

Description

Micromechanical electrostatic relay, and a method for its production

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The invention relates to a micromechanical electrostatic relay having

- a base substrate with a base electrode and with at least one stationary contact,
- 10 an armature spring tongue which is linked on one side to a carrier layer connected to the base substrate, has an armature electrode opposite the base electrode, is elastically curved away from the base substrate in the rest state forming a wedge-shaped air gap, and is
- 15 fitted at its free end with at least one moving contact opposite the stationary contact. In addition, the invention relates to a method for producing such a relay.

Such a micromechanical relay and an appropriate

20 production method have already been disclosed, in principle, in DE 42 05 029 C1. The essential feature in this case is that the armature spring tongue, which is exposed from a substrate, is curved in such a manner that the armature electrode forms a wedge-shaped air

25 gap with the opposite base electrode, which air gap, when a voltage is applied between the two electrodes, produces a rapid attraction movement on the basis of the so-called moving-wedge principle. Refinements of this principle have been disclosed, for example, in DE

30 44 37 259 C1 and DE 44 37 261 C1.

In the case of all these known relays with a micromechanical construction, a relatively high manufacturing effort is involved since two substrates, namely on the one hand a base substrate with the base

35 electrode and the stationary contact, and on the other hand an armature substrate with the armature spring tongue, the armature electrode and the moving contact, have to be produced separately

and connected to one another. In addition to the said main functional elements of the two substrates, further coating and etching processes are involved, for example for insulating layers, leads and the like. Each of the two substrates therefore has to be subjected on its own to all the complex processes involved before their main functional layers can be connected, facing one another. Since the switching elements are also intended to be protected against environmental influences, an additional covering part is, as a rule, required as a closing element, although there is no need to describe this in any more detail.

In order to simplify production, it would be desirable if it were possible to form all the functional elements of the relay on a substrate from one side. In this case, it is in principle feasible to form a stationary contact element and a spring tongue with a moving contact on one and the same substrate, in which case, for example, the stationary contact and the moving contact can be produced one above the other, and the contact gap can be formed by etching away a so-called sacrificial layer. Such an arrangement has been disclosed in principle in US-4 570 139. However, in the case of the micromechanical switch there, a cavity that is not accurately defined is created underneath the armature spring tongue, and this cavity is not suitable for the formation of an electrostatic drive. In the case of the switch there, provision is therefore made for both the armature spring tongue as well as the stationary contact to be provided with a magnetic layer in each case, and for the switch to be operated via an externally applied magnetic field. Even in the case of the relatively short contact gap which can be achieved between the moving contact and the rigid stationary contact using the sacrificial layer technique, such a magnetic field can be used to produce the required contact force. However, to do this, an additional device is required to produce the magnetic field, for example a coil, and this occupies considerably more

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space than is available for a micromechanical relay in
certain

applications.

The aim of the present invention is to develop the design of a micromechanical relay of the type mentioned initially such that greater contact forces
5 can be produced even with the electrostatic drive, but in which the functional elements of the relay can be produced on the base substrate by action from one side.

According to the invention, this aim is achieved in that the at least one stationary contact is
10 arranged on a stationary-contact spring tongue which, opposite the armature spring tongue, is linked like this on one side to a carrier layer and is elastically curved away from the base substrate in the rest state, and in that the at least one moving contact is formed
15 at the free end of the armature spring tongue such that it projects beyond said armature spring tongue and overlaps the stationary contact.

Thus, in the case of the invention, in contrast to previous proposals for micromechanical relays and
20 switches, the stationary contact is also no longer rigidly arranged on the base substrate but is seated, like the moving contact, on a curved spring tongue, which allows an additional switching movement to be achieved. The moving contact is seated on the armature
25 spring tongue and overlaps the stationary contact. The prior curvature of the two mutually opposite spring tongues thus allows an adequate over-travel to produce the desired contact force to be achieved from the start of contact-making to the final position of the armature
30 during switching. This effect is achieved even if only a relatively small free space can be created underneath the armature when the armature spring tongue is formed on a base substrate using the sacrificial layer technique, by virtue of which relatively small free
35 space the armature is given only a small, specific over-travel beyond its extended position when attraction to the opposing electrode occurs.

Production is particularly advantageous if both the armature spring tongue and the stationary-contact spring tongue are formed from the same carrier layer, and can thus be produced in one and the same etching process. The spring tongues, whose free ends are opposite one another, can engage in one another in an advantageous manner like teeth, so that the projecting moving contact can be connected, not only at its rear end but at least on one side as well, to the surface of the armature spring tongue. The specific design is dependent on whether the intention is to create a make contact or a bridge contact.

