PROCESS FOR FABRICATING A SILICON-ON-INSULATOR STRUCTURE

FIELD OF THE INVENTION

The present invention relates to a silicon-on-insulator structure comprising a silicon layer, a buried oxide layer the thickness of which is 25 nm or less, and a support substrate, and to a process for fabricating such a structure.

BACKGROUND OF THE INVENTION

Silicon-on-insulator (SOI) structures are frequently used in CMOS applications.

Such structures comprise, from their useful surface to their bottom side: a thin silicon layer; a buried layer made of a dielectric material that is typically an oxide, for example SiO_2, generally denoted by the acronym BOX for Buried OXide; and a support substrate.

The thicknesses of the thin silicon layer and the oxide layer may vary depending on the intended applications.

In particular, the thickness of the thin silicon layer is reduced to a thickness of 50 nm or less, even 20 nm or less, and especially to about 12 nm in order to allow what are called FDSOI (Fully Depleted SOI) structures to be obtained, which structures have the advantage of significantly reducing operational instability and considerably improved performance relative to what are called PDSOI (Partially Depleted SOI) structures in which the thickness of the thin silicon layer is about 70 to 90 nm, namely: low dynamic power, low leakage current, high transistor density.

Among these structures, UTBOX (UTBOX standing for Ultra-Thin Buried OXide) structures, having a ultrathin buried oxide layer, show great promise because the extreme thinness of this electrically insulating layer makes it possible to apply a voltage to the back side

of the structure (i.e. to the side opposite the thin silicon layer) and therefore to precisely control the operation of the device.

The term "ultrathin" is understood to mean having a thickness of 50 nm or less.

The fabrication processes of structures having a buried oxide layer with a thickness of between 25 and 50 nm are, at the present time, quite well characterized and it is possible to produce such structures with a defectivity level that is compatible with subsequent component fabrication.

However, UTBOX structures with a buried oxide layer having a thickness of 25 nm or less, and particularly of 15 nm or less, can currently only be fabricated with a defectivity level that is not easily compatible with the requirements of component manufacturers.

More precisely, this defectivity is due to a bubbling or blistering effect that is observed at the bonding interface located between the thin silicon layer and the mechanical support, in the case of an SOI substrate fabricated using the Smart Cut™ process.

Figure 1 shows the variation in the defectivity as a function of the thickness of the BOX layer expressed in nm.

The defectivity shown in this graph is the number of bubbles counted on the surface of an SOI structure straight after the thin silicon layer has been transferred.

In the case of structures in which the BOX layer has a thickness below 15 nm (hatched zone), the bubbling is so widespread that it is impossible to count the bubbles.

Figures 2A to 2D illustrate the main steps of a first known process for fabricating such a structure employing the Smart Cut™ process.

With reference to Figure 2A, an oxide layer 2 is formed on the surface of a donor substrate 31 from which the thin silicon layer will be transferred.

A weak zone 32 is formed, at a depth corresponding to the thickness of the thin layer 3 to be transferred, through the oxide layer 2, for example by implantation of atomic species (represented by the arrows in Figure 2B).

With reference to Figure 2C, the donor substrate 31 (by way of the oxide layer 2) and the receiver substrate 1 are hydrophilically bonded by molecular adhesion.

This bonding step is followed by a bond-strengthening anneal intended to increase the bond strength.

Next, a supply of energy, for example thermal energy, causes the donor substrate 31 to cleave in the weak zone 32.

In general, the bond-strengthening anneal is carried out at a low temperature (i.e. at a temperature between 200 and 550°C) and it allows the bonding interface to be strengthened and the cleaving of the donor substrate to be initiated in the same step.

After the non-transferred part of the donor substrate has been detached, a silicon-on-insulator structure (Figure 2D) is obtained to which conventional finishing treatments (rapid thermal annealing (RTA), sacrificial oxidation, etc.) are applied, these treatments being intended *inter alia* to smooth the surface of the thin semiconductor layer and repair implantation-related defects.

The one or more RTA treatments are typically carried out at a temperature above 900°C.

In the step of bonding the two substrates, water molecules present at the interface contribute to the bonding of the surfaces.

