PREPARING A SURFACE OF A SEMICONDUCTOR WAFER FOR BONDING WITH ANOTHER WAFER

The present invention relates to bonding two wafers comprising semiconductor materials, for the production of structures for microelectronics, optics, or optoelectronics.

More precisely, the invention relates to preparing bonding surfaces of at least one of two wafers to be bonded together.

In order to ensure good contacting quality before bonding two wafers together, at least one of the two surfaces to be bonded must be cleaned.

The presence of isolated particles or contaminants on wafer surfaces can be prejudicial to good bonding when they are located at the interface of two wafers.

This is particularly the case when, prior to bonding, one of the two bonded wafers has undergone atomic species implantation near to the surface to be bonded, followed by detachment at the zone to be implanted during the course of a method known as Smart-Cut™. Those particles, which are then enclosed in the bonding interface, can lead to superficial blisters being formed in the structure obtained after detachment and/or to zones having not been transferred between the zone at which the species were implanted and the surface of said structure. Those blisters multiply and/or grow during heat treatment, for example heat treatment carried out during or after bonding to strengthen the bond.

Thus, it is important to find a means for removing such particles and contaminants from bonding surfaces.

A conventional cleaning technique which is known in the art comprises steps of chemically treating the wafers prior to bonding.

To clean an oxidized surface of a wafer, for example a wafer of a semiconductor material, it is known to employ a treatment known as the RCA clean, which comprises:

- a first dip with a solution of SC1 (Standard Clean 1); comprising ammonium hydroxide (NH_4OH), hydrogen peroxide (H_2O_2) and deionized water, generally used at a temperature in the range 30°C to 80°C;
- a second dip with a solution of SC2 (Standard Clean 2); containing hydrochloric acid (HCl), hydrogen peroxide (H_2O_2) and deionized water, used at a temperature in the range 70°C to 90°C.

The first dip is primarily intended to remove isolated particles on the wafer surface and particles buried near to the surface, and to prevent them from re-depositing.

Further, that first SC1 dip can improve the hydrophilicity of the surface of the wafer to be bonded, the hydrophilic property of the surface here constituting an essential condition for good bonding between the two wafers.

The SC2 solution is primarily intended to remove contamination by metals which have been deposited on the surface of the wafer, by forming chlorides.

The metal removal efficiency is typically between 95% and 99% between ambient temperature and 90°C. The depth of chemical action into the wafer is typically from about 1 angstrom (Å) to about 10 Å between ambient temperature and 90°C.

For this reason, the SC2 treatment is usually employed at temperatures in the range 70°C to 90°C.

However, the surfaces obtained after implementing such chemical treatments are still rough, which can, in some cases, be more significant than prior to treatment.

This profile existing on the surface of the wafers alter all the more the bonding than the roughness value is high, measuring in angstroms RMS (Root Mean Square).

The presence of isolated particles or contaminants on the surface of the wafers can also be prejudicial to a good bonding of the wafers when they are found at its interface.

After bonding, these particles, then enclosed at the bonding interface, may lead to the formation of surface blisters in the structure obtained after the Smart-Cut™ detachment, and/or areas not transferred between the area at the level of which the species were implanted and the surface of this structure. These blisters increase in size and/or grow during heat treatment such as heat treatment undertaken in the course of or subsequent to the bonding in order to solidify it.

EP 0 971 396 particularly discloses a technique consisting of preparing a such implanted surface by implementing a SC1, then a SC2, and finally another SC1 treatment. This process comprises three steps, with a total duration of SC1 treatment of about 8 minutes (2x4 minutes) at 80°C, and a SC2 treatment of about 4 minutes at 80°C.

With the aim of maximizing the improvement in the quality of bonding between two wafers, it is therefore necessary to carry out an RCA treatment adapted to optimize its cleaning and bonding preparation action.

Embodiments of the present invention seek to improve the situation. According to a first aspect of the present invention, there is provided a method for preparing an oxidised surface of a wafer for bonding with another wafer, the oxidised surface having been subject to an implantation of atomic species, the method including a first step of cleaning the oxidised surface by employing NH_4OH and H_2O_2, and a second step of cleaning by employing hydrochloric species (HCl), wherein the first step is implemented so as to etch from about 10 Å to about 120 Å, and wherein the second step is implemented at a selected temperature below around 50°C.

