METHOD FOR SIMULTANEOUSLY OBTAINING A PAIR OF SUBSTRATES COVERED BY A USEFUL LAYER

Example embodiments of the invention relate to a method of producing concurrently at least two structures each comprising at least one useful layer transferred to a substrate for applications within the fields of electronics, optoelectronics or optics.

According to the state of the art several layer transfer methods are known of.

One of them consists in implanting atomic species under the surface of a source substrate, so as to create a zone of weakness which delimits a thin layer. The next step is to bring into contact the free face of this thin layer with a support substrate, then to detach said thin layer from the remainder of the source substrate and to transfer it to said support substrate.

For a description of this method reference can be made to documentation relating to the method known under the registered trademark "Smart Cut".

This type of method generates a remainder of source substrate that need to be recycled so as to be reused during a future transfer of a layer.

This involves polishing and finishing operations that can be long and costly, as much due to the cost of the materials used to make them as to the time spent on them. In addition, for some extremely hard materials such as silicon carbide, the aforementioned recycling steps can prove to be very long and fastidious.

Another layer transfer method is known of, namely "BESOI" (Bond and Etch Back Silicon on Insulator), according to which after having bonded via molecular adhesion a source substrate onto a support substrate the next step is the burning-in method and/or etching via chemical attack then the polishing of the free surface (or rear face) of this source substrate until a thin layer of desire thickness is obtained on said support.

It is to be noted that such a method implies the destruction of the majority of the source substrate on each structure made, so that it is not economically viable, notably when the material constituting the thin layer to be transferred is expensive.

Finally, in the particular case of "SOI" (Silicon on Insulator) type materials that comprise a layer of thick silicon covered in a buried layer of silicon dioxide (SiO_2) and a transferred superficial layer of silicon, the same problems relative to recycling are present for the silicon material that was used to form said transferred layer.

Additionally, over and above the aforementioned recycling problems, it is also difficult to transfer very thin layers, that meaning of a thickness of less than 100 nanometres (100 nm), using the aforementioned Smart Cut type method. Indeed, the thin layers transferred this way have numerous defects, such as blisters, due to, for

example, a treatment carried out to strengthen the bonding interface between this thin layer and the support substrate.

This problem of transferring very thin layers of good quality also exists for SOI substrates, in which it is noted that below a certain thickness in particular of the buried silicon dioxide, for example 20 nm, the transferred layer of silicon has defects, the latter being all the more so if a high temperature thermal treatment is also used. In this regard, reference can be made to the article by Q.-Y. Tong, G. Cha, R. Gafiteau and U. Gösele, "Low temperature wafer direct bonding", J. Microelectomech Syst., 3, 29, (1994).

During the thermal treatments, for example to strengthen the bonding interface, known as "stabilising" coming into play after detachment, a gas is created in the bonding interface. In the case of a thick SOI substrate, the thickness of the transferred layer is great and fills the role of a stiffener.

In the case of a thin SOI substrate in which the transferred layer and/or the oxide layer are thin, the aforementioned absorption and stiffening phenomena do not take place and the degassing leads to the occurrence of poor bonding.

Further, it is also known, as per the document WO 01/115218, that the implantation steps of atomic species and the detachment steps create defects and that these are principally concentrated on the inside of the layer to be transferred. The thinner this layer is the poorer the quality will be.

A process of producing a SOI substrate, comprising steps of transferring a layer from a first substrate

toward a second one, is known from the document EP-0 867 921. However, this process does not aim to obtain two pairs of structures in one step.

It is also known, as per the document US-2002/068,418, a process, which consists in implanting hydrogen in both the front and the rear faces of a source substrate covered by an oxide layer, in order to define two delamination planes. Two receiving substrates are then applied on each of the opposite faces of the source substrate, then the detachment is conducted alond said delamination planes, in order to obtain jointly two SOI substrates.

However, this process needs to hold said source substrate by supporting means during the step of implantation. This support causes the pollution of at least one of the two front or rear faces of the source substrate, due to the presence of contaminants which are undesirable in the continuation of the process.

The example embodiments seek to overcome the aforementioned inconveniences and to provide an economic method for the transfer of layers, limiting the number of source substrates to be recycled.

