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TITLE OF THE INVENTION

SEMICONDUCTOR DEVICE AND MANUFACTURING METHOD
THEREOF

BACKGROUND OF THE INVENTION

5 The present invention relates to a semiconductor device and more particularly to an insulated gate field effect transistor having an SOI (silicon on insulator) structure.

10 An SOI-MOSFET (silicon on insulator - metal oxide semiconductor field effect transistor) formed on a thin single crystalline silicon layer on an insulated substrate can be integrated on a large scale on one substrate using a micro fabrication process for silicon. Furthermore, the SOI-MOSFET is suitable for
15 high speed operation because the parasitic capacity of a formed transistor is smaller than that when a conventional single crystalline silicon substrate is used, so that it has been noticed.

20 A semiconductor device (MOSFET) using a conventional single crystalline silicon substrate biases the channel unit using a substrate electrode. On the other hand, the SOI-MOSFET cannot bias from the lower part of the channel because there is the insulated layer (or insulated substrate) at the bottom
25 of the thin single crystalline silicon layer and there

is a problem imposed that it is called a "floating substrate" causing an unstable operation.

Namely, it is reported that the NMOS (N channel MOS) generates a large leakage current in the off
5 state because holes are accumulated in the channel unit and causes a kink (kink effect) in the current characteristic even in the on state. It is known that this problem appears remarkably in an NMOS having a large impact ionization.

10 An art for solving this problem is disclosed, for example, in Japanese Patent Application Laid-Open 4-34980 and Japanese Patent Application Laid-Open 7-273340.

As described in IEEE Electron Devices Letters, Vol.
15 15, No. 12, pp. 510 to 512, December 1994, it is considered to bias the channel unit (P-silicon) via the gate electrode. The MOSFET having a structure that the substrate and gate are connected can be regarded as a device in which a FET and a lateral bipolar
20 transistor coexist. It is reported that by such a MOSFET, a characteristic which is excellent particularly in low voltage operation (0.6 V max.) can be obtained.

Fig. 22 is a plane schematic layout showing the
25 device structure disclosed in the aforementioned

reference. The plane layout uses the same layout as that of the MOSFET formed on a conventional single crystalline silicon substrate. The characteristic of this structure is that a part of an active region 100
5 comprising a thin single crystalline silicon layer is patterned in the same shape as that of a gate (electrode) 500. At a contact 600 of the gate, the gate 500 and the active region are in contact with each other by wiring at the same time.

10 Fig. 23 shows only the active region 100 shown in Fig. 22 and at the contact portion of the gate, the active region is patterned in a so-called dog bone shape. The cross sectional structure of the contact is shown in Fig. 24. The cross sectional structure shown
15 in Fig. 24 is a cross sectional view of the section A-A. As shown in Fig. 24, the contact between the gate 500 and the active region 100 is realized by forming a contact hole piercing through the gate 500 and an oxide film 910 of the gate, allowing the active region
20 100 under the gate oxide film 910 to expose, and forming a metallic wire 700 in the contact hole.

SUMMARY OF THE INVENTION

With respect to the art disclosed in the aforementioned reference, when the active region is to
25 be processed, it is necessary to form a minute pattern

in accordance with the gate beforehand. When the contact is to be formed, it is necessary to perform a process of piercing through the gate and to stop the process so as to prevent piercing through the thin
5 silicon layer. It is also necessary to perform contact with the gate on the gate layer side (the inner wall of the contact hole). As a result, a problem of processing arises that no consistency with the ordinary MOS transistor process (the process for
10 forming a MOS transistor on a conventional single crystalline substrate) can be realized and the art is not suited to integration.

Therefore, it is necessary to solve the problem of floating substrate without performing a special
15 process.

An object of the present invention is to provide a semiconductor device having a new SOI structure for giving an electrical potential to the channel forming region.

20 Another object of the present invention is to provide a semiconductor integrated circuit device having a plurality of insulated gate field effect transistors having a new SOI structure for giving an electrical potential to the channel forming region
25 which are formed on a support substrate.

Still another object of the present invention is to provide a manufacturing method of a semiconductor device having a new SOI structure for giving an electrical potential to the channel forming region.

5 According to the semiconductor device of the present invention, in a semiconductor device including a single crystalline semiconductor layer mounted on an insulator and an insulated gate field effect transistor having a gate, a source, and a drain
10 electrode which are formed on the single crystalline semiconductor layer, the gate electrode has a 2-layer structure of an upper gate layer and a lower gate layer and the upper gate layer is electrically connected to the channel forming region of the
15 insulated gate field effect transistor.

 According to the present invention, the substrate is biased via the gate electrode, so that the problem of floating substrate can be avoided.

 As the explanation of the forming process which
20 will be described later shows obviously, the structure of the present invention is realized on a self-alignment basis. Therefore, it is obvious that a problem that no alignment can be realized due to the process of the prior art will not arise.

25 Namely, the lower gate electrode is processed by

continuous etching up to the SOI layer (the single crystalline semiconductor layer) and the side of the SOI layer is exposed. By this processing, the side for contact between the gate and the SOI layer (that is, the channel forming region) is formed. By depositing the upper gate layer on the lower gate layer, the lower gate layer and the SOI layer are automatically - connected at the sides thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Fig. 1 is a plan view showing the semiconductor device which is a first embodiment of the present invention.

Fig. 2 is a cross sectional view at the line A-A of the semiconductor device shown in Fig. 1.

15 Fig. 3 is a cross sectional view at the line B-B of the semiconductor device shown in Fig. 1.

Fig. 4 is a cross sectional view at the line C-C of the semiconductor device shown in Fig. 1.

20 Fig. 5 is a cross sectional view showing the semiconductor device of the second embodiment of the present invention.

Fig. 6 is a cross sectional view showing the semiconductor device of the third embodiment of the present invention.

25 Fig. 7 is a cross sectional view showing the

semiconductor device of the fourth embodiment of the present invention.

Fig. 8 is a cross sectional view showing the manufacturing process of the semiconductor device shown in Fig. 1.

Fig. 9 is a cross sectional view showing the manufacturing process of the semiconductor device following Fig. 8.

Fig. 10 is a cross sectional view showing the manufacturing process of the semiconductor device following Fig. 9.

Fig. 11 is a cross sectional view showing the manufacturing process of the semiconductor device following Fig. 10.

Fig. 12 is a plane schematic layout of the semiconductor device of the fifth embodiment of the present invention.

Fig. 13 is a plane schematic layout of the semiconductor device of the sixth embodiment of the present invention.

Fig. 14 is a plane schematic layout of the semiconductor device of the seventh embodiment of the present invention.

Fig. 15 is a plane schematic layout of the semiconductor device of the eighth embodiment of the

present invention.

Fig. 16 is a cross sectional view showing the manufacturing process of the semiconductor device of the ninth embodiment of the present invention.

5 Fig. 17 is a cross sectional view showing the manufacturing process of the semiconductor device of the ninth embodiment of the present invention.

10 Fig. 18 is a cross sectional view showing the manufacturing process of the semiconductor device of the ninth embodiment of the present invention.

Fig. 19 is a cross sectional view showing the semiconductor device of the tenth embodiment of the present invention.

15 Fig. 20 is a cross sectional view showing the semiconductor device of the eleventh embodiment of the present invention.

Fig. 21 is a plane schematic layout of the semiconductor device of the twelfth embodiment of the present invention.

20 Fig. 22 is a plan view of a conventional semiconductor device having the SOI structure.

Fig. 23 is a plan view of a thin single crystalline silicon layer of the conventional semiconductor device shown in Fig. 22.

25 Fig. 24 is a cross sectional view at the line A-A

of the conventional semiconductor device shown in Fig. 22.

Fig. 25 is a plan view of the semiconductor integrated circuit device of the thirteenth embodiment
5 of the present invention.

Fig. 26 is a plan view of the semiconductor integrated circuit device which is a fourteenth embodiment of the present invention.

Fig. 27 is a plan view of the semiconductor integrated circuit device which is a fifteenth
10 embodiment of the present invention.

Fig. 28 is a circuit diagram showing a power circuit (voltage limiter) for driving the semiconductor device (or semiconductor integrated
15 circuit device) of each embodiment of the present invention.

Fig. 29 is a circuit diagram showing an input-output protective circuit using the semiconductor device of the present invention as a protective
20 element.

Fig. 30 is a cross sectional view showing an electronic card in which the semiconductor device (or the semiconductor integrated circuit device) of the present invention is incorporated.

25 DESCRIPTION OF THE PREFERRED EMBODIMENTS

Detailed contents of the present invention will be explained hereunder on the basis of the embodiments.

Fig. 1 is a typical plan view showing a mask layout of a semiconductor device having the SOI structure which is a first embodiment of the present invention. Firstly, using an example of an N channel type insulated gate field effect transistor (hereinafter abbreviated to NMOS briefly), the structure and forming process thereof will be explained.

A gate pattern 500 is positioned across a rectangular active region (thin single crystalline silicon layer) 100 indicated by a thick line. Numeral 300A indicates a position of the opening mask when source and drain electrodes of the NMOS are to be formed by ion implantation of N-type impurities. Numeral 600 indicates a contact portion of a wire for each of the source region, drain region, and gate electrode. Numeral 700 indicates a wiring position.

The sectional structure of the NMOS arranged as mentioned above is shown in Figs. 2, 3, and 4. Figs. 2, 3, and 4 are cross sectional views at the line A-A (the perpendicular direction to the channel or the direction of the channel width), the line B-B (the direction of the channel length), and the line C-C

shown in Fig. 1 respectively. In the drawings, numeral 120 indicates, for example, a support substrate (body) comprising high resistivity single crystalline silicon. Numeral 110 indicates an insulating film comprising, 5 for example, a silicon oxide film. Numeral 100 indicates a first conductive single crystalline silicon layer (namely, SOI layer) located on the insulating film 110. Numeral 910 indicates a gate insulating film comprising a silicon oxide film 10 concretely. Numeral 550 indicates a lower gate layer and 500 indicates an upper gate layer. Numeral 350 indicates source and drain diffused layers indicating the conductivity type opposite to the first conductivity type. Silicon of the channel unit, that 15 is, the SOI layer 100 indicates the low concentration P-conductivity type. The source and drain diffused layers indicate the N-conductivity type. Numeral 700 indicates a metallic wiring layer, which is in contact with the diffused layers and electrodes respectively.