Silicon is the preferred material for the base substrate, in which case the carrier layer for the spring tongues is deposited or bonded on as a silicon layer with the interposition of the respectively required functional and insulating layers, and is etched free in the appropriate processes. Alternatively, the base substrate may be composed of glass or ceramic; these materials are considerably more cost-effective than silicon. However, ceramic requires an additional surface treatment in order to obtain the smooth surface required for the relay structures. The carrier layer which forms the spring tongues may, for example, be composed of deposited polysilicon or polysilicon with recrystallisation, or may be an exposed, doped silicon layer of a bonded-on silicon wafer. This layer can be produced by epitaxy or diffusion in a silicon wafer. Alternatively, a deposited layer of a spring metal, such as nickel, a nickel-iron alloy or nickel with other additives can be used in addition to this silicon structure. Other metals may also be used; the important factor is that the material has good spring characteristics and suffers little fatigue.

An advantageous method for producing a relay according to the invention has the following steps:

- a metal carrier layer is applied, with the interposition of an insulating layer and an intermediate space, to a base substrate which is provided with a metal layer as the base electrode,
- 5 - two spring tongues which are linked on one side and whose free ends are opposite one another are formed in the carrier layer,
- at least in places, the spring tongues are provided with a tensile stress layer on their top surface,
- 10 - a - preferably shorter - spring tongue is provided at its free end with at least one stationary contact,
- the - preferably longer - spring tongue is provided with at least one moving contact which overlaps the stationary contact, with the interposition of a sacrificial layer, and
- 15 - the curvature of the spring tongues upwards away from the substrate is achieved by etching the spring tongues free from one another and from the substrate.
- 20

Further refinements of the production method are quoted in Claims 14 to 16.

- The invention will be explained below in more detail on the basis of exemplary embodiments and with reference to the drawing, in which
- Figure 1 shows a section illustration of the layout of the essential functional layers of a micromechanical relay according to the invention,
- 25 Figure 2 shows the micromechanical relay from Figure 1 in the final state (without a casing) in the rest position,
- Figure 3 shows the relay from Figure 2 in the operating position,
- 30 Figure 4 shows a plan view of the relay from Figure 3, which forms a make contact,
- Figure 5 shows the same view as Figure 4, but with an embodiment which forms a bridge contact,
- 35

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Figure 6 shows a modified embodiment of a bridge-contact arrangement,

Figure 7 shows an illustration corresponding to Figure 1, but with a tensile-stress layer above a partial section of the armature spring tongue, Figure 8 shows a view corresponding to Figure 2 with
5 spring-tongue sections of different curvature, Figure 9 shows a layer structure which is somewhat modified from that in Figure 1, of a base substrate up to the formation of a carrier layer composed of polysilicon for the spring tongues,
10 Figure 10 shows a layer structure, modified from that in Figure 9, with a carrier layer composed of metal for the spring tongues, Figure 11 shows a layer structure, modified from that in Figures 9 and 10, with a lost-wafer layer bonded on
15 to the base substrate in order to form the carrier layer for the spring tongues, and Figure 12 shows a modified layer structure using an SOI wafer semi-finished product.

First of all, it should be mentioned that all
20 the layer illustrations show the layer sequence only schematically and not the thickness ratios of the layers.

Figures 1 to 3 show the functional layer structure of a micromechanical relay according to the
25 invention based on silicon. In this case, the base substrate 1 is composed of silicon. This base substrate is at the same time used as the base electrode; alternatively, a corresponding electrode layer can be formed by suitable doping, if required. An insulating
30 layer 2, composed of silicon nitride for example, is formed above the base substrate. A first sacrificial layer 3, which is etched out later, is in turn located on this insulating layer 2. This first sacrificial layer 3 is composed, for example, of silicon dioxide
35 and has a thickness d_1 of, preferably, less than $0.5 \mu\text{m}$. A carrier layer 4 is located above the sacrificial layer 3, in order to form the spring tongues. This carrier layer is electrically conductive and is composed, for example, of polysilicon with a

thickness of 5 to 10 μm . An armature spring tongue 41 and a stationary-contact spring tongue 42 will be etched out of this carrier layer 4 later.

In the layer structure, they are initially separated from one another by a second sacrificial layer 5. An insulating tensile-stress layer 6 is arranged on the two spring tongues 41 and 42 and, once the spring
5 tongues have been etched free, produces the upward curvature of the spring tongues away from the base substrate, by virtue of its tensile stress. This state is shown in Figure 2.

A stationary contact 7 is deposited on the
10 stationary-contact spring tongue 42 by means of an appropriate coating method, while a moving contact 8 is formed on the free end of the armature spring tongue 41 in such a way that it overlaps the stationary contact 7, with the interposition of the second sacrificial
15 layer 5. The height of the switching contacts can be varied as required, and is typically between 2 and 10 μm . Depending on the requirement, the thicknesses and the material compositions of the switching contacts may also be asymmetric. As is shown in Figure 4, the
20 two spring tongues 41 and 42 engage in one another like teeth, so that a central projection 44 on the spring tongue 42 is surrounded by two lateral projections 43 on the armature spring tongue 41, in the form of pliers. In this way, the moving contact 8 has three
25 side sections which rest on the armature spring tongue. In this configuration, it forms a single make contact with the stationary contact 7. As can also be seen, the moving contact 8 has an S-shaped or Z-shaped cross-section, in order to ensure the overlap with the
30 stationary contact 7. The interposed sacrificial layer 2 typically has a thickness d_2 of less than 0.5 μm .