According to a first aspect of the present invention, there is provided a method of producing concurrently at least a pair of structures each comprising at least one useful layer transferred to a substrate for applications within the field of electronics, optoelectronics or optics, comprising the steps consisting in:

a) preparing a structure termed of rank 1, comprising a useful layer transferred to a support substrate;

b) forming a zone of weakness on the inside of said useful layer of the structure of rank 1, via the implantation of atomic species, so as to define two layers, termed "front useful layer" and "rear useful layer", the rear useful layer being located between said front useful layer and said support substrate;

c) adhering a stiffening substrate onto the free surface of said front useful layer;

d) proceeding to the detachment of the stacks of layers obtained in step c), along said zone of weakness, via the application of stresses, so as to obtain two structures known as of rank 2, the first comprising at least said support substrate and said rear useful layer and the second comprising at least said stiffening substrate and said front useful layer.

According to an alternative of the invention, the cycle of operations as described in steps b) to d) is to be repeated using as a starting structure at least one of the structures of rank 2 and using stiffening substrates and, if need be, this cycle of operations is repeated at least once, from at least one of the structures of following ranks.

Preferably, the transferring operation of step a) comprises a bonding step, the useful layer coming directly into contact with the support substrate, or one or several intermediate layers being inserted between the useful layer and the support substrate.

Also preferably, the adhering operation of step c) is via bonding, the stiffening substrate coming directly into contact with the free surface of the front useful layer, or at least an interposed layer being inserted

between the stiffening substrate and the free surface of the front useful layer.

Advantageously, the aforementioned bonding may be via molecular adhesion.

According to other advantageous and non-restrictive characteristics of the example embodiments, taken alone or combined:

- the intermediate layer is made in a material chosen from among silicon dioxide (SiO_2), silicon nitride (Si_3N_4), high permittivity insulating materials, diamond and strained silicon;
- the interposed layer is made in a material chosen from among silicon dioxide (SiO_2), silicon nitride (Si_3N_4), high permittivity insulating materials, and diamond;
- at least one of the elements from among the support substrate, the stiffening substrate and the useful layer is made in a semiconductor material;
- the support substrate comprises at least one layer of material chosen from among silicon, silicon carbide, sapphire,, diamond, germanium, quartz, yttrium-stabilised zirconia and an alloy of silicon carbide;
- the stiffening substrate comprises at least one layer of material chosen from among silicon, silicon carbide, sapphire, diamond, germanium, quartz, yttrium-stabilised zirconia and an alloy of silicon carbide;
- the useful layer is made in a material chosen from among silicon, silicon carbide, sapphire, diamond, germanium, silicon-germanium, III-V compounds and II-VI compounds;
- according to a particular alternative, the support substrate is in single-crystal or poly-crystal silicon, the useful layer in single-crystal silicon, the

stiffening substrate in single-crystal or poly-crystal silicon, the intermediate layer and the interposed layer in silicon dioxide;

- the useful layer of the structure of rank 1 is obtained via the creation of an initial zone of weakness on the inside of a source substrate, this initial zone of weakness separating said useful layer from the remainder of the source substrate, via the application of this source substrate onto said support substrate then via detachment of said remainder along the initial zone of weakness;

- the initial zone of weakness is created via the implantation of atomic species or is a porous zone;

Other characteristics and advantages of the invention become clearer upon reading the following description of several embodiments of the invention. This description is in reference to the annexed drawings in which:

- Figures 1A to 1C are diagrams illustrating the different steps of a method of producing a structure comprising a useful layer transferred to a support substrate;

- Figures 2A to 2C are diagrams illustrating an alternative embodiment of the method represented in Figures 1A to 1C according to which a structure comprising a useful layer transferred to a substrate via an intermediate layer is obtained;

- Figures 3A to 3F are diagrams illustrating the different steps of a first embodiment of the method of producing concurrently at least a pair of structures according to the invention;

- Figures 4A to 4F are diagrams illustrating an alternative embodiment of the method represented in Figures 3A to 3F;

- and Figures 5A to 5F are diagrams illustrating the different steps of a second embodiment of the method according to the invention.

The method according to the invention is carried out from a first structure 5 or 5', termed of rank 1, obtained for example via one of the methods whose successive steps are illustrated in Figures 1A to 1C or 2A to 2C.

Figure 1A shows a source substrate 1 whose inside has a zone of weakness 4 delimiting two parts, i.e one useful layer 11 and the remainder 12 of this source substrate or rear part. In the continuation of this description and in the claims, this zone of weakness 4 is named "initial zone of weakness".

The source substrate 1 has a face 13, termed the "front face" which is intended to come into contact with a support substrate 2 which will be described later.

Advantageously, the source substrate 1 is chosen from among semiconductor materials, notably those commonly used for applications in the field of electronics, optoelectronics or optics.