However, during the bond-strengthening anneal, water molecules diffuse through the oxide layer 2, and above all through the thin native-oxide layer on the surface of the receiver substrate 1, and react with the silicon of the semiconductor layer 3, and above all

with the silicon of the receiver substrate 1, the reaction being the following oxidation reaction:

$2\ H_2O + Si \rightarrow SiO_2 + 2\ H_2$

This reaction therefore produces molecules of hydrogen gas, which are trapped in the buried oxide layer, the buried oxide layer thus acting as a hydrogen-gas reservoir.

However, in the case of an ultrathin oxide layer, the layer is not thick enough to store all of the hydrogen gas molecules.

The buried oxide layer therefore becomes saturated and can no longer absorb the molecules of hydrogen gas. The excess accumulates at the bonding interface where it generates defects.

This is because, as soon as the temperature of the bonded structure exceeds about 300°C, the hydrogen gas subjects defects present at the bonding interface to pressure, forming bubbles.

This effect is described in the following articles: "A model of interface defect formation in silicon wafer bonding", S. Vincent *et al.*, Applied Physics Letters, **94**, 101914, (2009); and "Study of the formation, evolution, and dissolution of interfacial defects in silicon wafer bonding", S. Vincent *et al.*, Journal of Applied Physics, **107**, 093513, (2010).

By carrying out an anneal at a temperature of between 300°C and 400°C, the generation of hydrogen gas is limited and thus the bubbling effect is prevented.

Thus, after the cleaving, a structure with a very low defectivity is obtained.

However, the bonding interface still needs to be adequately strengthened and the SOI substrate still needs to be finished without allowing bubbles to appear in the finishing steps.

At temperatures of 900°C and above, hydrogen gas is soluble in silicon.

After the cleaving, the objective is therefore to increase the temperature to 900°C (temperature above which hydrogen outgases from the silicon) rapidly

enough to set the structure and thus to prevent generation of defects at the bonding interface.

However, after a conventional RTA treatment micro-bubbles are observed to form in the structure and, although these bubbles are much smaller than those observed after the known process described with reference to Figures 2A to 2D, they make it impossible to use the structures for the intended applications.

This is a result of the fact that during the RTA the temperature was not increased rapidly enough to set the structure and prevent the bubbling effect.

It is therefore still necessary to develop a process that prevents bubbles from forming in the case of structures the BOX layers of which are 15 nm or less in thickness and in particular 10 nm or less in thickness.

To prevent H_2 from forming, document WO 2010/049496 describes a second process, the steps of which are represented in Figures 3A to 3E.

With reference to Figure 3A, an oxide layer 21 is formed on the surface of the donor substrate 31.

A weak zone 32 is formed, at a depth corresponding to the thickness of the thin layer 3 to be transferred, through the oxide layer 21, for example by implantation of atomic species (represented by the arrows in Figure 3B).

With reference to Figure 3C, an oxide layer 22 is formed on the surface of the receiver substrate 1.

Next, molecular adhesion (oxide/oxide) bonding is used to bond the donor substrate 31 to the receiver substrate 1, the oxide layers 21, 22 being located at the interface and together forming the buried oxide layer 2 of the SOI substrate.

After this bonding step, the donor substrate is cleaved.

This process achieves good results in terms of defectivity in so far as the H_2-generating reaction is limited by the presence of the two facing buried oxide layers that form a barrier to water-molecule diffusion.

Specifically, these molecules cannot reach the oxide/silicon interface, the silicon oxidation reaction cannot take place and the generation of H_2 molecules is thereby prevented.

However, bonding substrates by way of their respective oxide layers 21, 22 has the drawback that the bonding interface is not completely closed, i.e. when the structure is observed with a transmission electron microscope after the finishing anneals (RTA at 1200°C for 30 seconds), the interface between the two layers (represented by the dot-dash line 23 in Figure 3E) may still be seen.

This incompletely closed interface is liable to create electrical problems that could interfere with the operation of the electronic devices formed in or on the structure.

To produce a bond having a closed interface, the Applicant has developed an oxide-to-silicon bonding process, i.e. a process in which the oxide layer intended to form the BOX layer is formed only on one of the two substrates leaving silicon on the free surface of the other substrate.

