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A DIELECTRICALLY ISOLATED SEMICONDUCTOR DEVICE AND A METHOD FOR ITS MANUFACTURE

TECHNICAL FIELD

The present invention relates to a dielectrically isolated semiconductor device which has charge carrier depleted regions of reduced electrical field strength and which comprises

- a semiconductor body:
- a component region in the semiconductor body with an upper surface;
- a dielectrically isolating layer which delimits the component region from the semiconductor body;
- a sunken region in the component region, this sunken region extending from the upper surface of the component region and down thereinto;
- a PN-junction at the delimiting surface of the sunken region which surface delimits said region from a remaining part of the component region, said part having an opposite type of doping to the type of doping of the sunken region; and
- a semiconductor component in the component region having at least one electrical connection region in each of the sunken region and the remaining part of the component region;
- wherein the regions of reduced electrical field strength are depleted of charge carriers by electric voltages that are applied via the electrical connection regions; and
- a method for manufacturing the semiconductor device.

BACKGROUND ART

Semiconductor circuits are required to withstand a relatively high voltage in many different kinds of applications. An example of one such application is found in the subscriber line circuits of telephone exchanges. In older Swedish telephone exchanges, the line to a subscriber was required to

have an applied voltage of 48 volts, and modern subscriber line circuits in semiconductor techniques are adapted to these voltages. Higher voltages are required in other countries, for instance 68 volts in Germany, while other applications of semiconductor circuits may use still higher voltages, for instance voltages of 400 volts or more.

One problem with these relatively high voltages is that the electrical field strength may exceed the critical field strength of the semiconductor material in certain regions of a component. This can result in a current breakthrough which destroys the semiconductor material if the current is not limited. The same problem of high field strength also occurs in very small and rapid semiconductor components intended for calculating or computing circuits. Although these components are connected to low voltages, in the order of 3 to 5 volts, the small extensions of the components enable the electrical field strength to reach high values.

In certain applications, the problem of high electric field strength is pronounced at the surface of a semiconductor component, as described in an article in IEEE, Proceedings from IEDM, 1979, pages 238-241, by J.A. Appels and H.M.J. Vaes: "High Voltage Thin Layer Devices (Resurf Devices)", this article being herewith incorporated in the present description. The semiconductor component has a surface layer in which there is included a PN-junction in which the critical field strength of the material is reached at a given applied voltage. The surface layer is weakly doped on one side of the PN-junction and this weakly doped part can be depleted of charge carriers by making the surface layer relatively thin. The applied voltage is herewith distributed over a long distance along the component surface, so that the maximum field strength will adopt a value beneath the breakdown field strength. The phenomenon is well known within semiconductor technology and has been given the personal acronym RESURF

(REduced SURface Field). The resurf technique is described in more detail in an article in Philips J. Res. 35, 1-13, 1980, J.A. Appels, et al: "Thin Layer High-Voltage Devices". This article is also incorporated in the present description.

In addition to the aforesaid problem of current breakthrough in semiconductor components, the individual components mounted on a common semiconductor substrate influence one another in an undesirable manner. It is known to overcome this problem by isolating the components one from the other, for instance in the manner described in European Patent Application EP-A1-0,418,737. According to this prior publication, a semiconductor substrate is provided with an oxidized surface which forms an isolating layer on which a relatively thin wafer of monocrystalline semiconductor material is mounted. This monocrystalline wafer has etched therein grooves which extend down to the isolating layer and the side surfaces of the grooves are oxidized and the grooves filled with polycrystalline semiconductor material. Semiconductor components are formed in the dielectrically isolated box-like regions thus formed. These components have an external connection which is connected to a heavily doped connection layer beneath respective components on the bottoms of respective box-like regions, in direct abutment with the isolating oxide layer. A plurality of different types of components are shown, for instance field effect transistors and bipolar transistors.

The European Patent Application No. A2-0,391,056 describes an alternative method of forming a semiconductor substrate with dielectrically isolated regions. The isolated regions are produced by repeatedly etching the substrate and coating with semiconductor material. The dielectric isolation is comprised of oxidized semiconductor material. The regions have a weakly doped area in which the actual component is formed and a heavily doped connection layer which is located beneath said

component and lies against the dielectrically isolating layer.

One type of component which often occurs is the so-called JFET (Junction Field Effect Transistor), described, for instance, in a textbook on semiconductor components written by S.M. Sze: "Physics of Semiconductor Devices", second edition, chapters 6.1 and 6.2. The book is published by John Wiley & Sons, Inc., 1981. Field effect transistors JFET are produced in accordance with known techniques, by mounting individual semiconductor layers on top of one another and it is a relatively complicated process to produce these transistors in a dielectrically isolated region.

DISCLOSURE OF THE INVENTION

According to one aspect, the present invention solves the problem of providing semiconductor components, for instance the aforesaid JFET transistor, which can be readily produced in the dielectrically isolated box-like component regions on a semiconductor substrate. The box-like component region has an electrically isolated bottom surface and is surrounded by the walls of the box which have the form of vertical dielectrically isolated layers. The component region is relatively weakly doped with a predetermined type of doping material, either positively or negatively. The component has two wafer-like subregions which extend along the isolating layers on two mutually opposing sides of the component region. These subregions are doped with a type of doping material which is opposite to the type of doping material used in the component region, so as to form a PN-junction between the component region and the wafer-like subregions. These subregions may be used, for instance, to form a gate in the JFET transistor. The two wafer-like subregions may be mutually joined to form a continuous U-shaped region commonly doped with the same type

of doping material. This continuous region is used for a plurality of different types of components or component combinations.

The wafer-like subregions and the connection therebetween are achieved by diffusion or implantation of doping material down into the component region, via the surface of said region. The thus doped regions can therefore be produced readily in the dielectrically isolated component region. The doped regions can also readily be given desired forms, simply by appropriate choice of the configuration of the mask used in the doping process.

Another aspect of the invention solves the problem of producing voltage durable components within the delimited, dielectrically isolated component region.

The components in the component region have electrical connections to which electrical voltages are applied. The aforesaid PN-junctions between the wafer-like subregions and the remainder of the component region are reverse-biassed with the aid of these voltages. This enables parts of the component region to be depleted of charge carriers in accordance with the aforesaid RESURF method, so that the voltage applied will be distributed over a large distance within the component region. The electrical field strength in the component region will therefore be low and can be maintained beneath a breakdown field strength for the semiconductor material. The component region and the wafer-like subregions contain a relatively low concentration of doping substances and can therefore readily be depleted of charge carriers.

The invention has the characteristic features set forth in the following Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail with reference to exemplifying embodiments thereof and also with reference to the accompanying drawings, in which

Figure 1 is a perspective view of an inventive component;

Figure 2 is a cross-sectional view of the component shown in Figure 1;

Figure 3 shows the component in Figure 1 from above;

Figure 4 illustrates from above an alternative embodiment of the component shown in Figure 1;

Figure 5 illustrates a circuit containing two series-connected transistors;

Figure 6 is a cross-sectional view of the inventive transistors shown in Figure 5;

Figure 7 illustrates the transistors in Figure 6 from above; and

Figures 8-14 are cross-sectional views which illustrate individual method steps in the manufacture of the transistor shown in Figure 1.

