

METHOD FOR PRODUCING A MULTI-MATERIAL SUBSTRATE

TECHNICAL FIELD OF THE INVENTION

5 The field of the invention is that of producing multi-material substrates, and in particular producing a substrate comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer of a third material. The invention applies in particular to substrates intended to be used for producing optoelectronic and/or photonic circuits, but also for producing microelectronic circuits or
10 photovoltaic devices.

PRIOR ART

 Some costly materials, such as III-V materials based on GaAs and/or InP, which are used in the fields of microelectronics, photonics or photovoltaics on account of their particular electrical and/or optical properties, are only available in the form of substrates of small
15 dimensions, for example of diameter equal to 100 mm or 150 mm. This dimensional limit of these substrates is due in particular to difficulties encountered during the growth of these crystalline materials. Furthermore, producing substrates comprising such materials is very expensive.

 Notwithstanding the high cost associated with the use of these materials,
20 technologies making use of these particular materials and which are compatible with substrates of small dimensions may carry out integrations of components or circuits directly on these substrates. On the other hand, for integrations requiring substrates of larger diameters, as is the case for example for a co-integration of InP-based chips with silicon components for which 200 mm or 300 mm diameter substrates are used, commercial InP
25 substrates of small dimensions are not suitable.

 To carry out co-integration of InP on silicon, a first solution consists of cutting an InP substrate, of small diameter and integrating a barrier layer of crystalline material buried under an epitaxial layer of InP at the desired thickness for chips, into multiple portions, then mounting the InP portions on a silicon substrate of greater diameter at the desired locations
30 on the silicon substrate. The mounted InP portions are then thinned to the desired thickness (by grinding, etching (chemical or plasma), CMP (chemical mechanical planarisation, or

thinning), etc.), i.e. up to the barrier layer. This barrier layer allows removal of the chip. It is indeed removed by selective etching so as only to retain the epitaxial InP film.

A major drawback of this first solution is that the InP removed by thinning, the thickness of which is several hundred microns, is lost. Therefore, the problem of cost always arises with this first solution in view of the large quantity of InP lost during thinning. Furthermore, this first solution requires, for the thinning of the InP portions, the presence of a necessarily crystalline barrier layer.

A second solution for carrying out a co-integration of InP-on-silicon chips consists of cutting an InP substrate of small diameter into multiple portions, then mounting the InP portions on a first silicon substrate. The InP portions attached to the first silicon substrate are then used as donors to mount on a second silicon substrate, with a Smart-cut™ type method, an InP thin film in the form of separated, and non-contiguous, portions, disposed next to each other. This second solution makes it possible for example to manufacture an InPOSi substrate (oxide being present between the InP portions and the second silicon substrate) of diameter equal to 200 mm or 300 mm. The InP portions attached to the first silicon substrate may be reused several times to mount InP thin films in the form of separated portions on several other second silicon substrates.

However, this second solution poses numerous integration problems, in particular:

- the density with which the InP portions are attached on the first silicon substrate and the position of these portions on the first substrate are not modifiable and must correspond to those sought for all the substrates produced;
- partial transfer of the InP at the plate edge, in that the InP portions attached to the first substrate are separated, or non-contiguous, from each other;
- difficulties implementing CMP, both on the InP thin film mounted on the second substrate and on the remaining parts of the InP portions attached to the first substrate, in that these CMP operations are carried out on mutually separated InP portions.

Moreover, the size of the final substrate, corresponding to that of the second silicon substrate, and its InP coverage rate must be taken into account when attaching the InP portions on the first substrate and determines its diameter. This may result in a low density of InP portions on the first and second silicon substrates, accentuating in this case the problems described above.

The various problems described above are also encountered for materials other than InP, in particular for any materials for which substrate production is costly and/or for which the dimensions of the substrates of these materials are limited.

DISCLOSURE OF THE INVENTION

5 The present invention aims to remedy all or some of the drawbacks of the prior art cited above, and in particular to propose a solution for producing a substrate that can have large dimensions and comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer of a third material, minimising the use of the first material and not requiring the use of a barrier layer of crystalline material.