20 The characteristics of the present invention are shown in Fig. 2. In Fig. 2, both sides of the SOI layer 100 which are opposite to each other are in contact with the upper gate layer 500 and electrically energized because there is no gate insulating film 910.

25 Therefore, a bias voltage applied to the metallic

wiring layer 700 is given to the SOI layer 100 (the channel forming region under the gate electrode) via the upper gate layer 500. The lower gate layer 550 produces a field effect via the gate insulating film 910 and can perform an operation as a field effect transistor (FET). As shown in Fig. 4, the sides of the SOI layer 100 and the diffused layers 350 are arranged away from each other. Namely, the PN junction comprising the diffused layers 350 and the SOI layer 100 is formed inside the SOI layer 100 so that it will not arrive at the sides of the SOI layer 100. Since there is a distance between the contact portion with the gate and the diffused layers, a sufficient breakdown voltage can be obtained between the gate and the drain.

In correspondence with the sectional structure shown in Fig. 3, other embodiments are shown in Figs. 5, 6, and 7 respectively.

The second embodiment shown in Fig. 5 shows a case that the SOI layer 100 is made thinner. The thickness of the SOI layer 100 is, for example, 10 nm and the thickness of the gate insulating film 910 is about 1/2 of the thickness of the SOI layer 100.

The electrical connection between the gate and the channel forming region in this embodiment is realized

by the structure shown in Fig. 2.

According to this embodiment, characteristic improvement in the subthreshold operation region can be realized. Namely, since the gate electrode and the channel active region are electrically connected, when
5 the gate voltage (V_G) of the transistor (NMOS) is 0 V (the off state), the off state of the transistor is made stronger. Namely, the threshold voltage is increased. Therefore, the threshold leakage current
10 can be reduced.

Though it is an intrinsic effect of the SOI structure, the parasitic capacity of the diffused layers can be reduced.

The third embodiment shown in Fig. 6 is an NMOS
15 having the SOI structure with shallow low-concentration impurity diffused layers 340 provided which is known as an LDD (lightly doped drain) structure. Namely, the layers 340 have a lower concentration than that of the source and drain
20 diffused layers to which the metallic wires of the diffused layers are connected and formed shallowly. By use of the LDD structure like this, the hot electron effect can be reduced and an NMOS having the SOI structure can be made minuter.

25 The electrical connection between the gate and the

channel forming region in this embodiment is realized by the structure shown in Fig. 2.

In Fig. 6, a side wall spacer for the gate electrodes 500 and 550 is omitted.

5 The fourth embodiment shown in Fig. 7 has a structure that the high-concentration diffused layers 350 to which the metallic wiring layer 700 is connected are covered with the low-concentration diffused layers 340 which are called a DDD (double
10 diffused drain) structure and the drain breakdown voltage can be increased.

Also in this embodiment, the electrical connection between the gate and the channel forming region is realized by the structure shown in Fig. 2.

15 In Fig. 7, the high-concentration diffused layers 350 are away from the edges of the gate electrodes 500 and 550. However, actually in the same way as with the low-concentration diffused layers 340, the high-concentration diffused layers 350 are formed by self-
20 alignment for the edges of the gate electrodes 500 and 550. As a result, the edges of the high-concentration diffused layers 350 in contact with the gate insulating film 910 are located under the gate electrode.

25 Next, the manufacturing method of the first

embodiment shown in Fig. 1 will be explained.

Figs. 8 to 11 are cross sectional structure diagrams showing the manufacturing process of the first embodiment. Figs. 8 to 11 show the manufacturing process at the cross section at the line A-A of the semiconductor device including the gate shown in Fig. 1.

As shown in Fig. 8, the silicon oxide film 110 is formed on the silicon substrate 120 as a support substrate. The silicon substrate 120 is a relatively high resistivity single crystalline silicon. On the silicon oxide film 110, the single crystalline silicon layer (SOI layer) 100 which is 100 nm in thickness and of the P-conductivity type and has a resistivity of 1 Ω .cm is formed. By doing this, the SOI substrate as a starting material is prepared. On the surface of this SOI substrate, the gate oxide film 910 with a thickness of 10 nm is formed by thermal oxidation and the polycrystalline silicon layer 550 which is doped to the P-conductivity type using the CVD method is deposited in a thickness of 100 nm.

Next, as shown in Fig. 9, the active region is patterned using the photoresist method. Namely, the lower gate layer 550, the gate insulating film 910, and the SOI layer 100 are sequentially etched using a

photoresist mask. In this case, the sides of the SOI layer 100 can be exposed in a shape of active region.

The active region means a region where an insulated gate field effect transistor is formed and includes the source and drain regions and the channel forming region between them.

Next, as shown in Fig. 10, the polycrystalline silicon layer (upper gate layer) 500 in which boron is doped in high concentration is deposited. By doing this, the lower gate layer 550 and the SOI layer 100 are connected on the exposed sides of the SOI layer. Doped boron in the polycrystalline silicon is diffused from the sides of the SOI layer by the subsequent heat treatment process (for example, heat treatment such as forming of CVD protective film) and forms a high-concentration layer in the SOI layer. This high-concentration layer can be made thinner by lowering the temperature of the process (for example, 60000°C to 700°C or so). Therefore, it is omitted in the drawing.

Next, as shown in Fig. 11, the gate electrode is patterned by the photoresist method. Concretely, the gate electrode is processed by anisotropic dry etching. In this case, on the SOI layer 110, the upper gate layer 500 and the lower gate layer 550 can be processed together. Namely, as shown in Fig. 1, the

gate electrode (500) is formed.

Generally, when there is a level difference like the SOI layer 100, an etching residue of the upper gate layer 550 is generated on the sides of the SOI layer. However, by using a condition of a high etching selection ratio of the gate insulating film 910 and the upper gate layer 550, the layers 500 and 550 can be processed.

Since the forming process is the same as that of an ordinary MOSFET, the drawing will be omitted. By performing ion-implantation in which arsenic is accelerated with an ion dose of $5 \times 10^{15} \text{ cm}^2$ and implantation energy of 25 keV using the gate electrode 500 and the opening mask 300A (see Fig. 1) as a mask and then annealing it, the diffused layers (source and drain regions) 300 are formed. By using the opening mask 300A, the interval between the diffused layers and the sides of the SOI layer which is in contact with the gate electrode is set to 0.3 micron (μm). By doing this, the junction breakdown voltage between the P-type high concentration layer (not shown in the drawing due to shallow junction) diffused and formed from the gate 500 to the surface of the SOI layer and the diffused layers 300 can be increased. BPSG (borophospho silicate glass) is deposited by the CVD method

and flattened by heat-treating and then a contact is formed on each electrode. By depositing and processing metallic wires, an element (NMOS) is formed.

As the aforementioned process makes it clear,
5 without forming a contact pattern on the SOI layer, the substrate 100 and the gate electrode can be made conductive.

By reversing the conductivity type used here, a PMOS (P channel MOS) can be formed. It is clear that
10 by forming a P-conductivity type SOI layer and an N-conductivity type SOI layer respectively on the silicon oxide layer 110 and using the PMOS forming mask and NMOS forming mask appropriately, the CMOS process can be realized.

15 Fig. 12 shows the fifth embodiment. The drawing shows a layout of SOI-NMOS having a so-called dual gate structure in which a plurality of gates (electrodes) are arranged in parallel with each other particularly so as to generate a large current. In Fig.
20 12, the diffused layer 300 is formed smaller than the pattern of the active region (SOI layer) 100.

Also in this embodiment, each gate electrode 500, as shown in Fig. 2, has a two-layer structure comprising an upper gate layer and a lower gate layer
25 and the upper gate layer and the sides of the active

region are in contact with each other.

When the structure and forming process of the present invention are used, contact of the electrode (P-conductivity type gate electrode 500) having the conductivity opposite to that of the diffused layer with the active region can be easily realized because they are of the same conductivity type. A bipolar transistor can be obtained at the same time.

Fig. 13 shows the basic arrangement of the polar transistor of the sixth embodiment. For example, in the case of PMOS, the transistor is structured so that the N-conductivity type SOI layer to which the gate 500 is connected is set as an N type base, and the P type source region and P type drain region are set as an emitter and collector respectively, and the transistor can be operated as a lateral PNP bipolar transistor.

Fig. 14 is a plane schematic layout of the semiconductor device of the seventh embodiment of the present invention. This embodiment constitutes only a lateral bipolar transistor instead of MOSFET. Namely, as shown in Fig. 14, the electrodes 500 are patterned as a base pull-out electrode. In the same way as with the sixth embodiment mentioned above, the electrodes 500 are connected to the sides of the SOI layer 100.

The emitter region and collector region can be selectively formed inside the SOI layer by the well-known ion implantation using the opening mask patterns 300 and 310 as a mask.

5 Fig. 15 is a plane schematic layout of the semiconductor device of the eighth embodiment of the present invention.

As shown in Fig. 15, it is possible to arrange the active region (SOI layer) 100 in a ring shape on an
10 insulating film (not shown in the drawing) and form a device. This device can be applied, for example, as an input protection diode (PN junction diode) of SOI-MOSFET. Namely, the P-conductivity type diffused layer 300 is selectively formed on the N-conductivity type
15 SOI layer 100 so as to reach the insulating film. With the side wall inside the ring-shaped SOI layer 100 on which the P-conductivity type high-concentration impurity diffused layer 300 is formed, the electrode 500 is in contact. The main surface of the electrode
20 500 and the main surface of the SOI layer are covered with a layer insulating film (not shown in the drawing) and contact holes 600 are arranged on the layer insulating film. As shown by dotted lines, anode lines M_A and M_K are connected.

25 According to this embodiment, the electrode 500 is

in contact with the side wall inside the ring-shaped SOI layer opposite to the whole PN junction, so that it is possible to send a surge current uniformly.

Next, a manufacturing method of another
5 semiconductor device which is a ninth embodiment will be shown in Figs. 16 to 18.

The cross sectional views shown in Figs. 16 to 18- correspond to cross sectional views in the cutting direction of the line A-A.

10 When the lower gate layer 550 shown in Fig. 9 is to be processed, a silicon nitride film 925 is deposited on the lower gate layer 550, and the silicon nitride film 925 and the lower gate layer 550 are etched, and the processing is stopped once at the gate
15 insulating film 910. Next, by a spacer forming art in which the known CVD method and dry etching (anisotropic etching) are combined, a spacer 920 can be formed on the sides of the lower gate layer 550 (Fig. 16).