The other required layers are formed in a known manner, for example a lead 71 to the stationary contact 7, a lead 81 to the moving contact 8, and a further
35 insulating layer 8 for passivation of the top surface of the armature spring tongue.

Figure 2 shows the complete arrangement after the spring tongues have been exposed by etching away the two sacrificial layers 3 and

5, in which case there is a free space 31 underneath the armature spring tongue 41. As mentioned, the two spring tongues 41 and 42 curve upwards because of the tensile-stress layer 6, so that the arrangement according to Figure 2 is produced, with an open contact. The armature spring tongue curves because of the prestressing to form an unobstructed opening x_1 at the spring end. In the same manner, the stationary-contact spring tongue 42 curves upwards, after exposure, through the unobstructed opening x_2 . The unobstructed contact gap thus becomes

$$x_K = x_1 - x_2 + d_2 \text{ and approximately}$$

$$x_K = x_1 - x_2.$$

This unobstructed contact gap x_K can be set as required by the geometry of the armature spring tongue and the stationary-contact spring tongue as well as the tensile stress caused in the spring by the layer 6.

Figure 3 shows the relay in the closed switching state. In this case, the armature spring tongue 41 is resting directly on the opposing electrode, that is to say it is touching the insulation layer 2 of the opposing electrode or of the base substrate. The armature spring tongue is thus bent downwards by the thickness of the first sacrificial layer 3, namely d_1 . This results in an overtravel of

$$x_u = x_2 - d_2 + d_1, \text{ that is to say, approximately}$$

$$x_u = x_2.$$

This overtravel is independent of the manufacturing tolerances of the contact heights.

As mentioned, Figure 4 shows a plan view of the spring tongues 41 and 42 according to Figures 1 to 3. The shape and the arrangement of the contacts can be seen in this case, namely of the stationary contact 7 on the projection 44 on the spring tongue 42, as well as of the moving contact 8, which is attached on three sides to the projections 43 on the spring tongue 41. In addition, a hole grid 10 for etching through the first sacrificial layer 3 is shown by way of indication.

Figure 5 shows an embodiment, modified from that in Figure 4, with a bridge contact. In this case, the spring tongue 42 has two separate stationary contacts 7 with corresponding interconnects on two outer projections 46, while the spring tongue 41 forms a central projection 47, on which the moving contact 8 rests. A slot H2a in the stationary-contact spring tongue 42 ensures a high level of torsional flexibility in order that both contacts close reliably in the event of an equal erosion. In the case of this example, this is used as a bridge contact, in that it overlaps the stationary contacts 7 on both sides.

The same effect can also be achieved with a structure according to Figure 6. There, an armature spring tongue 141 is provided with a central projection 147 on which a moving bridge contact 148 rests, which projects on both sides. This bridge contact 148 interacts with two stationary contacts 144 and 145, which are seated on two separate stationary-contact spring tongues 142 and 143. These stationary-contact spring tongues 142 and 143 are positioned transversely with respect to the armature spring tongue 141, that is to say their clamping-in lines 142a and 143a are at right angles to the clamping-in line 141a of the armature spring tongue.

In order to optimize the switching characteristic, it is expedient to curve the armature spring tongue only in places, as is described in detail in the documents DE 44 37 260 C1 and DE 44 37 261 C1. Figures 7 and 8 show schematically a configuration during production and in the completed state, in which the armature spring tongue is designed to be only partially curved. In comparison to Figures 1 and 2, the major difference is that, in Figures 7 and 8, a tensile-stress layer 61 extends only over a part of the armature spring tongue 41, so that a curved zone 62 of the armature spring tongue is limited to the region of the clamping-in point, while a zone 63 runs in a straight line, or with relatively little curvature,

towards the spring end. In the illustration in Figures 7 and 8, an insulation layer 64 without any built-in stress is illustrated on the silicon carrier

layer 4, and this insulation layer 64 forms the DC isolation of the load circuit with the lead 81 from the spring tongue. The already mentioned tensile-stress layer 61 is located above this.