10 For this, the invention proposes a method for producing a substrate comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer of a third material, including at least the following steps:

- ion implantation in a first substrate comprising the first material, forming a separation interface, or plane, between a first part of the first substrate corresponding to a
15 superficial layer and a second part of the first substrate;

- attaching the first substrate on a temporary substrate such that the superficial layer of the first substrate is disposed between the temporary substrate and the second part of the first substrate;

- detaching, at the separation interface, the second part of the first substrate with
20 respect to an assembly comprising at least the superficial layer of the first substrate and the temporary substrate;

- cutting said assembly into several portions such that each of the portions includes at least a part of the superficial layer of the first substrate and/or a part of a layer of the second material previously formed from the superficial layer of the first substrate, and a
25 part of the temporary substrate;

- attaching each of the portions on the support layer such that, for each of the portions, the part of the superficial layer of the first substrate and/or the layer of the second material is disposed between the support layer and the part of the temporary substrate;

- removing the part of the temporary substrate of each of the portions, the parts
30 of the superficial layer of the first substrate and/or the layer of the second material remaining

on the support layer forming the superficial layer of the first material and/or the second material.

The portions are thus individualised from each other, i.e. separated. During the cutting step, the temporary substrate is crossed entirely such that each of the portions
5 obtained includes a fraction of the temporary substrate.

A first advantage of this method is that there is not substantial thickness of the first material and/or the second material to be removed, in that only a superficial layer of the first substrate is mounted on the temporary substrate.

Another advantage of this method is that cutting the portions, before mounting
10 on the second substrate, is not carried out directly in the first substrate before after mounting the superficial layer of the first substrate on the temporary substrate. Thus, the first substrate may be reused to produce several substrates with densities of the parts of the first material and/or the second material on the second substrates and/or positions of these parts on the second substrates than may be different from one substrate to another. Furthermore, this
15 makes it possible to avoid a partial transfer of the first material and/or the second material at the edge of the portions.

Such a method makes it possible to lift several technological barriers inherent to pseudo-donor use, render the manufacture of the final substrate more versatile (geometry, size, distribution, chip density, type of final substrate, etc.) and offers at the same time new
20 possibilities (for example III-V integration on intermediate substrates, etc.).

Advantageously, the first material may correspond to at least one of the following materials: InP, GaAs, GaN, LTO, LNO, SiC, diamond.

Furthermore, in an advantageous configuration, the diameter of the first substrate (or more generally the dimensions of the first substrate in the principal plane of the first
25 substrate) may be equal to that of the temporary substrate and less than or equal to that of the final substrate (which corresponds to that of the support layer).

In an example embodiment, the method may be such that:

- the first substrate has a diameter less than or equal to 150 mm, and
- the support layer has a diameter greater than or equal to 200 mm, and
- 30 - the temporary substrate has a diameter less than or equal to 150 mm.

The method may further include, between the detachment step and the cutting step, a chemical mechanical planarisation of faces of the second part of the first substrate and

the superficial layer of the first substrate obtained from the separation interface. In this case, the planarisation is carried out on solid surfaces, not split into several portions, which facilitates its implementation.

The method may further include:

5 - before attaching the first substrate on the temporary substrate, producing a first bonding layer on the superficial layer of the first substrate, attaching the first substrate on the temporary substrate including bonding (for example direct bonding) the first bonding layer against a second bonding layer produced on the temporary substrate, and/or

 - before attaching each of the portions on the support layer, producing a third
10 bonding layer on the superficial layer of the first substrate or the layer of the second material, attaching each of the portions on the support layer including bonding (for example direct bonding) the third bonding layer against a fourth bonding layer produced on the support layer.

Advantageously, the bonding layers may include an amorphous material, for example oxide such as silicon oxide, or for example amorphous silicon. In this case, the
15 bondings carried out may correspond to direct bondings between these bonding layers.

In a particular embodiment, the method may further include, between the detachment and cutting steps, producing the layer of the second material on the superficial layer of the first substrate, and wherein attaching each of the portions on the support layer is implemented such that, for each of the portions, the part of the layer of the second material
20 is disposed between the support layer and the part of the superficial layer of the first substrate.

In this case, the method may further include, after removing the part of the temporary substrate of each of the portions, removing the parts of the superficial layer of the first substrate remaining on the support layer.