BEST MODES OF CARRYING OUT THE INVENTION

Figure 1 is a perspective view of an inventive semiconductor component, a field effect transistor JFET, which is partially exposed in the Figure. The upper surface of a semiconductor substrate 1, in this case a silicon substrate, is oxidized to form a dielectrically isolated layer 2 of silicon dioxide. Mounted on the layer 2 is a monocrystalline silicone wafer 3 having a relatively low concentration of negative charge carriers, designated n in the Figure. The monocrystalline wafer 3 has a thickness A1. In the case of the illustrated embodiment, A1 = 6 μm. The substrate 1, the layer 2 and the wafer 3 form a semiconductor body which carries an elongated component region 4. This component region is formed in the wafer 3 and is delimited from a surrounding region 4a by a

dielectrically isolating layer 5 comprised of silicon dioxide and polycrystalline silicon. The isolating layer 5 extends from the surface of the monocrystalline wafer 3 down to the dielectrically isolating layer 2 and completely surrounds the component region 4 containing the junction field effect transistor JFET. The component region is thus a box-like semiconductor region which is completely isolated electrically against surrounding parts of the semiconductor body. For the sake of clarity, parts of the isolating layer 5 have been excluded from the Figure, as have also parts of the surrounding region 4a. The field effect transistor JFET includes a gate comprised of two wafer-like regions G1, which are doped with positive charge carriers designated p in the Figure. The wafer-like regions G1 are placed opposite one another midway of a respective long side of the component region 4 and lie against the dielectrically isolated layer 5. The regions G1 extend from the surface of the component region 4 downwardly in said region to a depth A2, in the illustrated case to a depth A2 = 4 μm. Each of the gate regions G1 has a respective heavily and positively p^+-doped connection region G2 for an external electrical connection 6, which is only shown schematically for the sake of clarity. A PN-junction 10 is provided in a border region between the gate regions G1 and the remainder of the component region 4. One end of the component region 4 has a heavily and negatively n^+-doped source region S2, and the other end of said region has a heavily n^+-doped drain region D2 for the field effect transistor JFET. The source region S1 and the drain region D2 are electrical connection regions for the field effect transistor JFET and each has an external electrical connection 7, shown schematically in the Figure.

Figure 2 is a cross-sectional view of the field effect transistor JFET, taken on the section line A-A in Figure 1. The Figure illustrates the component region 4 with the two gate regions G1 in abutment with the dielectrically isolated

layer 5. The gate connections G2 are shown in the Figure as is also the source region S2 although the latter region is not included in the section A-A. Figure 2 also shows an electrically isolating protective layer 8 of silicon dioxide on the surface of the component region 4. The protective layer 8, which is not shown in Figure 1, includes recesses 9 for the external electrical connections 6 and 7. According to one alternative, indicated in broken lines L1 in the Figure, the wafer-like gate regions G1 may extend from the surface of the component region 4 right down to the dielectrically isolating layer 2.

Figure 3 is a view from above of the field effect transistor JFET, including the component region 4, the isolating layer 5, the two gate regions G1 with gate connections G2, the source connection S2 and the drain connection D2. A gate voltage V_G is applied to the external connection 6, and a source voltage V_S and a drain voltage V_D are applied to respective external connections 7. In a normal operational case, these voltages may, for instance, be

$V_G = 0$ V (earth)
$V_S = 0$ V
$V_D = 400$ V

These voltages inversely bias the PN-junction 10 and a depletion region D10 is formed. This region extends in two lobes, as illustrated by chain lines L2 in the Figure. At the aforesaid voltage $V_D = 400$ V, the two lobes merge with one another to form a common depletion range, in accordance with chain lines L3. The electrical field strength E of an electric field in the depletion region can be maintained beneath a critical breakdown field strength $E_{CR} = 3 \cdot 10^5$ V/cm for silicon, with a relatively high degree of surety. This can be achieved because the semiconductor material in the component region 4 is doped relatively weakly and can therefore be depleted readily of charge carriers. It should be noted that

the gate regions G1 are also depleted partially, particularly in that part of the gate regions which lies proximal to the drain region D2.

An alternative embodiment of the invention is illustrated in Figure 4, which shows a field effect transistor JFET1. Similar to the aforegoing, the component region 4 is delimited electrically by the dielectrically isolating layer 5. The source region S2 is placed in one end of the component region and the drain region D2 is placed in the other end of the component region. As described above the field effect transistor JFET1 includes two wafer-like gate regions G11 which extend down into the component region 4 from the surface of said region. Each of the gate regions G11 is placed midway along a respective long side of the component region 4 and the respective rear sides of said gate regions lie against the isolating layer 5. The gate regions G11 are relatively weakly positively p-doped and each has a heavily positively p^+-doped connection region G12. Each of the gate regions G11 has a respective PN-junction 11 which faces towards the component region 4. Distinct from the gate regions G1, the gate regions G11 of this embodiment are relatively thick, having a thickness t1, at the end thereof which lies proximal to the source region S2, and is relatively thin, with a thickness t2, at the end thereof which lies proximal to the drain region D2. When the voltages V_G, V_S and V_D are applied to respective gate, source and drain connections 6 and 7, the PN-junction 11 is inversely biassed and a depletion region D11 is formed at the gate regions G11. Because the gate regions G11 of the field effect transistor JFET1 taper, the depletion region D11 has a different form to the depletion region D10 of the field effect transistor JFET of the Figure 3 embodiment.

The field effect transistors JFET and JFET1 in the dielectrically isolated component region 4 have been described in the aforegoing. According to the invention, it is also possible to

arrange two or more series-connected semiconductor components in the component region 4. Figure 5 illustrates schematically a first field effect transistor DMOS 3 which is connected in series to a second field effect transistor JFET4. The transistor DMOS3 has a gate region G3 which is connected to an external connection 31, and a source region S3 which is connected to an external electrical connection 32. The source region S3 is connected to a gate region G4 of the transistor JFET4, which in turn has a source region S4 which is connected to a drain region D3 of the transistor DMOS3. Finally the transistor JFET4 has a drain region D4 which is connected to an external electrical connection 41.

The two field effect transistors DMOS3 and JFET4 formed in the component region 4 are illustrated in Figure 6 and Figure 7. Figure 7 is a view taken from above and Figure 6 is a cross-sectional view taken on the section line B-B in Figure 7. In the Figure 6 embodiment, the n-doped component region 4 is surrounded by the dielectrically isolating layer 5 and its upper surface is covered by a dielectrically isolating layer 35 of silicon dioxide and includes recesses 38 for electrical connections. The transistor DMOS3 has a relatively weakly, positively p-doped region 33 which extends down into the component region 4 from the surface of said region. The region 33 is located at one end of the component region 4 and has a PN-junction 37 at its surface bordering on the remainder of the component region. The source region S3 is comprised of a heavily n^+-doped region at the surface of the region 33, and the external electrical connection 32 is connected to the source region S3. A heavily, positively p^+-doped contact region 39 lies adjacent the source region S3 and forms an electrical contact for the region 33. In a normal operational case, the electrical contact region 39 is short-circuited with the source region S3, as illustrated by a broken line connection SS. A very thin layer 34 of silicon dioxide, a so-called gate oxide, lies on the surface of the component region on one

side of the source region S3. The gate oxide 34 extends on the surface of the region 33 from the edge of the source region S3 over the PN-junction 37 and out slightly on the negatively doped part of the component region 4. The channel region 36 of the transistor DMOS3 is located beneath the gate oxide 34. The gate region G3 is comprised of a layer of doped, polycrystalline silicon which lies on top of the gate oxide 34 and the oxide layer 35 and is connected to the external electrical connection 31. The drain region D3 of the transistor DMOS3 is located in the component region 4 outside the channel region 36, in direct connection with the PN-junction 37. The drain region D3 also forms the source region S4 of the field effect transistor JFET4. The gate region of this field effect transistor is comprised of two wafer-like regions G4 of relatively weakly p-doped material, wherein each of said regions extends along a respective one of the two mutually opposing long sides of the component region 4. The wafer-like gate regions G4 correspond to the wafer-like gate regions G1 that have been described above in more detail with reference to Figure 1. These wafer-like regions, which are shown in broken lines in Figure 6, are connected at one end thereof to the weakly p-doped region 33. Each of the gate regions G4 has a respective heavily p^+-doped gate connection region G41 which is connected to the heavily p^+-doped region 39, as shown in Figure 7. The drain region D4 of the transistor JFET4 is comprised of a heavily negatively n^+-doped region at the other end of the component region 4, and the drain region D4 is connected to the electrical connection 41.

