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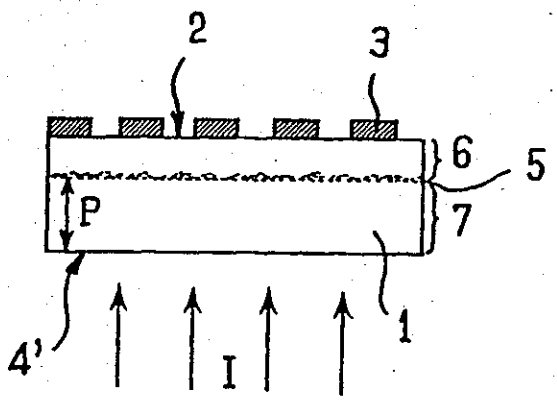
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[Suite sur la page suivante]

(54) Title: METHOD FOR OBTAINING A SELF-SUPPORTED SEMICONDUCTOR THIN FILM FOR ELECTRONIC CIRCUITS

(54) Titre : PROCEDE D'OBTENTION D'UNE COUCHE MINCE AUTO-PORTEE D'UN MATERIAU SEMI-CONDUCTEUR SUPPORTANT AU MOINS UN COMPOSANT ET/OU CIRCUIT ELECTRONIQUE



(57) Abstract: The invention concerns a method for obtaining a self-supported thin film made of a semiconductor material, supporting at least an electronic component and/or circuit (3) one of its surfaces, from a wafer (1) of said material, the latter including a front side (2), supporting or designed to support at least an electronic component and/or circuit (3) and a rear side (4'). Said method is characterised in that it comprises steps which consist in: a) implanting atomic species inside said wafer (1), from its rear side (4, 4'), so as to obtain a weakened zone (5) delimiting a front part (6) extending from said front side (2) to said weakened zone (5) and a rear part (7) formed by the rest of the wafer (1); d) removing said rear part (7), the front part (6); repeating, if required, steps a) and b) on the rear side of said front part (6) until the latter has the desired thickness for forming said self-supported thin film.

(57) Abrégé : L'invention concerne un procédé d'obtention d'une couche mince auto-portée d'un matériau semi-conducteur, supportant au moins un composant et/ou circuit électronique (3) sur une de ses faces, à partir d'une plaquette (1) dudit matériau, celle-ci présentant une face avant (2), supportant ou destinée à supporter au moins un composant et/ou circuit électronique (3) et une face arrière (4'). Ce procédé est remarquable en ce qu'il comprend les étapes consistant à : a) implanter des espèces atomiques à l'intérieur de ladite plaquette (1), depuis sa face arrière (4, 4'), de façon à obtenir une zone de fragilisation (5) délimitant une partie avant (6) s'étendant de ladite face avant (2) à ladite zone de fragilisation (5) et une partie arrière (7) formée du reste de la plaquette (1), b) détacher ladite partie arrière (7), la partie avant (6), c) répéter, si nécessaire, les étapes a) et b) sur la face arrière de ladite partie avant (6) jusqu'à ce que celle-ci présente l'épaisseur désirée pour constituer ladite couche mince auto-portée.

WO 03/017357 A1

A METHOD OF OBTAINING A SELF-SUPPORTED THIN SEMICONDUCTOR LAYER FOR ELECTRONIC CIRCUITS

The present invention relates to a method of obtaining a self-supported thin layer of a semiconductor material, supporting or for supporting at least one electronic component and/or circuit.

In certain fields of electronics, optics, optoelectronics, or sensors, technical advances have pushed manufacturers towards the fabrication of thinner and thinner layers provided with electronic components and circuits.

In the particular field of smart cards, there is a need for them to become thinner and thinner and thus flexible, since they will then be more tolerant to deformation. In other words, at constant deformation, the more flexible the thin layer, the greater the possibility of producing circuits of large dimensions.

In certain radio frequency type applications, an integrated circuit carried on the front face of a wafer constituted by a silicon on insulator (SOI) type substrate is coupled to an antenna to produce contact-free detection. An example is a bus or metro ticket that can validate passage for one person remote from a transceiver station.