25 In another embodiment, the method may further include, before attaching the first substrate on the temporary substrate, producing the layer of the second material on the superficial layer of the first substrate, and wherein attaching the first substrate on the temporary substrate is implemented such that the layer of the second material is disposed between the superficial layer of the first substrate and the temporary substrate.

30 The method may further include, before attaching the first substrate on the temporary substrate, producing a layer of the second material on the superficial layer of the

first substrate, and may further include, between the detachment and cutting steps, removing the superficial layer from the first substrate.

5 The method is advantageously implemented to produce substrates of large dimensions on which chips of InP or any other material for which the implementation of this method is advantageous are disposed, for example any material not being capable of being obtained directly in the form of a substrate of large dimensions.

10 The method may be implemented to produce InPOX type substrates, i.e. including InP portions disposed on a support layer, for example based on silicon, with a bonding layer disposed between the support layer and the InP portions. The bonding layer may include an amorphous material, for example oxide such as silicon oxide, or for example amorphous silicon.

15 Throughout the document, the term “on” is used irrespective of the orientation in space of the element to which this term relates. For example, in the feature “on a face of the first substrate”, this face of the first substrate is not necessarily oriented upwards but may correspond to a face oriented in any direction. Furthermore, the arrangement of a first element on a second element should be understood as possibly corresponding to the arrangement of the first element directly against the second element, without any intermediate element between the first and second elements, or as possibly corresponding to the arrangement of the first element on the second element with one or more intermediate element(s) arranged between the first and second elements.

BRIEF DESCRIPTION OF THE FIGURES

25 Other advantages, aims and particular features of the present invention will appear from the following non-limiting description of at least one particular embodiment of the devices and methods according to the present invention, with reference to the appended drawings, wherein:

- Figures 1 to 7 represent the steps of a method for producing a substrate comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer of a third material, according to the present invention, according to a first embodiment;
- 30 - Figures 8 to 16 represent the steps of a method for producing a substrate comprising a superficial layer of a first material and/or a second material obtained from the

first material, disposed on a support layer of a third material, according to the present invention, according to a second embodiment;

- Figures 17 to 23 represent the steps of a method for producing a substrate comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer of a third material, according to the present invention, according to a third embodiment;

- Figures 24 to 31 represent the steps of a method for producing a substrate comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer of a third material, according to the present invention, according to a fourth embodiment.

Identical, similar or equivalent parts in the different figures described hereinafter bear the same reference numerals so as to make it easier to switch from one figure to another.

The various parts shown in the figures are not necessarily represented on a uniform scale, to make the figures easier to read.

The different possibilities (variants and embodiments) should be understood as not being exclusive of one another and may be combined together.

DETAILED DESCRIPTION OF THE INVENTION

A first embodiment of a method for producing a substrate 100 comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer, or substrate 104 of a third material is described hereinafter with reference to Figures 1 to 7.

This method is implemented using a first substrate 106 comprising the first material which corresponds for example to a material that is costly and/or only available in the form of a substrate of small diameter, such as an III-V material based on GaAs, InP, GaN, etc. or other types of materials such as LTO (lithium tantalate oxide) and/or LNO (LaNiO₃) or SiC (silicon carbide). In the example embodiment described, the first material of the first substrate 106 (seen in Figure 1) corresponds to InP.

The first substrate 106 has for example a diameter less than or equal to 150 mm. In the example embodiment described, the first substrate 106 has a diameter equal to 100 mm.

The first substrate 106 is intended to be attached to a temporary substrate 108 of the same diameter as that of the first substrate 106. In the example embodiment described, this attachment is obtained by direct bonding between bonding layers formed previously on the first substrate 106 and the temporary substrate 108. Thus, a first bonding layer 110, comprising for example an amorphous material such as oxide, in particular SiO_2 , and amorphous silicon, is therefore deposited on the first substrate 106, on the side of the face of the first substrate 106 intended to be part of the superficial layer of the substrate 100 which will be obtained at the end of the method.

Ion implantation is carried out in the first substrate 106, through the first bonding layer 110. The ions implanted in the first substrate 106 correspond for example to H^+ ions. This ion implantation forms, in the first substrate 106, a separation interface or plane 112 between a first part 114 of the first substrate 106 and a second part 116 of the first substrate 106 (see Figure 2). The first part 114 of the first substrate 106 forms a superficial layer of the first substrate 106 on which the first bonding layer 110 is disposed.