Figure 7 illustrates the transistors DMOS3 and JFET4 from above, with the dielectrically isolating layer 35 and the gate region G3 removed so as to bring clearly into view other parts of the transistors. The region 39 is connected to the gate connection regions G41, which extend in the gate regions G4 and form electrical connections for these regions. The gate oxide 34 covers the PN-junction 37 and the channel region 36

of the transistor DMOS3. The common drain region D3 and the source region S4 extend at the PN-junction 37 between the gate regions G4. The Figure illustrates how these gate regions G4 are connected to the p-doped region 33 and lie against the isolating layer 5 along the two long sides of the component region 4. The drain region D4 of the transistor JFET4 is also shown.

The relatively weakly n-doped component region 4 between the wafer-like gate regions G4 can be depleted of charge carriers by connecting the connections of the transistors DMOS3 and JFET4 to external voltages. Figure 7 indicates with a broken line a depleted region DR4 of the transistors DMOS3 and JFET4 which occurs when the source region S3 and the gate region G3 are both connected to earth potential 0 V and the drain region D4 is connected to a voltage of +100 V. As previously mentioned, the electrical contact region 39 is short-circuited with the source connection S3. A curve C discloses an electrical field strength $E = 1 \cdot 10^5$ V/cm which lies well beneath the critical field strength $E_{CR} = 3 \cdot 10^5$ V/cm of silicon at which there is a risk of current breakthrough in the material.

A method of manufacture of the aforesaid components will now be described by way of example with reference to Figures 8-14. The starting material used is a so-called bonded wafer comprising a silicon substrate 1, the isolating oxide layer 2 and the monocrystalline silicon wafer 3, as illustrated in Figure 8. Such a bonded wafer can be produced, for instance, in the manner described in the aforecited European Patent Application No. A1-0,418,737, and is commercially available. According to Figure 9, the upper surface of the wafer 3 is coated with a photoresist layer 51, which is exposed in a predetermined pattern and developed so as to form openings 52 in the layer 51. Deep trenches 53 are formed through these openings, by plasma etching down to the isolating layer 2 and the photoresist 51 is removed. According to Figure 10, the

side surfaces of the trenches 53 are oxidized to form silicon dioxide coatings 54, and the remaining parts of the trenches 53 are filled with polycrystalline silicon 55. The box-like component region 4 is delimited electrically in this way from the surrounding parts 4a of the monocrystalline wafer 3. The silicon dioxide layer 54 and the polycrystalline silicon 55 together form the dielectrically isolating layer 5, mentioned in the aforegoing with reference to Figure 1. As illustrated in Figure 11, the wafer 3 is coated with a new photoresist mask 56 having two openings 57, of which one is shown in the Figure. The openings 57 have a narrow, elongated shape and extend along the long sides of the component region 4 adjacent the dielectrically isolating layers. Doping with positive doping material is effected through these openings 57, so as to obtain the two wafer-like gate regions G1. The mask 57 is removed and a further photoresist mask 58 is applied, as illustrated in Figure 12. The mask 58 has openings 59 through which heavy positive doping of the gate connections G2 is effected. The mask 58 is removed and a further photo-resist mask 60 is applied, as illustrated in Figure 13. The mask 60 has openings 61 through which heavy negative doping of the source region S2 and the drain region D2 is effected. Subsequent hereto, the mask 60 is removed and the surface of the monocrystalline wafer 3 is oxidized to form the isolating silicone-dioxide layer 8, as illustrated in Figure 14. This layer 8 is coated with a photoresist mask 62 which has openings 63 through which the connection openings 9 are etched in the layer 8. The mask 62 is removed and the component is provided with the aforesaid external connections 6 and a protective layer. The connections and the protective layer are not shown in the Figure.

For the sake of simplicity, the gate region G1, the source region S2 and the drain region D2 have been shown in the same cross-sectional view in conjunction with the description of the method of manufacture, despite these regions being

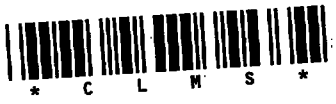
laterally displaced in relation to one another in reality. It should be carefully noted that all of the different stages of manufacture, for instance oxidation, application of masks, diffusion of doping materials and etching, are well known to the person skilled in this art.

The novel inventive features of the method lie, for instance, in the possibility of producing the field effect transistor JFET in the isolated component region 4 in a simple fashion, in that the configuration of this transistor is determined by simple selection of the configuration of the three masks 56, 58 and 60, and in that simple modifications of the manufacturing method, for instance modifications to the configuration of the masks, enables a large number of different types of component to be produced.

It is mentioned in the introduction that large field strengths can also occur in components intended for calculating or computing circuits which are connected to voltages in the order of 3 to 5 volts. These components are very rapid, contain high concentrations of doping substances and are small in size. For instance, the thickness of these components, corresponding to the distance A1 in Figure 1, may be only about 0.5 μm. The invention can also be applied to these components, which have a high connecting voltage in relation to their size. It can be mentioned that in the case of these thin components, the aforesaid separation layer 5 can be replaced with a layer produced by so-called local oxidation (LOCOS), which is a relatively simple isolation method.

The invention has been exemplified with reference to silicon components, although it will be understood that other semiconductor materials, such as germanium and gallium arsenide can be used equally as well. The doping types, p and n, referred to in the examples can be reversed without digressing from the invention.

The inventive components provide several advantages in addition to their voltage durability. By applying the resurf technique in the aforedescribed manner, the applied voltage is distributed over a large part of the component. Consequently, the component need only occupy a relatively small surface area of the substrate, as described above. In addition, the components may advantageously be made thin, which enables the components to be isolated laterally with the illustrated dielectrical separation layers 5 and 25 respectively. This results in a further reduction in the space required on the substrate. When practicing the invention, the requisite surface area of a semiconductor substrate which is to carry a specific number of components can be at least halved in comparison with earlier known techniques. This is particularly beneficial in the case of, for instance, subscriber line circuits in a telephone system in which each subscriber has its own line circuit. Another advantage afforded by the invention is that the components can be produced easily, since they are formed in a finished monocrystalline semiconductor layer and since their form is determined by selection of photoresist masks.



CLAIMS

1. A dielectrically isolated semiconductor device which has charge carrier depleted regions (D10) of reduced electrical field strength (E) and which comprises

- a semiconductor body (1, 2, 3);
- a component region (4) in the semiconductor body with an upper surface;
- a dielectrically isolating layer (2, 5) which delimits the component region (4) from the semiconductor body;
- a sunken region (G1) in the component region(4), this sunken region extending from the upper surface of the component region and down thereinto;
- a PN-junction (10) at the delimiting surface of the sunken region (G1) which surface delimits said region from a remaining part of the component region (4), said part having an opposite type of doping (n) to the type of doping (p) of the sunken region (G1); and
- a semiconductor component (JFET) in the component region (4) having at least one electrical connection region (G2, S2, D2) in each of the sunken region (G1) and the remaining part of the component region (4);
- wherein the regions (D10) of reduced electrical field strength are depleted of charge carriers by electric voltages (V_G, V_S, V_D) that are applied via the electrical connection regions

c h a r a c t e r i z e d in that

- the component region (4) has two mutually opposing sides which are delimited against the semiconductor body (1, 2, 3) by the dielectrically isolating layer (2, 5);
- in that the sunken region includes two mutually opposing wafer-like subregions (G1) which at the aforesaid mutually opposing sides of the component region (4) extend along the dielectrically isolating layer (2) from the upper surface of the component region (4) and down into said region, said

subregion (G1) having a relatively low concentration of doping material (p);

- in that the component region (4) has a relatively low concentration of doping material (n) at least in a region between the mutually opposing subregions (G1); and
- in that one of the charge carrier depleted regions (L2, L3) extends in the low-doped (n) region between the mutually opposing subregions (G1) and into said subregions so that the electrical field strength (E) in the depleted region lies beneath a breakdown field strength (E_{CR}) of the semiconductor material.

2. A dielectrically isolated device according to Claim 1, characterized in that the wafer-like subregions (G11) have a larger thickness (t1) at one end than at their other end (t2).

3. A dielectrically isolated device according to Claim 1 or 2, characterized in that the wafer-like subregions (G1, G11) has each a heavily doped (p^+) electrical connection region (G2, G12).