The advantage of using an SOI type substrate is that the power consumed by components deposited on its surface is much less than the power consumed by components made on a layer of silicon. Thus for equal power, an increase in operating range is obtained.

By coupling the advantages provided by components produced on a silicon on insulator substrate with the use of the thinnest possible active layers, it is possible to obtain a product - for example a ticket - with enhanced sensitivity and for which the mechanical resistance to external stresses is very greatly improved.

Currently, the thickness of thin films before embedding (i.e. fixing the chip on the plastics card

acting as the support) is of the order of one hundred micrometers.

The technique used to obtain this range of thickness consists in carrying out a thinning operation on the rear face of a substrate, i.e. the face opposite to that supporting the electronic components. That thinning is carried out by mechanical abrasion using a grinder (grinding) and/or by chemical attack using an acid (one technique is known as spin-etching). Thin layers are thus obtained with a thickness in the range comprised between 80 micrometers (μm) and 120 μm. That technique allows high volume production.

A variety of attempts have already been made to obtain thin layers with a final thickness of less than 100 μm. However, manufacturers have come up against problems regarding yield, because of the large number of defective parts obtained, especially due to notches or cleavage of the wafers. The smart card field is one of the fields in electronics in which costs have to be as low as possible and because of this fact, yield losses of a few percent or even a few tenths of a percent cannot be tolerated.

However, because of the predicted future development of smart cards, it would be desirable to produce self-supported thin layers or thin wafers with a thickness of close to 30 μm, and supporting electronic components and/or circuits.

The prior art discloses known methods of producing self-supported layers with thickness close to a few tens of micrometers.

European patent EP-A-0 849 788 describes a method of fabricating a semiconductive article in which the surface of a monocrystalline silicon substrate is rendered porous, then a layer of non-porous silicon with the desired thickness of the active layer is grown epitaxially on that porous layer. A porous, and thus weakened, layer is thus obtained, buried between two non-

porous silicon layers. The active surface silicon layer can then be treated to deposit additional layers thereon, for example doped layers, then an adhesive film is applied to that stack of layers. Finally, after peeling off the adhesive film and breaking the stack of layers at the porous layer, and then subsequent elimination of the residue of that porous layer, it becomes possible to produce electronic components on the active layer of silicon which can be self-supported.

Unfortunately, that method comes up against problems connected with the quality of the crystalline silicon layer formed on the porous layer and with producing the porous silicon layer. Production requires unusual equipment and introduces the possibility of metal contamination.

Further, that method necessitates the fabrication of a specific substrate prior to producing the electronic components, which means that component production method has to be significantly modified. Thus, it is not generally desirable for reasons of cost.

Techniques for obtaining thin layers are also known, based on the method known under the trade name "Smart-cut", which is well known to the skilled person.

All theses techniques for obtaining thin layers involve implanting atomic species in the front face of the substrate or wafer, i.e. the face carrying or intended to carry electronic components.

French document FR-A-2 747 506 discloses a method of implantating ions that generate gas micro-bubbles on the front face of the substrate after fabricating the electronic components.

However, implanting ions through electrically active layers constituting electronic components can create defects which render such components unusable.

FR-A-2 758 907 claims to overcome that problem by masking sensitive active zones and then producing a

discontinuous zone of weakness. However, that method remains difficult to carry out.

Finally, FR-A-2 748 851 offers another solution to the problem mentioned above of electronic component dysfunction. The method disclosed therein consists in carrying out ion implantation on the front face of a substrate prior to fabricating electronic components on the same face, then only subsequently carrying out detachment of the thin layer.

However, that method requires the production of a specific substrate prior to producing the electronic components, which may mean that the component fabrication method has to be significantly modified. This is not generally desirable for reasons of cost.

The aim of an embodiment of the invention is to overcome the problems mentioned above and to obtain a self-supported layer carrying electronic components and/or circuits, i.e., a layer that is less than 30 μm thick.