Prior to attaching the first substrate 106 to the temporary substrate 108, a second bonding layer 118, comprising for example an amorphous material such as oxide, in particular SiO_2 , or amorphous silicon, is deposited on the temporary substrate 108.

The first substrate 106 is then attached to the temporary substrate 108 such that the superficial layer of the first substrate 106, i.e. the first part 114 of the first substrate 106, is disposed between the temporary substrate 108 and the second part 116 of the first substrate 106 (see Figure 3). In the example embodiment described, this attachment corresponds to a direct oxide-oxide bonding carried out between the first and second bonding layers 110, 118.

The temporary substrate 108 has for example similar or close dimensions to those of the first substrate 106. In the embodiment described, the temporary substrate 108 has a diameter less than or equal to 150 mm, and here equal to 100 mm.

In the example embodiment described, the temporary substrate 108 includes silicon. Alternatively, the temporary substrate 108 may include any other material having for example a CTE similar to that of the material of the first substrate 106 and/or that is inexpensive, for example glass.

Alternatively to the example embodiment described here, it is possible that the attachment between the first substrate 106 and the temporary substrate 108 is obtained by

implementing a different bonding technique from a direct oxide/oxide bonding. In this case, the first and second bonding layers 110, 118 may not be produced on the first substrate 106 and the temporary substrate 108.

5 Detaching, at the separation interface 112, the second part 116 of the first substrate 106 with respect to the assembly comprising at least the first part 114 of the first substrate 106 and the temporary substrate 108 is then implemented. A heat treatment is then implemented during this detachment. The assembly obtained is represented in Figure 4 and further includes, in the example embodiment described, the bonding interface formed by the first and second bonding layers 110, 118. The substrate obtained is for example InPOSi (or InP on silicium) type.
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The second part 116 of the first substrate 106 is then recycled to be reused subsequently when producing a new assembly as represented in Figure 4. For example, the face of the second part 116 of the first substrate 106 which was detached from the first part 114 may be subjected to polishing and cleaning steps so that the second part 116 of the first substrate 106 can be usable for producing a new assembly as represented in Figure 4. Such
15 polishing and cleaning steps are also implemented on the first part 114 of the first substrate 106.

At this stage of the method, in a particular configuration, it is possible to implement, using the superficial layer formed by the first part 114 of the first substrate 106 mounted on the temporary substrate 108, integration steps conventionally carried out in the
20 field of III-V materials (heat treatment, epitaxy, cleaning, CMP, etc.).

The assembly obtained including at least the first part 114 of the first substrate 106 and the temporary substrate 108 is then cut into several portions, or chips, 120 such that each of the portions 120 includes at least a part of the superficial layer of the first substrate 106, i.e. the first part 114 of the first substrate 106, and a part of the temporary substrate 108.
25 In the example embodiment described, each of the portions 120 also has a part of the bonding interface formed by the first and second bonding layers 110, 118. In Figure 5, four portions 120 are represented. Each of the portions 120 corresponds to a chip with a rectangular-shaped cross-section, in a plane parallel with the face of the first part 114 of the first substrate 106 against which the first bonding layer 110 is located. Other shapes of portions 120 may be envisaged. Furthermore, the dimensions of each of the portions 120 are dependent on the
30 applications envisaged for the substrate 100, and are in particular such that the portions 120

can be subsequently handled during “pick and place” type steps (for example between a few millimetres and several centimetres).

Figure 5 also shows that the temporary substrate 108 is cut into several parts, i.e. it is crossed entirely along its thickness during cutting.

5 The portions 120 are then attached to the support layer 104 such that, for each of the portions 120, the part of the first part 114 of the first substrate 106 is disposed between the support layer 104 and the part of the temporary substrate 108. In the example embodiment described, this attachment is obtained between the bonding layers, corresponding for example to oxide layers for implementing a direct bonding, formed
10 previously on the first part 114 of the first substrate 106 and the support layer 104. Thus, prior to this attachment, a third bonding layer 122, corresponding for example to a layer of amorphous material such as oxide, for example SiO_2 , is therefore deposited on the first part 114 of the first substrate 106, and a fourth bonding layer 124, corresponding for example to a layer of amorphous material such as oxide, for example SiO_2 , is deposited on the support
15 layer 104. The positions of the portions 120 on the support layer 104 as well as the density with which the portions 120 are mounted on the support layer 104 are dependent on the targeted applications for the substrate 100 obtained at the end of the method.

