US 20030116791A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2003/0116791 A1

Baptist et al. (43) Pub. Date: Jun. 26, 2003

(54) SEMICONDUCTOR DEVICE WITH VERTICAL ELECTRON INJECTION AND METHOD FOR MAKING SAME

(76) Inventors: **Robert Baptist**, Jarrie (FR); **Fabrice Letertre**, Grenoble (FR)

Correspondence Address:
OBLON, SPIVAK, MCCLELLAND, MAIER & NEUSTADT, P.C.
1940 DUKE STREET
ALEXANDRIA, VA 22314 (US)

(21) Appl. No.: **10/276,691**

(22) PCT Filed: **May 23, 2001**

(86) PCT No.: **PCT/FR01/01603**

(30) **Foreign Application Priority Data**

May 26, 2000 (FR) 00/06761

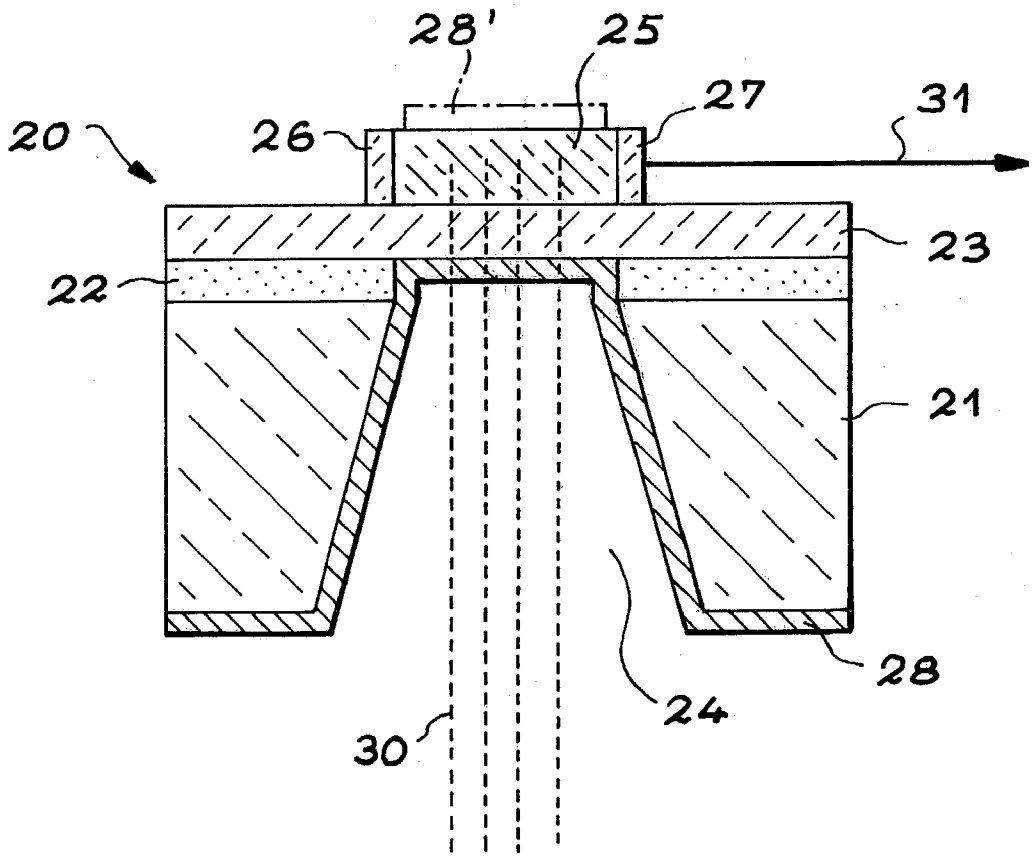
Publication Classification

(51) **Int. Cl.**[7] **H01L 29/76**

(52) **U.S. Cl.** **257/214**

(57) **ABSTRACT**

The present invention relates to a semiconductor device with vertical electron injection, comprising a support substrate (**2**), a structure comprising at least one monocrystalline thin film (**7**) transferred onto the support substrate and integral with the support substrate, and at least one electronic component, the support substrate (**2**) comprising at least one recess enabling electric or electronic access to the electronic component, through the monocrystalline thin film, the device also comprising means (**13, 14**) enabling vertical electron injection into the electronic component.