To this end, one aspect of the invention concerns a method of thinning a wafer made of semiconductor material, the wafer having a first face termed the "front face" supporting - or for supporting - at least one electronic component and/or circuit and an opposing face, termed the "rear face", characterised in that it comprises steps consisting in:

a) implanting atomic species in the interior of said wafer from its rear face, to obtain a zone of weakness defining a front portion extending from said front face of said zone of weakness and a rear portion formed by the remainder of the wafer;

b) removing said rear portion from said front portion, to thin the wafer; and

c) repeating steps a) and b) on the rear face of said front portion until said front

portion has the desired thickness for constituting a self-supported thin layer.

The characteristics of the invention may render it possible to obtain thin layers in high yields that are difficult to obtain with prior art techniques, without having to modify the electronic component fabrication method or producing a specific wafer, as was often the case in the prior art.

Other advantageous but non-limiting characteristics of the invention, taken alone or in combination, are as follows:

- prior to any first implantation step a), the method consists in thinning said wafer by a mechanical and/or chemical thinning method carried out on the rear face;
- it consists in producing at least one electronic component and/or circuit on the front face of said wafer, prior to any first implantation step;
- the step of removing the rear portion is carried out by applying a heat treatment and/or applying external mechanical stresses;
- the step of removing the rear portion is carried out by blowing a jet of fluid;
- the step of removing the rear portion is carried out by scrubbing;
- the step of removing the rear portion is carried out by applying a stiffener to the rear face of said wafer, then applying a heat treatment and/or external mechanical stresses to said stiffener;
- the stiffener is applied by deposition;
- the stiffener is a layer of silicon oxide;
- the stiffener is a rigid plate;
- the rigid plate is formed from monocrystalline or polycrystalline silicon, or from glass;
- the stiffener is a flexible film;
- the stiffener is an adhesive film;
- the stiffener is a layer of wax;

- prior to the step of detaching the rear portion, a stiffener is applied to the front face of said wafer and said stiffener is removed after having obtained the self-supported thin layer;
- the wafer is formed from silicon;
- the wafer is a silicon on insulator wafer;
- the wafer is produced from a material selected from germanium, an alloy of silicon and germanium (Si-Ge), silicon carbide, gallium arsenide, indium phosphide (InP), gallium nitride (GaN) or aluminum nitride (AlN).

Other characteristics and advantages of the invention become apparent from the following description of three preferred implementations of the invention, given by way of non-limiting illustrative examples. This description is made with reference to the accompanying drawings in which:

- Figures 1 to 6 are diagrams illustrating the different successive steps of a first implementation of the method of the invention;
- Figures 7 to 12 are diagrams illustrating the different successive steps of a second implementation of the method of the invention; and
- Figures 13 to 17 are diagrams illustrating the successive steps of a third implementation of the method of the invention;
- Figures 18 to 21 are diagrams illustrating the successive steps of a variation of the method.

It should be noted that in the three implementations of the method of the invention described, the first two steps (illustrated respectively in Figures 1 and 2 for the first implementation, 7 and 8 for the second implementation and 13 and 14 for the third implementation) are identical. As a result, they are described in detail only for the first implementation.

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Figure 1 shows a wafer 1 having a first planar face 2 termed the "front face" supporting - or for supporting - at least one electronic component and/or circuit 3, and a second opposing planar face 4, termed the "rear face".

The term "electronic component and/or circuit" means any completely or partially produced structure or structural element prepared with the aim of producing components, circuits and devices in the electronics, optics, optoelectronics, or sensor fields, and more generally in the fields of applications connected with semiconductors.

The expression "supporting - or for supporting - at least one electronic component and/or circuit" means that said component(s) and/or circuit(s) have either already been produced on the front face 2 of said wafer 1 prior to commencing the steps of the method of the invention, or will subsequently be produced, but on said front face 2, while all of the other steps of the method of the invention will be carried out on the opposing face termed the "rear face".

For simplification, in the remainder of the description (and as shown in the figures), we have elected to describe the case in which the components and/or circuits 3 have been produced on the wafer 1 prior to carrying out the various thinning steps of the method of the invention.

It should be noted that in prior art methods in which the components 3 are produced after thinning, they have been produced on the front face 2.

