

SUBSTRATE FOR FRONT SIDE TYPE IMAGER AND METHOD OF MANUFACTURING SUCH A SUBSTRATE

5 FIELD OF THE INVENTION

The present invention relates to a substrate for a “front side” type imager, an imager incorporating such a substrate, and a method of manufacturing such a substrate.

PRIOR ART

10 The document US 2016/0118431 describes a “front side” type imager.

As illustrated in figure 1, said imager comprises a SOI (Semiconductor-On-Insulator) type substrate comprising, from its rear side to its front side, a silicon support substrate 1' having a certain doping, a silicon oxide layer 2', and a monocrystalline silicon layer 3' designated active layer having a doping which can be different to that of the support
15 substrate 1', in which is defined a matrix array of photodiodes each defining a pixel.

However, such an imager has low sensitivity in the near infrared, that is to say for wavelengths comprised between 700 nm and 3 μm .

Indeed, the active silicon layer 3' has a coefficient of absorption which decreases markedly with the wavelength of the radiation to which it is exposed, namely around 10^6
20 cm^{-1} for a wavelength of 300 nm to several 10^3 cm^{-1} from 700 nm.

However, monocrystalline silicon is at the moment the favoured material to form the active layer of the substrate for the imager, because it has the advantage of being compatible with microelectronic methods enabling the manufacture of the imager, and of having a crystalline quality (in particular an absence of dislocations) suitable to the
25 function of the active layer.

DESCRIPTION OF THE INVENTION

An aim of the invention is to overcome the aforementioned problem and to propose a substrate for a “front side” type imager which makes it possible to increase the
30 absorption of light in the near infrared while respecting the constraints of compatibility with the method of manufacturing the imager and the crystalline quality of the active layer.

To this end, the invention proposes a substrate for a front side type imager, successively comprising a semiconductor support substrate, an electrically insulating layer and a semiconductor active layer, characterised in that the active layer is an epitaxial
35 layer made of silicon-germanium, the germanium content of said silicon-germanium layer being less than 10%.

By “epitaxial layer” is meant a layer grown by epitaxy, as described in the subsequent description.

“Front side” is taken to mean in the present text the side of the imager intended to be exposed to light radiation, which is located on the same side of the substrate as the associated electronic components.

Advantageously, the germanium content of the active layer is less than or equal to 8%.

Preferably, the thickness of the active layer is less than a critical thickness of the silicon-germanium layer defined as being a thickness beyond which silicon-germanium relaxation takes place.

According to one embodiment, the substrate further comprises a silicon layer between the electrically insulating layer and the silicon-germanium layer.

According to one embodiment, the electrically insulating layer is made of silicon oxide.

The thickness of the electrically insulating layer is comprised between 10 and 200 nm.

According to another embodiment, the electrically insulating layer is constituted of a stack of dielectric and/or metal layers chosen in such a way that the reflectivity of said stack in a range of wavelengths comprised between 700 nm and 3 μ m is greater than the reflectivity of a silicon oxide layer having a thickness equal to that of said stack.

According to one particular embodiment, said electrically insulating layer successively comprises, from the support substrate to the active layer, a silicon oxide layer, a titanium nitride layer and a silicon oxide layer.

The invention also relates to a front side imager comprising such a substrate and a matrix array of photodiodes in the active layer of said substrate.

Another object of the invention relates to a method of manufacturing such a substrate.

Said method comprises the following steps:

- provision of a donor substrate comprising a semiconductor material suitable for the epitaxial growth of silicon-germanium;
- provision of a support substrate;
- bonding of the donor substrate on the support substrate, an electrically insulating layer being at the bonding interface;
- thinning of the donor substrate so as to transfer a layer of the semiconductor material onto the support substrate;
- epitaxial growth, on the transferred layer of semiconductor material, of a silicon-germanium layer whose germanium content is less than 10%, preferably less than or equal to 8%.

According to one embodiment, the semiconductor material of the donor substrate suitable for the epitaxial growth of silicon-germanium is silicon-germanium.

Said semiconductor material may be formed by epitaxy on a base substrate, said semiconductor material and the base substrate together forming the donor substrate.

According to another embodiment, the semiconductor material of the donor substrate suitable for the epitaxial growth of silicon-germanium is silicon.