 In the example embodiment described, the support layer 104 corresponds to a substrate of which the diameter is greater than that of the first substrate 106, for example
20 greater than or equal to 200 mm. The support layer 104 includes for example silicon. Alternatively, the support layer 104 may include one or more materials different from silicon, according to the targeted applications for the substrate 100 obtained at the end of the method.

 A consolidation annealing of the bonding carried out between the portions 120
25 and the support layer 104 may be implemented.

 The substrate 100 is completed by removing the part of the temporary substrate 108 of each of the portions 120. In the example embodiment described, the parts of the bonding interface formed by the first and second bonding layers 110, 118 and present in each of the portions 120 are also removed. This material removal is for example carried out by
30 implementing a grinding and/or CMP and/or liquid phase or plasma chemical etching step. The substrate 100 obtained is represented in Figure 7. In the substrate 100, the parts of the superficial layer of the first substrate 106 (formed by the first part 114 of the first substrate

106) present on the support layer 104 (and also on the bonding interface formed by the third and fourth bonding layers 122, 124) form a superficial layer of the first material of the substrate 100.

5 A second embodiment of a method for producing a substrate 100 comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer 104 of a third material is described hereinafter with reference to Figures 8 to 16.

10 The steps previously described with reference to Figures 1 to 4 are implemented at first, these steps being represented in Figures 8 to 11. The first substrate 106, the bonding layers 110, 118 and the temporary substrate 108 used in this second embodiment are for example similar to those used in the first embodiment. Following these steps, the assembly obtained includes the first part 114 of the first substrate 106 forming a superficial layer disposed on a temporary substrate 108 and attached thereto by a bonding interface formed by the first and second bonding layers 110, 118.

15 A layer 126 of at least one second material is then produced on the first part 114 of the first substrate 106 (see Figure 12). This layer 126 is for example produced by epitaxy using the first part 114 of the first substrate 106 as growth substrate. The second material corresponds to a material wherein the crystallographic structure is lattice-matched with that of the first material of the first part 114 of the first substrate 106. When the first material
20 corresponds to InP, the second material corresponds for example to an III-V material such as InGaP or InGaAs. The layer 126 may also correspond to a stack of several different materials, forming for example devices such as diodes, sensors, etc.

25 The assembly obtained is then cut into several portions 120 such that each of the portions 120 includes at least a part of the superficial layer of the first substrate 106, i.e. the first part 114 of the first substrate 106, and a part of the temporary substrate 108. In the example embodiment described, each of the portions 120 also has a part of the bonding interface formed by the first and second bonding layers 110, 118 and a part of the layer 126 of the second material. In Figure 13, four portions 120 are represented. Each of the portions 120 has a geometry (shape, dimensions) for example similar to that described above for the
30 first embodiment.

The portions 120 are then attached to the support layer 104 such that, for each of the portions 120, the part of the layer 126 of the second material is disposed between the

support layer 104 and the part of the temporary substrate 108 (see Figure 14). In the example embodiment described, this attachment is obtained between the bonding layers, corresponding for example to oxide layers for implementing a direct bonding, formed previously on the layer 126 of the second material and the support layer 104. Prior to this
5 attachment, a third bonding layer 122, corresponding for example to a layer of amorphous material such as oxide, for example SiO_2 , is therefore deposited on the first part 126 of the second material, and a fourth bonding layer 124, corresponding for example to a layer of amorphous material such as oxide, for example SiO_2 , is deposited on the support layer 104. The positions of the portions 120 on the support layer 104 as well as the density with which
10 the portions 120 are mounted on the support layer 104 are dependent on the targeted applications for the substrate 100.

The support layer 104 used in this second embodiment is for example similar to that previously described with reference to the first embodiment.

A consolidation annealing of the bonding carried out between the portions 120
15 and the support layer 104 may then be implemented.

The part of the temporary substrate 108 of each of the portions 120 is then removed. In the example embodiment described, the parts of the bonding interface formed by the first and second bonding layers 110, 118 and present in each of the portions 120 are also removed. This material removal is for example carried out by implementing a grinding
20 and/or CMP and/or liquid phase or plasma chemical etching step. The structure obtained at this stage is illustrated in Figure 15.