The wafer 1 is produced from a semiconductor material, which can be monocrystalline, polycrystalline or amorphous, in particular from a silicon-based material.

Said silicon can be solid, or it can be obtained by epitaxial growth on a substrate.

Said wafer 1 can also be a "silicon on insulator" wafer, i.e., comprising a thin layer of insulator (for

example silicon oxide) inserted between an active silicon layer on which the electronic circuit is etched and a substrate acting as a mechanical support. Such a wafer is known by the acronym "SOI".

In a variation, said wafer 1 can also be produced from a material selected from germanium, an alloy of silicon and germanium (Si-Ge), silicon carbide, gallium arsenide, indium phosphide (InP), gallium nitride (GaN) or aluminum nitride (AlN).

Said wafer 1 is a few hundred micrometers thick (as an example, a 200 millimeter (mm) diameter silicon wafer is about 725 μm thick). Thus, said wafer 1 is not shown to scale in Figure 1.

The rear face 4 of said wafer 1 is then thinned employing one of the conventional methods mentioned above, i.e. mechanical abrasion and/or chemical acid attack, as shown symbolically by arrow A. It would also be possible to thin down by plasma etching. The rear face 4 is the face which does not carry electronic components.

The thinned wafer illustrated in figure 2 is obtained with thickness in the range 80 μm to 120 μm, or even 50 μm.

The rear face of said thinned wafer carries reference numeral 4'.

This step is advantageous in that it can remove a large quantity of material cheaply using a technique that is well known to the skilled person and in routine use. However, it can only be continued until a thin layer of the desired thickness is obtained since, as explained above, it results in large reduction in yield.

Continuing this method beyond thicknesses of 50 μm mentioned above greatly increases the risk of wafer rupture or notching.

Furthermore, the thickness obtained, in particular after chemical etching, is no longer homogeneous.

Further still, mechanical thinning by grinding leaves a surface zone a few microns thick that is slightly damaged - which is unacceptable when approaching the final thickness.

Finally, after chemical attack, the wafer is generally attacked more strongly at its periphery than at its center. When small thicknesses are reached, this results in a reduction in diameter and thus in a reduction in the area that can be occupied by components.

However, it should be noted that this first mechanical and/or chemical thinning step, albeit advantageous from an economical viewpoint, is optional and the subsequent step of implanting atomic species could be carried out directly on the rear face 4 of the non-thinned wafer 1.

The third step of the method shown in Figure 3 consists in implanting atomic species (arrows I) in the interior of said wafer 1, to obtain a zone of weakness 5 or a zone for the appearance of defects, at a depth close to the mean implantation depth P for said atomic species.

In accordance with a fundamental characteristic of the invention, said implantation is carried out from the rear face 4' (or 4 if the wafer has not been thinned in advance).

The term "atomic species implantation" means any bombardment of atomic species, molecular or ion, capable of introducing said species into a material with a maximum concentration of said species in said material, that maximum being located at a depth that is determined with respect to the bombarded surface. The molecular or ion atomic species are introduced into the material with energy that is also distributed about a maximum.

Implanting atomic species into the material can be carried out, for example, using an ion beam implanter or a plasma immersion implanter.

Preferably, said implantation is accomplished by ion bombardment. This consists in an ion implantation step

during which the rear race of the wafer 1 is bombarded with atomic species. Preferably, these are selected from rare gas ions (helium, neon, krypton, xenon) and hydrogen gas, taken in isolation or in combination, to create a zone of weakness 5 in the volume of the substrate at a mean ion penetration depth.

However, the implanted atomic species preferably consist of hydrogen alone.

The zone of weakness 5 that is formed defines a front portion 6 corresponding to the upper portion of the wafer 1 extending from the front face 2 supporting components 3 to said zone of weakness 5 and a rear portion 7 formed by the remainder of said wafer 1.

The energy of the implanted atomic species determines the mean species implantation depth P, calculated from the surface of the rear face 4', while the mean implanted dose allows the quantity of structural defects formed at that depth P to be determined. The skilled person will adjust these two parameters as a consequence. The expression "mean depth P" means that it does not have a single value, but can have several similar values.