Characteristics of the method for preparing a surface of an oxidised wafer are (all references to unit mass of NH_4OH correspond to NH_4OH diluted at a ratio of about 30% in water):

- the etching of the first step may be implemented so as to etch between about 10 angströms and about 60 angstroms;
- the treatment parameters of the first step may be chosen so as to remove from the surface isolated particles with an average diameter of more than about 0.1 micrometres;
- the treatment parameters of the first step may be chosen so that the roughness after treatment is less than about 5 Å RMS, or more particularly less than about 4 Å RMS;
- the dosing per unit mass of NH_4OH/H_2O_2 may be in the range from about 1/2 to about 4/4, the temperature at which this first step is processed may be between from about 30°C to about 90°C;
- percentage dosing per unit mass of NH_4OH/H_2O_2 may be about 1/2, the temperature of this mix is about 50°C, and the cleaning time of the first step may be about 3 minutes;
- the percentage dosing per unit mass of NH_4OH/H_2O_2 may be about 2/4, the temperature of this mix is about 70°C and the cleaning time of the first step may be about 3 minutes;
- the dosing per unit mass of NH_4OH/H_2O_2 may be about 3/4, the temperature of this mix is about 80°C, and the cleaning time of the first step may be about 3 minutes;
- the second step of cleaning may be carried out so that about 95% to 99% of the metallic contaminants present on the wafer surface are removed;
- the selected temperature at which the mixture of the second step may be employed is about room temperature;

- the selected temperature employed during the second step may be greater than about 0°C;

the cleaning time of the second step may be less than about 10 minutes, and more specifically about 3 minutes;

- a step of plasma activation may be implemented previously to the first step.

According to a second aspect of the present invention, there is provided a method of removing a thin layer from a first wafer having superficial oxide layer, comprising the following steps:

a) forming a zone of weakness in the first wafer at a depth close to the thickness of the thin layer to be formed,
b) preparing the oxide surface of the first wafer in accordance with the said method for preparing an oxidized surface,
c) bonding the first wafer to a second wafer at the surface prepared in step b),
d) supplying energy to detach the thin layer bonded to the second wafer, at the zone of weakness.

Characteristics of the method of removing a thin layer according to embodiments of the present invention are:

- a step of thermal oxidation of the surface to be prepared in step b) may be carried out prior to step b);
- the method may further comprise preparing the bonding surface of the second wafer in accordance with the said method for preparing an oxidized surface;
- a step of thermal oxidation of the surface of the second wafer may be carried out prior to preparing said surface;
- the zone of weakness formed during step a) may be obtained by implanting atomic species to a depth close to that of the zone of weakness.

According to embodiments of the present invention, there is provided an application of the thin layer removal method to the producing of a semiconductor-on-insulator structure.

Other aspects, purposes and advantages of the invention are described in the remainder of this document in illustration of the following figures.

Figure 1 shows the different steps (figures 1a - 1d) of a "Smart-Cut™" technology.

Figure 2 is a graph showing measurements of the roughness on wafers after different cleaning operations.

Figure 3 is a graph showing the same measurements as those shown in figure 2, here used to predict the roughness obtained during more substantial cleaning operations.

- Figure 4 is a graph showing measurements of the effectiveness of surface particle removal from a wafer as a function of depths of etch caused by the cleaning.

Figure 5 is a graph showing measurements of the number of blisters observed on wafers obtained after removal using a Smart-Cut™ method, in which prior to bonding, a SC2 treatment has been carried out at a temperature of 50°C or a SC2 treatment has been carried out at a temperature of 80°C, after a SC1 treatment according to the invention.

The wafer cleaning steps according to the invention may be included in a thin layer removal process according to the so-called Smart-Cut™ process.

With reference to figure 1a, a first stage of this layer removal process may consist in oxidising a wafer of semi-conductor material, so as to make a donor wafer 10 having a superficial oxide layer 11.

This oxidation may be native or made under heat treatment (i.e. thermal oxidation), or by deposit of aggregates of SiO_2.

With reference to figure 1b, the donor wafer 10, so oxidised, is subjected, through one of these oxidised surfaces, to an implantation of atomic species, such as an implantation of hydrogen and/or helium.

These atomic species, used during the implantation, are dosed and are sent with a pre-set energy, to a pre-set depth under the surface of the donor wafer 10, an embrittlement area 15 that has a particular brittleness relative to the rest of the donor wafer 10. Thus, a film 16 is formed, delimited by the embrittlement area 15 and the oxidised surface that has been subject to the implantation 12.