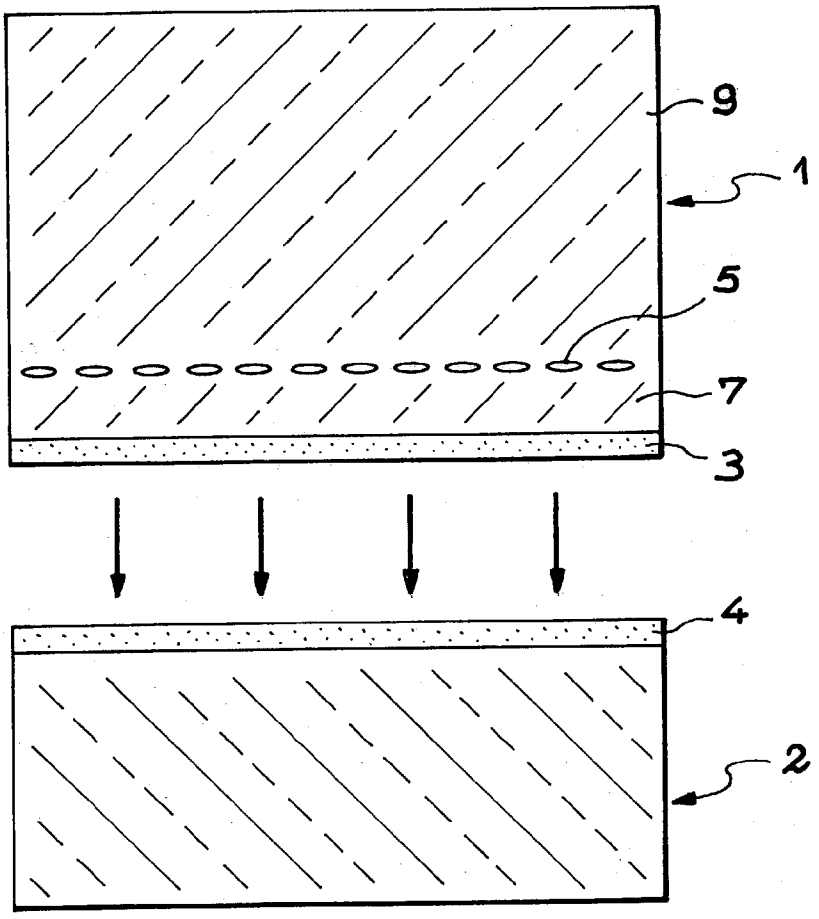


FIG. 1A

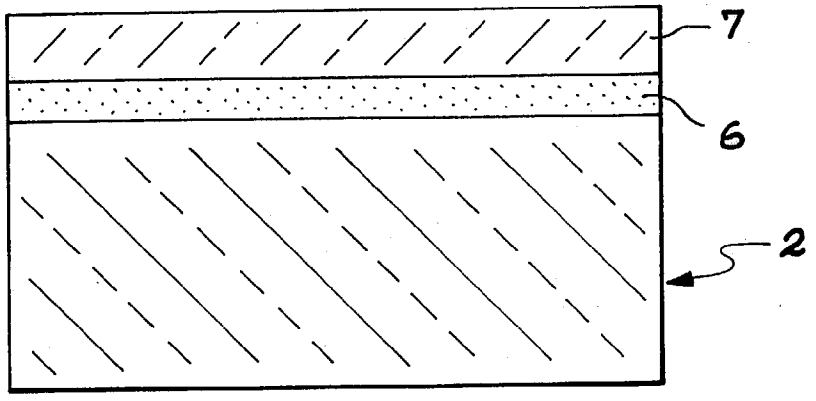


FIG. 1B

FIG. 1 C

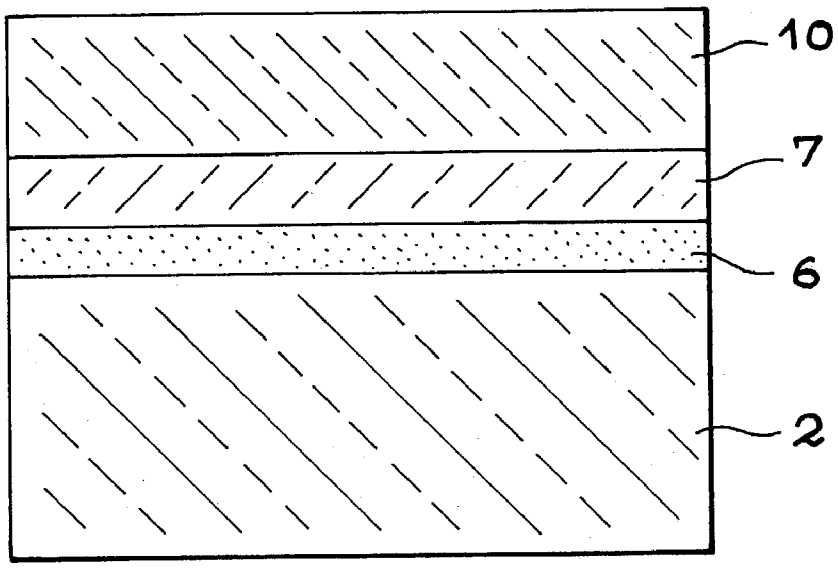