In the implementation shown in Figure 3, high energy implantation is used, i.e. carried out at about 1 mega-electron-volt (MeV).

By way of illustrative example, with such an implantation energy and by implanting monoatomic hydrogen into a silicon wafer in a suitable dose (of the order of 10^{17} hydrogen atoms, for example), it is possible to obtain an implantation depth of about 15 μm.

Equipment for accomplishing such an implantation energy currently exists. In Japan, for example, the *Japan Atomic Energy Research Institute (JAERI)* has developed and used a hydrogen implanter in the 1 MeV energy range with the specific property of retaining a charge state of -1 for hydrogen ions (H- ions). For

helium, International patent application WO-A-00/61841, for example, uses an implantation energy of 3.8 MeV.

The subsequent steps of the method, shown in Figures 4 and 5, consist in detaching the rear portion 7 of the wafer 1.

In the present case, said rear portion 7 is sufficiently thick to be in the form of a monoblock layer, i.e., forming a whole.

It is then detached from the front portion 6 by applying heat treatment and/or by applying external mechanical stresses.

More precisely, detachment can be accomplished either solely under the action of supplying a suitable thermal budget, by heating the wafer 1 to a temperature sufficient to cause detachment (arrows S, see Figure 6) of the two portions 6 and 7 of the wafer, or solely by applying external mechanical stresses with no heat treatment.

In a variation, detachment can also be accomplished by means of an external mechanical stress applied during or after the heat treatment step.

Applying a mechanical stress may consist in applying a bending and/or tensile stress, or applying shear to the two portions 6 and 7, or introducing a blade or a jet of a fluid (liquid or gas), which may be continuous or may vary with time, at the interface of the layers to be detached.

Ultrasound can also be applied.

The source of the external mechanical stresses can also be electrical energy (application of an electrostatic or an electromagnetic field).

Stresses derived from heat energy may originate from applying an electromagnetic field, an electron beam, thermoelectric heating, a cryogenic fluid, a super-cooled fluid, etc.

The front portion 6 obtained constitutes a thin layer with a thickness of about 35 μm. This thin layer supports components and/or circuits 3.

The rear face 4" of said thin layer can be polished in some cases (see Figure 6) or it can undergo a variety of appropriate surface treatments so that it becomes completely planar. However, flatness is not obligatory since it is after all only the rear face.

The thin layer 6 obtained has sufficient thickness to be self-supported, and can then be cut and transferred chip by chip, to a plasticized support card, for example. Chip cutting can also take place prior to thinning.

If the thickness removed, i.e. the thickness of the rear portion 7, is insufficient, the steps of implantation and detachment illustrated in Figures 3, 4 and 5 are repeated on the rear face 4" of the front portion 6 (or thin layer 6) until it has the desired thickness, i.e. a thickness close to 30 μm.

It should be noted that very high energy implantation, i.e. beyond 1 MeV (for example 5 MeV) could increase the ion implantation depth P and remove a still greater thickness of material.

By means of the method of the invention, it is possible to thin the wafer 1 without deteriorating the electronic components 3 when these components are present on the front face 2 prior to implanting.

Further, by knowing the thickness of the original wafer 1 and by appropriate selection of the atomic species implantation parameters, it becomes possible to reduce the thickness of said wafer 1 in one or more passes by eliminating a pre-determined thickness to produce, in a relatively accurate manner, the desired final thickness for the layer 6.

The method of the invention enables implantation units to be used in an optimum manner. In general, we commence with thinning by high energy implantation to remove a rear portion 7 of substantial thickness, then it

is refined by implanting at a lower energy to remove a smaller thickness.

A second implementation of the method of the invention is illustrated in Figures 7 to 12.

Figure 9 illustrates the step of implanting atomic species carried out on the rear face 4' of the thinned wafer (or even directly on the rear face 4 of the wafer 1 that has not already been thinned).

In this case, implantation is carried out using implanters that are currently routinely used in microelectronics. The implantation energy is low, i.e. close to a few hundred kilo-electron-volts (keV).