5 Advantageously, the thickness of the silicon layer transferred onto the support substrate is less than or equal to 400 nm.

At the end of the epitaxial growth of silicon-germanium, the silicon layer may be conserved between the electrically insulating layer and the silicon-germanium layer.

10 Alternatively, the method may further comprise a step of condensation of the silicon-germanium of the active layer so as to convert the silicon layer from which the epitaxial growth of silicon-germanium has been carried out into a silicon-germanium layer.

In a particularly advantageous manner, the method comprises a step of formation of an embrittlement zone in the donor substrate so as to delimit a layer of the semiconductor material suitable for the epitaxial growth of silicon-germanium, and the thinning of the
15 donor substrate comprises a detachment along said embrittlement zone.

Preferably, the formation of the embrittlement zone comprises an implantation of atomic species in the donor substrate.

According to one particular embodiment, the electrically insulating layer is formed by deposition, on the support substrate, of a stack of dielectric and/or metal layers chosen in
20 such a way that the reflectivity of said stack in a range of wavelengths comprised between 700 nm and 3 μ m is greater than the reflectivity of a silicon oxide layer having a thickness equal to that of said stack.

In this case, a sacrificial oxide layer is advantageously formed on the donor substrate before the implantation of the atomic species to form the embrittlement zone,
25 the implantation of the atomic species being carried out through said sacrificial layer, said sacrificial oxide layer being removed before bonding of the donor substrate on the support substrate.

DESCRIPTION OF THE FIGURES

30 Other characteristics and advantages of the invention will become clear from reading the detailed description that follows, with reference to the appended drawings, in which:

- figure 1 is a sectional view of a SOI substrate for a front side imager as described in the document US 2016/0118431;

35 - figure 2 is a sectional view of a substrate according to one embodiment of the invention;

- figure 3 shows the coefficient of absorption of silicon-germanium as a function of wavelength for different germanium contents;

- figure 4 shows the critical thickness of a silicon-germanium layer as a function of the germanium content thereof;

- figure 5 is a sectional view of a substrate according to an alternative embodiment of the invention;

5 - figures 6A to 6F illustrate the main steps of a method of manufacturing a substrate for a front side imager according to one embodiment of the invention;

- figures 7A to 7C illustrate the steps of an alternative of the manufacturing method illustrated in figures 6A to 6F;

10 - figures 8A to 8D illustrate the main steps of a method of manufacturing a substrate for a front side imager according to one embodiment of the invention;

- figure 9 is a sectional view of a substrate according to a particular embodiment of the invention,

- figure 10 illustrates the reflectivity of a stack of dielectric layers as a function of wavelength (in nm),

15 - figures 11A to 11E illustrate the main steps of a method of manufacturing a substrate for front side imager according to one embodiment of the invention,

- figure 12 is a sectional view of a pixel of a "front side" type imager comprising a substrate according to one embodiment of the invention.

20 For reasons of legibility of the figures, the different layers are not necessarily represented to scale.

DETAILED DESCRIPTION OF THE INVENTION

25 Figure 2 is a sectional view of a substrate for a front side imager according to one embodiment of the invention.

Said substrate successively comprises, from its rear side to its front side, a semiconductor support substrate 1, an electrically insulating layer 2 and a monocrystalline silicon-germanium (SiGe) layer 3 designated active layer.

30 The support substrate 1 is generally obtained by cutting of a monocrystalline ingot. Advantageously, the substrate 1 is made of silicon.

According to one embodiment, the electrically insulating layer is a silicon oxide layer.

Advantageously, the thickness of said electrically insulating layer is comprised between 10 and 200 nm.

35 The layer 3 is intended to receive a matrix array of photodiodes (not represented) enabling the capture of images. The thickness of the layer 3 is typically greater than or equal to 1 μm , or even greater than 2 μm . Said layer 3 may be lightly doped.

As may be seen in figure 3, which illustrates the coefficient of absorption (in cm^{-1}) of SiGe as a function of wavelength (in μm) for different compositions of said material, the

coefficient of absorption, in particular in the infrared, increases with the germanium content.

However, the design of the layer 3 does not only concern the concentration of germanium but also the thickness of said layer. Indeed, since the SiGe layer is formed by epitaxy on a silicon substrate, the lattice parameter of which is different to that of silicon-germanium, relaxation of the SiGe layer takes place beyond a certain thickness, designated critical thickness. This relaxation results in the formation of dislocations within the SiGe layer.