20 Next, the SOI layer 100 is processed using the silicon nitride film 925 and the spacer 920 as a mask (Fig. 17).

Next, by removing the spacer 920 and the silicon nitride film 925 and performing ion implantation using
25 the lower gate layer 550 as a mask, P-conductivity

type high-concentration impurity diffused layers 330
can be provided on a self-alignment basis in the
peripheral area of the SOI layer 100. Hereafter, when
the forming process (gate etching) of the first
5 embodiment shown in Fig. 10 is performed, an element
can be obtained (Fig. 18). When this process is
performed, even if a metallic material is used as the-
upper gate layer 500, it can be made conductive with
the SOI layer with a low resistance without having a
10 schottky barrier.

In the structure of the present invention, it is
obvious that a gate can be formed by laminating
different materials and a combination thereof can be
designed so as to obtain a necessary gate resistance.
15 The gate constitution of 2 layers is mentioned above.
However, for example, it is possible that the lower
gate comprises a laminated film of N type
polycrystalline silicon and titanium nitride (TiN) on
the N type polycrystalline silicon and the upper gate
20 comprises P type polycrystalline silicon. Namely, a
laminated layer gate structure such as a polyside gate
or a salicide gate which is developed so as to reduce
the resistance of the gate and set a threshold voltage
can be used as it is.

25 Fig. 19 shows the 10th embodiment in which an

insulating film 930 is located between the upper gate 500 and the lower gate 550. By doing this, a floating gate memory cell can be obtained easily.

Therefore, a semiconductor integrated circuit
5 device in which a MOSFET which has a two-layer structure comprising an upper gate layer and a lower gate layer like the aforementioned embodiment (for example, the first embodiment) and is in contact with the sides of the upper gate layer and of the active
10 region and the aforementioned floating gate memory cell are loaded in the SOI layer 100 can be formed.

Figs. 20 and 21 show the eleventh embodiment and the twelfth embodiment respectively and show the MOSFET of the previous embodiment as well as a
15 deformation example of a PN junction diode which can be formed on the SOI layer 100.

The diode shown in Fig. 20 comprises PN junction between the P-conductivity type SOI layer (substrate) 100 and the N type layer 370. The forming method of
20 this diode will be described briefly hereunder.

Firstly, no gate insulating film is put on the surface of the substrate 100 and the lower gate layer 550 and the upper gate layer 500 are deposited. Concretely, the gate insulating film 910 shown in Fig.
25 8 is formed and then a part of the gate insulating

film 910 formed on the surface of the substrate 100 where a diode is to be formed is removed. Then, the lower gate layer 550 and the upper gate layer 500 are deposited. Since the gate insulating film is not found,
5 the substrate 100 can be etched at the gate electrode patterning process. Using the level differences of the sides generated at this time, insulating film spacers - 960 are formed. Tungsten 710 is selectively deposited on the exposed polycrystalline silicon 500 and the
10 substrate 100. Phosphorus is ion-implanted into the substrate 100 before tungsten deposition and the specified N type layer 370 is formed by the insulating film spacers 960. Numeral 360 indicates a P type impurity layer diffused from 550 because there is no
15 gate insulating film.

This embodiment can form a PN junction diode selectively using two-layer gate pattern etching.

In the CMOS process, both N type and P type are used for polycrystalline silicon for the gates. By
20 using it, a diode can be formed. Fig. 21 shows a typical layout. Contact takes place from the left side (CNT1) of the active region (P-conductivity SOI layer) 100 to the N-conductivity type region and contact from the right side (CNT2) to the P-conductivity type
25 region can be obtained.

The N-conductivity type region 300 is formed by implantation of arsenic ions using the opening mask 300A.

5 The contact between the gates and the substrate (SOI layer) of the present invention (hereinafter referred to as the substrate contact) is valid when the gates extend over a plurality of active regions. -
Namely, the present invention has a structure suited to high integration. Figs. 25, 26, and 27 show the
10 thirteenth, fourteenth, and fifteenth embodiments respectively. Arrangement examples of typical active regions 100 and gate 500 which are used in an LSI are shown respectively.

In the conventional substrate contact, it is
15 necessary to provide a plurality of contact forming regions.

However, according to the present invention, the substrate contact is realized on the side walls of the active regions 100, so that the substrate contact can
20 be easily realized for the active regions arranged as shown in Fig. 25 to 27. Therefore, a highly integrated semiconductor integrated circuit device which is driven at a low voltage can be obtained.

However, in the device structure of the present
25 invention, the leakage current increases at a high

voltage ($V_{cc} = 1.2 \text{ V to } 1.5 \text{ V}$), so that the structure is valid in an operation particularly at a low voltage ($V_{DL} \leq 0.6 \text{ V}$). Therefore, in a semiconductor integrated circuit device (hereinafter referred to as IC) in which a SOI.MOSFET having no substrate contact and a SOI.MOSFET having substrate contact like the present invention are integrated, it is possible that a voltage limiter as shown in Fig. 28 is provided in the IC and the internal circuit which is operated by the drive voltage VDL comprises the aforementioned SOI.MOSFETs of the present invention.

In Fig. 28, the resistors R1 and R2 are set so as to obtain the reference voltage Vref ($\leq 0.6 \text{ V}$).

Symbol DA indicates a differential amplifier.

An embodiment in which the SOI.MOSFETs of the present invention are used as a gate protective circuit element is shown in Fig. 29. In this embodiment, by connecting a large inverter (CMOS inverter) comprising the present invention between the bonding pad BP and the internal circuit 1, the IC can be operated as a gate protective element. Namely, the gate electrodes are connected to the power source V_{cc} or the grounding cable V_{ss} respectively via the PN junction. As a result, for example, when a positive surge voltage is applied to the bonding pad BP, it is

extracted to the grounding cable V_{ss} via the PN
junction of the NMOS. On the other hand, when a
negative surge voltage is applied to the bonding pad
BP, it is extracted to the grounding cable V_{cc} via the
5 PN junction of the PMOS.

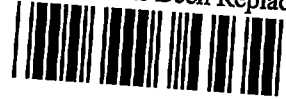
According to the present invention, the
semiconductor device has a characteristic that it
operates at a low voltage. Therefore, a photodetector
using the photovoltaic effect in which a problem of
10 low voltage is imposed, for example, a solar cell and
SOI.MOSFETs of the present invention can be integrated.
For example, the electronic card shown in Fig. 30 can
be assembled. In Fig. 30, a photodetector 122 is
formed on a well provided on the silicon substrate 120
15 and the embedded oxide film 110 is formed in a part of
the substrate 120. On the embedded oxide film 110,
SOI.MOSFETs of the present invention are formed. And,
for example, the silicon substrate 120 is sealed by a
transparent resinous substance 10. At the corner of
20 the resinous substance 10, an external terminal 11 is
provided.

It is possible to provide SOI.MOSFETs of the
present invention on one main surface of the substrate
120, provide a photodetector on the other main surface
25 opposite to the one main surface, protect the one main

surface with an opaque resinous substance, and protect the other main surface with a transparent resinous substance.

5 As mentioned above, according to the present invention, the gate electrodes are electrically in contact with the substrate which is a channel, accordingly power can be supplied to the channel, so - that a problem of floating substrate can be suppressed.

This Sheet Has Been Replaced



WHAT IS CLAIMED IS:

1. A semiconductor device including a support substrate having a main surface comprising an insulator, a first conductive single crystalline semiconductor layer patterned on said insulator main surface, a gate insulating film formed on the main surface of said single crystalline semiconductor layer, a first gate layer patterned on said gate insulating film, and a second gate layer connected to said first gate layer, wherein said second gate layer is connected at the sides of said single crystalline semiconductor layer.

2. A semiconductor device according to Claim 1, wherein said support substrate comprises a single crystalline semiconductor and an insulator having a silicon oxide film formed on the surface of said semiconductor.

3. A semiconductor device including a support substrate having a main surface comprising an insulator, a first conductive single crystalline semiconductor layer having a rectangle formed on said insulator main surface, a gate insulating film formed on the main surface of said single crystalline semiconductor layer, a first gate layer patterned on said gate insulating film, and a second gate layer



THIS SHEET HAS BEEN
REPLACED



connected to said first gate layer, wherein said second gate layer is connected at both sides of said single crystalline semiconductor layer which are opposite to each other.

5 4. A semiconductor device according to Claim 3, wherein said support substrate comprises a single crystalline semiconductor and an insulator having a silicon oxide film formed on the surface of said semiconductor.

10 5. A semiconductor device according to Claim 3, wherein said lower gate layer comprises a laminated film of polycrystalline silicon and titanium nitride and said upper gate layer comprises polycrystalline silicon.

15 6. A semiconductor integrated circuit device including a support substrate having a main surface comprising an insulator, first conductive single crystalline semiconductor layers having a plurality of rectangles formed on said insulator main surface, gate
20 insulating films formed on the main surfaces of said respective single crystalline semiconductor layers, first gate layers patterned on said respective gate insulating films, and second gate layers which are formed extending over said plurality of single
25 crystalline semiconductor layers and connected to said





first gate layers, wherein said second gate layers are connected at the sides of said respective single crystalline semiconductor layers.

5 7. A semiconductor device including a single crystalline semiconductor layer mounted on an insulator and an insulated gate field effect transistor having a gate, a source, and a drain electrode which are formed on said single crystalline semiconductor layer, wherein said gate electrode has a
10 2-layer structure and the upper gate layer is electrically connected to the channel forming region of said insulated gate field effect transistor.

15 8. A semiconductor device according to Claim 7, wherein the sides of said silicon single crystalline layer and said gate electrode are in contact with each other.

9. A semiconductor device according to Claim 7, wherein said lower gate layer and the active region are formed by the same pattern.

20 10. A manufacturing method of a semiconductor device comprising a step of forming a gate insulating film on a silicon single crystal on an insulator, a step of depositing a gate layer on said gate insulating layer, a step of patterning an active
25 region, a step of processing said gate layer and said





silicon single crystalline layer, a step of depositing
a second gate layer on said gate layer, said silicon,
and an insulating film substrate, a step of patterning
said gate and processing said first and second gate
5 layers, and a step of forming a predetermined impurity
region in said active region.

