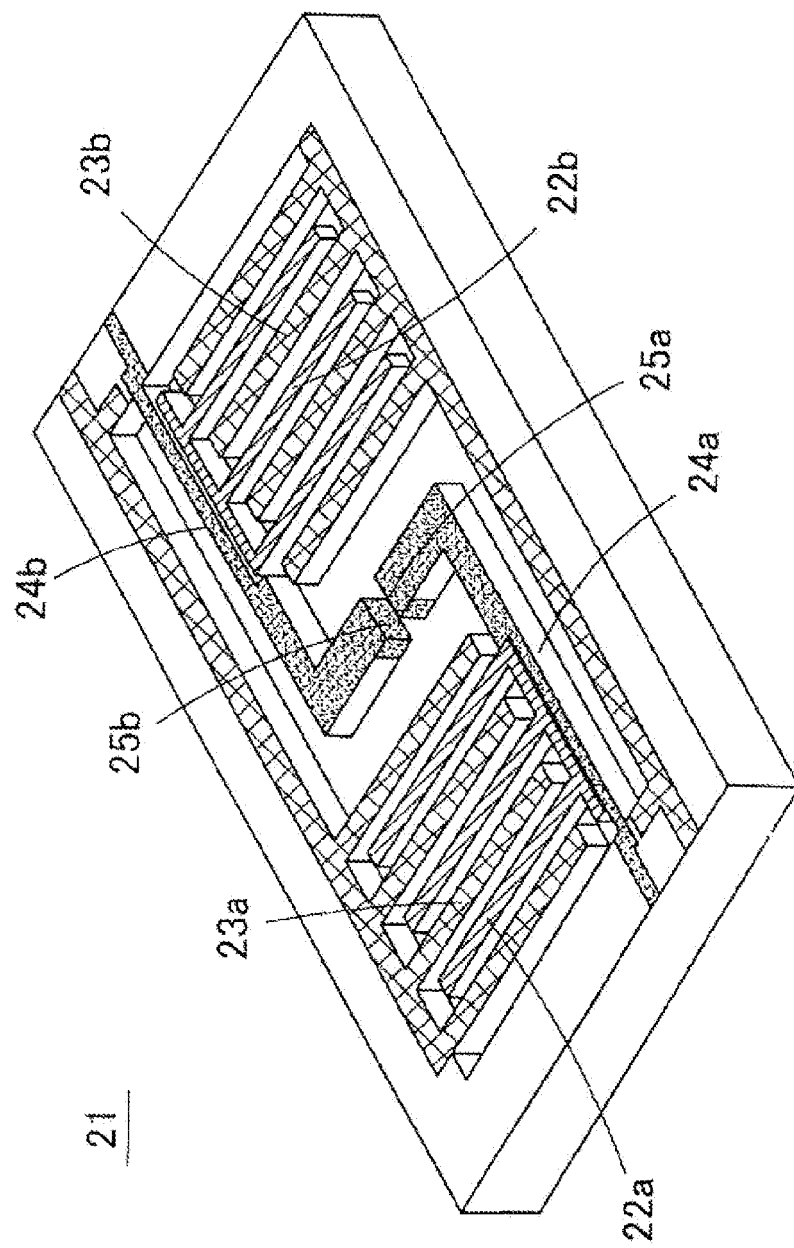


FIG. 3

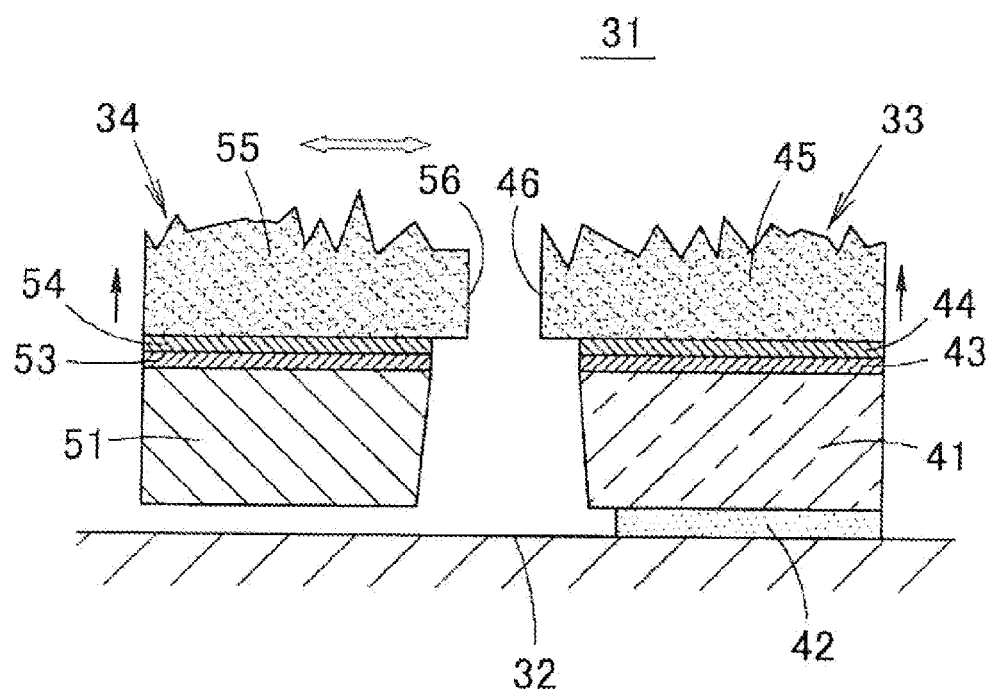


FIG. 4A

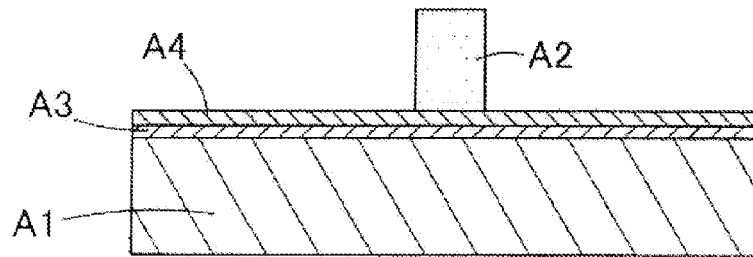