Such dislocations would make the SiGe layer inappropriate for the function of the active layer 3 and must thus be avoided.

As shown in figure 4, which illustrates the critical thickness (in Å) of a SiGe layer as a function of the germanium content (stoichiometric coefficient x corresponding to the composition $\text{Si}_{1-x}\text{Ge}_x$), the critical thickness is all the smaller the greater the germanium concentration.

The thickness of the active layer 3 and the germanium concentration of said layer thus result from a compromise between:

- on the one hand, a sufficiently large thickness to capture a maximum of photons in the wavelengths of the near infrared,
- on the other hand, a sufficient concentration of germanium to increase the capacity to absorb photons by the active layer in particular in the near infrared, and
- a limited thickness (depending on the concentration) to avoid silicon-germanium relaxation and the creation of crystalline defects (dislocations) that result therefrom.

Typically, it is sought to maximise the thickness and the germanium concentration of the layer 3 in order to have the best possible absorption in the infrared while minimizing dislocations in said active layer.

The germanium content of the active layer is less than 10%, preferably less than or equal to 8%. Figure 4 shows in fact that the critical thickness of a $\text{Si}_{0.9}\text{Ge}_{0.1}$ layer is of the order of a micrometre, which is suitable for the active layer of a "front side" type imager. For a $\text{Si}_{0.92}\text{Ge}_{0.08}$ layer, the critical thickness is greater than 2 μm ; besides, the absorption coefficient at a wavelength equal to 940 nm is three to four times greater than the one of silicon.

As compared to a silicon-germanium layer made by thermal mixing as described in document WO 2005/043614, the silicon-germanium epitaxial active layer implemented in the present invention presents a greater uniformity and a lower cost. Indeed, obtaining a silicon-germanium layer by thermal mixing implies the formation of a stack constituted (from its free surface to a substrate forming a mechanical support) of a silicon-germanium layer with a high germanium content (e.g. with a germanium content of the order of 80%), a thick silicon layer (substantially corresponding to the desired thickness of the final

silicon-germanium layer) and a barrier layer preventing any diffusion of the germanium atoms into the underlying substrate. However, the thicker the silicon layer, the greater the duration of the process (said duration including the duration of the epitaxy of the silicon layer followed by the duration of the heat treatment of the silicon-germanium layer to
5 cause the germanium atoms to diffuse within the silicon layer). In practice, said thermal mixing process is thus not adapted to the formation of an active layer having a thickness of the order of 1 μm that is required for an imager. In any case, the skilled person will be able to distinguish an epitaxial layer from a layer formed by thermal mixing by measuring the quantity of dislocations and the relaxation of said layer.

10 Examples of methods of manufacturing the substrate illustrated in figure 2 will now be described.

Generally speaking, the method of manufacturing a substrate according to the invention comprises the following steps.

On the one hand, a donor substrate is provided comprising a semiconductor
15 material suitable for the epitaxial growth of silicon-germanium. Said material may in particular be SiGe (enabling homoepitaxy) or a material different to SiGe but having a lattice parameter sufficiently close to that of SiGe to enable the epitaxial growth thereof (heteroepitaxy). In this latter case, said semiconductor material is advantageously silicon.

On the other hand, a receiver substrate is provided, and the donor substrate is
20 bonded on the receiver substrate, an electrically insulating layer being at the bonding interface.

The donor substrate is next thinned so as to transfer a layer of the semiconductor material onto the receiver substrate.

This thinning may be carried out by polishing or etching of the semiconductor
25 material so as to obtain the thickness and the surface state desired for the epitaxy of SiGe.

However, advantageously, before the bonding step, an embrittlement zone is formed in the semiconductor material so as to delimit a superficial layer to transfer. After the bonding step, the thinning consists in detaching the donor substrate along the
30 embrittlement zone, which leads to the transfer of the superficial layer onto the receiver substrate. Typically, the thickness of the transferred layer is less than or equal to 400 nm. Potentially, a finishing treatment of the free surface of the transferred layer is carried out in order to favour the implementation of the epitaxy, said treatment being able to lead to thinning of the transferred layer.

35 Finally, on the transferred layer of semiconductor material, which serves as seed layer, the epitaxial growth of a layer of silicon-germanium is implemented until the desired thickness is obtained for the active layer.