4. A dielectrically isolated device according to Claim 1, 2 or 3, characterized in that the wafer-like subregions (G1) include a gate of a field effect transistor (JFET), wherein the electrical connection regions include a heavily doped (n^+) region at each end of the component region (4), with the same doping type (n) as the remaining part of the component region, these connection regions forming the source region (S2) and the drain region (D2) respectively of the field effect transistor (JFET).

5. A dielectrically isolated device according to Claim 1 or 2, comprising a first field effect transistor (DMOS3) which is series-connected with a second field effect transistor (JFET4),

c h a r a c t e r i z e d in that

- the sunken region (33, G4) includes a relatively weakly doped (p) connecting region (33) at one end of the component region (4);
- both the wafer-like subregions (G4) are connected at one end thereof to said weakly doped connecting region (33);
- the first field effect transistor (DMOS3) has a strongly doped (n^+) source region (S3) with the same doping type (n) as the remaining part of the component region (4), said source region (S3) being located in the connecting region (33);
- the connecting region (33) has a heavily doped (p^+) contact region (39) having the same doping type (p) as the sunken region (33, G4);
- the first field effect transistor (DMOS3) has a channel region (36) which is located in the connecting region (33) at the surface of said region between the source region (S3) and the remaining part of the component region (4);
- the channel region (36) has mounted on the surface thereof an electrically isolating gate oxide (34) which carries an electrically conductive gate region (G3);
- the second field effect transistor (JFET4) has a heavily doped (n^+) drain region (D4) at the other end of the component region (4), this drain region having the same doping type (n) as the remaining part of the component region (4);
- the second field effect transistor (JFET4) has a gate which includes the wafer-like subregions (G4), each of said subregions having a respective gate connection region (G41) which is connected to the electrical contact region (39) of the connecting region (33); and
- in that a region in the remaining part of the component region (4) between the wafer-like subregions (G4) adjacent the connecting region (33) includes the drain region (33) of the first field effect transistor (DMOS3) and the source region (S4) of the second field effect transistor (JFET4).

6. A method of producing a dielectrically isolated semiconductor device, said method comprising the steps of

- oxidizing a surface of a semiconductor substrate (1) to form an electrically isolating oxide layer (2);
- applying to the oxide layer (2) a monocrystalline semiconductor wafer (3) doped with a first type of doping material (n);
- delimiting a component region (4) in the monocrystalline wafer (3) by means of dielectrically isolating layers (5, 54) which surround the component region and extend from the surface of the monocrystalline wafer (3) down to the isolating oxide layer (2);
- applying over the component region (4) a first mask (56) having provided therein recesses (57) which include two elongated openings that extend alongside the dielectrically isolating layer (5, 54) and along two mutually opposing sides of the component region (4);
- applying through the recesses (57) a second type (p) of doping material opposite to the first type (n) of doping material, wherein there is produced in the component region a sunken region which includes two wafer-like subregions (G1) on the opposing sides of the component region (4);
- applying over the component region at least one second mask (58, 60) provided with predetermined openings (59, 61); and
- supplying a predetermined type of doping material through the predetermined openings (59, 61) to produce the electrical connection regions (G2, D2, S2) of a semiconductor component (JFET) in the component region (4).

7. A method of producing a dielectrically isolated semiconductor device according to Claim 6, wherein the recess (57) in the first mask (56) includes a connecting opening in one end of the component region (4), this opening mutually connecting the two elongated openings of the recess (57).

8. A method of producing a dielectrically isolated semiconductor device according to Claim 6 or 7, wherein the component region (4) is delimited by the following method steps of:

- applying an etching mask (51) to the monocrystalline wafer (3), said etching mask having openings (52) for the dielectrically isolating layer (5; 54, 55);
- etching trenches (53) in the monocrystalline wafer (3) through the openings (52) in the etching mask (51), said trenches (53) extending down to the electrically isolating layer (2) on the semiconductor substrate (1);
- oxidizing the side surfaces of the trenches (53) to form semiconductor oxide layers (54); and
- filling the remainder of the trenches (53) with a polycrystalline semiconductor material (55).

A DIELECTRICALLY ISOLATED SEMICONDUCTOR DEVICE AND A METHOD FOR ITS MANUFACTURE

ABSTRACT

A semiconductor device (JFET, 4, 5) is supported by a semiconductor body which comprises a substrate (1), an oxide layer (2) and a weakly negatively doped (n) monocrystalline wafer (3). Trenches for a dielectrically isolating layer (5) which surrounds a component region (4) are etched in the wafer (3). A field effect transistor (JFET) in the component region has two positively doped (p) wafer-like gate regions (G1), which have been diffused in the component region with the aid of a first mask. Two heavily negatively (n^+) doped regions (S2, D2) are diffused in the component region with the aid of a second mask, these regions forming the source region and the drain region of the transistor (JFET). The semiconductor body (1, 2, 3) is easy to produce and is available commercially, which simplifies manufacture of the field effect transistor (JFET). Manufacture is also simplified because the configuration of both the component region (4) and the parts (G1, S2, D2) of the transistor (JFET) are determined by the simple choice of masks. The component region (4) is weakly doped (n) and is easy to deplete of charge carriers. The electrical field strength in the component region (4) is weak, according to the RESURF method, and the field effect transistor (JFET) withstands high voltages (V_S, V_D, V_G) without risk of current breakthrough. The component region (4) occupies only a relatively small area on the substrate (1).

Figure 1 for publication together with the Abstract.