5 Various methods which are known per se can be used to produce the layer arrangement described and illustrated. For example, Figure 9 shows the basic layer structure on the base substrate 1 as created using the so-called additive technique. In the case of
10 this method, the moving spring tongues and their carrier layer are produced from a material which is deposited on the substrate only during production. In the illustrated example in Figure 9 a wafer composed of p-silicon is used as the substrate. A control base
15 electrode 11 is first of all produced on this substrate n- by diffusion (for example with phosphorus); a depletion layer 12 is formed between the n-silicon of the electrode and the p-silicon of the base substrate. The insulation layer 2 and, above this, the sacrificial
20 layer 3 are applied and structured over the electrode. The carrier layer 4 is deposited above this, with a thickness of, for example, 5 to 10 μm . This carrier layer 4 is composed of polysilicon or of polysilicon with recrystallization. The structure of the spring
25 tongues is produced using a conventional mask technique. The rest of the structure is produced as in Figure 1. The various functional layers, namely an insulation layer between the load circuit and the moving drive electrode, possibly an additional
30 tensile-stress layer and the necessary load circuit interconnects are thus deposited. In addition, the described contacts are produced with the interposed second sacrificial layer as well as any passivation insulation required for the interconnects.

35 As already mentioned in the introduction, other materials may also be used. For example, Figure 10 shows schematically a layer arrangement in which the substrate is composed of glass. Alternatively, it could be composed of a silicon substrate with an

insulation layer, or of ceramic with appropriate surface treatment. A base electrode 11 in the form of a metal layer is produced above this substrate. An insulating layer 2 is then located on this metal layer and, above this, the sacrificial layer 3. In this example, an electrochemically applied metal layer is used as the carrier layer, this metal layer being composed of nickel or a nickel alloy (for example nickel-iron), or else of another metal alloy. The important factor is that this metal has a spring characteristic with little fatigue. Inhomogeneous nickel layers can be produced by appropriate current passage during the electrochemical process and these produce subsequent curvature of the structured spring tongues. The rest of the construction takes place analogously to Figure 9 and Figure 1.

A further option for producing the functional layers of the relay is the so-called lost-wafer technique. This will be described briefly with reference to Figure 11. In this case, two original substrates are used, although they experience layer processing from one surface. A base electrode 11 which, in this example, is recessed in an etched V-groove, is first of all applied to a base substrate 1 which, in turn, is composed of silicon or of glass. The insulation layer 2 is located above this base electrode 1. After this, a second silicon wafer 20 with an n-doped silicon layer 21, which is either applied by epitaxy or is produced by diffusion, is anodically bonded to the already structured base substrate 1. This is followed by the wafer 20 being etched back from the top surface using electrochemical etching resist so that only the epitaxial layer 21 remains, and this is used as the carrier layer for the moving spring tongues. The step of joining the lost wafer to the base substrate can also be carried out without the first sacrificial layer 3 (see Figure 1), provided a free space 31 can be formed without the insulation layer 2 firmly bonding to the doped silicon layer 21.

Finally, in the case of this example as well, the structuring of the load circuit elements is carried out analogously to the additive technique, as has already been described with reference to Figure 1 and Figure 6. Thus, for example, an insulation layer 64 for insulation between the load circuit and the drive electrode formed by the spring tongue 41, to the extent that this is required, an additional tensile-stress layer 61, the load circuit interconnects 71 and 81, the stationary contact 7, the second sacrificial layer 5 and the moving contact 8 are applied and structured successively. If any additional layers are required for passivation insulation, this is done in accordance with the knowledge within the experience of a person skilled in the art.

Another option for producing the structure according to the invention is to use a so-called SOI wafer (silicon-on-insulator). Figure 12 shows such an SOI wafer as a semi-finished product. The difference from the construction according to Figure 9 is that the individual layers are in this case not retrospectively deposited on the substrate but, instead of this, such an SOI wafer as a semi-finished product has a prefabricated layer structure, in which case an insulation layer 2, for example composed of silicon nitride, a first sacrificial layer 3, for example composed of silicon dioxide, and a crystalline silicon epitaxial layer as a carrier layer 4 with a thickness of, for example, 5 to 10 μm are arranged on the silicon substrate 1. The structuring of the load circuit elements is then carried out on this semi-finished product analogously to the additive technique described above, in which case the insulation layer 64, the additional tensile-stress layer 61, the load circuit interconnects 71 and 81, the stationary contact 7, the second sacrificial layer 5 (possibly also as passivation insulation for the interconnects) and the moving contact 8 are structured as functional layers.

The function of the relay results directly from the described structure. A control voltage U_s is applied to the electrodes

via appropriate connecting elements in order to operate the relay, that is to say according to Figure 2 to the substrate 1, which is at the same time used as the base electrode, or to the base electrode (which is
5 electrically insulated from the base substrate) according to the embodiments in Figures 9 to 11, and to the armature spring tongue 41, which is at the same time used as the armature electrode. Electrostatic charging results in the armature spring tongue 41 being
10 attracted to the base electrode, as a result of which the contacts close.

It is also clear to the person skilled in the art that the structure illustrated in the drawing is installed in a suitable manner in a casing, so that the
15 contacts are protected against environmental influences. It should also be mentioned that a plurality of illustrated switching units can be arranged alongside one another on one and the same substrate and can be arranged in a common casing, in
20 order to form a multiple relay.