For implantation, reference should be made to the above description of the first implementation.

As an example, when implanting monoatomic hydrogen into silicon at an implantation energy of 210 keV with an implantation dose in the range 2×10^{16} to 10^{17} monoatomic hydrogen atoms per square centimeter (cm^2), a zone of weakness 5 can be produced at an implantation depth P of about 1.5 μm to 2 μm.

Figures 10 and 11 illustrate the step of detaching rear portion 7.

In this range of small implantation thicknesses, the rear portion 7 does not exfoliate, or only partially. It does not have a homogeneous appearance. Blisters 10 are formed and the rear portion 7 has the appearance of a plurality of pieces of material (crumbs).

A shown in Figure 11, said rear portion 7 is then detached, for example using a scrubber 11 or by spraying a jet of a fluid (for example a jet of liquid under pressure or a jet of gas, such as compressed air). The scrubber 11 used is, for example, a scrubber such as those routinely used in microelectronics in association with chemical-mechanical polishing steps (CMP). The term "scrubbing" also encompasses any other equivalent technique that is known to the skilled person that can

remove particles and other pieces of material, such as polishing or using a scraper.

The steps of implantation and detachment of the rear portion 7, illustrated in Figures 9, 10 and 11, are repeated on the rear face 4" of the front portion 6 until the self-supported thin layer shown in Figure 12 is obtained.

Figures 13 to 17 illustrate a third implementation of the method of the invention.

The step of low energy atomic species implantation illustrated in Figure 15 is identical to that just described in relation to Figure 9.

After said implantation operation, a stiffener 12 is applied to the rear face 4' of the thinned wafer (or the rear face 4 of the unthinned wafer).

The term "application" means both application by deposition, such as spraying or chemical vapor deposition (CVD), and physical application consisting in placing a rigid plate or a flexible film on said front face 2. Such techniques are known to the skilled person.

The rigid plate may be a glass plate or a monocrystalline or polycrystalline silicon plate.

The flexible film may be a film formed from a plastics material, or polytetrafluoroethylene, trade mark "Teflon", or an adhesive strip.

The stiffener can also be a layer of wax.

In the case of a deposit, it is advantageously a layer of silicon oxide (SiO_2), for example.

When the stiffener 12 is a rigid plate or a flexible film, it can be bonded by molecular bonding or by eutectic bonding. In this case, the surface quality of the rear surface of the substrate must be high, or it must be polished.

Said stiffener 12 can also be bonded with an adhesive.

It is then removed (see Figure 17) by applying mechanical stresses (arrows S) or, when it is bonded, by

a heat treatment to eliminate the adhesive bonding it to the wafer 1, or by a chemical treatment, known as lift-off (dissolving the adhesive by the action of a suitable solvent).

The operations illustrated in Figures 15, 16 and 17 can be repeated a plurality of times on the rear face 4" of the front portion 6 (or thin layer 6) until it has the desired thickness (step illustrated in Figures 6 or 12).

Finally, Figures 18 to 21 illustrate a variation of the method of the invention, in which a stiffener 9 is applied to the front face 2 of the wafer 1, either prior to the atomic species implantation step (see Figure 18) or immediately after that step (see Figure 19), so that the stiffener 9 is present when the rear portion 7 is detached.

The description pertaining to the stiffener 12 is also applicable to stiffener 9, and thus said stiffener will not be described further.

Said stiffener 9 has the sole function of temporarily facilitating manipulation of the front portion 6 obtained, in particular when the thinning operations carried out on the rear face are repeated a plurality of times.

Once the desired thickness of the self-supported layer 6 has been obtained, that stiffener 9 can be removed using a suitable treatment, during the last step of the method (see Figure 21). It can optionally be removed after cutting and embedding the layer 6.

The thinning method that has been described (regardless of the selected implementation) has the advantage of being carried out on standard wafers which are routinely used in micro-electronics, on which electronic components and/or circuits are disposed using the usual equipment. Thus, there is absolutely no need to modify those prior steps of producing the wafer before carrying out the method of the invention.