11. An electronic card characterized in that a -
photodetector is formed on a semiconductor body, and a
semiconductor layer is formed on one main surface of
10 said body via an insulating film, a MISFET using said
semiconductor layer as a channel forming region is
formed on said semiconductor layer, and the gate
electrode of said MISFET and said semiconductor layer
are electrically connected to each other, and said
15 semiconductor body is sealed by a resinous substance.

12. An electronic card according to Claim 11,
wherein said photodetector constitutes a solar cell
for driving said MISFET.

13. An electronic card according to Claim 12,
20 wherein said photodetector is sealed by a transparent
resinous substance.

14. An electronic card according to Claim 11,
wherein said photodetector is formed on another main
surface which is opposite to one main surface of said
25 body.





15. A manufacturing method of a semiconductor device having an insulated gate field effect transistor on a single crystalline semiconductor layer on an insulator comprising:

5 a step of depositing a first conductive layer on said single crystalline semiconductor layer via a gate insulating film;

10 a step of patterning for specifying the direction of the gate width for said first conductive layer and said single crystalline semiconductor layer;

15 a step of depositing a second conductive layer in contact with the main surface and sides of said first conductive layer and the sides of said single crystalline semiconductor layer on said first conductive layer and said single crystalline semiconductor layer which are patterned;

20 a step of patterning for specifying the direction of the gate length for said second conductive layer and said first conductive layer and forming laminated gate electrodes of said first gate layer and second gate layer; and

 a step of forming a source and a drain region specified by said laminated gate electrodes.



THIS SHEET HAS BEEN
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ABSTRACT

To suppress floating substrate in the thin
SOI.MOSFET formed on the SOI substrate, the gate
(electrode) has a two-layer structure and the upper
5 gate thereof is in contact with the sides of the SOI
layer (substrate).