FIG. 1 D

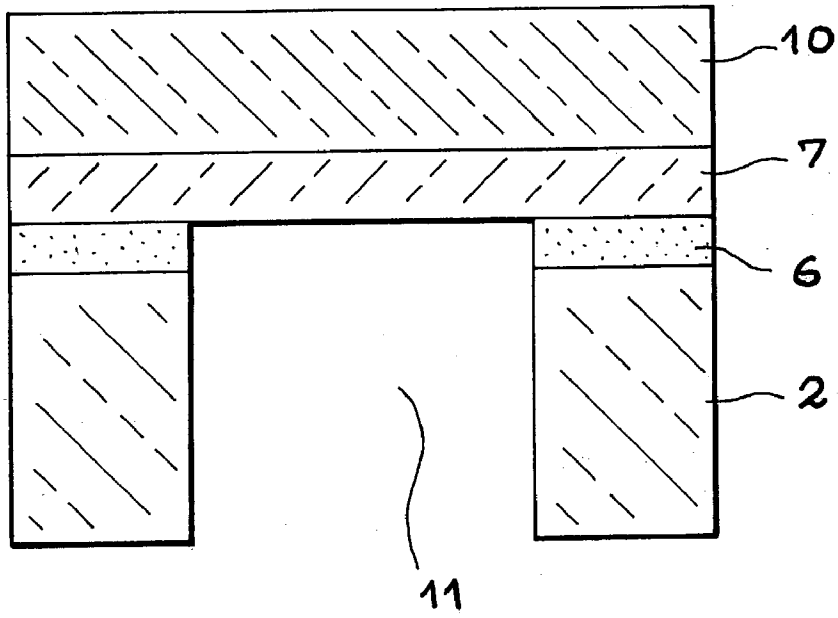


FIG. 1E

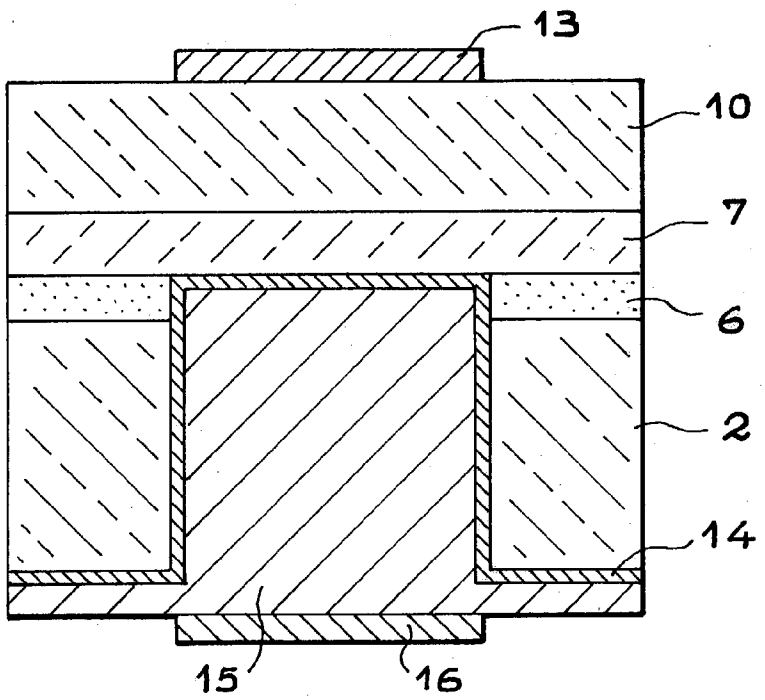
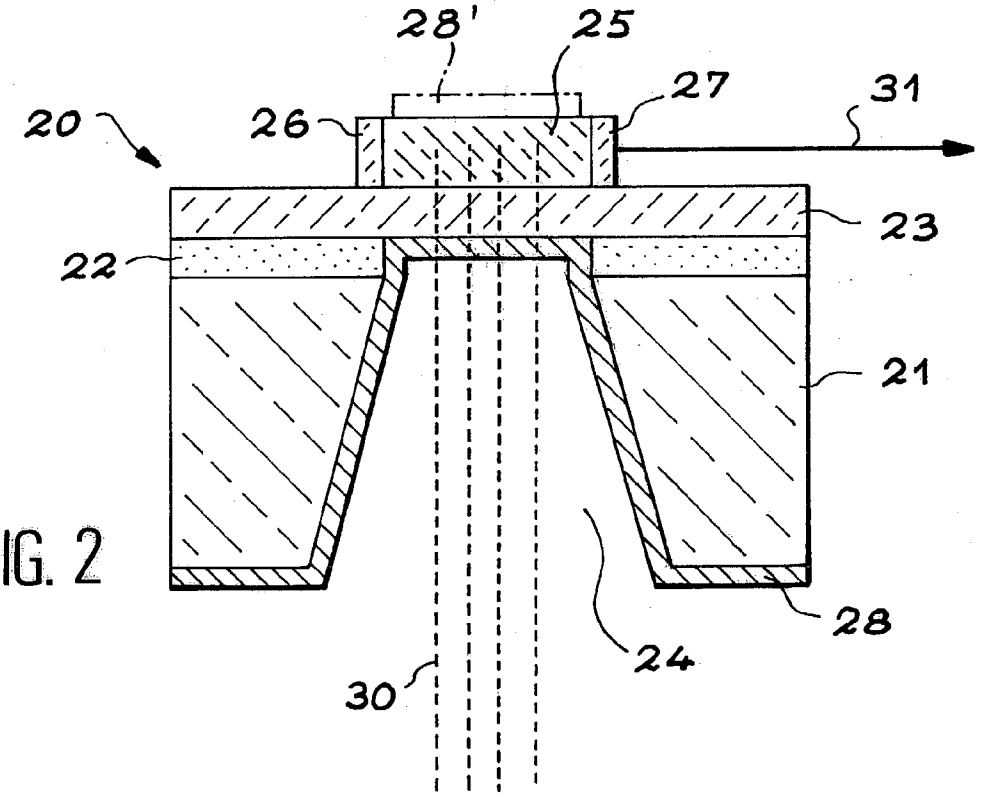