To produce such a bond, and with a view to closing the bonding interface, it is known to plasma activate the surface of the oxide, the plasma activation being intended to increase the bond strength.

However, such an activation increases the amount of water present at the interface and therefore risks further amplifying the bubbling effect that it is desired to prevent.

Embodiments of the invention seek to define a process for fabricating a silicon-on-insulator structure having a buried oxide layer the thickness of which is 25 nm or less, and in particular 10 nm or less, allowing the formation of bubbles or blisters due to hydrogen to be prevented or at the very least minimized.

More precisely, said process preferably comprises an oxide-to-silicon bond in order to obtain a completely closed bonding interface without excessive heating of the structure being required.

Moreover, said process is preferably industrializable on existing SOI-structure production lines.

Embodiments of the invention also seek to provide a silicon-on-insulator structure comprising a buried oxide layer having a thickness of 25 nm or less, and in particular 10 nm or less, and having a very low "bubble" defectivity.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with an aspect of the invention, a process is provided for fabricating a silicon-on-insulator structure comprising a silicon layer, a buried oxide layer the thickness of which is smaller than or equal to 25 nm, and a support substrate, said process comprising the following steps:

(a) providing a donor substrate comprising said silicon layer and said support substrate, only one of said substrates being covered with said oxide layer;

(b) forming, in the donor substrate, a weak zone bounding the silicon layer;

(c) plasma activating said oxide layer;

(d) bonding the donor substrate to the support substrate, the oxide layer being located at the bonding interface, said bonding being carried out in a partial vacuum;

(e) implementing a bond-strengthening anneal at a temperature of 350°C or less, said anneal causing the donor substrate to cleave along the weak zone; and

(f) applying, to the silicon-on-insulator structure, a heat treatment for repairing defects at a temperature above 900°C - the transition from the cleaving temperature of step (e) to the defect-repairing temperature of step (f) being achieved at a ramp rate above 10°C/s.

The term "oxide" is understood in the present text to mean silicon dioxide (SiO_2).

The expression "partial vacuum" is understood to mean that the bonding step is carried out in a chamber in which the pressure is below atmospheric pressure, and in a moisture-free atmosphere i.e. an atmosphere containing less than 100 ppm of water.

According to an embodiment of the invention, the bonding step employs a partial vacuum of between 0.1 and 100 mbar, preferably of between 0.5 and 10 mbar and even more preferably of 1 mbar.

It is particularly advantageous for the anneal of the bond-strengthening step to be an anneal at a constant temperature lying between 300 and 350°C of between 5 and 15 hours in length.

Optionally, additional mechanical energy may be applied to cleave the donor substrate during or after the bonding anneal.

An oxygen plasma is preferably employed in step (c) of activating the oxide layer.

Moreover, the thickness of the silicon layer, immediately after transfer of the thin layer by the Smart Cut™ process, is advantageously 600 nm or less and preferably lies between 270 nm and 510 nm, preferably being equal to 330 nm.

According to an embodiment of the invention, the thickness of the oxide layer is 15 nm or less.

The formation of the weak zone preferably comprises implanting atomic species into the donor substrate.

There is also disclosed a silicon-on-insulator structure comprising a silicon layer, a buried oxide layer the thickness of which is 25 nm or less, and a support substrate, said structure being characterized in that the defectivity of the structure in terms of defect clusters is 60 or less.

According to a preferred embodiment, said structure is a 300 mm-diameter wafer.

The thickness of the silicon layer, after the SOI substrate has been finished, is advantageously 50 nm or less, and preferably 20 nm or less, and even more preferably 12 nm.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the invention will become clear from the following detailed description given with reference to the appended drawings in which:

- Figure 1 is a graph illustrating the variation in the defectivity as a function of the thickness of the BOX layer in a silicon-on-insulator structure;
- Figures 2A to 2D illustrate the various steps in a first known process for fabricating an SOI structure;
- Figures 3A to 3E illustrate the various steps in a second known process for fabricating an SOI structure;
- Figures 4A to 4E illustrate the various steps in the process for fabricating an SOI structure according to the invention;
- Figure 5A is a histogram showing the bond strength as a function of the pressure during the bonding of the substrates; and
- Figure 5B is a graph illustrating the optimization of the pressure of the bonding in a partial vacuum with respect to the post-cleaving defectivity.