FIG. 4B

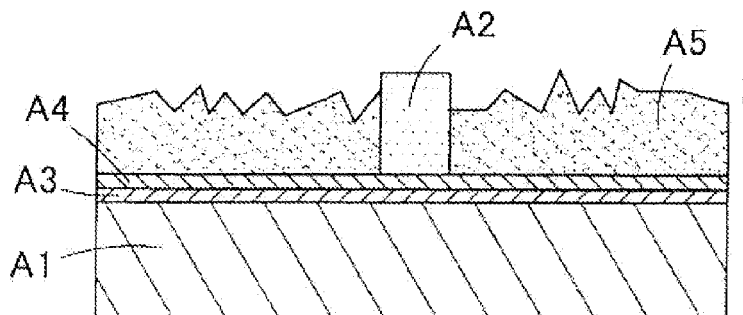


FIG. 4C

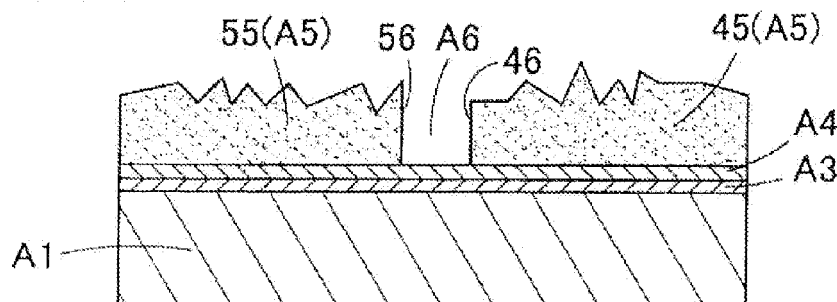


FIG. 4D