Patent Claims

1. Micromechanical electrostatic relay having
- a base substrate (1) with a base electrode (1, 11)
5 and with at least one stationary contact (7),
an armature spring tongue (41) which is linked on one
side to a carrier layer (4) connected to the base
substrate (1), has an armature electrode (41) opposite
the base electrode (1, 11), is elastically curved away
10 from the base substrate (1) in the rest state forming a
wedge-shaped air gap, and is fitted at its free end
with at least one moving contact (8) opposite the
stationary contact (7),
characterized in that the at least one stationary
15 contact (7) is arranged on a stationary-contact spring
tongue (42) which, opposite the armature spring tongue
(41), is linked like this on one side to a carrier
layer (4) and is elastically curved away from the base
substrate (1) in the rest state, and
20 in that the at least one moving contact (8) is formed
at the end of the armature spring tongue (41) such that
it projects beyond said armature spring tongue (41) and
overlaps the stationary contact (7).
2. Relay according to Claim 1,
25 characterized in that the armature spring tongue (41)
and the stationary-contact spring tongue (42) are
formed from the same carrier layer (4).
3. Relay according to Claim 1 or 2,
characterized in that the at least one moving contact
30 (8) has an approximately Z-shaped cross-section, one
end limb resting on the armature spring tongue (41) and
an end limb which is approximately parallel to the
first overlapping the stationary contact (7).



4. Relay according to one of Claims 1 to 3, characterized in that the free ends of the armature spring tongue (41) and of the stationary-contact spring tongue (42) engage in one another in a tooth shape, in each case one projection (44; 47) on the one spring tongue (42; 41) engaging in a recess in the other spring tongue (41; 42), and in that the at least one stationary contact (7) rests on a projection (44; 46) on the stationary-contact spring tongue (42), while the at least one moving contact (8) extends over a recess in the other spring tongue (41).

5. Relay according to Claim 4, characterized in that, in the extended state, the end section (43), which is designed in the form of pliers, of the armature spring tongue (41) encloses a central projection (44), which is fitted with the fixed contact (7), on the stationary-contact spring tongue (42), and in that a moving contact (8) which rests on the stationary contact (7) on both sides extends freely over this stationary contact (7).

6. Relay according to Claim 4, characterized in that, in the extended state, a central projection (47) on the armature spring tongue (41) engages between two projections (46), which are provided with stationary contacts (7), on the stationary-contact spring tongue (42), and in that a moving bridge contact (8) is mounted on the central projection (47) and extends on both sides freely over the stationary contacts (7).

7. Relay according to Claim 4, characterized in that a central projection (147) on the armature spring tongue (141) is fitted with a bridge contact (148) which projects on both sides, and in that two stationary-contact spring tongues (142, 143) are each fitted with a stationary contact (144, 145) which interacts with the bridge contact (148).



8. Relay according to one of Claims 1 to 7, characterized in that the carrier layer (4) of the spring tongues is a layer which is deposited on the base substrate (1) with the interposition of a partially etched-away sacrificial layer (3).
9. Relay according to one of Claims 1 to 8, characterized in that the base substrate (1) and the carrier layer (4) are composed of silicon, and in that the two electrode layers in the base substrate and in the armature spring tongue are formed by intrinsic or doped silicon.
10. Relay according to one of Claims 1 to 9, characterized in that the spring tongues (41, 42) each have on their side facing away from the base substrate and at least over a part of their length a layer (6; 61) which produces a tensile stress.
11. Relay according to one of Claims 1 to 10, characterized in that the carrier layer which forms the spring tongues (41; 42) is composed of deposited polysilicon or polysilicon with re-crystallisation.
12. Relay according to one of Claims 1 to 10, characterized in that the carrier layer (4) which forms the spring tongues (41, 42) is formed from an electrochemically deposited metal layer, in particular nickel, nickel-iron or any other nickel alloy.
13. Relay according to one of Claims 1 to 9, characterized in that the base substrate (1) is composed of silicon or glass, and in that the spring layer (4) which forms the spring tongues (41, 42) is formed by a silicon layer (21) (which is bonded onto the base substrate and is exposed) of a silicon wafer (20).



14. Method for producing a micromechanical electrostatic relay according to one of Claims 1 to 13, characterized by the following steps:

- 5 - an electrically conductive carrier layer (4; 21) is applied, with the interposition of an insulating layer (2) and an intermediate space (31), to a base substrate (1) which is provided with an electrically conductive layer as the base electrode,
- 10 - two spring tongues (41, 42) which are linked on one side and whose free ends are opposite one another are formed in the carrier layer (4; 21),
- at least in places, the spring tongues (41, 42) are provided with a tensile stress layer (6; 61) on their top surface,
- 15 - a - preferably shorter - spring tongue (42) is provided at its free end with at least one stationary contact (7),
- the - preferably longer - spring tongue (41) is provided with at least one moving contact (8)
- 20 which overlaps the stationary contact (7), with the interposition of a sacrificial layer (5), and
- the curvature of the spring tongues (41, 42) upwards away from the substrate is achieved by
- 25 etching the spring tongues (41, 42) free from one another and from the substrate (1).