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FIG. 1

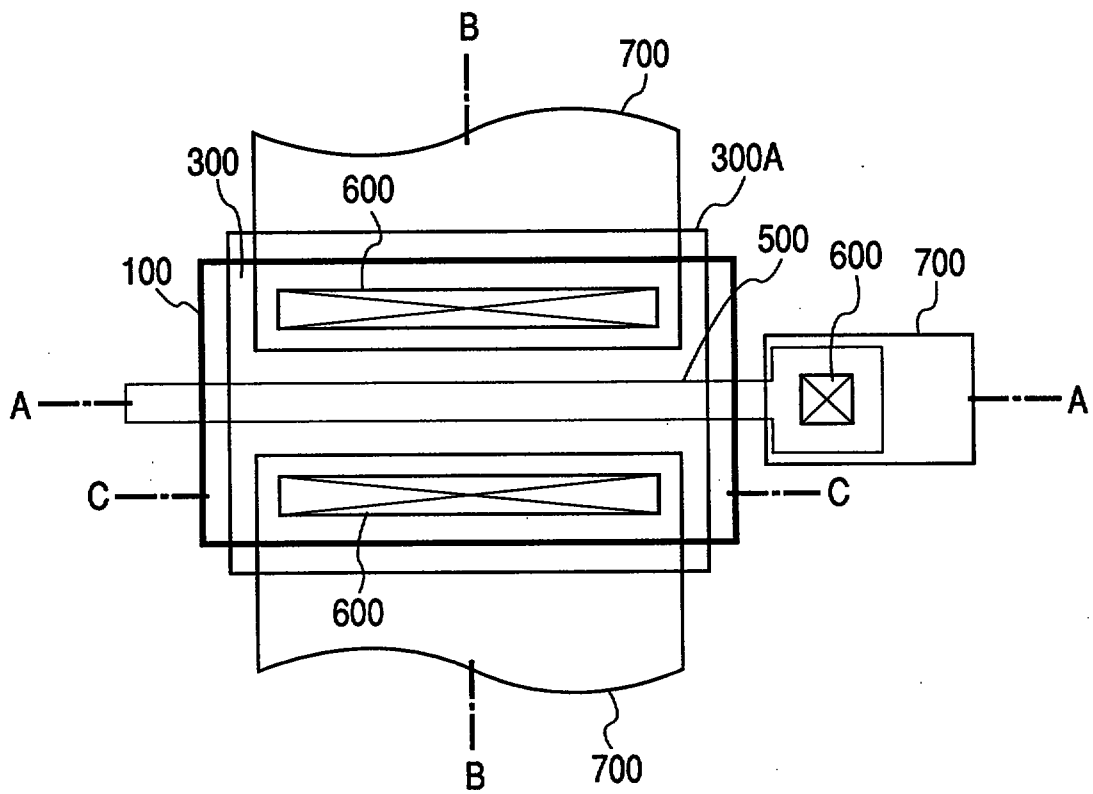


FIG. 2

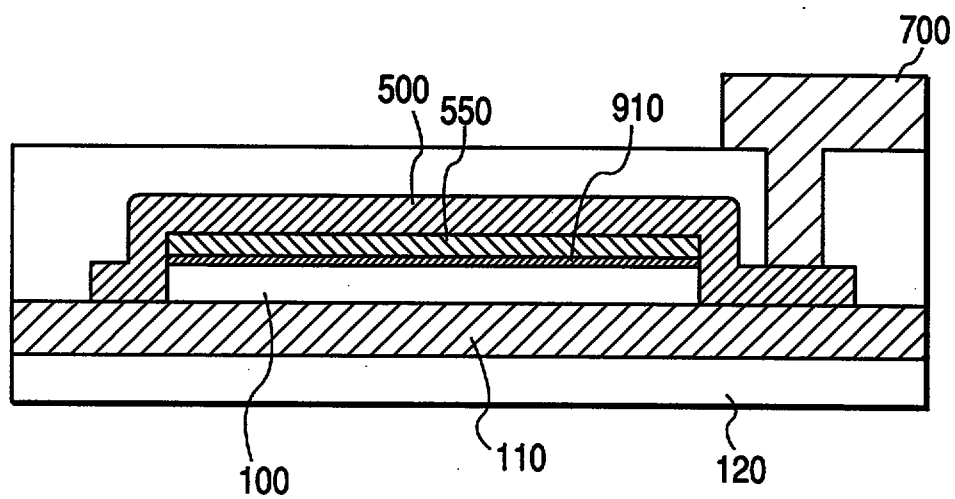


FIG. 3

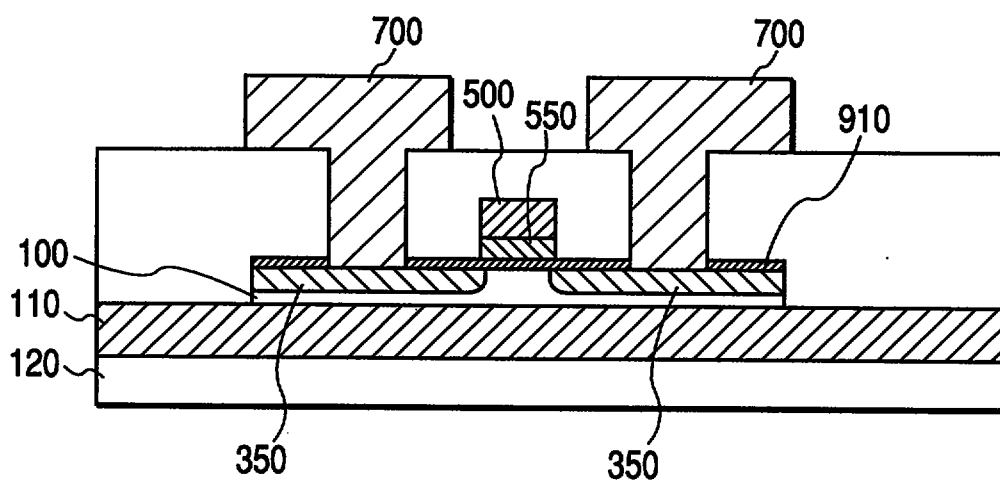


FIG. 4

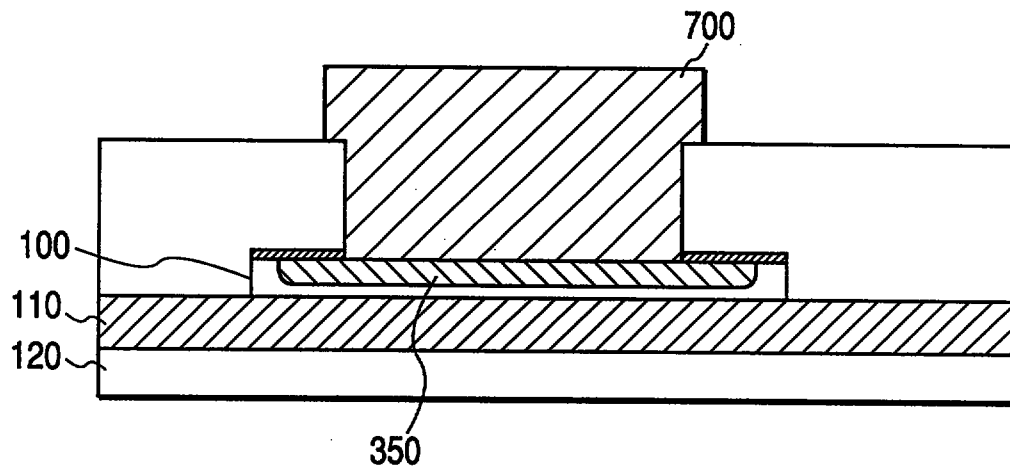


FIG. 5

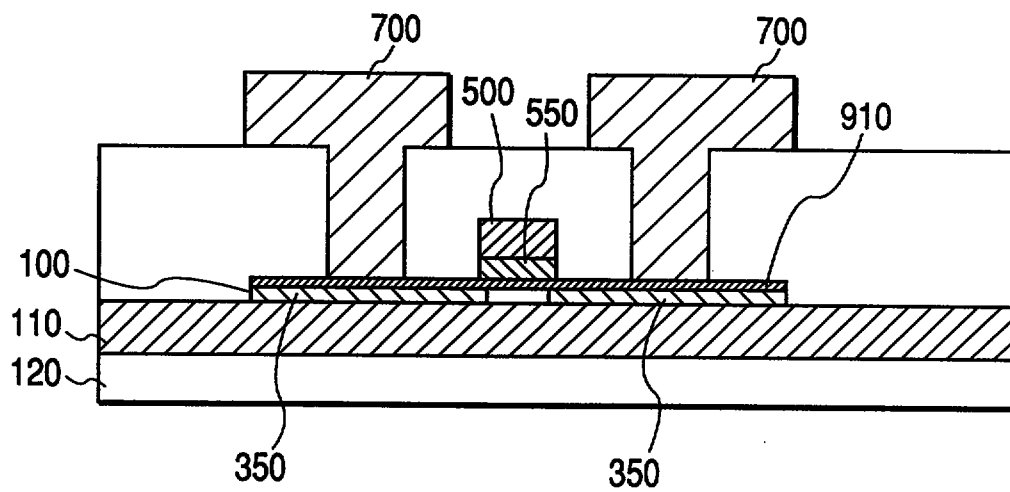


FIG. 6

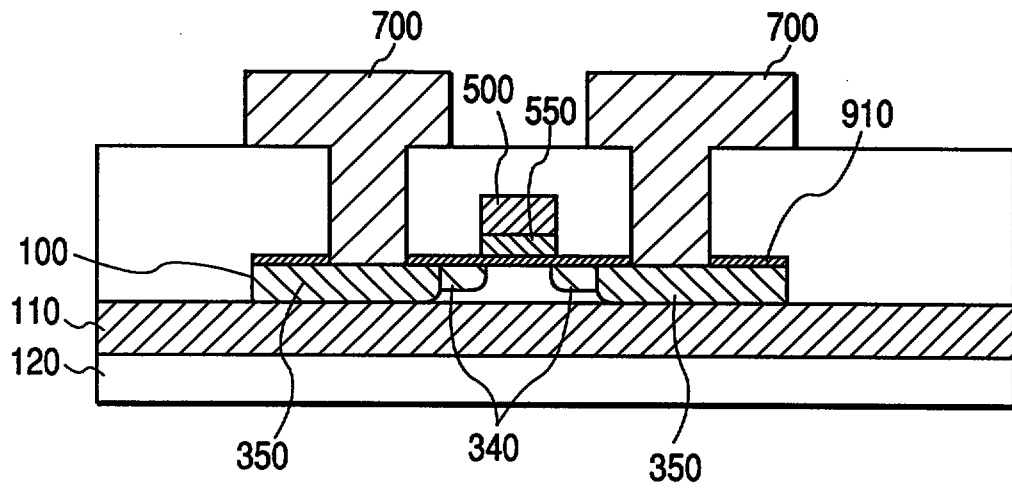


FIG. 7

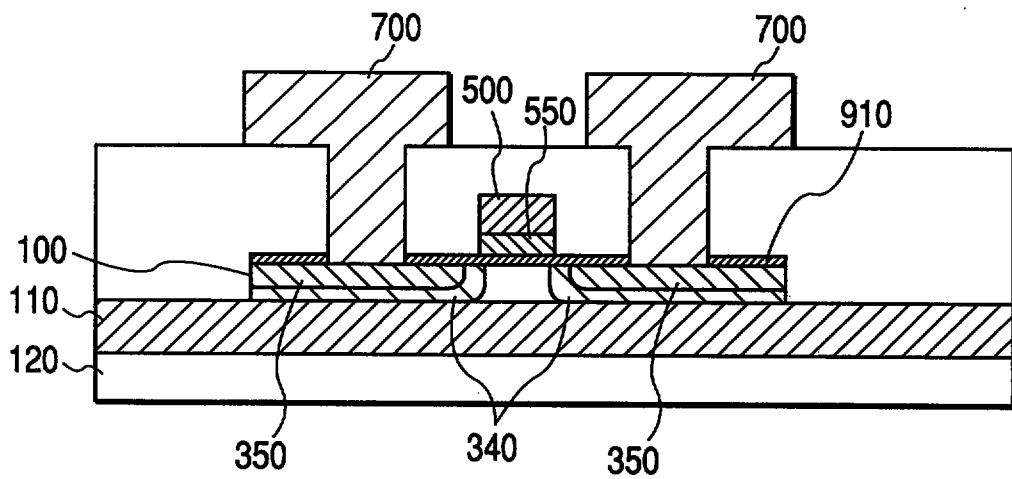


FIG. 8