With reference to figure 1c, a receiver wafer 20 is brought into contact with the oxidised surface, which has been subject to the implantation 12, of the donor wafer.

The bonding property firstly used is a molecular adhesion between the surfaces brought into contact.

An optional heat treatment is then carried out to enhance the bonding linkages between the two wafers. It is carried out at one or more predetermined temperatures and for a predetermined duration so that the bonding efficiency is optimal and to avoid the creation of structural defects on the wafer surface. As an example, it may be possible to use a temperature of about 300°C for about 30 minutes. Actually, this heat treatment will cause the disappearance of a large proportion of the SiOH bonds to the advantage of the stronger covalent Si-O-Si bonds.

Then, sufficient energy, such as heat and/or mechanical energy, is supplied to break the weak bonds of the embrittlement area 15, and thus to cause the detachment of the thin film 16 from the donor wafer 10, thus forming the semiconductor-on-insulator structure 30, shown in figure 1d, the thin film 16 removed from the donor wafer 10 then forming the semiconductor part, and the underlying oxide layer 17 then forming the electrically insulating part of the structure 30.

The detached and bonded surface is advantageously finished, for example by chemical etching, sacrificial oxidation, polishing, chemical mechanical polishing or CMP, atomic species bombardment or any other smoothing technique. The final structure is then intended for applications in microelectronics, optics or optoelectronics.

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It will for example be possible to form components in the detached layer.

It is thus possible to make semiconductor-on-insulator structures such as SOI, SGOI (Silicon Germanium on Insulator), SOQ (Silicon on Quartz), GeOI (Germanium On Insulator) structures, an alloy constituted by components belonging to the III-V on insulator family; each having an insulating layer comprising the cleaned oxide according to the invention interposed between the detached layer and the other wafer.

As we have shown above, the stage of bonding the donor wafer 10 to the receiver wafer 20 constitutes an essential stage in the Smart-Cut™ process.

A major purpose of the present invention is therefore to improve this bonding between the two wafers 10 and 20, particularly by meeting the four following objectives:

- to remove isolated particles from the surface of at least one of the wafers to be bonded so as to reduce the appearance of post-bonding defects;
- to reduce the size and the number of the roughness on the wafer surface so as to increase the contact areas of the surfaces to be bonded, and thus to improve the bonding energy;
- to make and to keep the surfaces hydrophilic to maximize bonding energy;
- to remove contaminants on the surface of at least one of the wafers to be bonded to reduce the appearance of post-bonding defects.

Another purpose is the possibility of meeting these purposes by means of a simple, fast and cost-effective technique.

Another purpose is to produce a semiconductor-on-insulator structure from a Smart-Cut™ process incorporating steps according to the invention.

Another purpose is to control the preparation for the bonding of an oxidised surface that has been subject to an implantation 12. Indeed, the Applicant has noticed that such a surface is about 5 times more sensitive to such a preparation than if it had not been subject to an implantation. To this end, it is therefore imperative to set preparation parameters that are adapted and calibrated very accurately.

The wafer to be prepared may be constituted by any type of semiconductor material.

However, the wafer material will here be restricted to silicon, which is the material on which the Applicant has made the studies described below.

This wafer was oxidised naturally (we then speak of native oxide) or artificially (this is for example the case with a thermally formed oxide).

Optionally, a preliminary step of plasma activation of at least one oxide surface to bond may be implemented.

The invention proposes then a method for preparing this surface of the wafer for bonding with another wafer, implementing at least one chemical treatment step that employs ammoniated chemical species mixed with molecules of H_2O_2.

Preferably, these chemical species are supplied in a moist medium.

The chemical species are for example diluted in deionised water. An ammoniated solution of this kind is also called a SC1 solution.

This first cleaning step implemented by means of this SC1 solution is particularly the result of the following effects (obtained by the chemical action of this solution):

- the etching of the surface by digging under the particles and thus by "stripping" them (otherwise known as a "lift-off" effect),
- the creation of an opposite electric potential between the surface and the particles, linked directly to the high pH of the solution causing the detachment of isolated particles,
- the prevention of the migration of particles from the bath to the plate, given by the opposite electrical potential created.

This cleaning is therefore linked particularly to the high pH of the ammoniated solution, including as a result a significant concentration of OH^- ions in solution.