15. Method according to Claim 14, the electrically conductive spring-tongue layer (4), composed of polysilicon or polysilicon with re-crystallization with

30 the structure of the two spring tongues (41, 42), is deposited on the base substrate (1), which is composed of silicon, with the interposition of a first sacrificial layer (3), the contacts and the contours of the spring tongues being separated from one another by

35 a second sacrificial layer (5), and the two sacrificial layers (3, 5) being etched out once the contacts have been fitted.



16. Method according to Claim 14, the structure of the spring tongues (41, 42), which are composed of nickel or a nickel alloy, in particular nickel-iron, being electrochemically deposited on the base substrate (1), which is composed of glass, ceramic or silicon, with the interposition of a first sacrificial layer (3), at least one stationary contact (7) and, after a second sacrificial layer (5) has been applied to the other spring tongue (41), a moving contact (8) which overlaps the stationary contact (7) being fitted on one of the spring tongues (42), and, finally, the two sacrificial layers (3, 5) being etched out once the contacts have been fitted.

17. Method according to Claim 14, in which

- 15 - the opposing electrode (11) and, above it, an insulating layer (2) are deposited on the base substrate (1), which is composed of silicon or glass,
- a silicon wafer (20) with a doped silicon layer (21), in particular an epitaxial layer or a diffused layer, is bonded as the spring-tongued layer onto the base substrate (1),
- after this, the wafer (20) is etched back until only the doped silicon layer (21) remains, and the structures of the two spring tongues (41, 42) are then etched out of this silicon layer,
- 25 - at least one stationary contact is then fitted to the one spring tongue (42),
- at least one moving contact (8), which overlaps the stationary contact (7), is then fitted to the other spring tongue (41) with the interposition of a sacrificial layer (5), and
- 30 - finally, the sacrificial layer (5) is etched away.



Abstract

Micromechanical electrostatic relay, and a method for its production

The micromechanical relay has a base substrate (81) on which an armature spring tongue (41) is structured which is linked on one side and has a moving contact (8), in such a manner that, in the rest state, this armature spring tongue (41) is curved away from the substrate in a sprung manner. A stationary contact (7) which interacts with the moving contact is arranged on a sprung stationary-contact spring tongue (42), which is likewise curved away from the base substrate, in such a manner that the free ends of the two spring tongues are opposite one another, and the moving contact (8) overlaps the stationary contact. By arranging the contacts on two sprung tongues, a relatively large over-travel at the contacts is achieved despite a short armature movement (which is possible in the case of an electrostatic drive) beyond the extended state, by which means an adequate contact force is produced.