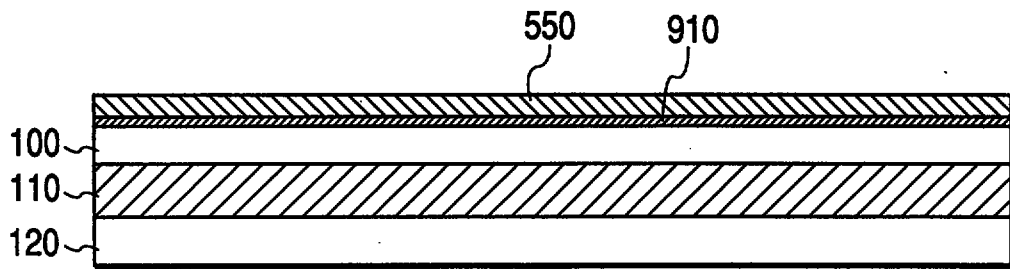


FIG. 9

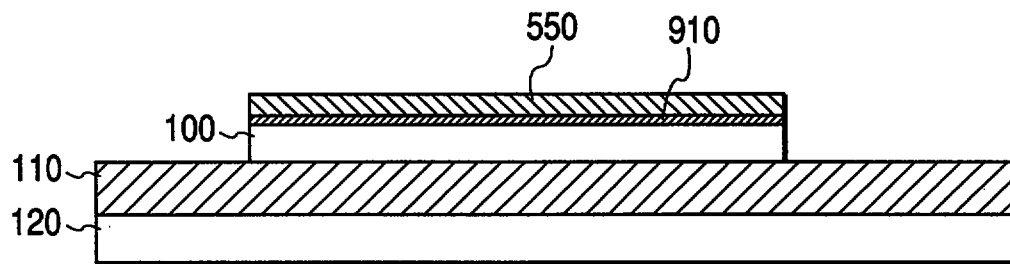


FIG. 10

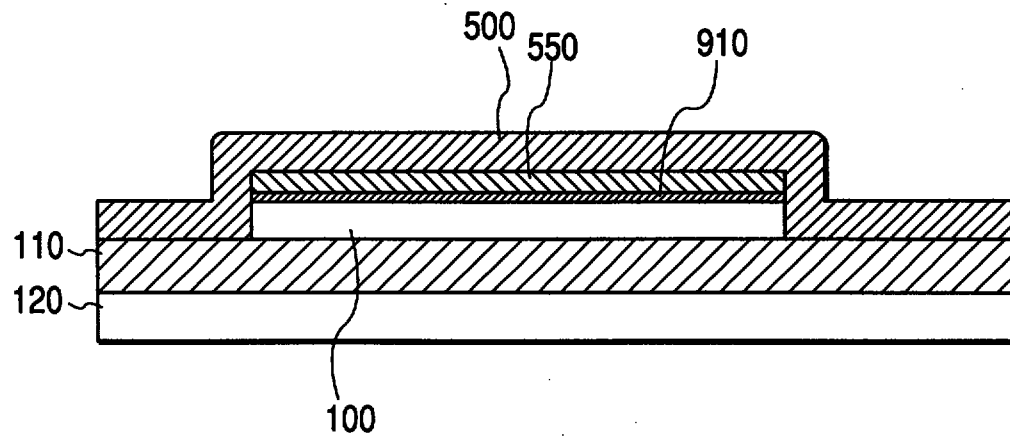


FIG. 11

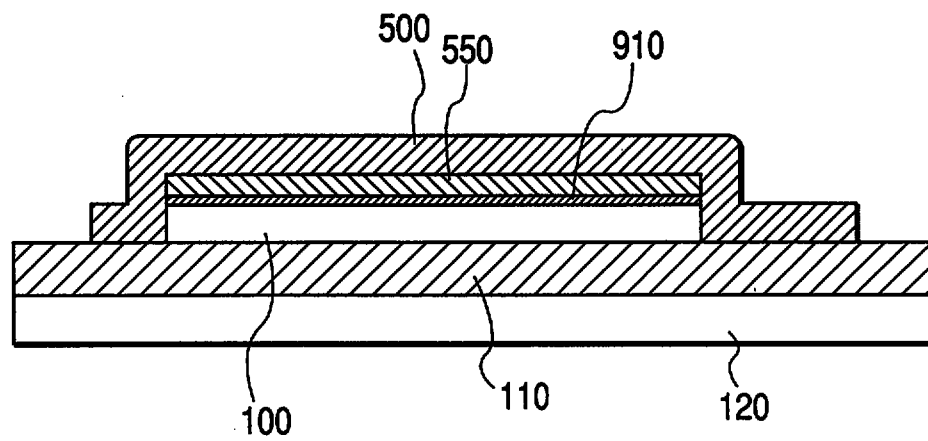


FIG. 12

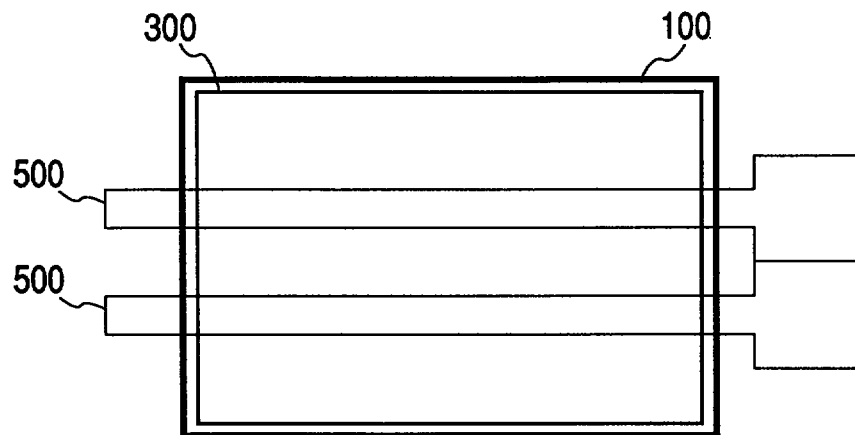


FIG. 13

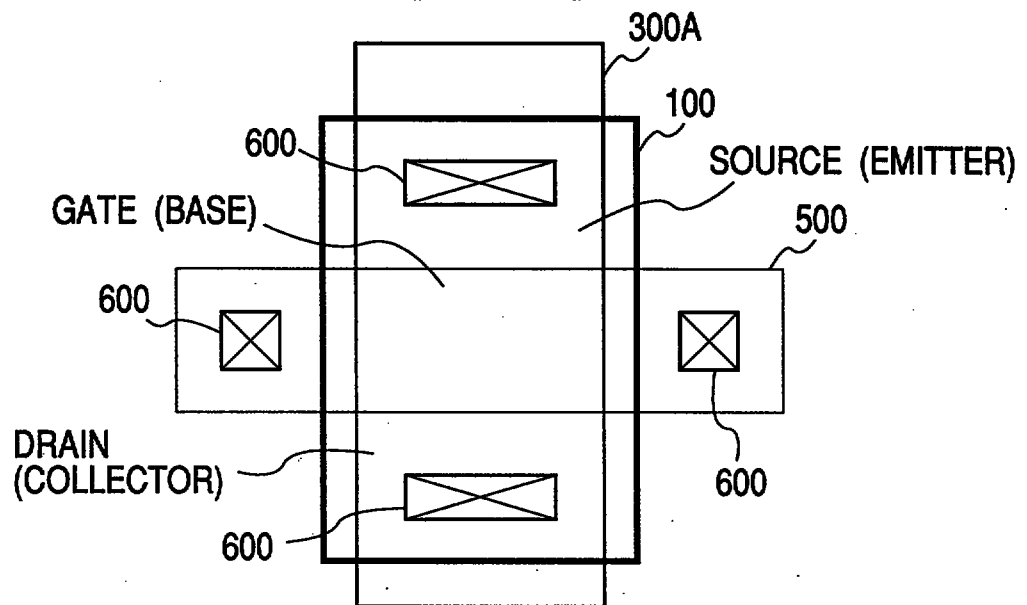


FIG. 14

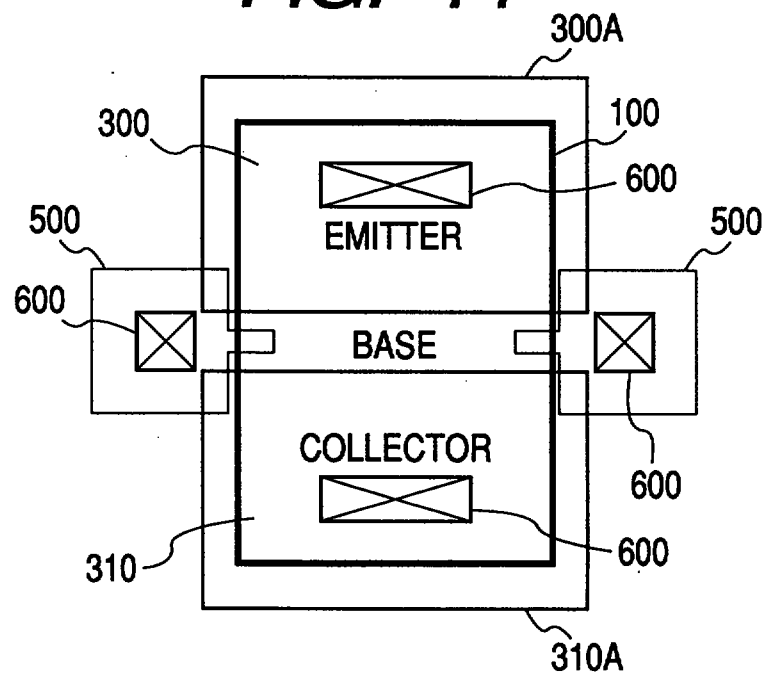


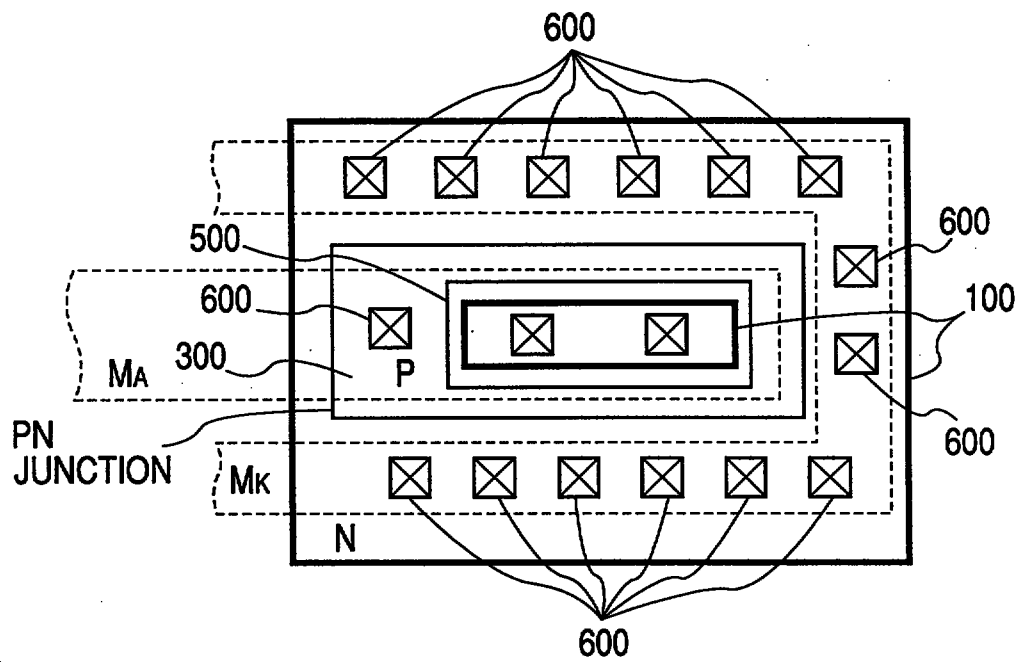
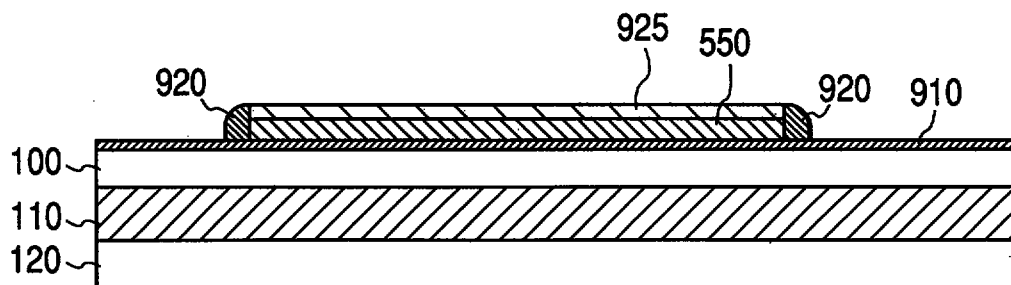
FIG. 15**FIG. 16**