In order to make the figures easier to understand, certain very thin layers have been enlarged and the various layers in the figures are therefore not drawn to scale.

DETAILLED DESCRIPTION OF THE INVENTION

The fabrication of a silicon-on-insulator structure having a buried oxide layer that is 25 nm or less in thickness will now be described.

To form such a structure, a donor substrate is provided from which a silicon layer, intended to form

the ultrathin layer of the SOI wafer, must be transferred.

In so far as the final ultrathin layer results from thinning of the layer transferred after the cleaving, the thickness of the silicon layer transferred from the donor substrate is substantially larger than the thickness of the final silicon layer of the SOI substrate.

Thus, to form the ultrathin layer of silicon of an SOI substrate, i.e. having a thickness of 50 nm or less, a silicon layer having a thickness of 600 nm or less is transferred from the donor substrate.

The donor substrate may be a single-crystal bulk silicon substrate.

Alternatively, the donor substrate may be a composite substrate, i.e. it may consist of a multilayer of various materials, the surface layer of which comprises the single-crystal silicon layer to be transferred.

With reference to Figure 4A, an oxide layer 2 is formed on the surface of the donor substrate 31.

Said oxide layer 2 is intended to form the buried oxide layer of the SOI structure.

Said oxide layer therefore has a thickness of 25 nm or less and preferably a thickness of 15 nm or less.

Specifically, the surface of the donor substrate 31 may be thermally oxidized.

Alternatively, the oxide may be deposited, for example by chemical vapour deposition (CVD).

Alternatively, said oxide layer 2 could be formed on the receiver substrate, by exposing the silicon to the surface of the donor substrate.

However, it is preferable for the oxide layer 2 to be formed on the surface of the donor substrate 31, especially when the weak zone is formed by implantation of atomic species. This is because the implantation is then achieved through the oxide layer 2.

A weak zone is formed in the donor substrate, this weak zone defining the silicon layer to be transferred.

Figure 4B shows the weak zone 32 being formed in the donor substrate 31 by implantation of atomic species, for example hydrogen and/or helium.

The implantation energy is chosen so that the weak zone 32 is formed at a depth substantially corresponding to the thickness desired for the layer 3 to be transferred, i.e. a thickness of 600 nm or less, preferably a thickness of between 210 and 570 nm and even more preferably a thickness of about 330 nm.

However, the formation of the weak zone is not restricted to an implantation process.

The weak zone may also be formed by any technique that can introduce atomic species into the donor substrate at the desired depth, for example a diffusion technique may be used.

With reference to Figure 4C, the donor substrate 31 is bonded by molecular adhesion to a receiver substrate 1, the oxide layer 2 being located at the interface.

The receiver substrate 1 is typically a silicon substrate, optionally covered with a native oxide.

Thus, oxide-to-silicon (donor substrate-receiver substrate) bonding is obtained.

Alternatively, as indicated above, if the donor substrate is not covered with the oxide layer 2 but has its silicon surface exposed, the oxide layer would be formed on the receiver substrate 1 and an oxide-to-silicon (receiver substrate-donor substrate) would also be obtained.

By employing such a bonding step, there is no risk of an interface that is not completely closed being obtained, in contrast to the case of oxide-to-oxide bonding as mentioned in the introduction.

Before the substrates are brought into contact, the oxide layer 2 located on the surface of the donor substrate 31 is subjected to a plasma treatment.

Preferably, said plasma is an O_2 plasma, but a plasma based on oxygen, argon, nitrogen and/or helium may also be employed.

Said plasma treatment activates the surface of the oxide layer and increases the bond strength.

The step in which the substrates are brought into contact with a view to bonding them is carried out in a partial vacuum, generally at room temperature.

Specifically, the substrates to be bonded are placed in a chamber 100 the interior of which may be depressurized.