FIG. 2



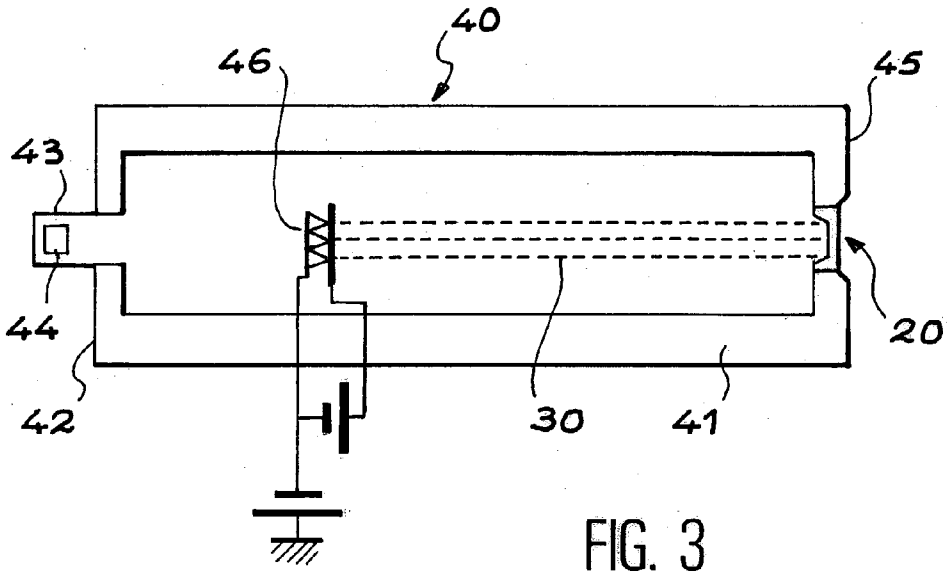


FIG. 3

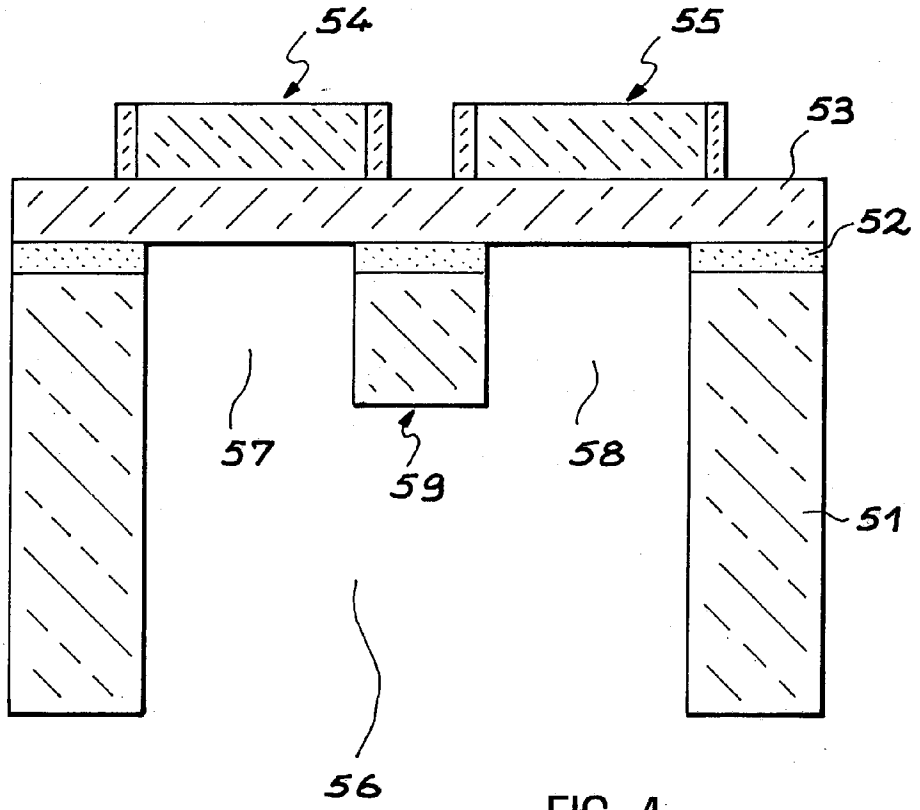


FIG. 4

SEMICONDUCTOR DEVICE WITH VERTICAL ELECTRON INJECTION AND METHOD FOR MAKING SAME

TECHNICAL FIELD

[0001] The present invention relates to a semiconductor device with vertical electron injection. It also concerns a manufacturing method for such a device.

[0002] The semiconductor device with vertical electron injection is produced in an active layer in semiconducting material with a small gap or a big gap. However, the invention proves to be of particular interest in the case of an active layer in semiconducting material with a big gap.

STATE OF PRIOR ART

[0003] Semiconductors are characterised by their forbidden band or gap separating the last filled states of the valence band and the following empty states in the conduction band. Among the semiconductors, one can distinguish between semiconductors with a small gap, such as silicon and germanium, and semiconductors with a big gap such as, for example, GaN and SiC.

[0004] At present it is extremely difficult or even impossible to obtain solid substrates in a semiconductor with a big gap. In the case of GaN for example, no solid substrate of electronic quality exists despite intense research carried out in this field. On the other hand, hetero-epitaxial GaN on a solid substrate in sapphire or in SiC exists. This technique was developed for production of blue diode type optoelectronic components.

[0005] Nonetheless, epitaxy of GaN on sapphire is made particularly delicate because of the difference in lattice structure existing between GaN and sapphire (of the order of 16%). Therefore, obtaining crystalline layers of sufficiently high quality for producing optoelectronic devices requires perfecting sophisticated epitaxy methods. The use of the sapphire substrate is essentially explained by its structural and chemical compatibility with GaN, its low cost and its availability under the form of large diameter substrate. The electrically insulating property of sapphire requires production, in the epitaxial GaN, of horizontal components with electrodes located in the front face.

[0006] The other method used for retail components is that of GaN on a solid SiC substrate. SiC substrates remain rare and very expensive. This is the method developed and marketed by the company of Cree Research Inc., profiting from the advantage it has of retailing the major part of SiC substrates. The interest of solid SiC for epitaxy and the production of devices with a GaN base is evident. First of all, the low difference in lattice structure (3.5%) between SiC and GaN makes it possible to simplify epitaxy methods while still producing layers with high crystalline quality. Furthermore, the use of a conducting SiC substrate makes it possible to produce a vertical component for passing current (that is, with an electrode on each face). This structure enables production of components of smaller size than those produced on an insulating substrate, which is of interest from the economic point of view. Moreover, the use of SiC, with its high thermal conductivity, makes it possible to adjust or lower the component temperature during its operation. This is an important point as far as performance, service life and reliability are concerned.

[0007] Other methods are also being studied, but their present state of development restricts them to laboratory use. The general approach consists of using a substrate of solid silicon in order to benefit from the low cost and large size of these substrates. Thus one can obtain GaN on SiC covering silicon. These techniques, developed under laboratory conditions, rely on the use of a film of epitaxial cubic SiC either on an SOI substrate or directly on a solid silicon substrate. This SiC layer must make it possible to facilitate epitaxy by reducing the difference in the lattice parameter between the GaN and the silicon, that is to arrive at a configuration of epitaxial GaN on SiC. Apart from the problem of producing epitaxial GaN, the first epitaxy of SiC poses significant technical problems. However, the growth of GaN on such a structure is of particular interest because it would make it possible to obtain GaN with cubic structure (sapphire obtains a hexagonal structure) which, because of its properties, is interesting for optoelectronic applications. For the moment this method is still at the research stage.

[0008] Finally, a more recent method relates to the direct epitaxy of GaN on silicon, without any buffer film of SiC. For this, one uses silicon (**111**). This approach, based on a principle equivalent to that adopted for epitaxy on sapphire, suffers at present from being far behind, relative to other techniques. Nonetheless, correct control of the material silicon makes it possible to envisage using electrically insulating or conducting epitaxial support substrates, leaving a certain freedom for the operating mode of the epitaxied device (vertical or horizontal).

[0009] The optoelectronic components produced on the above-mentioned materials therefore have either a lateral structure (with two electrodes located on the front face of the substrate), or a vertical structure with one electrode on the active layer (generally in GaN) and another electrode on the rear face of the solid substrate (in SiC, for example). According to the structure adopted, or imposed by the nature of the substrate, the size of the chip evidently varies. From a strictly economic point of view, the production of a vertically operational chip is clearly more advantageous because it makes it possible to produce more compact devices.