FIG. 17

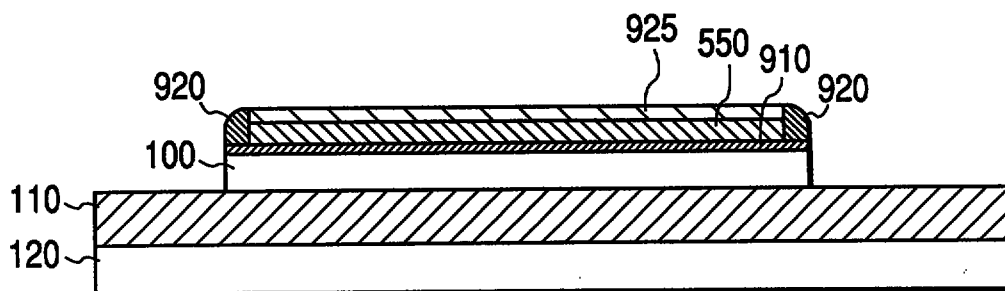


FIG. 18

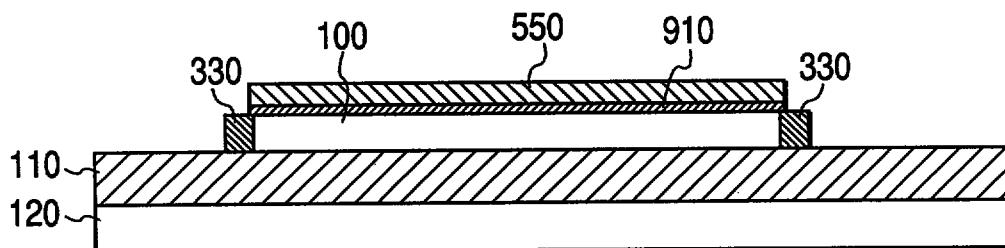


FIG. 19

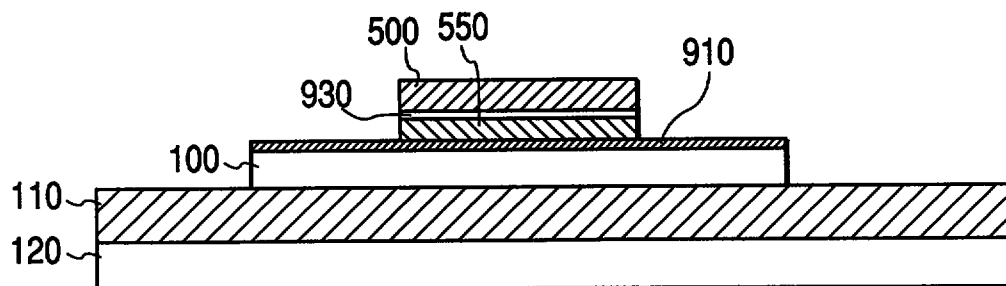


FIG. 20

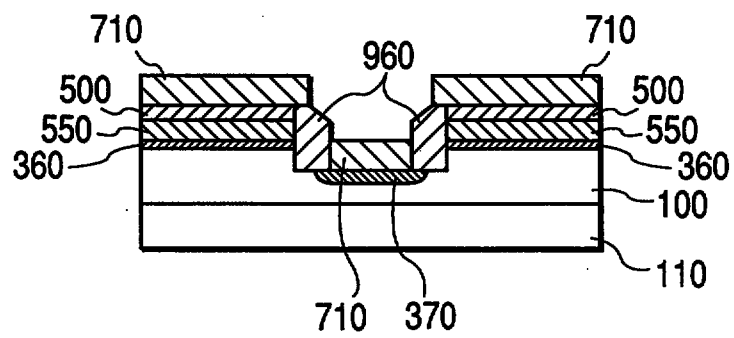


FIG. 21

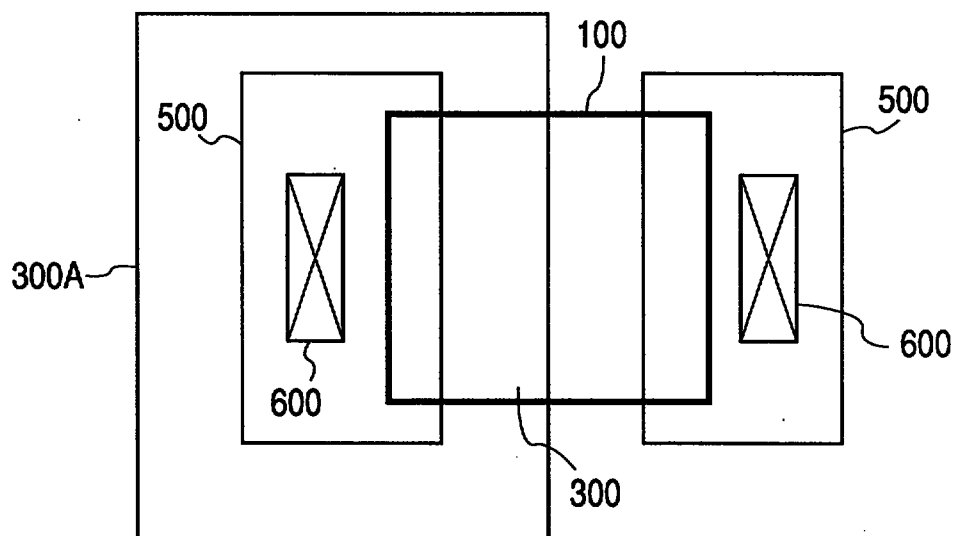


FIG. 22
PRIOR ART

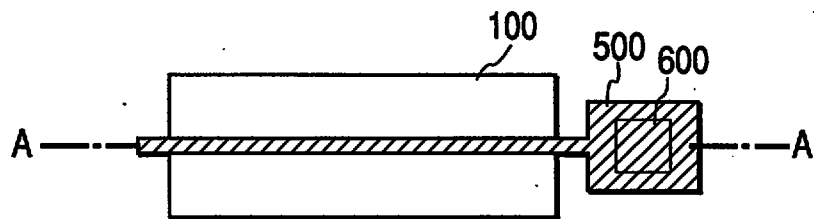


FIG. 23
PRIOR ART

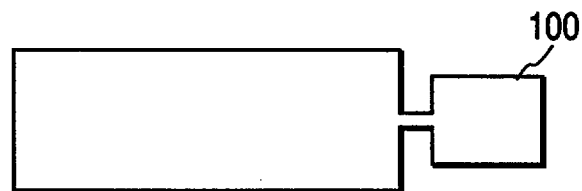


FIG. 24
PRIOR ART

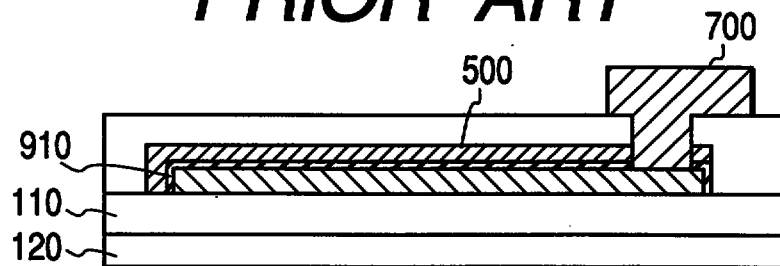


FIG. 25

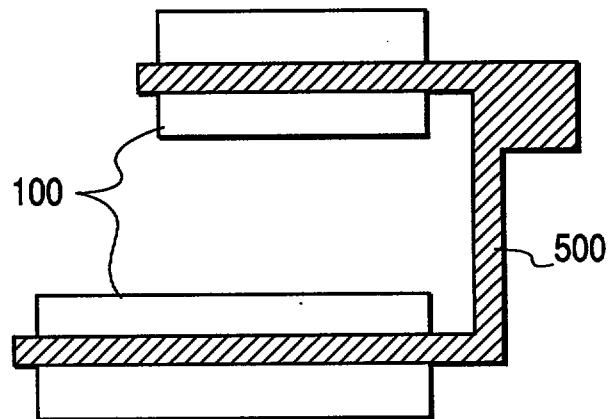


FIG. 26

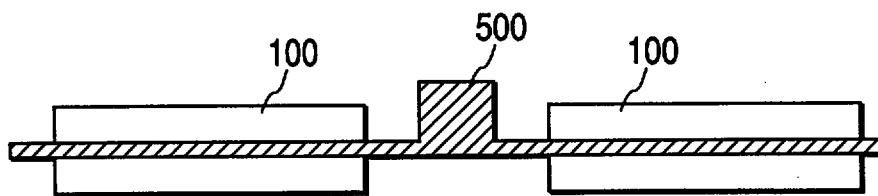


FIG. 27

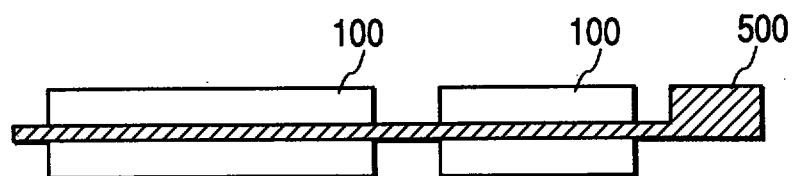
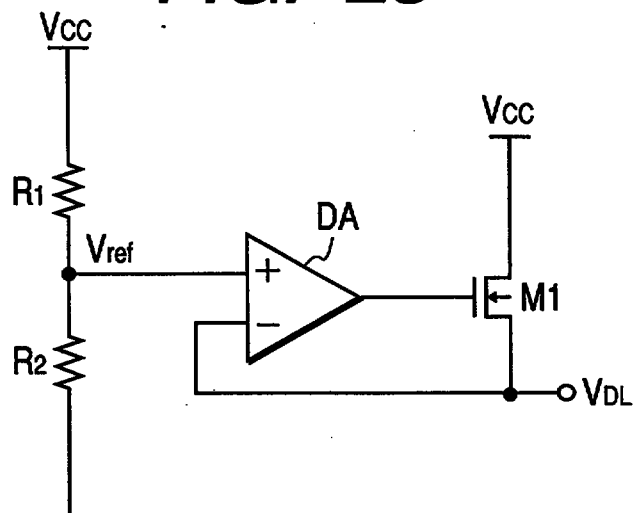
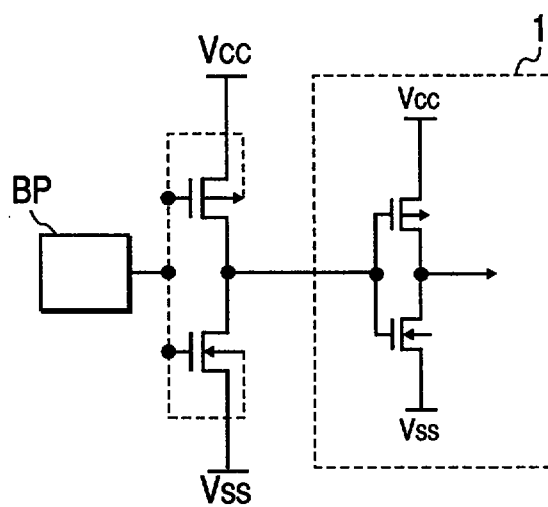
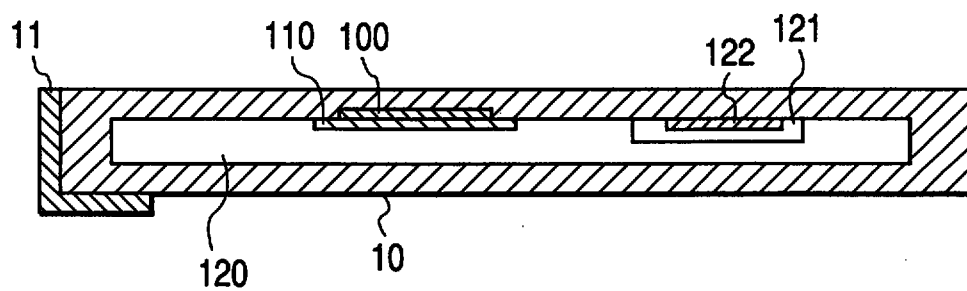


FIG. 28**FIG. 29****FIG. 30**

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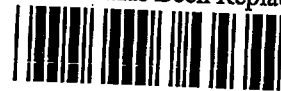
SEMICONDUCTOR DEVICE AND MANUFACTURING METHOD
THEREOF

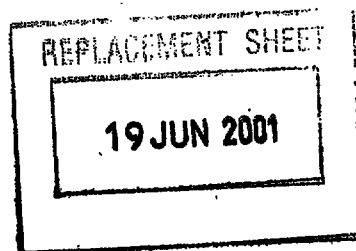
ABSTRACT

To suppress floating substrate in the thin SOI.MOSFET formed on the SOI substrate, the gate (electrode) has a two-layer structure and the upper gate thereof is in contact with the sides of the SOI layer (substrate).

FIG. 1

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WHAT IS CLAIMED IS:

1. A semiconductor device including a support substrate having a main surface comprising an insulator, a first conductive single crystalline semiconductor layer patterned on said insulator main surface, a gate insulating film formed on the main surface of said single crystalline semiconductor layer, a first gate layer patterned on said gate insulating film, and a second gate layer connected to said first gate layer, wherein said second gate layer is connected at the sides of said single crystalline semiconductor layer.
2. A semiconductor device according to Claim 1, wherein said support substrate comprises a single crystalline semiconductor and an insulator having a silicon oxide film formed on the surface of said semiconductor.
3. A semiconductor device including a support substrate having a main surface comprising an insulator, a first conductive single crystalline semiconductor layer having a rectangle formed on said insulator main surface, a gate insulating film formed on the main surface of said single crystalline semiconductor layer, a first gate layer patterned on said gate insulating film, and a second gate layer





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connected to said first gate layer, wherein said second gate layer is connected at both sides of said single crystalline semiconductor layer which are opposite to each other.

5 4. A semiconductor device according to Claim 3, wherein said support substrate comprises a single crystalline semiconductor and an insulator having a silicon oxide film formed on the surface of said semiconductor.

10 5. A semiconductor device according to Claim 3, wherein said lower gate layer comprises a laminated film of polycrystalline silicon and titanium nitride and said upper gate layer comprises polycrystalline silicon.