It will be noted that, when the seed layer is not made of SiGe, for example when it is made of silicon, at the end of the epitaxy of SiGe, the seed layer under the active layer 3 remains.

5 This situation is illustrated in figure 5, which corresponds to one particular embodiment of the invention. The seed layer is designated by the reference 42.

The seed layer is sufficiently thin (of a thickness less than or equal to 300 nm) compared to the thickness of the active layer so as not to affect notably the properties of the active SiGe layer in terms of absorption in the infrared.

10 However, it is possible to remove the seed layer, for example by means of a condensation method. In a manner known per se, said method comprises an oxidation of the SiGe layer, said oxidation having the effect of consuming uniquely the silicon (to form silicon oxide) and to make the germanium migrate to the face opposite to the free surface of the SiGe layer. A SiO₂ layer, which can be removed by etching, is then obtained on the surface.

15 According to a first embodiment, illustrated in figures 6A to 6F, the starting point is a donor substrate 30 comprising a superficial SiGe layer 31.

Said SiGe layer is typically formed by epitaxy on a base substrate 32, generally made of silicon. Said SiGe layer is sufficiently thin to be stressed.

20 In a first version of this embodiment, an embrittlement zone is formed in the SiGe layer.

In a particularly advantageous manner, as illustrated in figure 6B, said embrittlement zone 33 is formed by implantation of atomic species (typically, hydrogen and/or helium) through the free surface of the SiGe layer 31. The embrittlement zone 33 thereby delimits a SiGe layer 34 at the surface of the donor substrate.

25 With reference to figure 6C, a receiver substrate is moreover provided comprising a support substrate 1 and an electrically insulating layer 2.

With reference to figure 6D, the donor substrate is bonded on the receiver substrate, the SiGe layer 31 and the electrically insulating layer 2 being at the bonding interface.

30 Next, as illustrated in figure 6E, the donor substrate is detached along the embrittlement zone. Said detachment may be initiated by any technique known to those skilled in the art, such as a mechanical, chemical, and/or thermal stress.

The SiGe layer 34 is thereby transferred onto the support substrate.

35 If need be, a surface treatment of the SiGe layer is carried out to remove defects linked to the implantation and to the detachment, and to make it sufficiently smooth for the epitaxy step that is going to follow.

In a second version of this embodiment, an embrittlement zone 33 is formed in the donor substrate 30 situated under the SiGe layer 31 (cf. figure 7A).

In a particularly advantageous manner, said embrittlement zone 33 is formed by implantation of atomic species (typically, hydrogen and/or helium) through the free surface of the layer 30. The embrittlement zone 33 thereby delimits a SiGe layer and a portion 38 of the base substrate 32 on the surface of the donor substrate.

5 With reference to figure 6C, a receiver substrate is moreover provided comprising a support substrate 1 and an electrically insulating layer 2.

With reference to figure 7B, the donor substrate is bonded on the receiver substrate, the SiGe layer 31 and the electrically insulating layer 2 being at the bonding interface.

10 Next, the donor substrate is detached along the embrittlement zone 33. Said detachment may be initiated by any technique known to those skilled in the art, such as a mechanical, chemical, and/or thermal stress.

The SiGe layer 31 and the portion 38 of the base substrate are thereby transferred onto the support substrate (cf. figure 7C).

15 A treatment of the surface created is then carried out to remove the portion 38 of the superficial donor substrate until a surface of SiGe is revealed, thereby removing defects linked to the implantation and to the detachment, and making it sufficiently smooth for the epitaxy step that is going to follow.

As in figure 6E, a portion 34 of the SiGe layer 31 on the support substrate 1 is thereby obtained.

20 As illustrated in figure 6F (step common to the two versions of the embodiment), epitaxy is then resumed in order to make a SiGe layer 35 grow on the transferred layer 34 which fulfils the role of seed layer, up to the desired thickness for the active layer 3, which is formed of both of the two SiGe layers 34 and 35 together. During epitaxy, it is possible to dope lightly the layer 35, depending on the desired electrical properties. The doping of
25 the layer 35 is not necessarily identical to that of the seed layer 34.

The substrate illustrated in figure 2 is thereby obtained.