By way of example, purely illustrative, it could be in silicon, silicon carbide, sapphire, diamond, germanium, silicon-germanium, III-V compounds or II-VI compounds.

III-V compounds are compounds of which one of the elements belongs to the column III of the periodic table and the other to the column V, such as for example, gallium nitride (GaN), gallium arsenide (AsGa) or indium phosphide (InP).

II-VI compounds are compounds of which one of the elements belongs to the column II of the periodic table and the other to the column VI, such as for example, cadmium telluride (CdTe).

The source substrate 1 can also be a compound substrate, that meaning a substrate composed of a solid part, for example in silicon, on which lies a buffer layer, for example in silicon germanium (SiGe).

According to a first alternative embodiment, the initial zone of weakness 4 can be obtained via implantation of atomic species.

The expression "implantation of atomic species" means any bombardment of atomic, molecular or ionic species, which can introduce these species into a material, with a maximum of concentration of these species located at a predetermined depth with respect to the bombarded surface 13.

The implantation of atomic species in said source substrate 1 can be carried out for example using an ion beam implanter or a plasma immersion implanter.

Preferably, this implantation is carried out by ion bombardment. More preferably, the ionic species that is implanted is hydrogen. Other ionic species can be advantageously used alone or combined with hydrogen, such as rare gases (for example helium).

This implantation results in creating in the volume of the source substrate 1 and at an average depth of penetration of the ions, the initial zone of weakness 4 which extends substantially parallel to the plane of the front face 13. The useful layer 11 extends between the front face 13 and this zone of weakness 4.

For the carrying out of this step reference can be made to the documentation regarding the method known under the registered trademark "Smart Cut".

The initial zone of weakness 4 can also be constituted by a porous layer obtained for example as described in the document EP-0 849 788. In this case, the useful layer 11 is obtained via epitaxy.

The support substrate 2 acts as a mechanical support and thus generally has a thickness of at least about 300 micrometres.

Preferably it is constituted of any single-crystal or poly-crystal semiconductor material often used in the aforementioned applications.

This support substrate 2 can be a single-layer solid substrate chosen for example from among silicon, silicon carbide, sapphire, diamond, germanium, quartz, yttrium-stabilised zirconia ($ZrO_2(YO_3)$) and an alloy of silicon carbide.

The support substrate 2 has one face 20, termed the "front face" which is intended to receive the front face 13 of the source substrate 1.

Then, as represented in Figure 1B, the front face 13 of the useful layer 11 is directly bonded onto the support substrate 2, that meaning without an intermediate layer. Advantageously, this bonding is carried out via molecular adhesion.

After a possible thermal annealing step, the detachment of the remainder 12 along the initial zone of weakness 4 is carried out via the application of stresses (see Figure 1C).

To do this, one of the following techniques is used: the application of stresses of mechanical or electric

origins, chemical etching or the application of energy, for example the use of a laser, of microwaves, of an inductive heater, a thermal treatment in an oven. These techniques of detachment are known to those skilled in the art and will not be described in any further detail. They can be used alone or combined.

The structure termed of rank 1, reference 5, comprising the useful layer 11 transferred to a support substrate 2 is thus obtained.

Figures 2A to 2C illustrate an alternative embodiment of the method which has been jointly described with Figures 1A to 1C but differ to the latter in that at least one intermediate layer 3 is inserted between the useful layer 11 and the support substrate 2.

All the same, for simplification reasons, in Figures 2A to 2C and in Figures 5A to 5F only one intermediate layer 3 has been represented.

Advantageously, each of these intermediate layers 3 are made in a material chosen from among silicon dioxide (SiO_2), silicon nitride (Si_3N_4), high permittivity insulating materials, and diamond.

It is also possible to have an intermediate layer of strained silicon on a useful layer of relaxed silicon-germanium (SiGe). In the case where there are several intermediate layers 3, the latter can be either of the same nature or of a different nature.

This intermediate layer 3 can be obtained via chemical plating techniques in vapour phase or any other technique known to those skilled in the art, carried out either on the front face 20 of the support substrate 2, on the front face 13 of the source substrate 1, or on the

two front faces, and this prior to these two substrates being applied one against the other.

When this intermediate layer 3 is an oxide layer, it can also be obtained via thermal oxidation of one or the other of the two substrates 1 or 2.

Irrespective of how the intermediate layers 3 were obtained, the free surface of the upper intermediate layer is bonded to the free surface of the substrate 1 or 2 facing it, preferably via molecular adhesion.