15 6. A semiconductor integrated circuit device including a support substrate having a main surface comprising an insulator, first conductive single crystalline semiconductor layers having a plurality of rectangles formed on said insulator main surface, gate
20 insulating films formed on the main surfaces of said respective single crystalline semiconductor layers, first gate layers patterned on said respective gate insulating films, and second gate layers which are formed extending over said plurality of single
25 crystalline semiconductor layers and connected to said





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first gate layers, wherein said second gate layers are connected at the sides of said respective single crystalline semiconductor layers.

7. A semiconductor device including a single
5 crystalline semiconductor layer mounted on an insulator and an insulated gate field effect transistor having a gate, a source, and a drain electrode which are formed on said single crystalline semiconductor layer, wherein said gate electrode has a
10 2-layer structure and the upper gate layer is electrically connected to the channel forming region of said insulated gate field effect transistor.

8. A semiconductor device according to Claim 7,
wherein the sides of said silicon single crystalline
15 layer and said gate electrode are in contact with each other.

9. A semiconductor device according to Claim 7,
wherein said lower gate layer and the active region
are formed by the same pattern.

20 10. A manufacturing method of a semiconductor device comprising a step of forming a gate insulating film on a silicon single crystal on an insulator, a step of depositing a gate layer on said gate insulating layer, a step of patterning an active
25 region, a step of processing said gate layer and said



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REPLACEMENT SHEET

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silicon single crystalline layer, a step of depositing
a second gate layer on said gate layer, said silicon,
and an insulating film substrate, a step of patterning
said gate and processing said first and second gate
5 layers, and a step of forming a predetermined impurity
region in said active region.

11. An electronic card characterized in that a
photodetector is formed on a semiconductor body, and a
semiconductor layer is formed on one main surface of
10 said body via an insulating film, a MISFET using said
semiconductor layer as a channel forming region is
formed on said semiconductor layer, and the gate
electrode of said MISFET and said semiconductor layer
are electrically connected to each other, and said
15 semiconductor body is sealed by a resinous substance.

12. An electronic card according to Claim 11,
wherein said photodetector constitutes a solar cell
for driving said MISFET.

13. An electronic card according to Claim 12,
20 wherein said photodetector is sealed by a transparent
resinous substance.

14. An electronic card according to Claim 11,
wherein said photodetector is formed on another main
surface which is opposite to one main surface of said
25 body.



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REPLACEMENT SHEET

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15. A manufacturing method of a semiconductor device having an insulated gate field effect transistor on a single crystalline semiconductor layer on an insulator comprising:

5 a step of depositing a first conductive layer on said single crystalline semiconductor layer via a gate insulating film;

a step of patterning for specifying the direction of the gate width for said first conductive layer and
10 said single crystalline semiconductor layer;

a step of depositing a second conductive layer in contact with the main surface and sides of said first conductive layer and the sides of said single crystalline semiconductor layer on said first
15 conductive layer and said single crystalline semiconductor layer which are patterned;

a step of patterning for specifying the direction of the gate length for said second conductive layer and said first conductive layer and forming laminated
20 gate electrodes of said first gate layer and second gate layer; and

a step of forming a source and a drain region specified by said laminated gate electrodes.



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16. A semiconductor device comprising:
a support substrate having a main surface
comprising an insulator;

a first conductive semiconductor layer
patterned on said insulator main surface;

a gate insulating film formed on the a surface
of said first conductive semiconductor layer;

a first gate layer patterned on said gate
insulating film; and

a second gate layer connected to said first
gate layer,

wherein, said second gate layer is electrically
connected to said first conductive semiconductor layer at
a side of said first conductive semiconductor layer.

17. A semiconductor device comprising:

a substrate;

an insulating layer formed on said substrate;

a silicon layer patterned on said insulating
layer;

a gate insulating film formed on a main surface
of said silicon layer; and

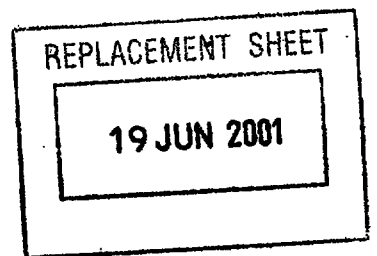
a gate layer patterned on said gate insulating
film, said silicon layer and said insulating layer,

wherein, said gate layer is electrically
connected to said silicon layer at a side of said silicon
layer.

18. A semiconductor device according to claim 17,
wherein:



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Said silicon layer includes a diffusion layer,
and said diffusion layer and contact surface between said
silicon layer and said gate layer are arranged away from
each other.

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ABSTRACT

To suppress floating substrate in the thin
SOI.MOSFET formed on the SOI substrate, the gate
(electrode) has a two-layer structure and the upper
5 gate thereof is in contact with the sides of the SOI
layer (substrate).

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WHAT IS CLAIMED IS:

1. A semiconductor device including a support substrate having a main surface comprising an insulator, a first conductive single crystalline semiconductor layer patterned on said insulator main surface, a gate insulating film formed on the main surface of said single crystalline semiconductor layer, a first gate layer patterned on said gate insulating film, and a second gate layer connected to said first gate layer, wherein said second gate layer is connected at the sides of said single crystalline semiconductor layer.
2. A semiconductor device according to Claim 1, wherein said support substrate comprises a single crystalline semiconductor and an insulator having a silicon oxide film formed on the surface of said semiconductor.
3. A semiconductor device including a support substrate having a main surface comprising an insulator, a first conductive single crystalline semiconductor layer having a rectangle formed on said insulator main surface, a gate insulating film formed on the main surface of said single crystalline semiconductor layer, a first gate layer patterned on said gate insulating film, and a second gate layer



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connected to said first gate layer, wherein said second gate layer is connected at both sides of said single crystalline semiconductor layer which are opposite to each other.

5 4. A semiconductor device according to Claim 3, wherein said support substrate comprises a single crystalline semiconductor and an insulator having a silicon oxide film formed on the surface of said semiconductor.

10 5. A semiconductor device according to Claim 3, wherein said lower gate layer comprises a laminated film of polycrystalline silicon and titanium nitride and said upper gate layer comprises polycrystalline silicon.

15 6. A semiconductor integrated circuit device including a support substrate having a main surface comprising an insulator, first conductive single crystalline semiconductor layers having a plurality of rectangles formed on said insulator main surface, gate
20 insulating films formed on the main surfaces of said respective single crystalline semiconductor layers, first gate layers patterned on said respective gate insulating films, and second gate layers which are formed extending over said plurality of single
25 crystalline semiconductor layers and connected to said



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first gate layers, wherein said second gate layers are connected at the sides of said respective single crystalline semiconductor layers.

7. A semiconductor device including a single
5 crystalline semiconductor layer mounted on an insulator and an insulated gate field effect transistor having a gate, a source, and a drain electrode which are formed on said single crystalline semiconductor layer, wherein said gate electrode has a
10 2-layer structure and the upper gate layer is electrically connected to the channel forming region of said insulated gate field effect transistor.

8. A semiconductor device according to Claim 7, wherein the sides of said silicon single crystalline
15 layer and said gate electrode are in contact with each other.

9. A semiconductor device according to Claim 7, wherein said lower gate layer and the active region are formed by the same pattern.

20 10. A manufacturing method of a semiconductor device comprising a step of forming a gate insulating film on a silicon single crystal on an insulator, a step of depositing a gate layer on said gate insulating layer, a step of patterning an active
25 region, a step of processing said gate layer and said



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silicon single crystalline layer, a step of depositing
a second gate layer on said gate layer, said silicon,
and an insulating film substrate, a step of patterning
said gate and processing said first and second gate
5 layers, and a step of forming a predetermined impurity
region in said active region.

11. An electronic card characterized in that a
photodetector is formed on a semiconductor body, and a
semiconductor layer is formed on one main surface of
10 said body via an insulating film, a MISFET using said
semiconductor layer as a channel forming region is
formed on said semiconductor layer, and the gate
electrode of said MISFET and said semiconductor layer
are electrically connected to each other, and said
15 semiconductor body is sealed by a resinous substance.

12. An electronic card according to Claim 11,
wherein said photodetector constitutes a solar cell
for driving said MISFET.

13. An electronic card according to Claim 12,
20 wherein said photodetector is sealed by a transparent
resinous substance.

14. An electronic card according to Claim 11,
wherein said photodetector is formed on another main
surface which is opposite to one main surface of said
25 body.



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15. A manufacturing method of a semiconductor device having an insulated gate field effect transistor on a single crystalline semiconductor layer on an insulator comprising:

5 a step of depositing a first conductive layer on said single crystalline semiconductor layer via a gate insulating film;

a step of patterning for specifying the direction of the gate width for said first conductive layer and
10 said single crystalline semiconductor layer;

a step of depositing a second conductive layer in contact with the main surface and sides of said first conductive layer and the sides of said single crystalline semiconductor layer on said first
15 conductive layer and said single crystalline semiconductor layer which are patterned;

a step of patterning for specifying the direction of the gate length for said second conductive layer and said first conductive layer and forming laminated
20 gate electrodes of said first gate layer and second gate layer; and

a step of forming a source and a drain region specified by said laminated gate electrodes.



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16. A semiconductor device comprising:

a support substrate having a main surface
comprising an insulator;

a first conductive semiconductor layer
patterned on said insulator main surface;

a gate insulating film formed on the a surface
of said first conductive semiconductor layer;

a first gate layer patterned on said gate
insulating film; and

a second gate layer connected to said first
gate layer,

wherein, said second gate layer is electrically
connected to said first conductive semiconductor layer at
a side of said first conductive semiconductor layer.

17. A semiconductor device comprising:

a substrate;

an insulating layer formed on said substrate;

a silicon layer patterned on said insulating
layer;

a gate insulating film formed on a main surface
of said silicon layer; and

a gate layer patterned on said gate insulating
film, said silicon layer and said insulating layer,

wherein, said gate layer is electrically
connected to said silicon layer at a side of said silicon
layer.

18. A semiconductor device according to claim 17,
wherein:



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Said silicon layer includes a diffusion layer,
and said diffusion layer and contact surface between said
silicon layer and said gate layer are arranged away from
each other.



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ABSTRACT

To suppress floating substrate in the thin
SOI.MOSFET formed on the SOI substrate, the gate
(electrode) has a two-layer structure and the upper
5 gate thereof is in contact with the sides of the SOI
layer (substrate).