Indeed, the Applicant has observed that carrying out the bonding step in a partial vacuum, and not at atmospheric pressure, allows the formation of bubbles to be substantially reduced.

Preferably, the absolute pressure of said partial vacuum lies between 0.1 and 100 mbar and preferably between 0.5 and 10 mbar.

Even more advantageously, the Applicant has demonstrated that a partial vacuum with an absolute pressure of 1 mbar allows the presence of water at the bonding interface to be minimized without adversely affecting the bonding quality, i.e. sufficient bond strength is preserved to allow complete transfer of the layer and thus to avoid non-transferred zones being generated in the SOI structure.

In an SOI substrate, non-transferred zones (NTZs) are holes in the thin silicon layer where the silicon has not transferred to the receiver substrate. These defects are generally due to the bond between the transferred layer and the receiver substrate not being strong enough.

Therefore, when reducing the amount of water at the interface, care should be taken to ensure that the bond between the substrates is strong enough.

Furthermore, the atmosphere of the chamber 100 is moisture-free, i.e. an atmosphere containing less than 100 ppm of water.

This very low moisture content and the partial vacuum compensate for the additional water molecules contributed by the plasma treatment.

Thus, the amount of water at the bonding interface can be minimized (without however reducing the number of water molecules to zero since the bonding will not take place in the absence of water) while, by virtue of the plasma treatment, a bond that is strong enough to prevent non-transferred zones is obtained.

Figure 5A illustrates the bond strength E (expressed in mJ/m^2) for various pressure values P applied in the chamber 100 during the bonding.

This histogram shows the results of trials in which a donor substrate with a 10 nm-thick oxide layer that was or was not subjected to an O_2 plasma activation was bonded to a silicon receiver substrate at various pressures.

For each data pair, the left-hand column corresponds to the case where the bonding was carried out without prior plasma treatment of the substrates, whereas the right-hand column corresponds to the case where the bonding was preceded by an O_2 plasma treatment of the oxide layer covering the donor substrate.

It may be seen that, when the bonding is carried out in a partial vacuum, the bond strength is lower than when the bonding is carried out at atmospheric pressure (1013 mbar).

However, the bond strength varies little between 1 and 100 mbar and a satisfactory value is obtained when a plasma treatment is applied to the donor substrate. Under these conditions, bonding in a partial vacuum does not lead to NTZs.

However, in the absence of the plasma treatment, the bond strength is too low and the number of non-transferred zones significantly increases.

Figure 5B illustrates the variation in the post-cleaving defectivity D (in terms of the number of bubbles and non-transferred zones) as a function of the pressure P applied in the chamber 100 during the bonding of the substrates.

This graph shows the results of trials in which a donor substrate with a 10 nm-thick oxide layer that was subjected to an O_2 plasma activation was bonded to a silicon receiver substrate at various pressures.

After the cleaving of the donor substrate, bubbles and non-transferred zones were counted using a visual inspection method.

It may be seen in this graph that the most advantageous pressure range (in terms of post-cleaving defectivity) lies between 0.1 and 100 mbar.

A pressure of about 1 mbar is the optimal pressure for minimizing the presence of water while also minimizing the defectivity. Furthermore, Figure 5A confirms that a pressure as low as 1 mbar is not disadvantageous in terms of bond strength and therefore in terms of NTZ defects.

It may therefore be concluded from the above that, to obtain a satisfactory compromise between bubble defects on the one hand and NTZ defects on the other hand, it is necessary both to carry out the bonding in a partial vacuum of between 0.1 and 100 mbar, preferably of about 1 mbar, and to activate the surface of the donor substrate beforehand by means of a plasma treatment.

After the substrates 1 and 31 have been brought into contact, a bond-strengthening heat treatment is carried out that also has the effect of initiating the cleaving of the donor substrate 31 in the weak zone 32.

For this purpose, a tool (oven) other than the bonding tool is used.

According to the invention, this heat treatment consists of an anneal carried out at a temperature of 350°C or less at atmospheric pressure.

It is particularly advantageous for the cleaving to initiate at a constant temperature lying between 300 and 350°C.