[0010] Furthermore, the nature of the substrate chosen for epitaxy has an influence on the performance of the device via the problem of heat dissipation during operation. From this point of view, solid SiC has a considerable advantage. The limitations recognised concerning devices produced on GaN supported by sapphire, are under study at present. Two methods are described in publications concerning the solution of this problem for sapphire. Each depends on eliminating the sapphire substrate after producing active epitaxial layers.

[0011] The first method depends on eliminating the sapphire substrate and producing a thick epitaxy of GaN (greater than 100 μm) at the rear face in order to obtain a self-supporting rigid membrane. This again means producing a GaN substrate. This approach makes it possible to produce a device with vertical operation and to dissipate the generated heat.

[0012] The second method depends on eliminating the sapphire substrate and adhering the active layer onto an electrically and thermally conducting sole (adhesion on a

copper substrate, for example). Thus it would be possible to obtain a vertically operational device enabling dissipation of the produced heat.

[0013] Thus it can be understood that the SiC approach represents a very promising future for developing optoelectronic branches with a GaN base. The trend for growth techniques other than those on SiC is to produce devices with vertical current flow and to eliminate the generated heat as much as possible during operation of the device, whatsoever the epitaxial support. In the case of epitaxy on sapphire, this substrate only plays the role of epitaxial support and no longer limits the operation of devices because it can be eliminated.

DESCRIPTION OF THE INVENTION

[0014] The present invention proposes a new device that can be less costly than prior art solutions, for obtaining a semiconductor device with vertical electron injection.

[0015] A first aim of the invention consists of a vertical electron injection semiconductor device comprising a support substrate, a structure comprising at least one monocrystalline thin film transferred onto the support substrate and integral with the support substrate, at least one electronic component, the support substrate comprising at least one recess enabling electric or electronic access to the electronic component, through the monocrystalline thin film, the device also comprising means enabling vertical electron injection into the electronic component.

[0016] The structure may comprise at least one active layer formed by crystal growth of semiconducting material on the monocrystalline thin film, the electronic component being produced in said active layer. The epitaxial active layer is homogeneous or heterogeneous depending on the applications. The monocrystalline thin film can be an active layer, from which the electronic component is formed.

[0017] Possibly, the device can furthermore comprise a layer called an adhesion layer, situated between the support substrate and the structure and making it possible to solidarise the monocrystalline thin film on the support, the adhesion layer allowing electric or electronic access to the electronic component. This adhesion layer can be in SiO_2.

[0018] Possibly, the adhesion layer is insulating and comprises at least one recess enabling electric or electronic access to the electronic component. The adhesion layer can also be conducting or semiconducting.

[0019] The monocrystalline thin film can comprise at least one recess enabling direct electric or electronic access to the electronic component.

[0020] Advantageously, the support substrate can be in silicon, in SiC, in A1N, in sapphire or in GaN, the monocrystalline thin film can be in SiC, in silicon, in GaN, in sapphire or in ZnO, and the active layer can comprise a semiconducting material selected from among the group consisting of SiC, GaN, the compounds III-V and their derivatives, and diamond.

[0021] The electronic component can comprise at least one junction produced from two semiconductors of the same nature or of different natures. It can comprise at least one metal-semiconductor type junction. Furthermore, it can comprise at least one stack of the semiconductor-metal-oxide type.

[0022] According to an embodiment of the invention, the means enabling vertical electron injection into the electronic component comprise an electrode set on the electronic component and an electrode set under the electronic component, in said recess enabling access to the electronic component. In this case, an earth can be provided in said recess, in contact with said electrode set under the component in order to constitute a heat sink.

[0023] According to another embodiment of the invention, the electron injection being achieved by means of an electron beam directed onto the electronic component by passing through said recess, the means enabling vertical electron injection comprise a conducting coating for guiding the electrons towards the electronic component.

[0024] According to a further embodiment of the invention, the recess in the support substrate comprises cells enabling electric or electronic access to electronic components formed from the structure.

[0025] The electronic component can be selected from among the group consisting of light emitters, light detectors, power electronic components and diodes.

[0026] The structure can be chosen to be vacuum sealed. In this case, if the electronic component is a component able to emit a light beam in response to an electron beam received, the monocrystalline thin film can be such that it allows passage of said electron beam. The structure can form a membrane that is deformable under the effect of a pressure difference, said electronic component being a component providing a signal representative of the deformation undergone by the membrane.

[0027] A second aim of the invention consists of a manufacturing method for such a semiconducting device with vertical electron injection, characterised in that it comprises the following stages:

[0028] transfer of the monocrystalline thin film onto a first face of the support substrate,

[0029] production of at least one electronic component from the structure,

[0030] formation of at least one recess from a second face of the substrate to allow electric or electronic access to the electronic component through the monocrystalline thin film,

[0031] production of means allowing vertical electron injection into the electronic component.

[0032] The method can furthermore comprise a stage for formation of at least one active layer by crystal growth of semiconducting material on the monocrystalline thin film, the electronic component being produced in said active layer, the crystal growth being produced before or after transfer. If the thin film is an active layer, the electronic component can be formed from this monocrystalline thin film.

[0033] Possibly, the electronic component can be partly made before the transfer; especially when the active layer is produced before the transfer.

[0034] According to a particularly advantageous embodiment of the invention, the transfer stage of the monocrystalline thin film comprises the following operations:

[0035] definition of said monocrystalline thin film in a substrate of monocrystalline material by introducing gaseous species into this substrate of monocrystalline material in order to create a fracture zone, the monocrystalline thin film being located between one face of the substrate in monocrystalline material and the cleavage zone,

[0036] solidarisation of said monocrystalline thin film on the first face of the support substrate,

[0037] fracture separation of the monocrystalline thin film from the rest of the substrate of monocrystalline material, the separation being produced before or after the solidarisation operation, obtained for example by molecular adhesion.

[0038] Preferably, the transfer of said monocrystalline thin film is carried out through the intermediary of an adhesion layer. This adhesion layer can be in SiO_2.

[0039] According to an application variant, the production of means enabling vertical electron injection into the electronic component comprises depositing an electrode on the electronic component and depositing an electrode under the electronic component, in said recess enabling access to the electronic component. The method can then comprise the deposit of an earth in said recess, in contact with said electrode set under the component in order to constitute a heat sink.