More generally, this method is applicable to any substrate carrying or intended to carry electronic components on its front face.

Seven particular examples of the method of the invention will now be given.

EXAMPLE 1

A monocrystalline silicon wafer 1, 200 mm in diameter and 725 μm thick, the front face 2 of which supported electronic components and/or circuits 3, underwent a first mechanical and/or chemical thinning step. A 50 μm thick thinned wafer was thus obtained.

A step of implanting H^+ ions with an energy of 1 MeV was then carried out on the rear face 4' of said thinned wafer using an implantation dose of 1.8×10^{17} H^+/cm^2. Implantation was carried out at ambient temperature. The mean implantation depth P was 15 μm.

Heat stress was then applied to the wafer by heating to 400°C, which allowed exfoliation of the rear portion 7 to a thickness of about 15 μm.

The thin layer 6 obtained was 35 μm thick.

EXAMPLE 2

The procedure was identical to that described for Example 1, except that the heat treatment was carried out at 350°C and the rear portion 7, in the form of a continuous monoblock film, was removed by tearing using an adhesive strip (temporary stiffener).

The thin layer 6 obtained was 35 μm thick.

EXAMPLE 3

The prior thinning and implantation steps were identical to those described for Example 2, except that before the first mechanical and/or chemical thinning step, a stiffener 9 was deposited on the front face 2 of the wafer. This stiffener 9 was a silicon wafer bonded by a 5 μm thick oxide layer, planarized prior to bonding, bonding being accomplished by wafer bonding.

The thin layer 6 obtained was 35 μm thick.

EXAMPLE 4

This example repeated Example 1, with the exception that after mechanical and/or chemical thinning, the wafer 1 was 35 μm thick, implantation was plasma implantation, the implantation energy was 200 keV, the mean implantation depth P was 2 μm, the implantation dose was 1×10^{17} H^+/cm^2 and the heat treatment was carried out at 400°C.

Scrubbing was then carried out to remove the rear portion 7.

The front portion 6 obtained was 33 μm thick.

The cycle of operations was repeated once more to obtain a thin layer 6 with a final thickness of 31 μm.

EXAMPLE 5

The prior thinning and implantation steps were identical to those described for Example 1 with the exception that after mechanical and/or chemical thinning, the wafer 1 was 35 μm thick, the implantation energy was 200 keV, the mean implantation depth P was 2 μm and the implantation dose was 1×10^{17} H^+/cm^2.

Prior to implantation, a temporary stiffener 9 constituted by a glass plate was bonded to the front face 2. Bonding was accomplished using a UV reversible adhesive.

After detaching the rear portion 7, the front portion 6 obtained was 33 μm thick.

The cycle of operations was repeated twice more to obtain a thin layer 6 with a final thickness of 29 μm after removing the stiffener 9, if necessary adding a new stiffener 9 to the front face 2 between each cycle.

EXAMPLE 6

The prior thinning and implantation steps were identical to those described for Example 1, with the exception that after mechanical and/or chemical thinning, the wafer 1 was 40 μm thick, the implantation energy was

750 keV, the mean implantation depth P was 10 μm and the implantation dose was 1.3×10^{17} H^+/cm^2.

Further, prior to the implantation step, a stiffener 9 constituted by a glass plate was bonded to the front face 2. Bonding was accomplished using a UV reversible adhesive.

After implantation, a stiffener 12 constituted by a glass plate was bonded to the rear face. Bonding was accomplished using a UV reversible adhesive.

The rear portion 7 was then mechanically removed by introducing a blade or a jet of air or compressed water between the two glass plates at the zone of weakness 5.

The self-supported layer 6 obtained was 30 μm thick.

EXAMPLE 7

A monocrystalline silicon wafer 1, 200 mm in diameter and a 725 μm thick, the front face 2 of which supported electronic components and/or circuits 3, underwent a first mechanical and/or chemical thinning step. A thinned wafer with a thickness of 40 μm was thus obtained.