30 According to a second embodiment, illustrated in figures 8A to 8D, the well-known Smart Cut™ method is used to form a SOI substrate comprising the support substrate, the electrically insulating layer, and a silicon seed layer intended for the epitaxial growth of the SiGe layer.

To this end, a donor silicon substrate 40 covered by the electrically insulating layer 2 (cf. figure 8A) is provided, then an embrittlement zone 41 delimiting a silicon layer 42 to transfer (cf. figure 8B) is formed by implantation of atomic species.

35 A receiver substrate is moreover provided, which is typically the support substrate 1 of the final substrate.

With reference to figure 8C, the donor substrate 40 is bonded on the receiver substrate 1, the electrically insulating layer 2 being at the bonding interface.

Next, the donor substrate is detached along the embrittlement zone. Said detachment may be initiated by any technique known to those skilled in the art, such as a mechanical, chemical, and/or thermal stress.

5 The silicon layer 42 is thereby transferred onto the support substrate 1 (cf. figure 8D).

If need be, a surface treatment of the silicon layer is carried out to remove defects linked to the implantation and to the detachment, and to make it sufficiently smooth for the epitaxy step that is going to follow.

10 Epitaxy of SiGe on the transferred silicon layer 42 which serves as seed layer is then resumed, up to the desired thickness for the active layer 3. During epitaxy, it is possible to dope lightly the layer 3, depending on the desired electrical properties.

The substrate illustrated in figure 5 is thereby obtained.

15 As mentioned above, the silicon seed layer may be conserved for the formation of the imager. Alternatively, the silicon layer may be removed by means of the aforementioned condensation method.

20 According to one particular embodiment of the invention, the electrically insulating layer 2 is not, as in conventional SOI substrates, a silicon oxide layer, but is constituted of a stack of dielectric and/or metal layers chosen so as to increase the reflectivity of said electrically insulating layer in the infrared. More precisely, the dielectric and/or metal layers forming this stack are chosen in such a way that the reflectivity of said stack in a range of wavelengths comprised between 700 nm and 3 μ m is greater than the reflectivity of a silicon oxide layer having a thickness equal to that of said stack. Furthermore, a metal layer of the stack is advantageously separated from the support substrate and from the active layer by at least one dielectric layer. Said dielectric layers thus ensure in particular
25 a function of electrical insulation of the active layer vis-à-vis the support substrate.

For example, as illustrated in figure 9, the electrically insulating layer successively comprises:

- a first silicon oxide layer 21 at the interface with the support substrate 1,
- a titanium nitride layer 22, and
- 30 - a second silicon oxide layer 23, at the interface with the active layer 3.

Titanium nitride is a metal material widely used in microelectronics.

35 The dielectric silicon oxide layers 21 and 23 make it possible to encapsulate the titanium nitride layer and thereby avoid any metal contamination of the active layer. The generation of electrical defects at the interface between the active layer and the electrically insulating layer and re-combinations between the SiGe of the active layer and the metal components of the imager, capable of doping the active layer, are thereby avoided.

Typically, the layer 21 has a thickness comprised between 300 and 500 nm, the layer 23 a thickness comprised between 10 and 50 nm, and the layer 22 a thickness comprised between 10 and 100 nm.

Such an electrically insulating layer has the advantage of reflecting more photons transmitted through the active layer 3 than a silicon oxide layer of identical thickness.

This is visible in figure 10, which shows the reflectivity of the following stack (from the support substrate to the active layer) as a function of wavelength (in nm):

- the first silicon oxide layer 21, of 400 nm thickness,
- the titanium nitride layer 22, of 50 nm thickness, and
- the second silicon oxide layer 23, of 20 nm thickness.

A reflectivity reaching 0.8 for a wavelength of 850 nm is thereby obtained. As a comparison, a 400 nm layer of silicon oxide has a reflectivity of 0.5 for a wavelength of 850 nm.

This increased reflectivity has the effect of increasing the length of the path of the photons within the active layer 3, and thereby of favouring their absorption by said layer.

Thus, with the simultaneous use of the active silicon-germanium layer and the stack of dielectric and/or metal layers forming the electrically insulating layer, the favourable effects of these two layers on the absorption of infra-red radiation are combined.

In this case, the method of manufacturing the substrate is adapted in the following manner.