[0040] According to another application variant, the method comprises the deposit of a conducting coating able to guide an electron beam directed onto the electronic component passing through said recess.

[0041] According to a further application variant, the method also comprises the formation of cells prolonging the recess in the support substrate to enable electric or electronic access to the electronic components formed from the structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] The invention will be understood better and other advantages and particularities will become clear by reading the description below, evidently given as a non-limiting example, and accompanied by the attached drawings in which:

[0043] **FIGS. 1A** to 1E show the main stages of a manufacturing method of a semiconductor device with vertical electron injection according to the invention,

[0044] **FIG. 2** shows, in cross-section, another semiconductor device with vertical electron injection according to the invention,

[0045] **FIG. 3** shows the device of **FIG. 2** installed on equipment provided with a cathode with micropoints,

[0046] **FIG. 4** shows, in cross-section, another semiconductor device with vertical electron injection and with cell structure, according to the invention.

DETAILED DESCRIPTION OF EMBODIMENTS ACCORDING TO THE INVENTION

[0047] The manufacture of a semiconductor device with vertical electron injection according to the invention comprises the transfer of a monocrystalline thin film of very high crystalline quality (semiconducting or not, insulating or electrically conducting) onto the front face of a substrate, semiconducting or not. This transfer can be carried out through the intermediary of an insulating thin film, metallic or semiconducting. The required active layer or layers are obtained by crystal growth before or after transfer. One or several electronic components are thus formed. The rear face of the substrate is machined or micro-machined locally in order to create a membrane. The monocrystalline thin film can possibly be thinned.

[0048] According to an embodiment of the invention, the active layer and the monocrystalline thin film form a single and same layer.

[0049] The electronic component or components can be manufactured before or after the formation of the membrane. Nonetheless, it is preferable to manufacture the electronic components before forming the membrane in order to relax the mechanic stresses in the device during manufacture.

[0050] Advantageously, transfer of the monocrystalline thin film can be carried out using the method known under the name of Smartcut® and described in particular in the document FR-A-2 681 472 (corresponding to the U.S. Pat. No. 5,374,564). **FIGS. 1A and 1B** show this transfer method.

[0051] **FIG. 1A** shows the fixation of a first substrate **1** in SiC onto a second substrate **2** in silicon, with an adhesion interface. The substrate **1** possesses a layer **3** of SiO_2 on its junction face with the substrate **2**. An ionic implantation produced through this face has made it possible to create a layer of micro-cavities **5** separating the substrate **1** into a thin film **7** and a remainder part **9** of the substrate. In this example, the substrate **2** also possesses a layer **4** of SiO_2 on its junction face with the substrate **1**. Nonetheless, the two opposite faces can be of different nature on condition that adhesion is possible.

[0052] Advantageously, the junction of the two substrates is obtained by molecular adhesion. Once the junction has been established, one proceeds to the fracture of the substrate **1** along the zone of micro-cavities **5**. This fracture can be obtained by means of heat treatment and/or by application of mechanical stresses. The fracture provides the structure shown in **FIG. 1B** and constituted of a support substrate **2** in silicon supporting first of all a layer **6** in SiO_2 (formed by the combination of layers **3** and **4**), and then a layer **7** of SiC. It would also be possible to transfer the layer **7** from its initial substrate **9** to the support substrate **2** via at least one intermediary substrate.

[0053] A thin film **10** of GaN is then epitaxied on the layer **7** of SiC with its free face prepared for this. This is shown in **FIG. 1C**. The layer **10** of GaN constitutes the active layer in which the electronic component can be formed.

[0054] As above-mentioned, the layer **10** could have been produced before transfer. In this case, the transfer of the structure formed by the layer **7** and the layer **10** must be made either by means of an intermediary support, or directly, the layer **7** needing to be eliminated for certain applications.

[0055] In order to obtain electric or electronic access to the component produced in the layer **10**, a recess is made starting from the rear face of the substrate **2**. **FIG. 1D** shows

that the recess **11** made in the substrate **2** is prolonged into the layer **6** of SiO_2, as far as the layer **7** of SiC. This layer **7** could also possibly be recessed.

[**0056**] Taking into account the different applications aimed at by the invention, at least two cases of electron excitation can be distinguished. The first case concerns an electron excitation through vertical passage of the current into the component formed in the active layer by two electrodes, one of these electrodes being deposited on the top of the component and the other being deposited under the component. The second case involves electron excitation by vertical passage of current in the component following electron injection by electron bombardment on the rear face of the device.

[**0057**] The first case requires the presence of electrodes on top of and underneath the device as shown in **FIG. 1E**. An electrode **13** has been formed on the front face of the electronic component produced in the layer **10**. A conducting material **14** is deposited on the rear face of the device. It covers the recessed rear face of the substrate **2** as well as the apparent face of the layer **7** of SiC. The electric connection with the component is obtained through the layer **7** of SiC which is electrically conducting. Possibly, the recess is filled with a conducting material advantageously forming a heat sink **15**, making it possible to evacuate the heat produced by the device during operation. An electrode **16** is deposited on the heat sink **15** to allow joining an electric connection wire. In the absence of the material **15**, the second electrode is formed by the conducting material **14**.

[**0058**] **FIG. 2** shows, in cross section, a device **20** according to the invention and with electron excitation by vertical passage of current through the device, the current being due to electron bombardment directed towards the rear face of the device.

[**0059**] The device **20** is produced as above, from a stacked structure comprising a substrate **21** in silicon, a layer **22** of SiO_2, and a thin film **23** of SiC. A recess **24** is made in the rear face of the substrate **21** as far as the thin film **23** of SiC. A layer of GaN has been epitaxied from the layer **23** of SiC and an electronic component **25** has been formed from the layer of GaN. In the example shown, the component **25** is a laser source. It is equipped on two opposite flanks with mirrors **26** and **27** enabling optical amplification. The production of such mirrors is known to those skilled in the art.