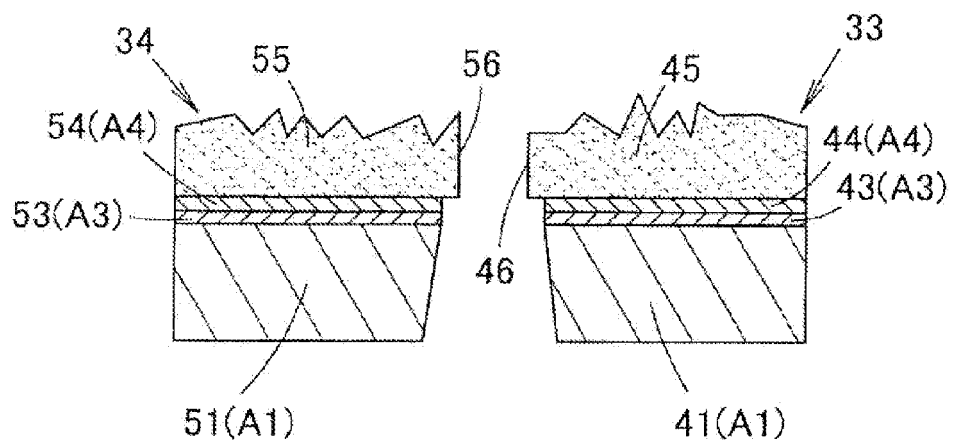


FIG. 5A

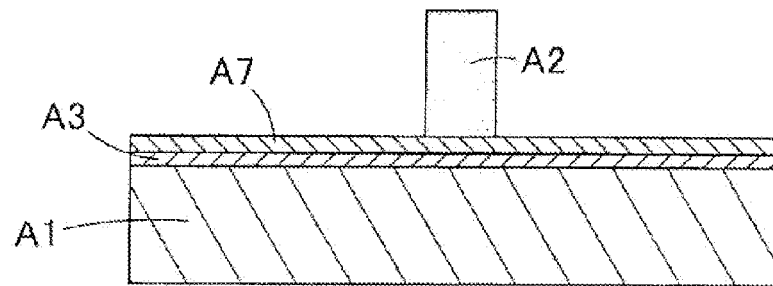


FIG. 5B

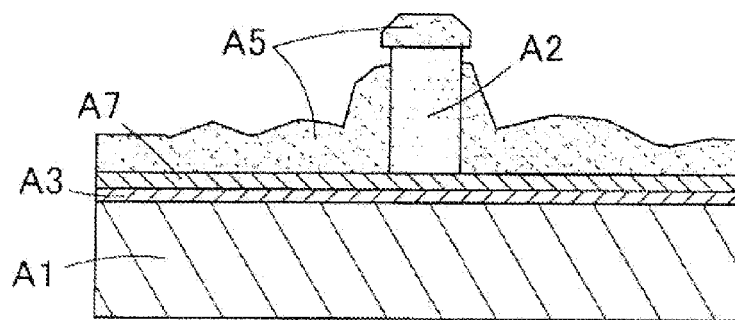