FIG 2

FIG 4

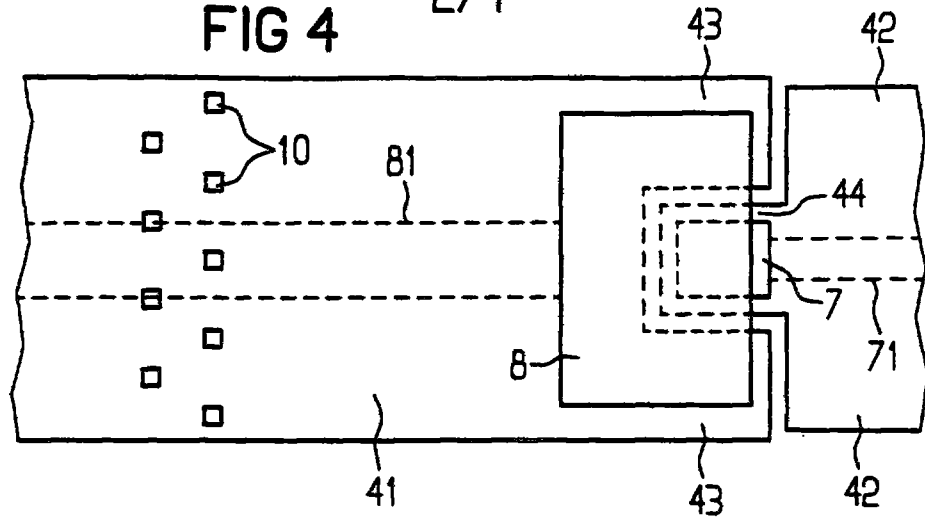


FIG 5

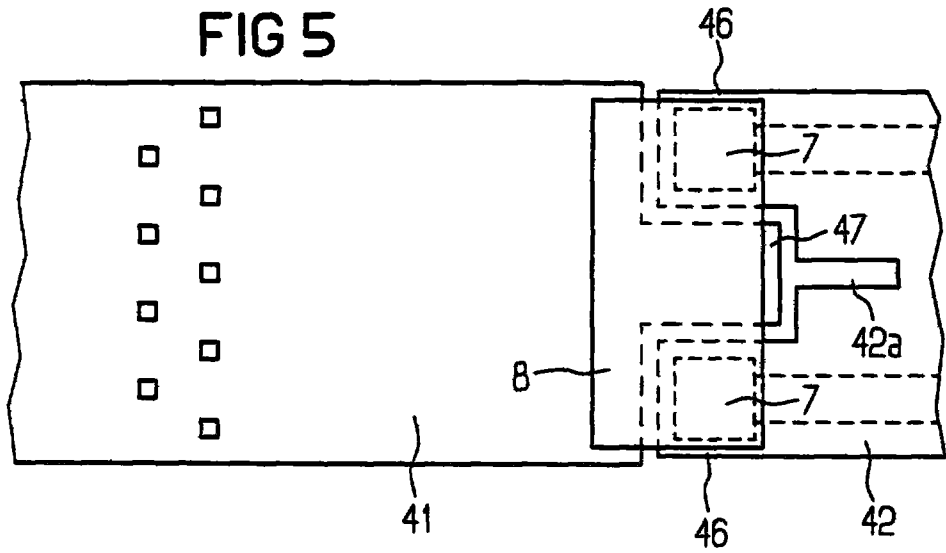


FIG 6

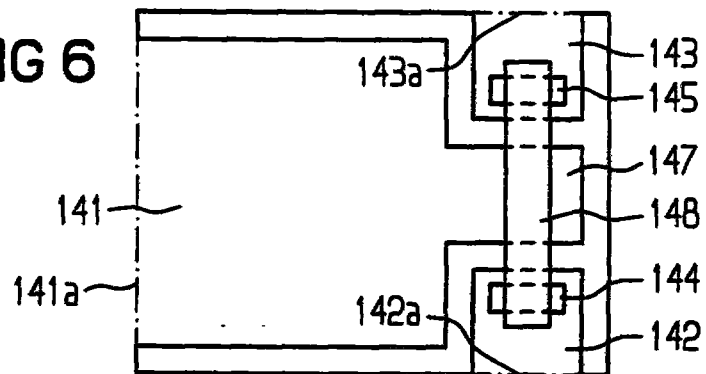


FIG 7

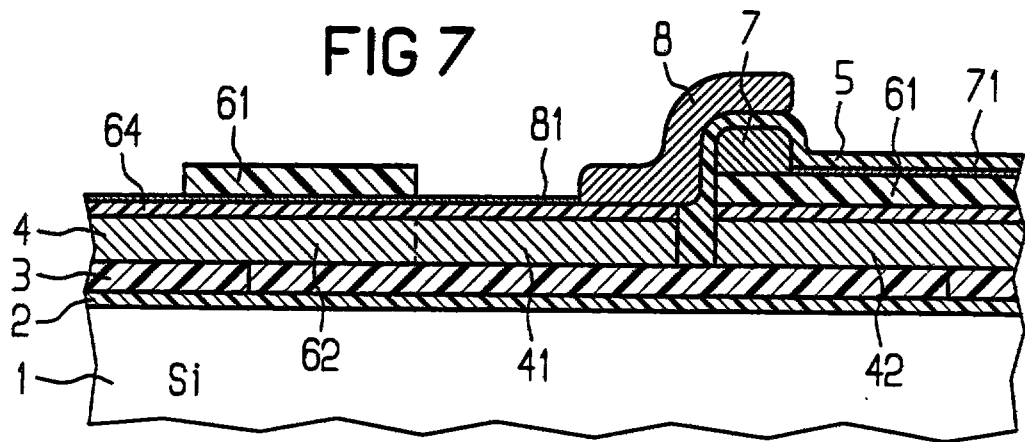