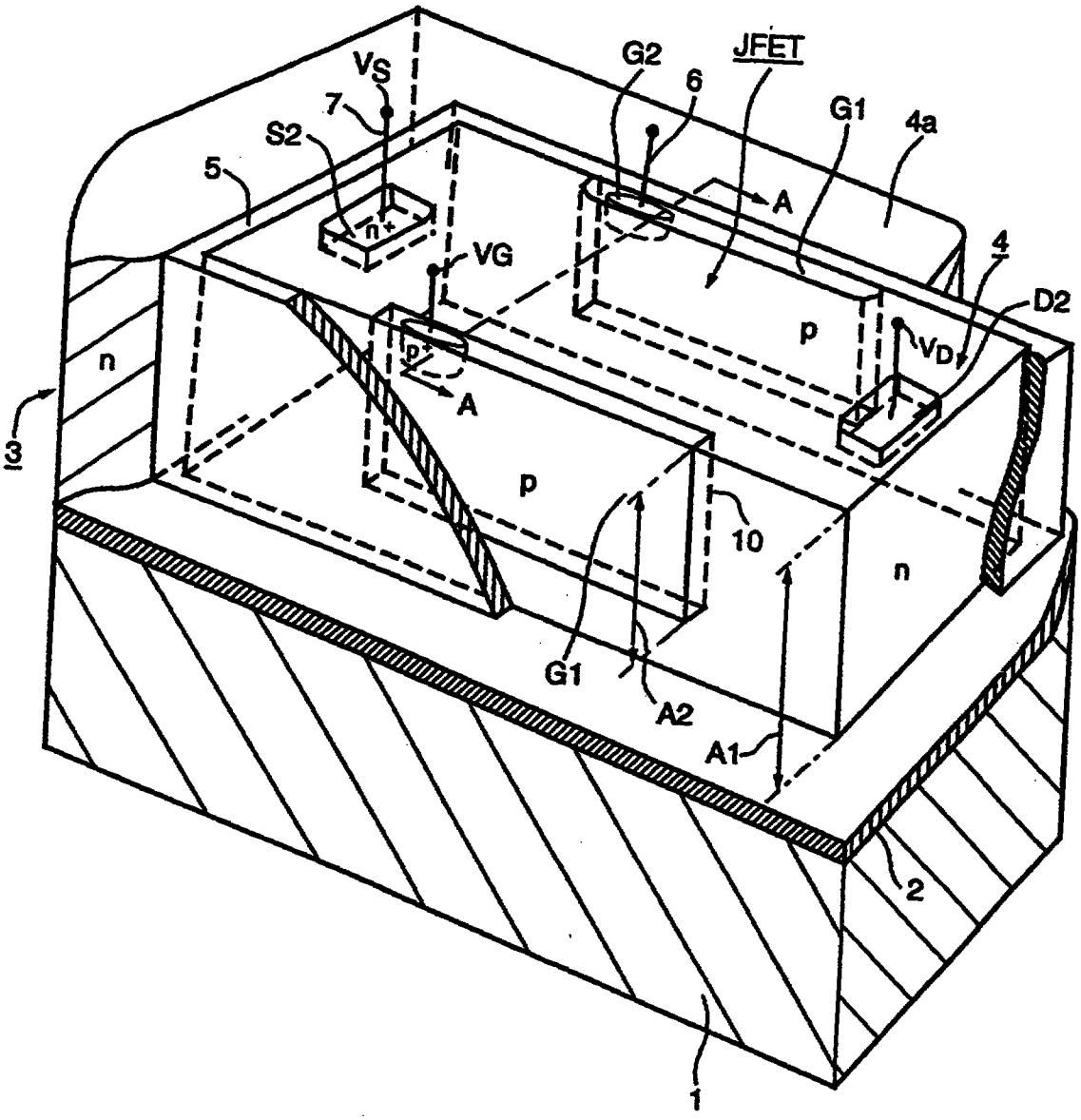


Fig. 1

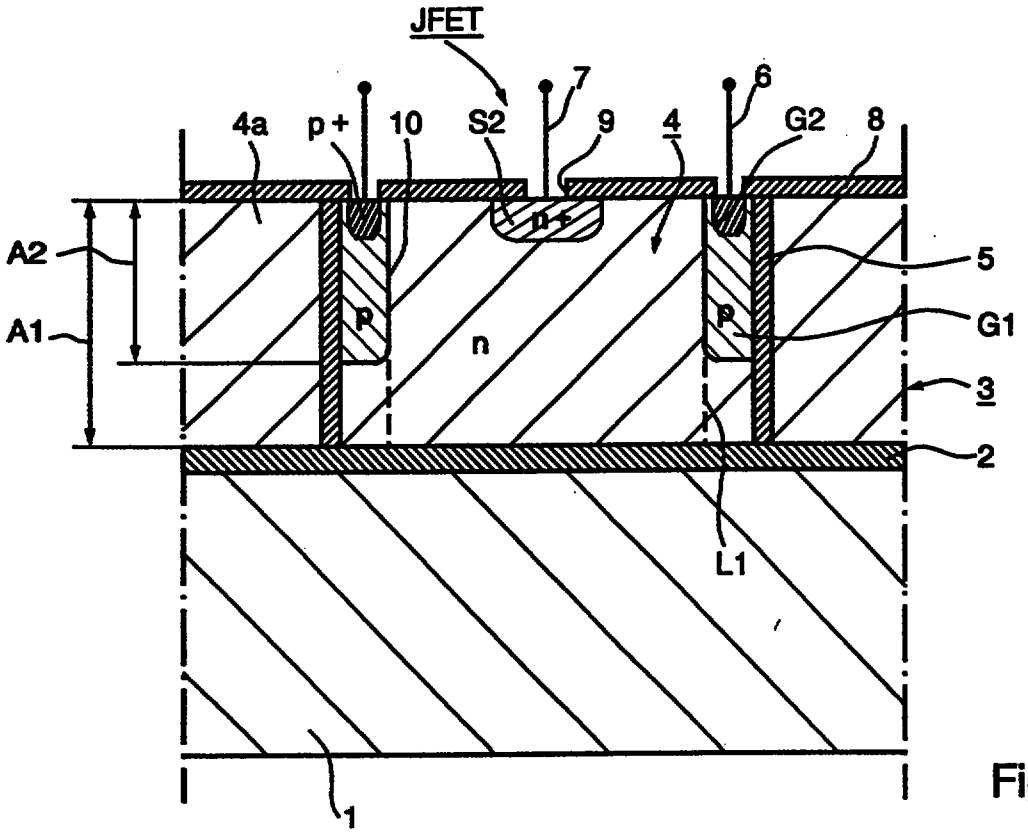

JFET
7
6
4a
p+
10
S2
9
4
G2
8
A2
A1
p+
5
p
n
p
G1
3
2
L1
1

Fig. 2

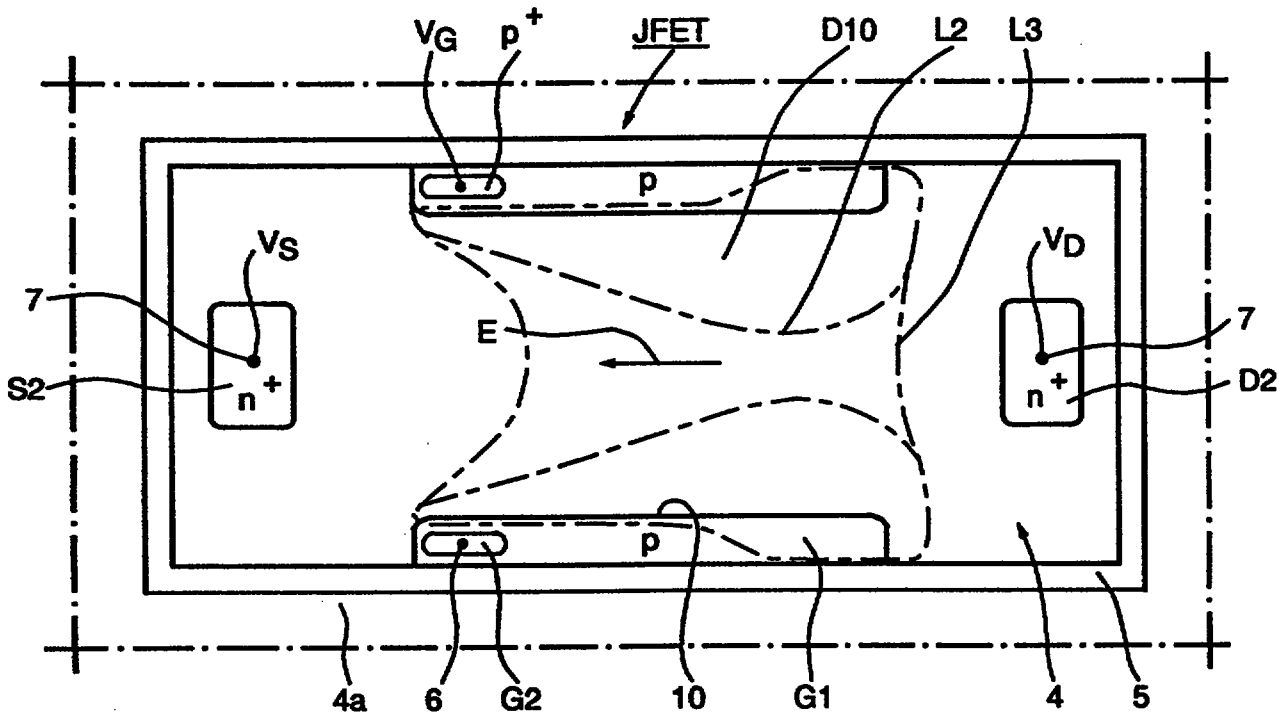

VG
p+
JFET
D10
L2
L3
p
VS
VD
7
E
7
S2
n+
n+
D2
p
4a
6
G2
10
G1
4
5