These ions, during the etching of the oxide by the ammonia, will react with the pendant bonds generated on the surface and saturate them in SiOH termination. This layer of SiOH formed on the surface will then create said repelling opposite potential, able to bring away from the surface the particles that are least bonded to the surface (in other words the isolated particles) and to prevent them from resettling.

These surface SiOH bonds will also be the point of adsorption of water molecules on the surface of the wafer, thus causing its hydrophilisation. This hydrophilisation will then improve the bonding with another wafer.

With reference to figure 2, the results are shown of a study undertaken by the Applicant that consists in finding relationships between the thicknesses of materials etched (also called depths of etch) by different SC1 solutions, with the roughness being measured that are present on the wafer surface.

The depths of etch are here measured by reflectometry, and the roughness is measured using an AFM (Atomic Force Microscope), on wafers of silicon that have been oxidised and have been subjected to ion implantations.

The level of particle removal is determined by reflectometry measurements prior to and following each SC1 treatment. Measurements, typically taken with a laser adjusted to a pre-set light spectrum, were taken to

about 0.13 microns, this value here constituting the average diameter of the smallest particles detectable by reflectometry.

The x-coordinates of the graph in figure 2 show the depths of etch obtained with different SC1 solutions, these depths of etch being expressed in angströms.

The y-coordinates of the graph in figure 2 show the values of roughness measured on the wafer for the different etches carried out on the wafers, these roughness values here being expressed in RMS angströms.

The roughness found, here presented as a function of the etchings implemented on the wafer surface are shown on the graph by black dots.

One first result of the measurement is that the average roughness increases with the depth of etch.

A second result is that a relationship is obtained that is roughly linear between the depth of etch and the roughness.

With reference to figure 3, and taking account of this substantially linear relationship between the etch and the roughness noted, a linear extension of the curve 1 in figure 2 is effected so as the form the curve 2 in figure 3.

Using this linear extension of the curve 1, and knowing a maximum pre-set roughness value beyond which the bonding energy becomes insufficient, it is then possible to deduce and predict the maximum depth of etch, that is associated with it, beyond which this bonding energy becomes insufficient.

Here, in said study carried out by the Applicant, it was considered that the maximum roughness value was set at about 5 RMS angströms, in compliance for example with the results of measurements disclosed in "Detailed characterisation of wafer bonding mechanisms", C. Malleville et al., published by "Electromechanical Society Proceedings volume 97-36", page 50 §3. Indeed it is shown that for a roughness above 5 RMS angströms, the bonding energy may reduce drastically.

Thus, with reference to figure 3, it may be deduced that the maximum depth of etch is found around 120 angströms.

Wafer bonding, when applied to the producing of a SOI structure by Smart-Cut™, requires a bond strength that is sufficient for avoiding any unbonding during the next detachment step. This is achieved experimentally in respect of roughness of less than four angströms RMS, thus reducing (again with reference to figure 3) the maximum etch around 60 to 70 angströms.

These measurements done by the Applicant have highlighted the need to restrict as far as possible the action of etching the wafer surface, with a maximum limit of depth of etch that must not be exceeded.

With reference to figure 4, another study was undertaken by the Applicant in order to find relationships between an efficiency of surface particle removal from the wafer, and the depth of etch of the wafer by different SC1 solutions.

To take these measurements, the Applicant first of all deliberately polluted the wafers by depositing a pre-set number of isolated particles, which will represent the particles to be removed.

The efficiency of the removal of these particles was found in particular by taking LPD (Light Point Defect) measurements on the surfaces of different wafers deliberately polluted in a similar way.

A LPD is a defect, which is also called a highlight, detectable by laser light scattering optical measurements.

A LPD measurement consists in illuminating the wafer surface by an incident optical wave emitted by the laser source, and in detecting, by means of an optical detector, the light scattered by the LPD defects present on the surface.

Since the light scattering on the wafer surface is correlated with the number of residual particles on the wafer surface, light scattering measurements provide information on the number of these residual particles.

Other techniques than LPD measurements may be implemented, taken alone or in combination with the LPD measurements.

As for the depth of etch, it is typically measured by reflectometry, in a substantially identical way to that used for the measurements of roughness (with reference to figure 2).

As x-coordinates, in the same way as for figures 2 and 3, are shown different depths of etch effected by means of different SC1 solutions, expressed in angströms.

As y-coordinates are shown isolated particles removal efficiencies, expressed as a percentage relative to the total number of isolated particles estimated to be present on the wafer surface.