The substrate 100 is completed by removing the parts of the superficial layer of the first substrate 106, i.e. of the first part 114 of the first substrate 106, present on the parts of the layer 126 of the second material. The layer 126 of the second material may be used as
25 a barrier layer. In the substrate 100 obtained seen in Figure 16, the parts of the layer 126 of the second material present on the support layer 104 (and also on the bonding interface formed by the third and fourth bonding layers 122, 124) form a superficial layer of the first material of the substrate 100.

Alternatively, it is possible not to remove the parts of the superficial layer of the
30 first substrate 106. In this case, the substrate 100 obtained corresponds to the structure seen in Figure 15, and comprising a superficial layer formed by the parts of the superficial layer of

the first substrate 106 and the parts of the layer 126 of the second material, i.e. comprising the first and second materials.

The different alternative embodiments described above for the first embodiment may also be applied to the second embodiment.

5 A third embodiment of a method for producing a substrate 100 comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer 104 of a third material is described hereinafter with reference to Figures 17 to 23.

10 The method according to this third embodiment is implemented using the first substrate 106 which is for example similar to that described above for the first and second embodiments (see Figure 17).

15 Unlike the first and second embodiments described above wherein the first bonding layer 110 is produced directly on the first substrate 106 before mounting the latter on the temporary substrate 108, the layer 126 of the second material is here produced directly on the first substrate 106, for example by epitaxy, on the side of the first substrate 106 intended to form the first part 114.

20 The layer 126 of the second material produced in this third embodiment is for example similar to that previously described with reference to the second embodiment. Similarly, the temporary substrate 108 used in this third embodiment is for example similar to that used in the first and second embodiments described above.

 The first bonding layer 110 is then produced on the layer 126 of the second material, then the ion implantation forming the separation interface 112 separating the first and second parts 114, 116 of the first substrate 106 is implemented. The assembly obtained at this stage of the method is shown in Figure 18.

25 Prior to attaching the first substrate 106 to the temporary substrate 108, a second bonding layer 118, corresponding for example to a layer of amorphous material such as oxide, for example SiO₂, is deposited on the temporary substrate 108.

30 The assembly formed by the first substrate 106, the layer 126 of the second material and the first bonding layer 110 is attached to the temporary substrate 108 such as the superficial layer of the first substrate 106, i.e. the first part 114 of the first substrate 106, is disposed between the temporary substrate 108 and the second part 116 of the first substrate 106, and that the layer 126 of the second material is disposed between the

superficial layer of the first substrate 106 and the temporary substrate 108 (see Figure 19). In the example embodiment described, this attachment corresponds to a direct oxide-oxide bonding carried out between the first and second bonding layers 110, 118. As for the first and second embodiments, other types of attachment are possible.

5 Detaching, at the separation interface 112, the second part 116 of the first substrate 106 with respect to the assembly comprising the first part 114 of the first substrate 106, the layer 126 of the second material and the temporary substrate 108 is then implemented. The assembly obtained is represented in Figure 20 and further includes, in the example embodiment described, the bonding interface formed by the first and second
10 bonding layers 110, 118.

The assembly obtained is then cut into several portions 120 such that each of the portions 120 includes at least a part of the superficial layer of the first substrate 106, i.e. the first part 114 of the first substrate 106, and a part of the temporary substrate 108. In the example embodiment described, each of the portions 120 also has a part of the bonding
15 interface formed by the first and second bonding layers 110, 118 and a part of the layer 126 of the second material. In Figure 21, four portions 120 are represented. Each of the portions 120 has a geometry (shape, dimensions) for example similar to that described above for the first embodiment.

The portions 120 are then attached to the support layer 104 such that, for each of
20 the portions 120, the part of the layer 126 of the second material is disposed between the support layer 104 and the part of the temporary substrate 108. In the example embodiment described, this attachment is obtained between the bonding layers, corresponding for example to layers of amorphous material such as oxide for implementing a direct bonding, formed previously on the first part 114 of the first substrate 106 and the support layer 104.
25 Prior to this attachment, a third bonding layer 122, corresponding for example to a layer of oxide such as SiO_2 , is therefore deposited on the first part 114 of the first substrate 106, and a fourth bonding layer 124, corresponding for example to a layer of oxide such as SiO_2 , is deposited on the support layer 104. The positions of the portions 120 on the support layer 104 as well as the density with which the portions 120 are mounted on the support layer 104
30 are dependent on the targeted applications for the substrate 100. The structure obtained after this attachment is illustrated in Figure 22. As for the first and second embodiments, other types of attachment are possible.