Fig. 3

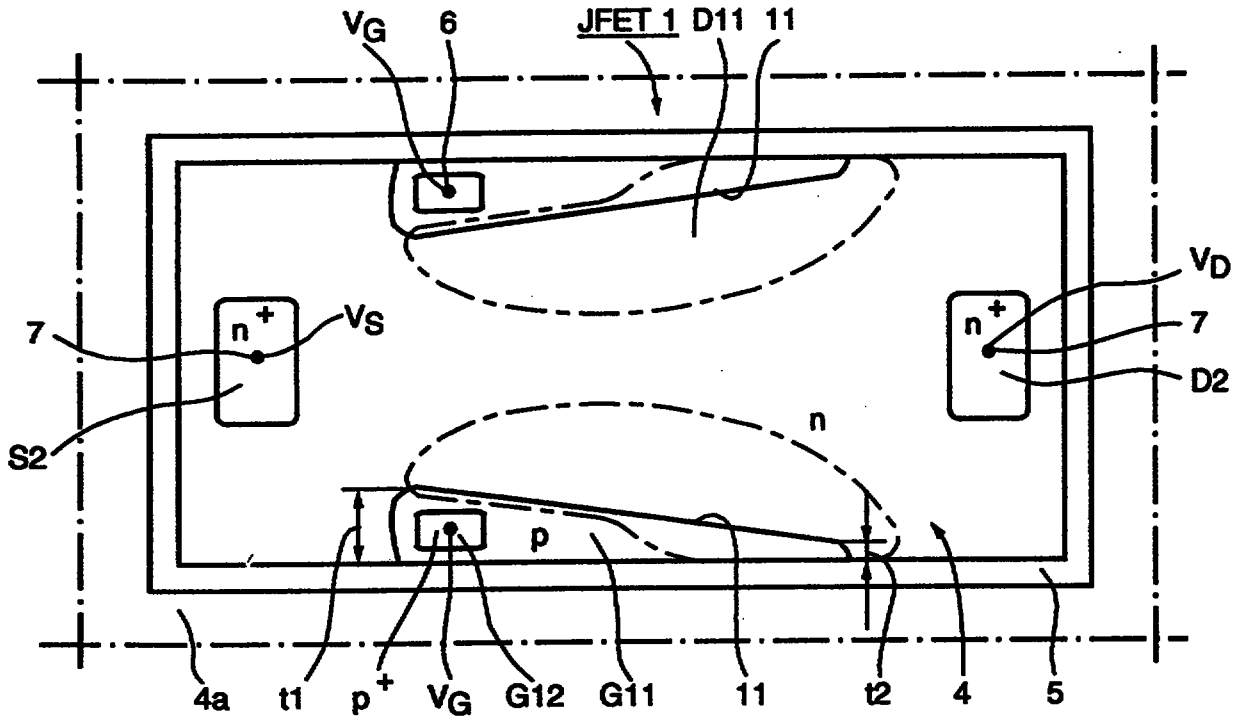

VG
6
JFET 1
D11
11
VD
7
n+
VS
7
D2
S2
n
p
4a
t1
p+
VG
G12
G11
11
t2
4
5

Fig. 4

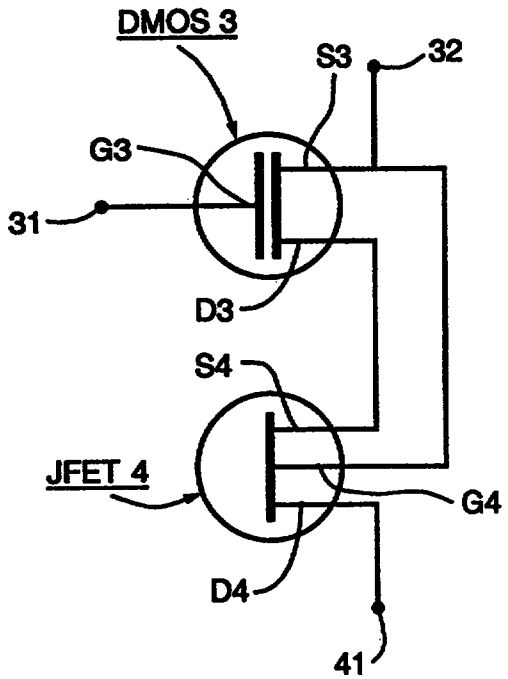

DMOS 3
S3
32
G3
31
D3
S4
JFET 4
G4
D4
41

Fig. 5

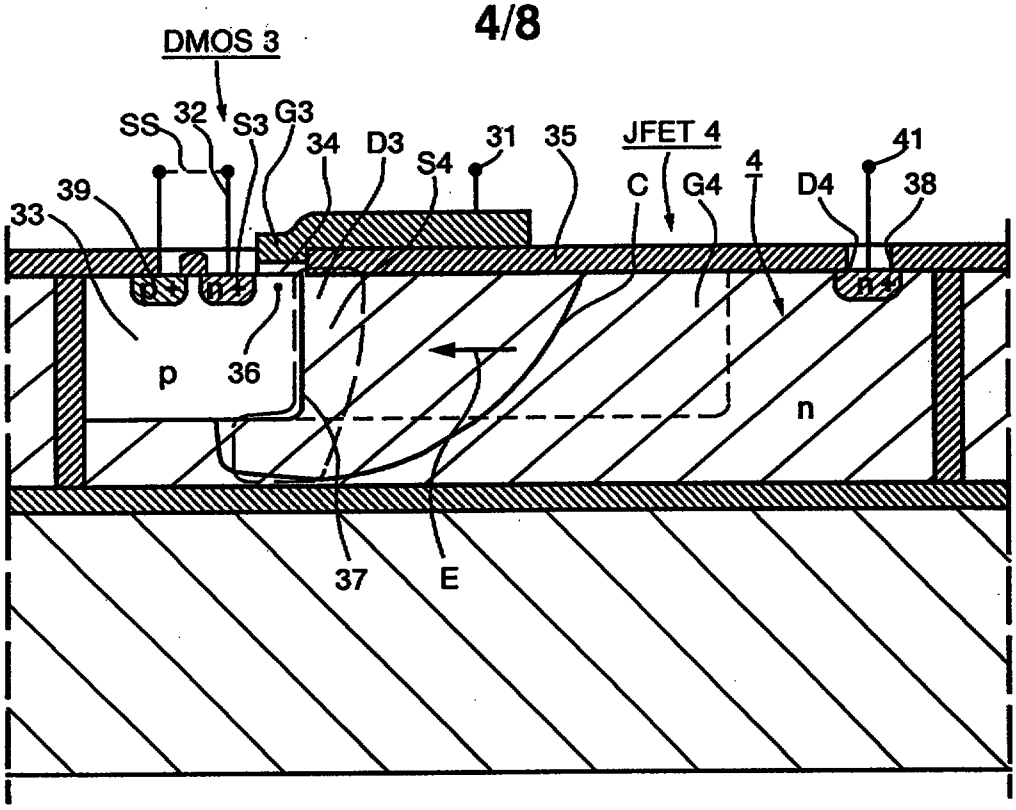

DMOS 3
SS
32