FIG. 5C

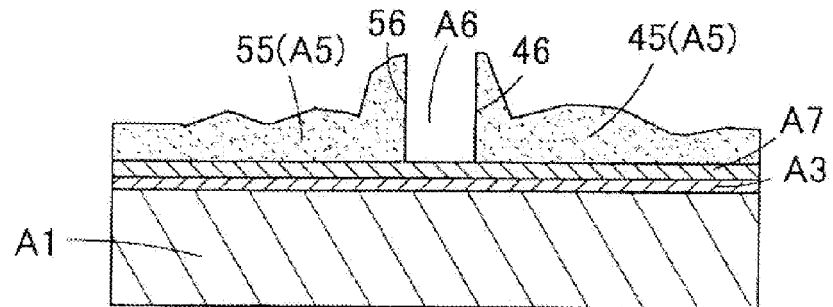


FIG. 5D

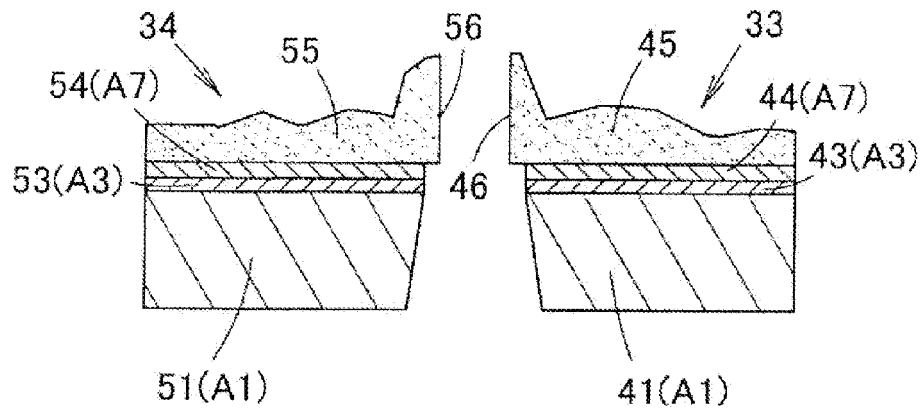


FIG. 6