At the end of this alternative embodiment of the method a first structure of rank 1, reference 5', is obtained comprising the source substrate 2, the useful layer 11 and the intermediate layer 3 inserted between them.

In the description and claims that follow, the word "transferred" in respects to a structure of rank 1 signifies that a useful layer is transferred to a support substrate via a method comprising at least one bonding step, with or without an intermediate layer 3.

According to another embodiment not represented in the figures, the useful layer 11 can be transferred to the support substrate 2 via the aforementioned BESOI technique, with or without an intermediate layer 3.

Figures 3A to 3C illustrate a complete cycle of steps of a first embodiment of the method according to the invention allowing for the obtaining of a pair of structures each comprising a useful layer transferred to a substrate.

As can be seen in Figure 3A, a zone of weakness 6 is formed on the inside of the useful layer 11 of the previously obtained structure 5 of rank 1, via the implantation of atomic species according to the

previously described technique for the obtaining of the initial zone of weakness 4.

Two layers are thus defined, namely, on one hand a front useful layer 110 and on the other hand a rear useful layer 120 located between said front useful layer 110 and the support substrate 2.

The following step illustrated in Figure 3B consists in adhering a stiffening substrate 71 to the free surface 130 of said front useful layer 110, via bonding, preferably by direct bonding via molecular adhesion.

Finally, the last step illustrated in Figure 3C consists in proceeding with the detachment of the stacks of layers obtained during the previous step, along said zone of weakness 6, via application of stresses, according to the techniques known to those skilled in the art and previously described jointly with Figures 1C and 2C.

Two structures 51 and 52 termed of rank 2 are thus obtained. The first structure 51 comprises the support substrate 2 and the rear useful layer 120 and the second structure 52 comprises the stiffening substrate 71 and the front useful layer 110.

It is to be noted that the useful layer 11 must have a sufficient thickness so that after the detachment step the two useful layers 110 and 120 obtained do not have any defects or blisters. The thickness of the two useful layers 110 and 120 can be identical or different according to the depth of implantation of the atomic species and therefore of the localisation of the zone of weakness 6.

It is then possible to repeat the cycle of operations that has just been described, i.e. the

creation of a zone of weakness, the adhesion of a stiffening substrate and the detachment along the created zone of weakness, to at least one of the structures 51, 52 of rank 2, or both of them, until, according to the situation, one or two pairs of structures of rank 3, respective references 511, 512, 521, 522 (see Figure 3F) are obtained.

As represented in Figure 3D, the front face 140 of the useful layer 110 is subjected to an operation of the creation of a zone of weakness 6, via implantation of atomic species, so as to define a rear useful layer 111 and a front useful layer 112.

A similar method is used to continue with the structure of rank 2, reference 51, and a front useful layer 122 and a rear useful layer 121 are obtained.

The next step is to adhere by bonding via molecular adhesion a stiffening substrate 72 to the front face 140 of the front useful layer 112 and a stiffening substrate 73 to the front face 150 of the rear useful layer 122.

As represented in Figure 3F, the next step is the detachment of the two stacks of obtained layers along the zone of weakness 6 so as to obtain four structures of rank 3.

The two structures 521 and 522 of rank 3 issue from structure 52 of rank 2 respectively comprise the stiffener 71 and the rear useful layer 111 for the first one, and the stiffener 72 and the front useful layer 122 for the second one, whereas the two structures 511 and 512 of rank 3 issue from the structure 51 of rank 2 respectively comprise the stiffener 73 and the front useful layer 122 for the first one, and the support

substrate 2 and the rear useful layer 121 for the second one.

It is then possible to repeat, if desired, the cycle of the three operations that has just been described using as the starting structure at least one of the structures of rank 3 or of the following ranks obtained later and this, until the useful layers transferred onto a substrate reach a thickness above which an extra cycle would result in the transfer of a poor quality useful layer, that meaning with defects or blisters.

Figures 4A to 4F illustrate an alternative embodiment of the method which distinguishes itself from the one described jointly with Figures 3A to 3F in that at least one interposed layer 8, respectively 8", is inserted between the stiffening substrates 71, respectively 73 and the useful layer facing it.

It is to be noted that in the figures, a single interposed layer 8, 8" has been represented for simplification reasons.

This interposed layer 8 or 8" can be made for example via chemical plating in vapour phase or any other layer plating technique known to those skilled in the art.

The interposed layers 8, respectively 8", can also be obtained via oxidation of the stiffening substrate 71, respectively 73.