S3
G3
34
D3
S4
31
35
JFET 4
41
39
C
G4
4
D4
38
33
p
36
n
37
E

Fig. 6

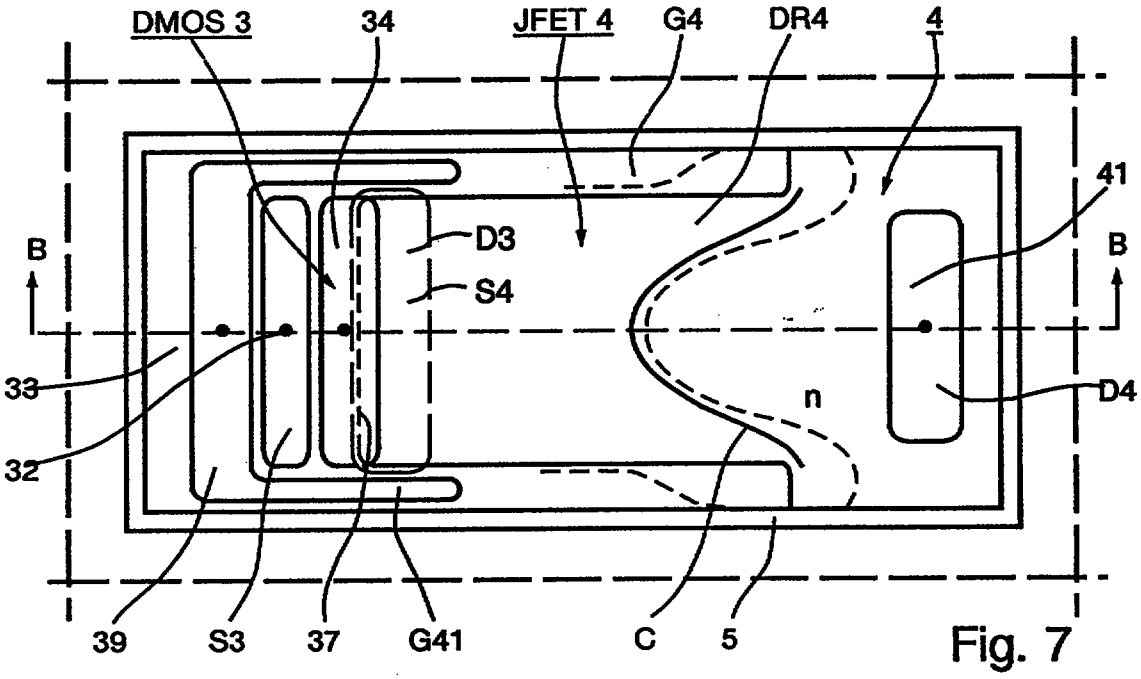

DMOS 3
34
JFET 4
G4
DR4
4
41
B
D3
S4
B
33
n
D4
32
39
S3
37
G41
C
5

Fig. 7

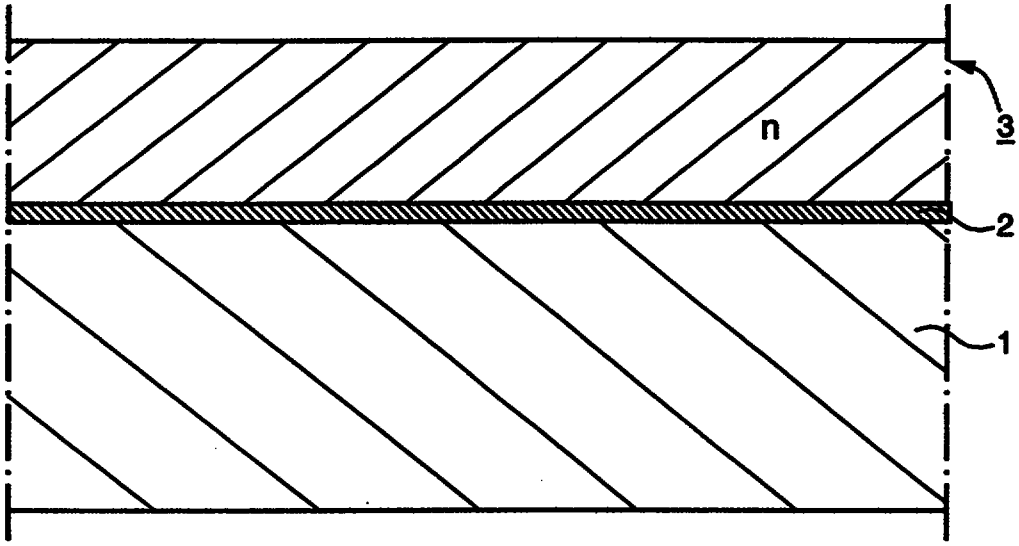


Fig. 8

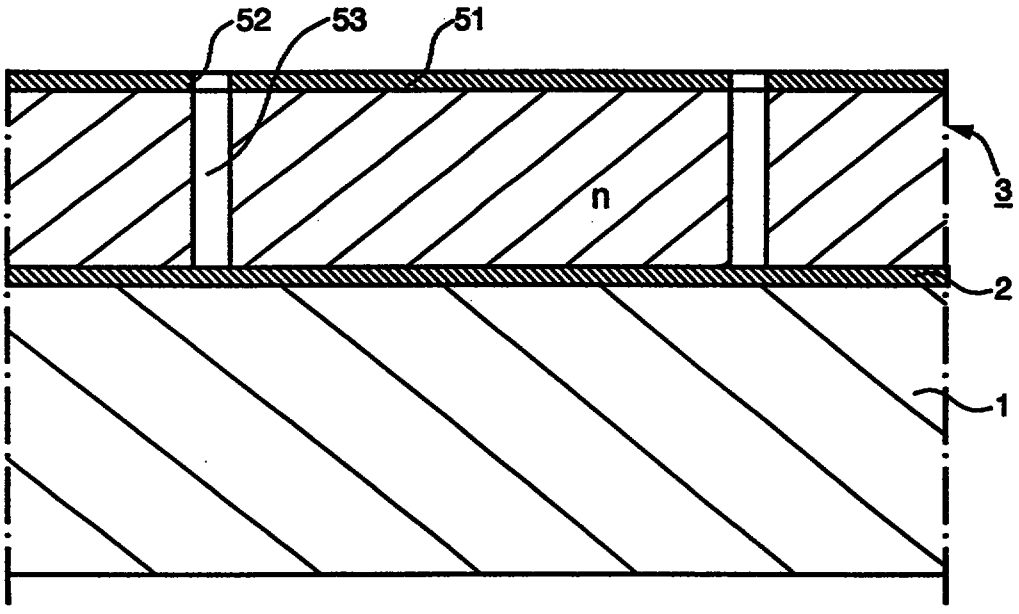