The support layer 104 used in this third embodiment is for example similar to that previously described with reference to the first and second embodiments.

A consolidation annealing of the bonding carried out between the portions 120 and the support layer 104 may be implemented.

5 The part of the temporary substrate 108 of each of the portions 120 is then removed. In the example embodiment described, the parts of the bonding interface formed by the first and second bonding layers 110, 118 and present in each of the portions 120 are also removed. This material removal is for example carried out by implementing a grinding and/or CMP and/or liquid phase or plasma chemical etching step. In the substrate 100
10 obtained seen in Figure 23, the parts of the layer 126 of the second material and the first part 114 of the first substrate 106 present on the support layer 104 (more specifically on the bonding interface formed by the third and fourth bonding layers 122, 124) form a superficial layer of the substrate 100 comprising the first material and the second material.

 The different alternative embodiments described above for the first and second
15 embodiments may also be applied to the third embodiment.

 A fourth embodiment of a method for producing a substrate 100 comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer 104 of a third material, is described hereinafter with reference to Figures 24 to 31.

20 The steps previously described with reference to Figures 17 to 20 are implemented at first, these steps being represented in Figures 24 to 27. The first substrate 106, the bonding layers 110, 118 and the temporary substrate 108 used in this fourth embodiment are for example similar to those used in the other embodiments. Following these steps, the assembly obtained includes the first part 114 of the first substrate 106 and the layer 126 of the second
25 material which form a superficial layer disposed on the temporary substrate 108 and attached thereto by the bonding interface formed by the first and second bonding layers 110, 118.

 The first part 114 of the first substrate 106 is then removed. This removal may be implemented using the layer 126 of the second material as barrier layer (see Figure 28).

 The assembly obtained is then cut into several portions 120 such that each of the
30 portions 120 includes at least a part of the layer 126 of the second material and a part of the temporary substrate 108. In the example embodiment described, each of the portions 120 also has a part of the bonding interface formed by the first and second bonding layers 110,

118. In Figure 29, four portions 120 are represented. The shape and the dimensions of the portions 120 are for example similar or close to those described for the preceding embodiments.

5 The portions 120 are then attached to the support layer 104 such that, for each of the portions 120, the part of the layer 126 of the second material is disposed between the support layer 104 and the part of the temporary substrate 108. In the example embodiment described, this attachment is obtained between the bonding layers, corresponding for example to oxide layers for implementing a direct bonding, formed previously on the layer 126 of the second material and the support layer 104. Prior to this attachment, a third bonding
10 layer 122, corresponding for example to a layer of oxide such as SiO_2 , is therefore deposited on the layer 126 of the second material, and a fourth bonding layer 124, corresponding for example to a layer of oxide such as SiO_2 , is deposited on the support layer 104. The positions of the portions 120 on the support layer 104 as well as the density with which the portions 120 are mounted on the support layer 104 are dependent on the targeted applications for the
15 substrate 100. The structure obtained after this attachment is illustrated in Figure 30.

The support layer 104 used in this fourth embodiment is for example similar to that previously described with reference to the preceding embodiments.

A consolidation annealing of the bonding carried out between the portions 120 and the support layer 104 may be implemented.

20 The part of the temporary substrate 108 of each of the portions 120 is then removed. In the example embodiment described, the parts of the bonding interface formed by the first and second bonding layers 110, 118 and present in each of the portions 120 are also removed. This material removal is for example carried out by implementing a grinding and/or CMP and/or liquid phase or plasma chemical etching step. In the substrate 100
25 obtained seen in Figure 31, the parts of the layer 126 of the second material present on the support layer 104 (more specifically on the bonding interface formed by the third and fourth oxide layers 122, 124) form a superficial layer of the substrate 100 comprising the second material.