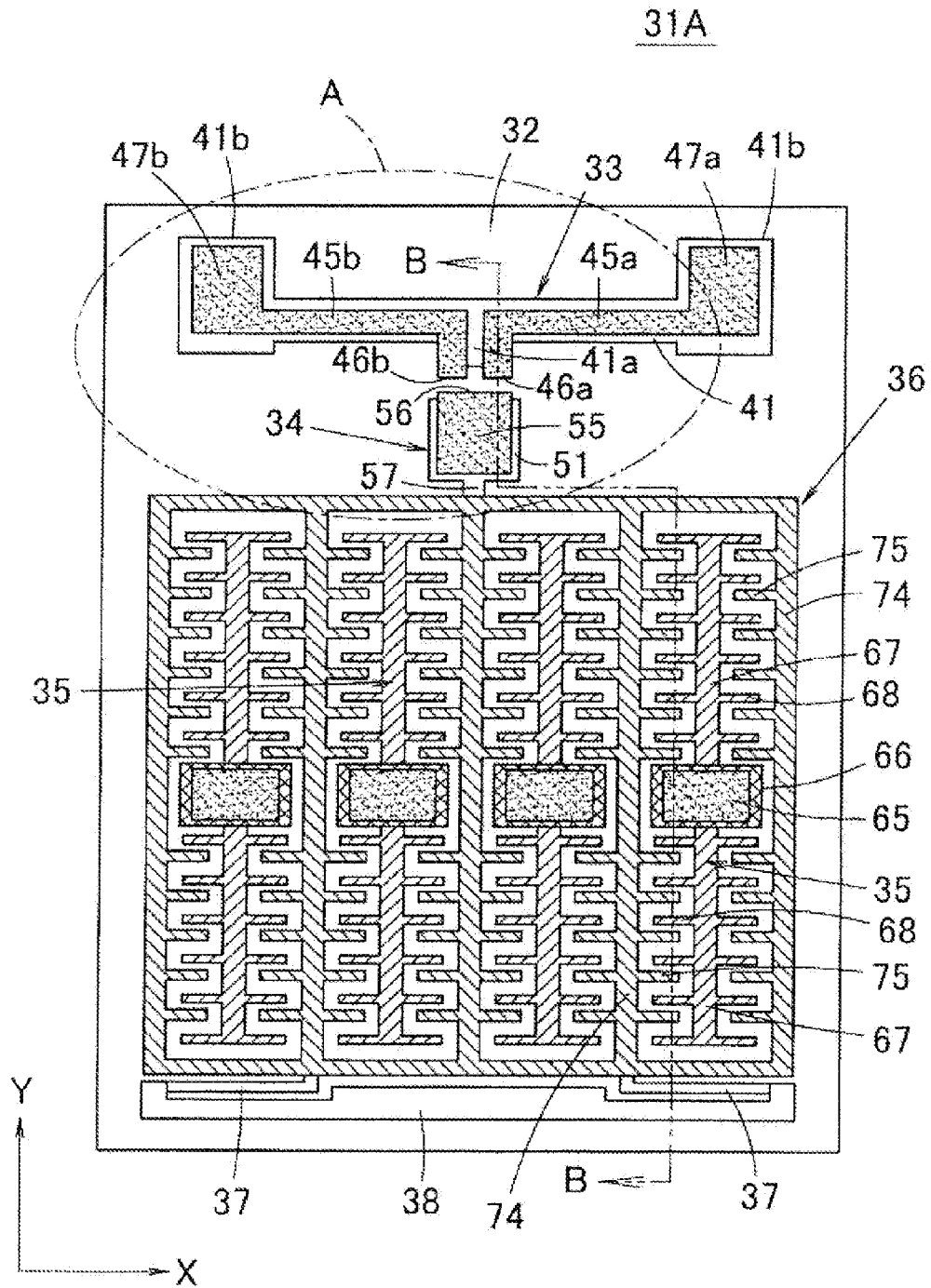


FIG. 7

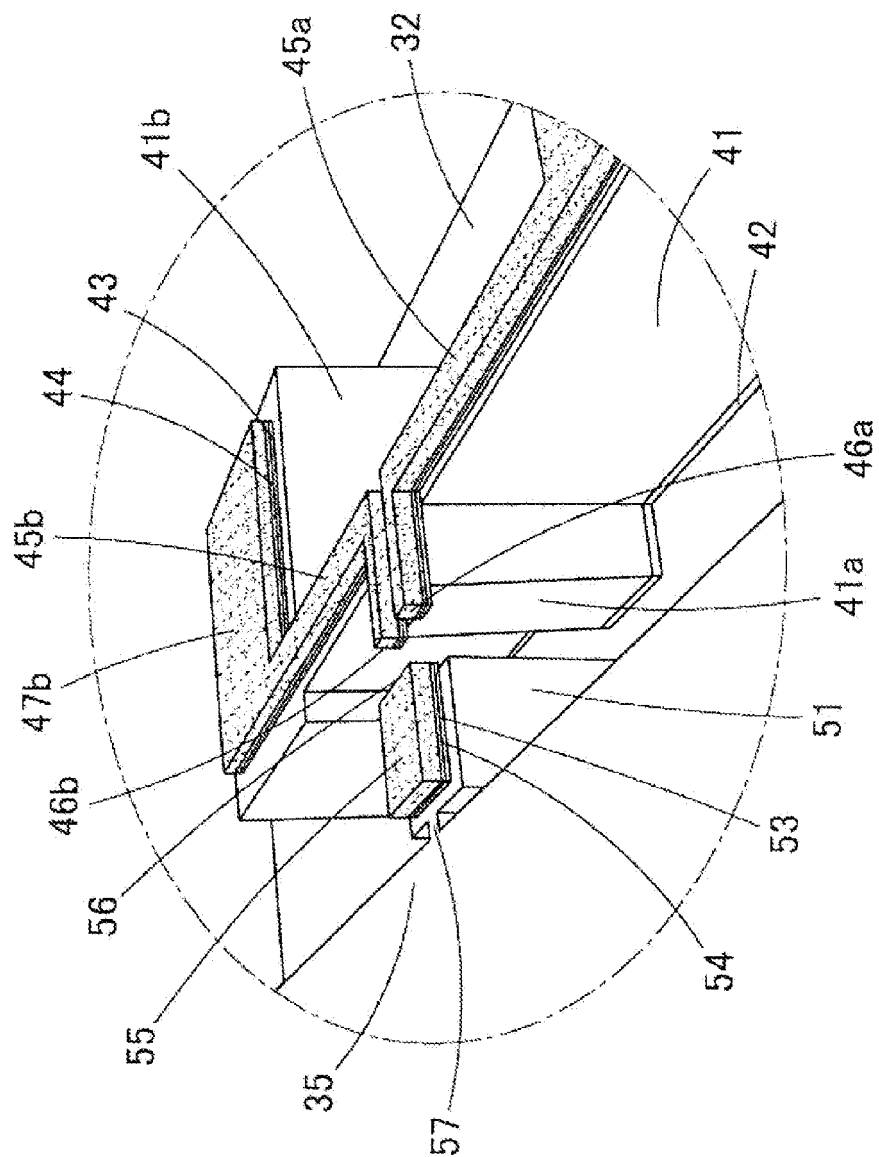
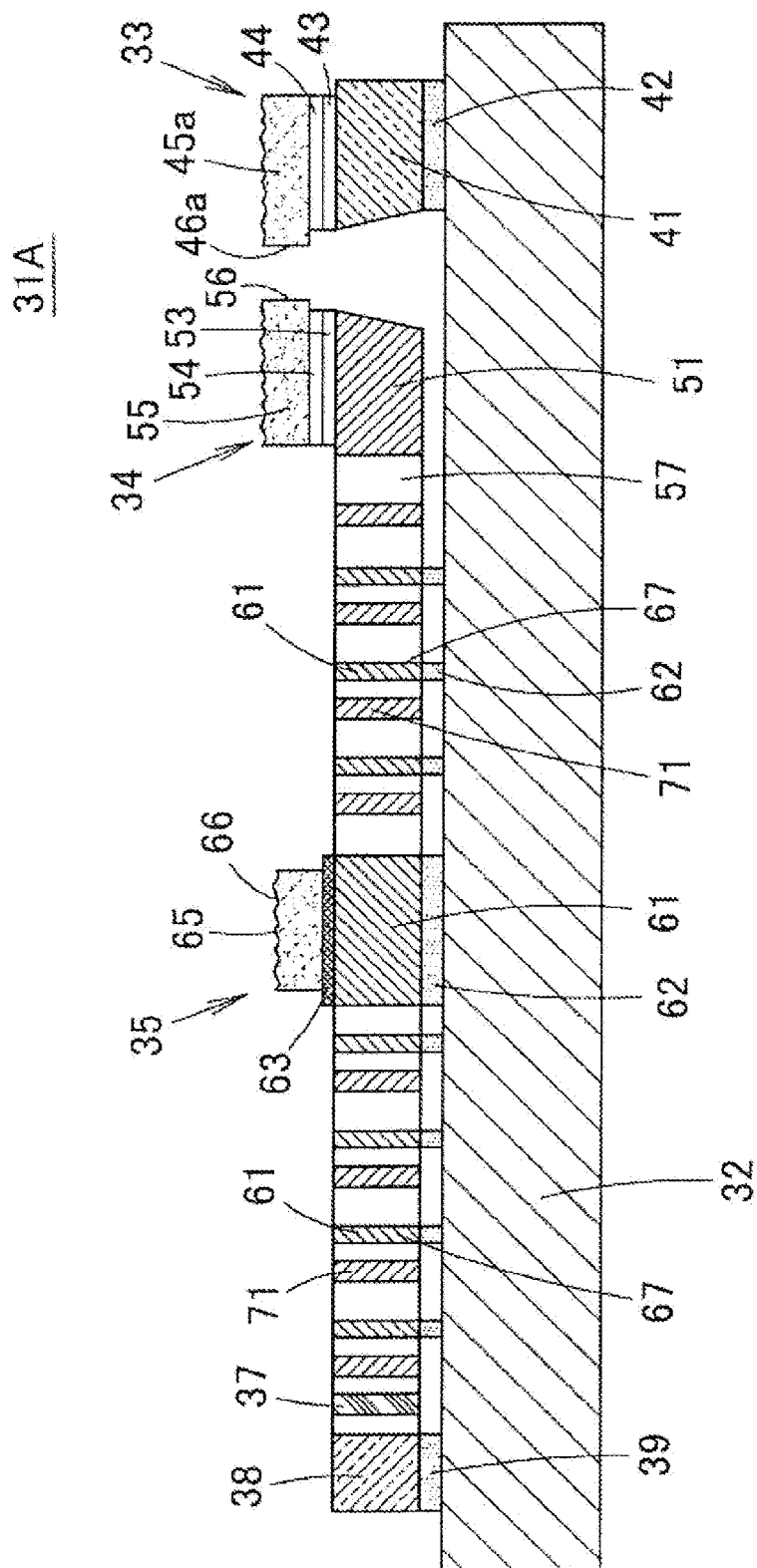