Fig. 9

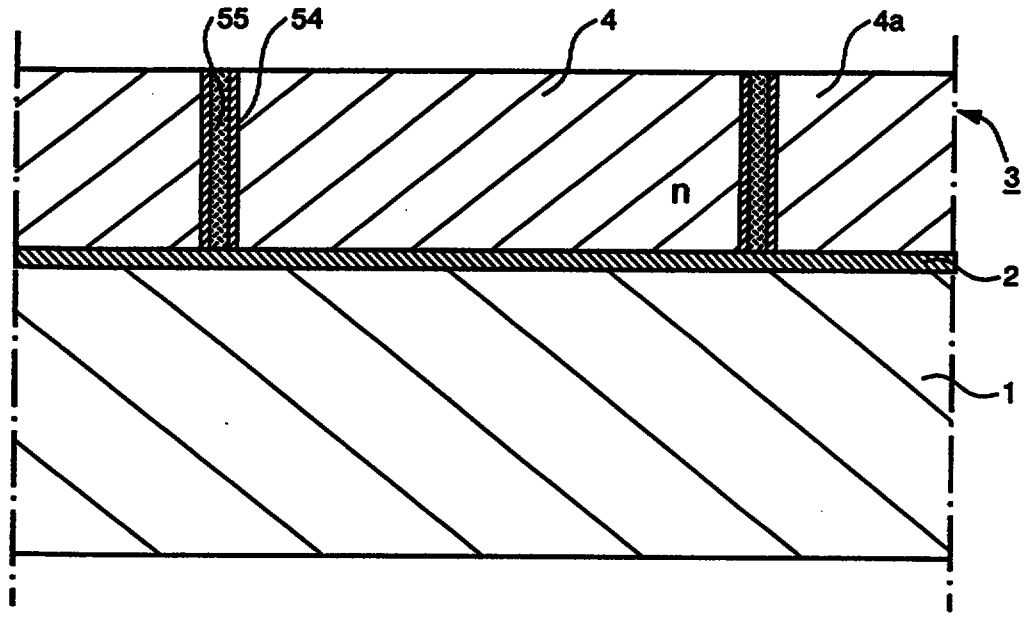


Fig. 10

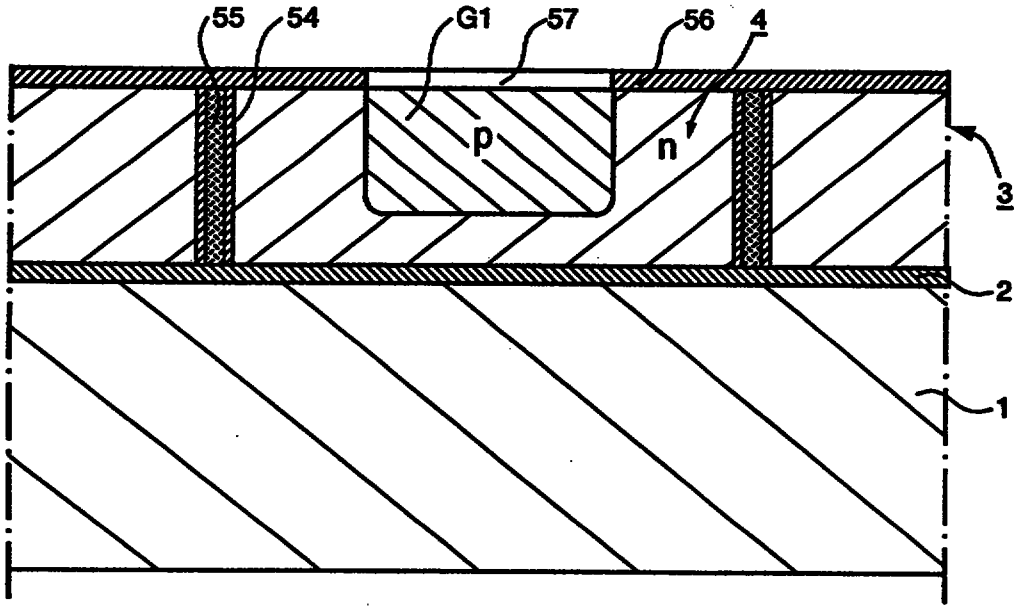


Fig. 11

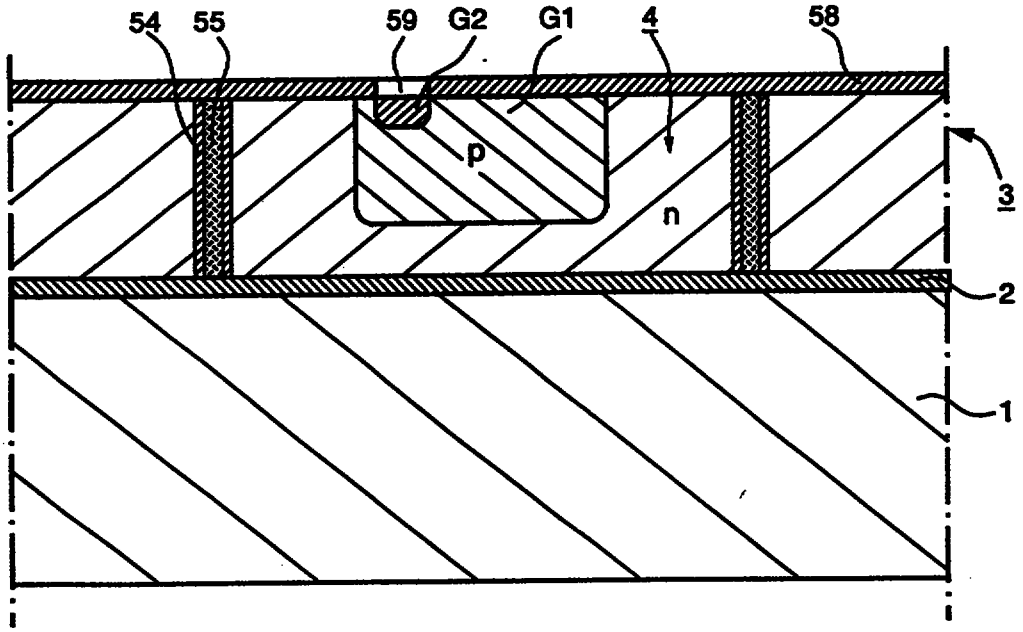


Fig. 12

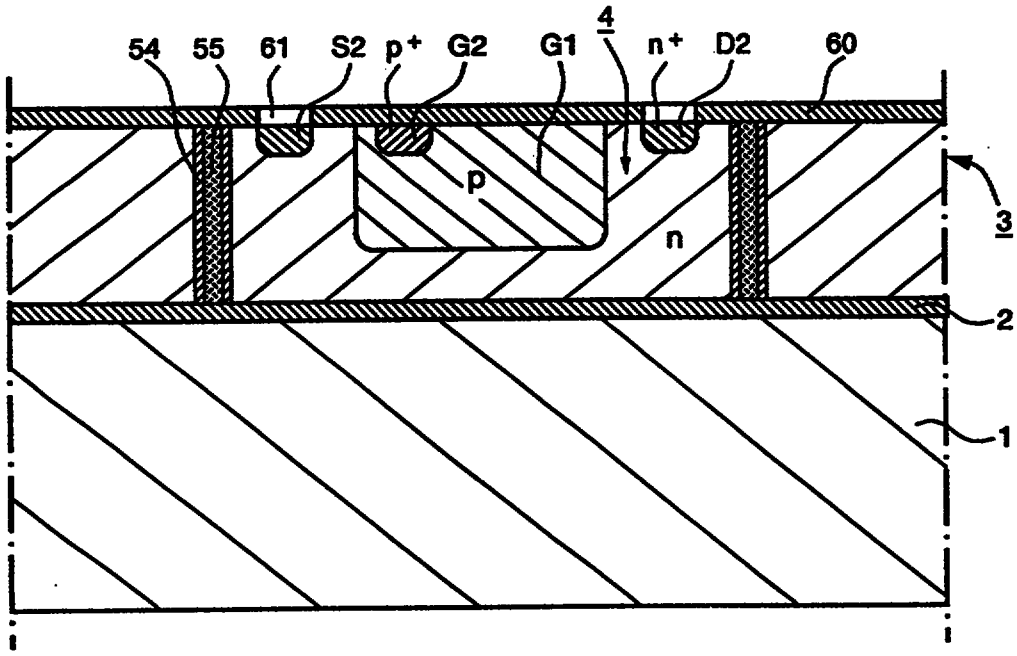


Fig. 13

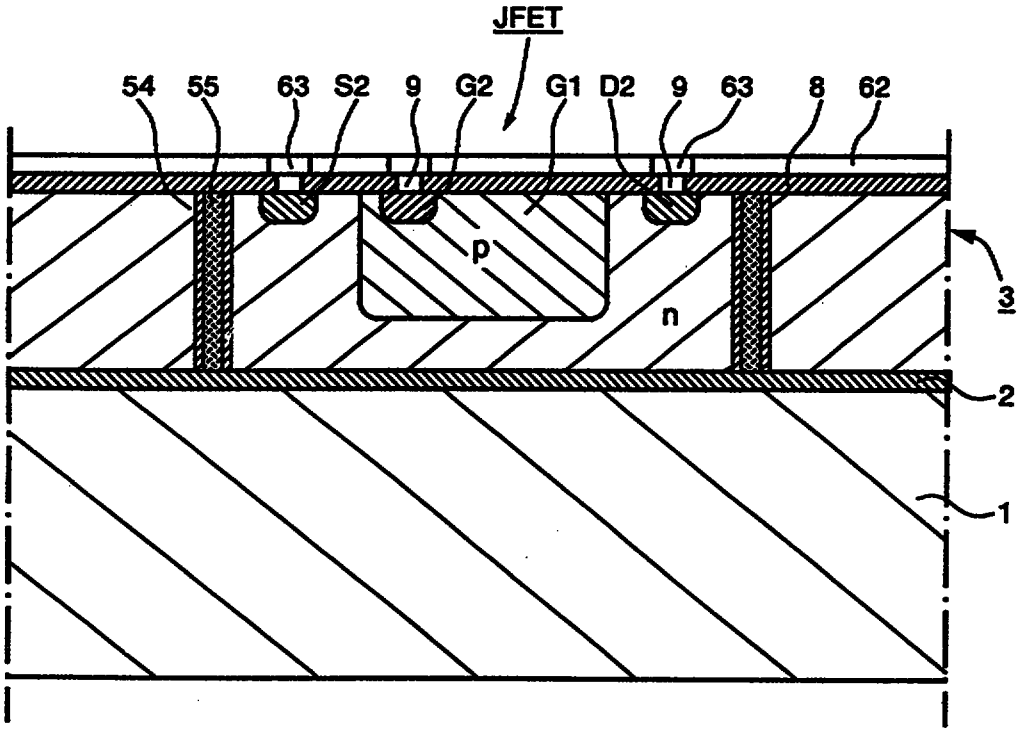


Fig. 14