The temperature of the anneal must not be too low (for example lower than 250°C) because it would not

sufficiently strengthen the bond and would therefore lead to non-transferred zones being formed.

Said anneal lasts a number of hours, preferably from 5 to 15 hours.

During this anneal, the cleaving of the donor substrate 31 in the weak zone 32 is initiated.

If required, the cleaving may be assisted or triggered by applying another energy source, for example an additional source of mechanical energy.

Thus, for example, a blade may be inserted into the weak zone 32.

As will be seen in more detail below, applying such a low-temperature bond-strengthening anneal, combined with bonding in a partial vacuum, unexpectedly allows the bubbling effect observed in the final SOI structure to be reduced.

With reference to Figure 4D, after the cleaving the structure formed by the receiver substrate 1, the oxide layer 2 and the transferred layer 3 is obtained.

To form the final SOI structure (illustrated in Figure 4E), various finishing treatments are carried out on the thin silicon layer.

After these treatments have been carried out, the final layer 3′ is substantially thinner than the layer 3 that was transferred.

Moreover, an RTA treatment is carried out to repair defects in the layer 3′.

Said treatment is typically carried out at a temperature above 900°C, for example at about 1200°C.

To prevent bubbles forming in the final SOI substrate, it is important to reach the temperature of the RTA treatment very rapidly.

Thus, it is necessary to pass from the temperature of the bond-strengthening and cleaving anneal to the temperature of the RTA treatment at a ramp rate of at least 10°C per second.

This is because a temperature rise that is this rapid allows the structure to be set and prevents the formation of bubbles.

This treatment may be carried out in a chamber equipped with an infrared lamp, allowing the treatment temperature plateau to be reached in a very short time. It may for example be carried out in an oven or an epitaxial reactor.

Once a temperature of about 900°C is reached, there is no risk of bubbling occurring because, above this temperature, outgassing of the hydrogen gas occurs.

The RTA treatment typically lasts for about a number of seconds to a number of minutes, for example between 30 seconds and 15 minutes.

After this treatment, it is unimportant what ramp rate is used to return to room temperature since the hydrogen has diffused beyond the bonding interface and is therefore not capable of generating bubbles.

The influence of the transferred layer 3 has also been demonstrated by the Applicant.

Comparative trials were carried out with weak zones of 32 to 275, 330 and 510 nm.

The greater the depth of the weak zone, the smaller the number of bubbles observed after the cleaving.

However, the closer the depth of the weak zone is to these limits, the greater the number of micro-bubbles observed after the RTA treatment.

The optimal thickness of the weak zone seems to be located at about 330 nm.

Moreover, it is important to note that the combination of bonding in a partial vacuum and a low-temperature bond-strengthening anneal results in an unexpected improvement in terms of bubbling.

Specifically, the Applicant has observed that implementing, in the known Smart Cut™ process, either bonding in a partial vacuum or a low-temperature bond-strengthening anneal does not sufficiently reduce the bubbling.

The table below demonstrates the synergistic effect of these two treatments, relative to a known

Smart Cut™ process and a Smart Cut™ process in which only one of these treatments is carried out.

The table shows, at various points in the process for fabricating an SOI substrate, the number of bubbles counted using a visual inspection method and/or using a KLA-Tencor SP2 inspection tool.

In any case, the SOI structure is produced from a silicon donor substrate covered with a 25 nm-thick oxide layer and implanted so as to form a weak zone at a depth of 330 nm, and from a silicon receiver substrate.

Process Step	Known Smart Cut™ process	Smart Cut™ process with bonding in a partial vacuum (1 mbar)	Smart Cut™ process with low-temperature (300°C) anneal	Smart Cut™ process with bonding at 1 mbar and 300°C anneal (embodiment of the invention)
Post-cleaving (visual inspection)	Several hundred visible defects (essentially bubbles)	A few tens of visible defects (bubbles and NTZs)	No or very few visible defects (no bubbles)	No or very few visible defects (no bubbles)
Post-RTA (SP2 and visual inspection)	-	-	Extensive micro-bubbling observed by visual inspection	No bubbling observed either by visual or SP2 inspection
After sacrificial oxidation (SP2 inspection)	-	-	-	No bubbling observed
Final SOI substrate	-	-	-	AC < 60 interface

(SP2 inspection)				closed

These data show that, for the known Smart Cut™ process, bubbling is already very widespread post-cleaving. The bubbling was therefore not measured in subsequent steps of the process for fabricating this SOI substrate.