FIG. 8





EUROPEAN SEARCH REPORT

Application Number
EP 11 15 1193

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2002/184949 A1 (GIANCHANDANI YOGESH B [US] ET AL) 12 December 2002 (2002-12-12)	1-7	INV. H01H1/00 H01H59/00 H01H1/06 H01H1/023
Y	* paragraph [0002] * * paragraph [0018] - paragraph [0019]; figures 1, 3 * * paragraph [0026] *	8	
A	----- GUCKEL H: "High-Aspect-Ratio Micromachining Via Deep X-Ray Lithography", PROCEEDINGS OF THE IEEE, IEEE. NEW YORK, US, vol. 86, no. 8, 1 August 1998 (1998-08-01), pages 1586-1593, XP011044068, ISSN: 0018-9219, DOI: DOI:10.1109/5.704264 * page 1587, column 2, paragraph 4 - page 1588, column 1, paragraph 2; figure 2 *	1-8	
Y,D	----- JP 9 251834 A (OMRON TATEISI ELECTRONICS CO) 22 September 1997 (1997-09-22) * abstract *	8	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			H01H
Place of search		Date of completion of the search	Examiner
Munich		8 June 2011	Dobbs, Harvey
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 15 1193

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08-06-2011

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2002184949	A1	12-12-2002	WO 02099441 A1	12-12-2002

JP 9251834	A	22-09-1997	NONE	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006526267 A [0002] [0004] [0019] [0021]
- JP 9251834 A [0003] [0005] [0019]