Compared to the methods described above, when the layer to transfer (whether it is a SiGe layer or a silicon layer) is delimited in the donor substrate by an embrittlement zone formed by implantation, the stack of dielectric and/or metal layers is not formed on the donor substrate but on the support substrate. Indeed, such a stack would be too thick for the implantation. On the other hand, advantageously, before implantation, a sacrificial silicon oxide layer, through which the atomic species intended to form the embrittlement zone are implanted, is formed on the donor substrate. Said sacrificial layer makes it possible to avoid the channelling effect during implantation. Said sacrificial layer is next removed from the donor substrate before the bonding thereof on the support substrate.

Figures 11A to 11E illustrate a preferred embodiment of a substrate for a front side imager comprising such a stack of dielectric layers. The elements designated by the same reference signs as in the preceding figures, in particular figures 8A-8D, designate the same elements. However, those skilled in the art could also apply the above method to the case where the transferred seed layer is a SiGe layer as in the method described with reference to figures 6A-6F or 7A-7C.

With reference to figure 11A, a donor silicon substrate 40 covered by a sacrificial silicon oxide layer 5 is provided, then an embrittlement zone 41 delimiting a silicon layer

42 to transfer is formed by implantation of atomic species through the layer 5. After the implantation, the sacrificial layer 5 is removed, for example by chemical etching.

With reference to figure 11B, a receiver substrate is moreover provided, which is typically the support substrate 1 of the final substrate, on which the stack of layers 21, 22, 23 intended to form the electrically insulating layer 2 is formed.

With reference to figure 11C, the donor substrate 40 is bonded on the support substrate 1, the stack of dielectric and/or metal layers forming the electrically insulating layer 2 being at the bonding interface.

Next, the donor substrate is detached along the embrittlement zone 41. Said detachment may be initiated by any technique known to those skilled in the art, such as a mechanical, chemical, and/or thermal stress.

The silicon layer 42 is thereby transferred onto the support substrate 1 (cf. figure 11D).

If need be, a surface treatment of the silicon layer is carried out to remove defects linked to the implantation and to the detachment, and to make it sufficiently smooth for the epitaxy step that is going to follow.

With reference to figure 11E, epitaxy of SiGe on the transferred silicon layer 42 which serves as seed layer is then resumed up to the desired thickness for the active layer 3. During epitaxy, it is possible to lightly dope the layer 3, depending on the desired electrical properties.

Figure 12 illustrates a part of a front side type imager comprising a substrate according to one embodiment of the invention corresponding to figure 2, but not limited thereto. Only a part of the imager corresponding to a pixel is represented in this figure, said pixel being electrically insulated from the other pixels formed in the active layer 3 by insulation trenches 7.

A doped region 36 of type different to that of the layer 3 is formed under the surface of the front side of the active layer 3. This region 36 forms with the active layer 3 a photodiode. A region 37 formed between the region 36 and the front side of the layer 3 advantageously has a doping level greater than that of the region 36 in order to passivate the interface. A passivation layer 6 is formed on the active layer 3 and may encapsulate elements making it possible to control said pixel electrically.

Potentially, other layers, such as filters, may be formed on the passivation layer 6, but they are not represented in figure 12.

The structure of the imager as such and its method of manufacture are known to those skilled in the art and will thus not be described in detail herein.

REFERENCES

US 2016/0118431

WO 2005/043614

CLAIMS

1. Substrate for a front side type imager, successively comprising a semiconductor support substrate (1), an electrically insulating layer (2) and a semiconductor active layer (3), characterised in that the active layer (3) is an epitaxial layer made of silicon-germanium, the germanium content of said active layer being less than 10%.
5
2. Substrate according to claim 1, wherein the germanium content of the active layer (3) is less than or equal to 8%.
10
3. Substrate according to one of claims 1 or 2, wherein the thickness of the active layer (3) is less than a critical thickness of the silicon-germanium layer defined as being a thickness beyond which silicon-germanium relaxation takes place.
15
4. Substrate according to one of claims 1 to 3, wherein the thickness of the active layer is greater than 1 μm , or even greater than 2 μm .
5. Substrate according to one of claims 1 to 4, further comprising a silicon layer (42) between the electrically insulating layer (2) and the silicon-germanium layer (42).
20
6. Substrate according to one of claims 1 to 5, wherein the electrically insulating layer (2) is made of silicon oxide.
7. Substrate according to one of claims 1 to 6, wherein the thickness of the electrically insulating layer (2) is comprised between 10 and 200 nm.
25
8. Substrate according to one of claims 1 to 5, wherein the electrically insulating layer is constituted of a stack of dielectric and/or metal layers (21, 22, 23) chosen in such a way that the reflectivity of said stack in a range of wavelengths comprised between 700 nm and 3 μm is greater than the reflectivity of a silicon oxide layer having a thickness equal to that of said stack.
30
9. Substrate according to claim 8, wherein the electrically insulating layer (2) successively comprises, from the support substrate (1) to the active layer (3), a silicon oxide layer (21), a titanium nitride layer (22) and a silicon oxide layer (23).
35