[**0060**] In this embodiment, the recess is of truncated shape with circular or polygonal cross sections. In order to guide an electron beam **30**, arriving on the rear face of the device, towards the component **25**, a conducting layer **28** is deposited on the rear face of the device. This conducting layer **28** acts as an anode relative to the electron beam and must allow it to pass. Possibly, a conducting layer **28'** can be deposited on the component **25** and connected electrically to the conducting layer **28** in order to define a potential and to direct the injected electrons more efficiently towards the rear face of the device. In response to the excitation by the electron beam **30**, the component **25** will emit a laser beam **31**.

[**0061**] **FIG. 3** shows, as an example of an embodiment, the device **20** shown in **FIG. 2** installed on equipment **40** provided with a micro-point cathode. The equipment **40** comprises a tubular chamber **41** with one end **42** provided with a tip **43** through which the vacuum is formed in the chamber **41**. The tip **43** can contain a getter **44**. The other end **45** of the chamber **41** comprises an opening which is closed by the device **20**, the recess **24** of the device **20** (see **FIG. 2**) being turned towards the inside of the chamber **41**.

[**0062**] Inside the chamber **41**, the equipment **40** comprises a cathode with micro-points **46** supplied live in appropriate fashion relative to the earth. The conducting layer **28** of the device **20** is also connected to the earth. When in use, the cathode with micropoints **46** emits an electron beam **30** in the direction of the device **20**.

[**0063**] As an example, the micro-points can be brought to −10 kV, the extraction grid of the cathode to about 50 or 100 V above this voltage, that is to −9950 or −9900 V. The conducting layer **28** of the rear face of the device **20** ensures that the voltage is well defined and that therefore the electrons will be certain to enter the recess of the device, crossing the thin film in SiC and penetrating the component **25**.

[**0064**] The thin film **23** of the device **20** provided with the conducting layer **28** and the component **25** plays the role of a sealed vacuum membrane in this application. It is permeable to electrons and serves as epitaxial substrate. The device has the advantages of compactness and of integration into a piece of equipment.

[**0065**] **FIG. 4** shows, in cross section, another semiconductor device with vertical electron injection and cell structure, according to the invention.

[**0066**] The device of **FIG. 4** comprises, superposed, a substrate **51** in silicon, a layer **52** of SiO_2 and a thin film **53** of SiC. A layer of GaN has been epitaxied from the layer of SiC and two electronic components **54** and **55** (laser sources here) have been formed from the layer of GaN.

[**0067**] A recess **56** has been made from the rear face of the substrate **51**. This recess is prolonged by two cells **57** and **58** revealing parts of the thin film **53** of SiC situated under the components **54** and **55**. Between the cells **57** and **58** there exists a part **59** of the initial structure acting as strengthener. This strengthener enables the membrane, constituted by the free part of the thin film **53**, to be made mechanically rigid. Thus one avoids risks of the membrane bursting when put under vacuum in equipment such as that of **FIG. 3**. It is to be noted that the cross section of the cells can be hexagonal just like a honeycomb element.

[**0068**] In particular, the invention has the following advantages. It makes it possible to manufacture a semiconductor device, especially with a big gap, electronic or optoelectronic, on a low cost substrate, for example in silicon, using well known techniques for transfer of layers, deep engraving and metallizing. It allows integration of an electronic device on a monocrystalline membrane. It enables the creation of a vacuum sealed membrane, permeable to an electron beam focussed on the rear face of the membrane whose front face supports one or several electronic components. It enables the production of vertical semiconductor devices on a substrate which is not necessarily an electrical conductor throughout the whole of its volume. The substrate can possibly possess an integrated heat sink. The manufacture of vertical structure components allows a reduction in the size of components. The invention makes it possible to manufacture vertical semiconductor devices with low elec-

trical resistance through replacement of the solid substrate by a semiconducting thin film. It makes it possible to integrate a laser on a micro-machined torch through the intermediary of a membrane which assures a three-fold role: sealing, permeability to electrons, and epitaxial substrate for the GaN.

1. Semiconductor device with vertical electron injection comprising a support substrate (**2**, **21**, **51**), a structure comprising at least one monocrystalline thin film (**7**, **23**, **53**) transferred onto the support substrate and integral with the support substrate, at least one electronic component (**25**, **54155**), the support substrate comprising at least one recess (**11**, **24**, **56**) enabling electric or electronic access to the electronic component through the monocrystalline thin film, the device also comprising means enabling vertical electron injection into the vertical component.

2. Device according to claim 1, characterised in that the structure comprises at least one active layer (**10**) formed by crystal growth of the semiconducting material on the monocrystalline thin film (**7**, **23**, **53**), the electronic component (**25**, **54**, **55**) being produced in said active layer (**10**).

3. Device according to claim 1, characterised in that the monocrystalline thin film is an active layer from which the electronic component is produced.

4. Device according to any one of claims 1 to 3, characterised in that it furthermore comprises a layer (**6**, **22**, **52**), called adhesion layer, situated between the support substrate (**2**, **21**, **51**) and the structure and enabling solidarisation of the monocrystalline thin film on the support, the adhesion layer enabling electric or electronic access to the electronic component.

5. Device according to claim 4, characterised in that the adhesion layer (**22**) is insulating and comprises at least one recess enabling electric or electronic access to the electronic component (**25**).

6. Device according to claim 4, characterised in that the adhesion layer is conducting or semiconducting.

7. Device according to any one of claims 1 to 6, characterised in that the monocrystalline thin film comprises at least one recess enabling direct electric or electronic access to the electronic component.

8. Device according to claim 1, characterised in that the support substrate (**2**, **21**, **51**) is in a material selected from the group consisting of silicon, SiC, AlN, sapphire and GaN.

9. Device according to claim 1, characterised in that the monocrystalline thin film (**7**, **23**, **53**) is in a material selected from the group consisting of SiC, silicon, GaN, sapphire or ZnO.

10. Device according to claim 5, characterised in that the adhesion layer (**6**, **22**, **52**) is in SiO_2.

11. Device according to claim 2, characterised in that the active layer (**10**) comprises a semiconducting material chosen among SiC, GaN, the compounds III-V and their derivatives, and diamond.