This plating can be carried out either on the stiffener prior to its application onto the useful layer, or onto the latter, preferably prior to the step of implantation of atomic species purposed to create the zone of weakness 6.

The interposed layer 8 or 8" is then bonded to the layer facing it, preferably by bonding via molecular adhesion.

By way of example, the interposed layers 8, 8" are made in a chosen material from among silicon dioxide (SiO_2), silicon nitride (Si_3N_4), high permittivity insulating materials, and diamond.

In the case where there are several interposed layers 8, 8", these can be of the same nature or of different natures.

Figure 4E shows that the stiffener 72 is directly bonded onto the front useful layer 112, that meaning without an interposed layer.

Four structures of rank 3 are thus obtained, of which only two, references 521' and 511', comprise a stiffener, a useful layer and an interposed layer.

Figures 5A to 5F show a second embodiment of the method of the invention which distinguishes itself from the one described jointly with Figures 4A to 4F in that, on one hand, the starting structure used is the structure of rank 1, reference 5', comprising an intermediate layer 3 inserted between the useful layer 11 and the support substrate 2 and in that, on the other hand, an interposed layer 8' is used between the stiffener 72 and the front useful layer 112.

This interposed layer 8' is of the same nature and is obtained in the same way as the previously described interposed layers 8 or 8".

Two structures of rank 2, references 51' and 52' and four structures of rank 3, the first three references 521', 522' and 511', are obtained each comprising a stiffener, an interposed layer 8, 8' or 8" and a useful

layer, the fourth 512' comprising the support substrate 2, the intermediate layer 3 and the useful layer 121.

In the description and claims that follow, the expression "adhere a stiffening substrate onto a useful layer" encompasses the case where there is close contact between the stiffener and the useful layer and the case where at least one interposed layer 8, 8' or 8" is present between them.

In the different methods which have just been described, the expression "stiffening substrate" refers to any type of substrate that acts as a mechanical support and allows for the detachment of the useful layer from the substrate from which it issues.

The choice of the nature of the stiffener 71, 72, 73 depends on the final targeted application for the obtained structure.

The stiffening substrates 71, 72, 73 can be chosen from among the given examples for the support substrate 2.

The different methods which have just been described and their alternatives allow for the obtaining of at least one pair of structures at the end of each cycle of the method for a single source substrate 1 to be recycled, so that they are more economic and commercially feasible than the methods known to the state of the art which needs the recycling of the source substrate for each structure created.

Moreover, upon each repetition of the cycle, the operator can choose to apply stiffeners of the same nature or of different natures and comprising or not an interposed layer 8, 8' or 8". This results in the possibility of obtaining concomitantly the structures comprising stacks of different layers.

Finally, depending on the parameters of implantation of atomic species, it is also possible to create a zone of weakness 6 so that the rear useful layers 120, 111 or 121 are very thin, for example a thickness less than 50 nanometers (50 nm), whereas the neighbouring front useful layers, respective references 110, 112 or 122, are much thicker. The thickness of the front useful layer associated with that of the stiffener which is pressed against it allows the carrying out at a later step of the thermal annealing treatment without deforming nor the occurring of blisters on the rear useful layer. A transferred rear useful layer is obtained much thinner than could be obtained until to date with the methods of implantation of atomic species such as the Smart Cut method.

Additionally, the steps of implantation of atomic species carried out on the substrates of rank 1 or higher concentrate the defects in the front useful layers 110 or 122, whereas the rear useful layers 120 or 121 which were not directly subjected to the implantation have a zone with defects linked to the implantation and to the detachment extending over a lesser thickness in the detachment zone than that of the front layer.

Below is the description of an example of the method according to the invention making reference to Figures 5A to 5F.

Example 1

The structure of rank 1 used here is a structure 5' of SOI substrate type comprising a support substrate 2 in single-crystal silicon, an intermediate layer 3 in silicon dioxide SiO_2 of a thickness of 20 nm and a useful

layer 11 in single-crystal silicon of a thickness of 1.5 µm.

The next step being the creating of a zone of weakness 6 via the implantation of hydrogen ions based on an implantation energy of about 150 keV and an implantation dose of about $6.10^{16}H^+/cm^2$. A rear useful layer 120 is thus created of a thickness of 20 nm.

Now a stiffener 71 is applied in single-crystal silicon covered in an interposed layer 8 of silicon dioxide SiO_2 of a thickness of 20 nm and then the detachment along the zone of weakness 6 is carried out.

Simultaneously, a pair of substrates SOI 51′ and 52′ are thus obtained.