10. Front side type imager, characterised in that it comprises a substrate according to one of claims 1 to 9 and a matrix array of photodiodes in the active layer (3) of said substrate.

- 5 11. Method of manufacturing a substrate for a front side type imager, comprising the following steps:
- provision of a donor substrate (30, 40) comprising a semiconductor material suitable for the epitaxial growth of silicon-germanium;
 - provision of a support substrate (1);
 - 10 - bonding of the donor substrate (30, 40) on the support substrate (1), an electrically insulating layer (2) being at the bonding interface;
 - thinning of the donor substrate (30, 40) so as to transfer a layer (34, 42) of the semiconductor material onto the support substrate (1);
 - epitaxial growth, on the transferred layer (34, 42) of semiconductor material, of a
15 silicon-germanium layer (35, 3), the germanium content of said silicon-germanium layer being less than 10%.

20 12. Method according to claim 11, wherein the semiconductor material of the donor substrate (30) suitable for the epitaxial growth of silicon-germanium is silicon-germanium.

25 13. Method according to claim 12, wherein said semiconductor material (31) is formed by epitaxy on a base substrate (32), said semiconductor material and the base substrate together forming the donor substrate (30).

 14. Method according to claim 11, wherein the semiconductor material of the donor substrate (40) suitable for the epitaxial growth of silicon-germanium is silicon.

30 15. Method according to claim 14, wherein the thickness of the silicon layer (42) transferred onto the support substrate (1) is less than or equal to 400 nm.

35 16. Method according to one of claims 14 or 15, wherein, at the end of the epitaxial growth of silicon-germanium, the silicon layer (42) is conserved between the electrically insulating layer (2) and the silicon-germanium layer (3).

 17. Method according to one of claims 14 or 15, further comprising a step of condensation of the silicon-germanium of the active layer (3) so as to convert the silicon

layer (42) from which the epitaxial growth of silicon-germanium has been carried out into a silicon-germanium layer.

18. Method according to one of claims 11 to 117 comprising a step of formation of
5 an embrittlement zone (33, 41) in the donor substrate (30, 40) so as to delimit a layer (34, 42) of the semiconductor material suitable for the epitaxial growth of silicon-germanium, and wherein the thinning of the donor substrate comprises a detachment along said embrittlement zone (33, 41).

10 19. Method according to claim 18, wherein the formation of the embrittlement zone (33, 41) comprises an implantation of atomic species in the donor substrate (30, 40).

20. Method according to one of claims 11 to 19, wherein the electrically insulating layer is formed by deposition, on the support substrate (1), of a stack of dielectric and/or
15 metal layers (21, 22, 23) chosen in such a way that the reflectivity of said stack in a range of wavelengths comprised between 700 nm and 3 μ m is greater than the reflectivity of a silicon oxide layer having a thickness equal to that of said stack.

21. Method according to claim 20 in combination with claim 19, wherein a
20 sacrificial oxide layer (5) is formed on the donor substrate (40) before the implantation of the atomic species, the implantation of the atomic species being carried out through said sacrificial layer (5), said sacrificial oxide layer (5) being removed before bonding of the donor substrate (30, 40) on the support substrate (1).

25 22. Method according to one of claims 11 to 21, wherein the thickness of the active layer (3) is greater than 1 μ m, or even greater than 2 μ m.

23. Method according to one of claims 11 to 22, wherein the thickness of the active layer (3) is less than a critical thickness of the silicon-germanium layer defined as
30 being a thickness beyond which silicon-germanium relaxation takes place.

24. Method according to one of claim 11 to 23, wherein the germanium content of the active layer (3) is less than or equal to 8%.