12. Device according to any one of claims 1 to 11, characterised in that the electronic component comprises at least one junction produced from two semiconductors of the same nature or of different natures.

13. Device according to any one of claims 1 to 11, characterised in that the electronic component comprises at least one junction of the metal-semiconductor type.

14. Device according to any one of claims 1 to 11, characterised in that the electronic component comprises at least one stack of the semiconductor-metal-oxide type.

15. Device according to any one of claims 1 to 14, characterised in that the means enabling vertical electron injection into the electronic component comprise an electrode (**13**) set on the electronic component and an electrode (**14**) set under the electronic component, in said recess enabling access to the electronic component.

16. Device according to claim 15, characterised in that an earth (**15**) is provided in said recess, in contact with said electrode (**14**) set under the component in order to constitute a heat sink.

17. Device according to any one of claims 1 to 14, characterised in that electron injection is carried out by means of an electron beam (**30**) directed onto the electronic component (**25**) passing in said recess (**24**), the means enabling vertical electron injection comprising a conducting coating (**28**) for guiding the electrons towards the electronic component (**25**).

18. Device according to any one of claims 1 to 17, characterised in that the recess (**56**) of the support substrate (**51**) comprises cells (**57**, **58**) enabling electric or electronic access to the electronic components (**54**, **55**) produced from the structure.

19. Device according to claim 1, characterised in that said electronic component is selected from the group consisting of light emitters, light detectors, power electronic components and diodes.

20. Device according to any one of claims 1 to 7, characterised in that the structure is vacuum sealed.

21. Device according claim 20, characterised in that the electronic component (**25**), being a component able to emit a light beam in response to a received electron beam (**30**), the monocrystalline thin film (**23**) is such that it allows passage of said electron beam.

22. Device according to claim 20, characterised in that the structure forms a membrane deformable under the effect of a pressure difference, said electronic component being a component providing a signal indicative of the deformation undergone by the membrane.

23. Manufacturing method for a semiconductor device with vertical electron injection according to claim 1, characterised in that it comprises the following stages:

- transfer of the monocrystalline thin film (**7**) onto a first face of the support substrate (**2**),
- production of at least one electronic component from the structure,
- formation of at least one recess (**11**) from a second face of the substrate (**2**) to enable electric or electronic access to the electronic component through the monocrystalline thin film (**7**),
- production of means (**13**, **14**) allowing vertical electron injection into the electronic component.

24. Method according to claim 23, characterised in that it furthermore comprises a stage of formation of at least one active layer (**10**) by crystal growth of semiconducting material on the monocrystalline thin film (**7**), the electronic component being produced in said active layer, the crystal growth being before or after transfer.

25. Method according to claim 23, characterised in that the monocrystalline thin film is an active layer, the electronic component being produced from this monocrystalline thin film

26. Method according to claim 23, characterised in that the transfer stage for the monocrystalline thin film (**7**) comprises the following operations:

definition of said monocrystalline thin film (**7**) in a substrate of monocrystalline material (**1**) by introducing gaseous species into this substrate of monocrystalline material in order to create a fracture zone (**5**), the monocrystalline thin film (**7**) being located between one face of the substrate in monocrystalline material (**1**) and the cleavage zone (**5**),

solidarisation of said monocrystalline thin film on the first face of the support substrate (**2**),

fracture separation of the monocrystalline thin film (**7**) from the rest (**9**) of the substrate (**1**) of monocrystalline material, the separation being produced before or after the solidarisation operation.

27. Method according to any one of claims 23 to 26, characterised in that the transfer of said monocrystalline thin film is carried out through the intermediary of an adhesion layer (**6**).

28. Method according to claim 26, characterised in that the solidarisation of said thin film is obtained by molecular adhesion.

29. Method according to any one of claims 23 to 28, characterised in that the transfer stage of the monocrystalline thin film (**7**) is formed on a first face of a support substrate in silicon (**2**).

30. Method according to any one of claims 23 to 28, characterised in that the transfer stage consists of transferring a thin film of monocrystalline SiC (**7**).

31. Method according to claim 27, characterised in that the transfer of said monocrystalline thin film (**7**) is carried out with the intermediary of an adhesion layer (**6**) in SiO_2.

32. Method according to claim 24, characterised in that the active layer (**10**) is formed by crystal growth on a layer of semiconducting material selected from the group consisting of SiC, GaN, the compounds III-V and their derivatives, and diamond.

33. Method according to any one of claims 23 to 32, characterised in that the production of means allowing vertical electron injection into the electronic component comprises the deposit of an electrode (**13**) on the electronic component and the deposit of an electrode (**14**) under the electronic component, in said recess (**11**) enabling access to the electronic component.

34. Method according to claim 33, characterised in that it comprises deposit of an earth (**15**) in said recess (**11**), in contact with said electrode (**14**) set under the component in order to constitute a heat sink.

35. Method according to any one of claims 23 to 32, characterised in that it comprises the deposit of a conducting coating (**28**) capable of guiding an electron beam (**30**) directed onto the electronic component (**25**) passing in said recess (**24**).

36. Method according to any one of claims 23 to 32, characterised in that it also comprises the formation of cells (**57**, **58**) prolonging the recess (**56**) of the support substrate (**51**) to allow electric or electronic access to the electronic components (**54**, **55**) formed from the structure.

37. Method according to any one of claims 23 to 32, characterised in that the formation stage of at least one electronic component consists of producing a component selected from the group consisting of light emitters, light detectors, power electronic components and diodes.

38. Method according to any one of claims 23 to 32, characterised in that the transfer stage of a monocrystalline thin film (**23**) consists of transferring a monocrystalline thin film such that the structure is vacuum sealed.

39. Method according to claim 38, characterised in that the stage for transferring a monocrystalline thin film (**23**) consists of transferring a monocrystalline thin film able to be crossed by an electron beam.

40. Method according to claim 38, characterised in that the stage for transferring a monocrystalline thin film consists of transferring a monocrystalline thin film such that the structure forms a membrane deformable under the effect of a difference of pressure, the stage of forming at least one electronic component comprising the production of a component providing a signal indicative of the deformation undergone by the membrane.

* * * * *