A step of implanting H^+ ions with an energy of 750 keV was then carried out on the rear face 4' using an implantation dose of 1.3×10^{17} H^+/cm^2. Implantation was carried out at ambient temperature. The mean implantation depth P was 10 μm.

Prior to the first mechanical and/or chemical thinning step, a stiffener 9 was deposited on the front face 2 of the wafer. Said stiffener 9 was a silicon wafer bonded via a 5 μm thick oxide layer, planarized prior to bonding, bonding being carried out by wafer bonding. The stiffener remained in place until the end of the method and would be removed when the desired thickness of layer 6 had been obtained.

Heat stress was then applied to the wafer by heating to 400°C then scrubbing, which allowed exfoliation of the rear portion 7.

The front portion 6 obtained was 30 μm thick and constituted a self-supported layer.

In the examples described above, the wafer 1 was formed from silicon.

However, it would also be possible to produce it from a material selected from germanium, an alloy of silicon and germanium (SiGe), silicon carbide, gallium arsenide, indium phosphide, gallium nitride or aluminum nitride. The wafer 1 could also be a SOI (silicon on insulator) type substrate.

CLAIMS

1. A method of thinning a wafer made of semiconductor material, the wafer having a first face termed the "front face" supporting - or for supporting - at least one electronic component and/or circuit and an opposing face, termed the "rear face", characterized in that it comprises steps consisting in:

a) implanting atomic species in the interior of said wafer, from its rear face to obtain a zone of weakness defining a front portion extending from said front face of said zone of weakness and a rear portion formed by the remainder of the wafer;

b) removing said rear portion from said front portion, to thin the wafer; and

c) repeating steps a) and b) on the rear face of said front portion until said front portion has the desired thickness for constituting a self-supported thin layer.

2. A method of thinning a wafer according to claim 1, characterized in that prior to any first implantation step a), it consists in thinning said wafer by a mechanical and/or chemical thinning method carried out on the rear face.

3. A method of thinning a wafer according to claim 1 or claim 2, characterized in that it consists in producing at least one electronic component and/or circuit on the front face of said wafer, prior to any first implantation step.

4. A method of thinning a wafer according to any preceding claim, characterized in that the step of removing the rear portion is carried out by applying a heat treatment and/or applying external mechanical stresses.

5. A method of thinning a wafer according to any preceding claim, characterized in that the step of removing the rear portion is carried out by blowing a jet of fluid.

6. A method of thinning a wafer according to any preceding claim, characterized in that the step of removing the rear portion is carried out by scrubbing.

7. A method of thinning a wafer according to any preceding claim, characterized in that the step of removing the rear portion is carried out by applying a stiffener to the rear face of said wafer, then applying a heat treatment and/or external mechanical stresses to said stiffener.

8. A method of thinning a wafer according to claim 7, characterized in that the stiffener is applied by deposition.

9. A method of thinning a wafer according to claim 8, characterized in that the stiffener is a layer of silicon oxide.

10. A method of thinning a wafer according to claim 7, characterized in that the stiffener is a rigid plate.

11. A method of thinning a wafer according to claim 10, characterized in that the rigid plate is formed from monocrystalline or polycrystalline silicon, or from glass.

12. A method of thinning a wafer according to claim 7, characterized in that the stiffener is a flexible film.

13. A method of thinning a wafer according to claim 7, characterized in that the stiffener is an adhesive film.

14. A method of thinning a wafer according to claim 7, characterized in that the stiffener is a layer of wax.

15. A method of thinning a wafer according to any preceding claim, characterized in that prior to the step of removing the rear portion, a stiffener is applied to the front face of said wafer and the stiffener is removed after having obtained the self-supported thin layer.

16. A method of thinning a wafer according to any preceding claim, characterized in that said wafer is formed from silicon.

17. A method of thinning a wafer according to any one of claims 1 to 15, characterized in that the wafer is a silicon on insulator wafer.

18. A method of thinning a wafer according to any one of claims 1 to 15, characterized in that said wafer is produced from a material selected from germanium, an alloy of silicon and germanium (Si-Ge), silicon carbide, gallium arsenide, indium phosphide, gallium nitride or aluminum nitride.