The cycle of the operations is then repeated using as a starting structure the SOI substrate of rank 2, reference 52'.

Once the surfaces have been prepared, the front useful layer 112 has a thickness of about 0.6 microns and the rear useful layer 111 of a thickness of about 0.6 microns. In using a stiffener 72 made in single-crystal silicon covered in a layer of silicon dioxide 8' of a thickness of 20 nm (20 nanometres), two SOI substrates of rank 3, references 521' and 522', are obtained whose respective useful layers 111 and 112, after detachment, have thickness of about 0.6 microns.

CLAIMS

1. Method of producing concurrently at least a pair of structures each comprising at least one useful layer transferred to a substrate for applications within the field of electronics, optoelectronics or optics, comprising the steps consisting in:

a) preparing a structure termed of rank 1, comprising a useful layer transferred to a support substrate;

b) forming a zone of weakness on the inside of said useful layer of the structure of rank 1, via the implantation of atomic species, so as to define two layers, termed "front useful layer" and "rear useful layer", the rear useful layer being located between said front useful layer and said support substrate;

c) adhering a stiffening substrate onto the free surface of said front useful layer;

d) proceeding to the detachment of the stacks of layers obtained in step c), along said zone of weakness, via the application of stresses, so as to obtain two structures known as of rank 2, the first comprising at least said support substrate and said rear useful layer and the second comprising at least said stiffening substrate and said front useful layer.

2. Method according to claim 1 for producing concurrently several pairs of structures each comprising at least one useful layer transferred to a

substrate, characterised in that the cycle of operations as described in steps b) to d) is repeated using as a starting structure at least one of the structures of rank 2 and using the stiffening structures and in that, if need be, this cycle of operations is repeated at least once, from at least one of the structures of following ranks.

3. Method according to claim 1 or 2, characterised in that the transferring operation of step a) comprises a bonding step, the useful layer coming directly into contact with the support substrate.

4. Method according to claim 1 or 2, characterised in that the transferring operation of step a) comprises a bonding step, one or several intermediate layers being inserted between the useful layer and the support substrate.

5. Method according to any one of the previous claims, characterised in that the adhering operation of step c) is via bonding, the stiffening substrate coming directly into contact with the free surface of the front useful layer.

6. Method according to any one of the previous claims, characterised in that the adhering operation of step c) is via bonding, at least one interposed layer being inserted between the stiffening substrate and the free surface of the front useful layer.

7. Method according to one of the claims 3 to 6, characterised in that the bonding is carried out via molecular adhesion.

8. Method according to claim 4, characterised in that said intermediate layer is made in a material chosen from among silicon dioxide (SiO_2), silicon nitride (Si_3N_4), high permittivity insulating materials, diamond and strained silicon.

9. Method according to claim 6, characterised in that said interposed layer is made in a material chosen from among silicon dioxide (SiO_2), silicon nitride (Si_3N_4), high permittivity insulating materials, and diamond.

10. Method according to any one of the preceding claims, characterised in that at least one of the elements from among the support substrate, the stiffening substrate and the useful layer is made in a semiconductor material.

11. Method according to any one of the preceding claims, characterised in that the support substrate comprises at least one layer of material chosen from among silicon, silicon carbide, sapphire, diamond, germanium, quartz, yttrium-stabilised zirconia and an alloy of silicon carbide.

12. Method according to any one of the preceding claims, characterised in that the stiffening substrate comprises at least one layer of material chosen from among silicon, silicon carbide, sapphire, diamond, germanium, quartz, yttrium-stabilised zirconia and an alloy of silicon carbide.

13. Method according to any one of the preceding claims, characterised in that the useful layer is made in a material chosen from among silicon, silicon carbide, sapphire, diamond,

germanium, silicon-germanium, III-V compounds and II-VI compounds.

14. Method according to any one of the preceding claims, characterised in that the support substrate is in single-crystal or poly-crystal silicon, the useful layer in single-crystal silicon, the stiffening substrate in single-crystal or poly-crystal silicon, the intermediate layer and the interposed layer in silicon dioxide.

15. Method according to any one of the preceding claims, characterised in that the useful layer of the structure of rank 1 is obtained via the creation of an initial zone of weakness on the inside of a source substrate, this initial zone of weakness separating said useful layer from the remainder of the source substrate, via the application of this source substrate onto said support substrate then via detachment of said remainder along the initial zone of weakness.

16. Method according to claim 15, characterised in that the initial zone of weakness is created via the implantation of atomic species.

17. Method according to claim 15, characterised in that the initial zone of weakness is a porous zone.