For the process in which the bonding was carried out at a pressure of 1 mbar, a significant decrease in the bubbling was observed post-cleaving.

However, the level of bubbling was still too high and therefore the bubbling was not measured in subsequent steps of the process for fabricating this SOI substrate.

For the process in which the bonding was carried out, in a known way, at atmospheric pressure, but in which a bond-strengthening and cleaving anneal was carried out at 300°C (or less), bubbling was not observed.

However, after the RTA treatment, micro-bubbling was observed, visible to the naked eye, over substantially the entire surface of the SOI substrate. The term "micro-bubbling" is understood to mean small bubbles present in a high density.

Although small, these bubbles are not acceptable for SOI substrates that are so thin and therefore the bubbling was not measured in subsequent steps of the process for fabricating this SOI substrate.

Therefore, applied independently of one another, bonding in a partial vacuum and the bond-strengthening and cleaving anneal alleviate the bubbling effect post-cleaving, but defects appear in subsequent steps, especially during the defect-repairing RTA treatment.

In other words, applied independently of one another, the bonding in a partial vacuum and the bond-strengthening and cleaving anneal simply seem to modify the bubbling effect, but do not allow it to be suppressed.

In contrast, combining these two treatments allows, at the end of the entire process for fabricating the SOI structure, a satisfactory level of bubbling to be obtained.

The sacrificial oxidation step carried out after the RTA treatment especially allows the useful layer of the SOI wafer to be thinned.

In the final SOI structure, the defectivity is measured in terms of defect clusters. The result of this measurement is called area count (AC).

A KLA Tencor SP2 inspection tool was used to make this measurement.

In this respect, the reader may refer to document FR 2 911 429 which describes a method and a system for detecting defect clusters.

Implementation of the process according to the invention allows an SOI structure having a defectivity, expressed in terms of defect clusters, of 60 or less, to be obtained.

CLAIMS

1. Process for fabricating a silicon-on-insulator structure comprising a silicon layer, a buried oxide layer the thickness of which is smaller than or equal to 25 nm, and a support substrate, said process comprising the following steps:

(a) providing a donor substrate comprising said silicon layer and said support substrate, only one of said substrates being covered with said oxide layer;

(b) forming, in the donor substrate, a weak zone bounding the silicon layer;

(c) plasma activating said oxide layer;

(d) bonding the donor substrate to the support substrate, the oxide layer being located at the bonding interface, said bonding being carried out in a partial vacuum;

(e) implementing a bond-strengthening anneal at a temperature of 350°C or less, said anneal causing the donor substrate to cleave along the weak zone; and

(f) applying, to the silicon-on-insulator structure, a heat treatment for repairing defects at a temperature above 900°C - the transition from the cleaving temperature of step (e) to the defect-repairing temperature of step (f) being achieved at a ramp rate above 10°C/s.

2. Process according to Claim 1, wherein the partial vacuum has a pressure of between 0.1 and 100 mbar, preferably of between 0.5 and 10 mbar and even more preferably of 1 mbar.

3. Process according to either of Claims 1 and 2, wherein the anneal of the bond-strengthening step is an anneal at a constant

temperature lying between 300 and 350°C of between 5 and 15 hours in length.

4. Process according to one of Claims 1 to 3, wherein additional mechanical energy is applied to cleave the donor substrate.

5. Process according to one of Claims 1 to 4, wherein an oxygen plasma is employed in step (c) of activating the oxide layer.

6. Process according to one of Claims 1 to 5, wherein the thickness of the silicon layer is 600 nm or less and preferably lies between 270 nm and 510 nm, preferably being equal to 330 nm.

7. Process according to one of Claims 1 to 6, wherein the thickness of the oxide layer is 15 nm or less.

8. Process according to one of Claims 1 to 7, wherein formation of the weak zone comprises implanting atomic species into the donor substrate.