FIG 8

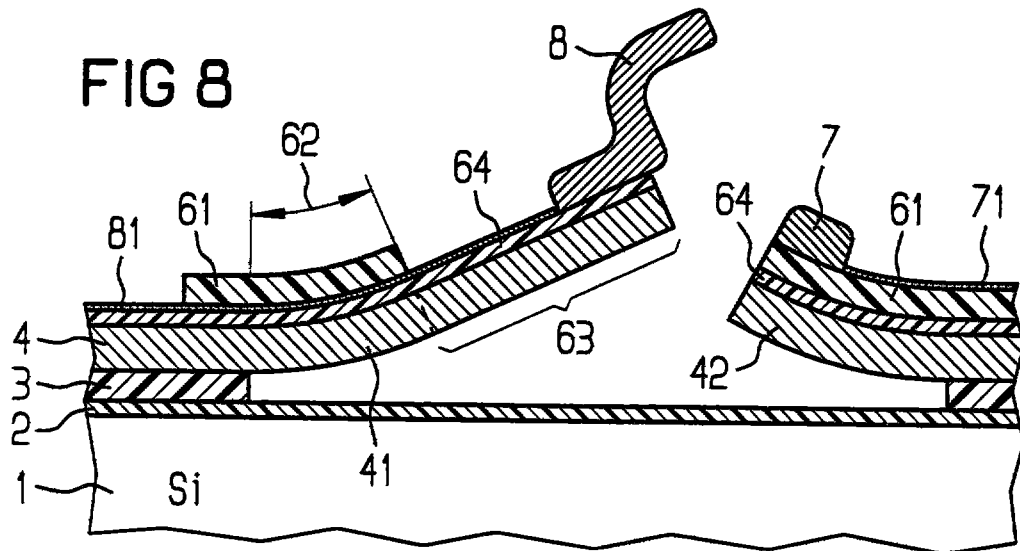


FIG 9

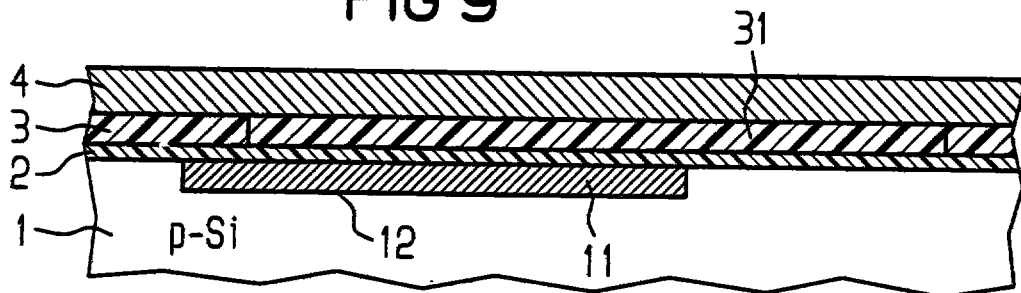


FIG 10

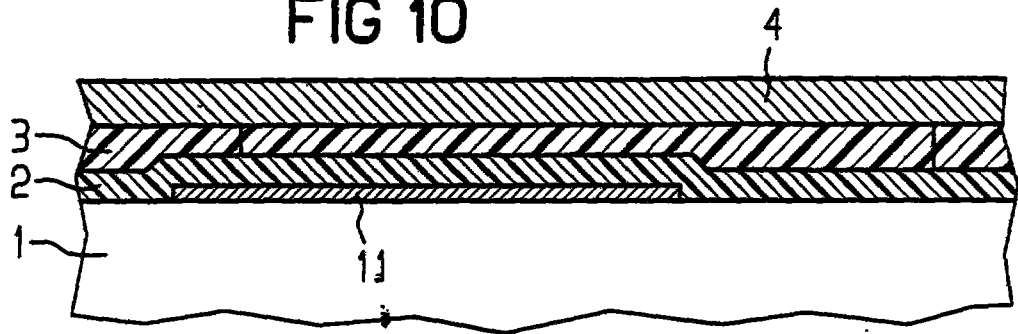


FIG 11

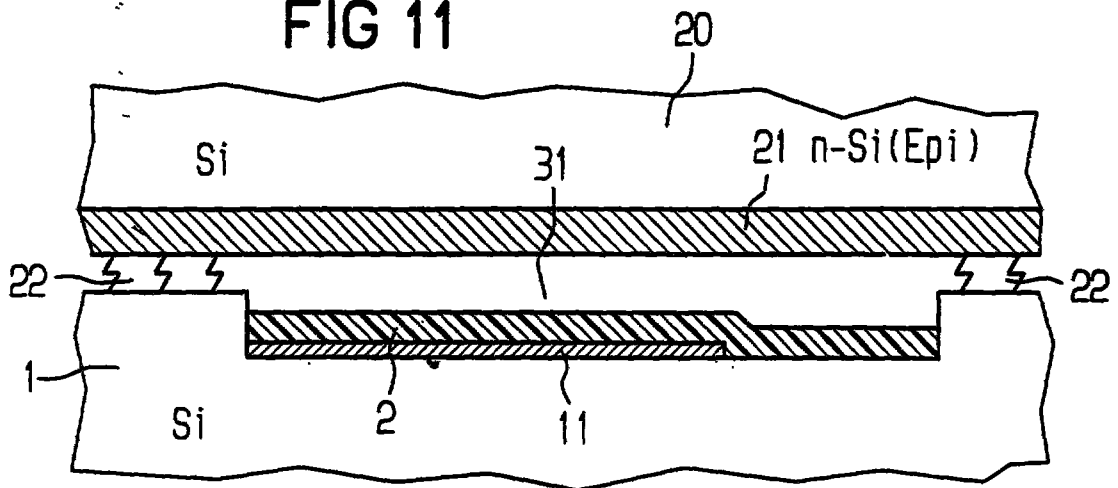


FIG 12