The different alternative embodiments described above for the first, second and
30 third embodiments may also be applied to the fourth embodiment.

In the different embodiments described above, the support layer 104 used corresponds to a substrate of material not including active elements, for example a silicon

substrate. Alternatively, it is possible that the support layer 104 corresponds to a substrate comprising several materials, for example semiconductor-on-insulator type substrate such as an SOI substrate (silicon on insulator), and/or including active elements or components such as CMOS components.

CLAIMS

5 1. Method for producing a substrate (100) comprising a superficial layer of a first material and/or a second material obtained from the first material, disposed on a support layer (104) of a third material, including at least the following steps:

 - ion implantation in a first substrate (106) comprising the first material, forming a separation interface (112) between a first part (114) of the first substrate (106) corresponding
10 to a superficial layer and a second part (116) of the first substrate (106);

 - attaching the first substrate (106) on a temporary substrate (108) such that the superficial layer of the first substrate (106) is disposed between the temporary substrate (108) and the second part (116) of the first substrate (106);

 - detaching, at the separation interface (112), the second part (116) of the first
15 substrate (106) with respect to an assembly comprising at least the superficial layer of the first substrate (106) and the temporary substrate (108);

 - cutting said assembly into several portions (120) such that each of the portions (120) includes at least a part of the superficial layer of the first substrate (106) and/or a part of a layer of the second material (126) previously formed from the superficial layer of the first
20 substrate (106), and a part of the temporary substrate (108);

 - attaching each of the portions (120) on the support layer (104) such that, for each of the portions (120), the part of the superficial layer of the first substrate (106) and/or the layer of the second material (126) is disposed between the support layer (104) and the part of the temporary substrate (108);

25 - removing the part of the temporary substrate (108) of each of the portions (120), the parts of the superficial layer of the first substrate (106) and/or the layer of the second material (126) remaining on the support layer (104) forming the superficial layer of the first material and/or the second material.

30 2. Method according to claim 1, wherein the first material corresponds to at least one of the following materials: InP, GaAs, GaN, LTO, LNO, SiC, diamond.

3. Method according to one of the preceding claims, wherein the diameter of the first substrate (106) is equal to that of the temporary substrate (108) and is less than or equal to that of the support layer (104).

5 4. Method according to one of the preceding claims, further including, between the detachment step and the cutting step, a chemical mechanical planarisation of faces of the second part (116) of the first substrate (106) and the superficial layer of the first substrate (106) obtained from the separation interface (112).

10 5. Method according to one of the preceding claims, further including:
- before attaching the first substrate (106) on the temporary substrate (108), producing a first bonding layer (110) on the superficial layer of the first substrate (106), attaching the first substrate (106) on the temporary substrate (108) including bonding the first bonding layer (110) against a second bonding layer (118) produced on the temporary
15 substrate (108), and/or
- before attaching each of the portions (120) on the support layer (104), producing a third bonding layer (122) on the superficial layer of the first substrate (106) or the layer of the second material (126), attaching each of the portions (120) on the support layer (104) including bonding the third bonding layer (122) against a fourth bonding layer (124) produced
20 on the support layer (104).

6. Method according to one of the preceding claims, further including, between the detachment and cutting steps, producing the layer of the second material (126) on the superficial layer of the first substrate (106), and wherein attaching each of the portions (120)
25 on the support layer (104) is implemented such that, for each of the portions (120), the part of the layer of the second material (126) is disposed between the support layer (104) and the part of the superficial layer of the first substrate (106).

7. Method according to claim 5, further including, after removing the part of the
30 temporary substrate (108) of each of the portions (120), removing the parts of the superficial layer of the first substrate (106) remaining on the support layer (104).

8. Method according to one of claims 1 to 5, further including, before attaching the first substrate (106) on the temporary substrate (108), producing the layer of the second material (126) on the superficial layer of the first substrate (106), and wherein attaching the first substrate (106) on the temporary substrate (108) is implemented such that the layer of the second material (126) is disposed between the superficial layer of the first substrate (106) and the temporary substrate (108).

9. Method according to one of claims 1 to 5, further including, before attaching the first substrate (106) on the temporary substrate (108), producing a layer of the second material (126) on the superficial layer of the first substrate (106), and further including, between the detachment and cutting steps, removing the superficial layer from the first substrate (106).