Particle removal efficiency measurements as a function of the depths of etch are shown on the graph by black dots.

With reference to figure 4, it can be seen that beyond a depth of etch value of about 10 angströms, particles removal efficiency is close to 100%, whereas below this value of about 10 angströms, particles removal is much less impressive since it has an efficiency of around 50% to 60%.

For etches of less than about 10 angströms, particles removal is therefore insufficient to allow a bonding in good conditions.

If the etched thickness is too small, the particles are no longer separated from the surface, and their removal efficiency falls very quickly.

Optionally, it is possible, simultaneously to the use of the SC1 bath, to apply megasounds that can help to separate the particles from the surface.

We may recall here, additionally, the particular sensitivity afforded by an oxidised surface that has been subject to an implantation in the face of a chemical treatment of this kind. Indeed, this sensitivity is about 5 times greater than that of the same surface not having been subject to an implantation.

To this end, the implementation and the calibration of the chemical treatment must be particularly minutely.

The measurements taken by the Applicant with reference to figures 2 and 4, have made it possible to evaluate the depth of etch that it is desirable to obtain when the wafer to be cleaned is brought into the presence of the SC1 solution, the depth of etch being bound to be located here in a range between about 10 angströms and about 120 angströms, or between about 10 angströms and about 60 angströms in an application embodying an SOI structure by Smart-Cut®.

Within this authorised range of depths of etch, the Applicant has conducted a considerable number of experiments attempting to optimise etch conditions using SC1 solutions, with a view to further increasing the post-cleaning bonding energy.

For these etch results, they have typically employed:

- dosings per unit mass of NH_4OH/H_2O_2 in a range from about 1/2 to about 4/4, or from about 1/2.5 to about 4/4 (all references to unit mass of NH_4OH correspond to NH_4OH diluted at a ratio of about 30% in water), and
- temperatures running from about 30°C to about 80°C,
- etch times from a few seconds to several hours.

In the following table are given the conditions of cleaning by SC1 which have proved to be particularly impressive:

SC1	% per unit mass NH_4OH/H_2O_2	T(C)	Cleaning time
	1/2	50	3mn
	2/4	70	3mn
	3/4	80	3mn

The Applicant has deduced in particular that with:

- a % per unit mass NH_4OH/H_2O_2 = approximately ½
- a temperature of about 70°C,
- a cleaning time of about 3 minutes,

an etch of about 20 angströms was obtained, leading to roughness of about 3 RMS angstroms, and a level of particle removal of more than about 90%, thus attaining an optimum bonding energy.

Optionally one or more cleaning stages precede or follow the previous cleaning stage.

In this way, a second step of SC2 treatment is advantageously implemented subsequent to the previous SC1 treatment, this SC2 treatment being on the basis of a solution comprising a mix of HCl and of H_2O_2.

The prior use of a chemical treatment at a basic pH, such as a treatment employing ammoniacal chemical species during the SC1-type treatment, for example, has greatly improved the hydrophilicity of the wafer surface.

The high concentration of hydroxide ions in solution will indeed allow these OH- ions to react with pendent bonds generated on the surface of the wafer and to saturate them with SiOH terminations. Such superficial SiOH bonds will then constitute the adsorption position of molecules of water on the wafer surface, thus causing hydrophilization thereof. Said hydrophilization will then improve bonding with another wafer. Further, said SiOH layer formed on the surface will create an opposing repulsive potential which can unbond the

least bonded particles (i.e. isolated particles) from the surface and prevent them from being re-deposited.

Thus, a basic solution employed on the surface will both remove undesirable particles (by preventing them from re-depositing) and increase the adhesive potential of the wafer with another wafer.

The hydrophilic or hydrophilized surface then undergoes a chemical treatment using hydrochloric chemical species (HCl).

In a first embodiment of this second step of the method of the invention, said chemical species are supplied by a wet procedure.

In a second embodiment of the method of he invention, said chemical species are supplied by a dry procedure.

In the latter case, said chemical species can be diluted in deionized water, for example. Such a hydrochloric solution is then termed a SC2 solution.

Tests have been carried out by the Applicant to attempt to optimize the cleaning temperature to achieve a maximum bonding energy.

In particular, the Applicant has undertaken to observe the impact of temperature during hydrochloric treatment on bonding energy by dint of tests.

With reference to Figure 5, the Applicant recorded the number of blisters (already discussed) which appeared on substantially identical SOI structures produced by Smart-Cut™, each formed from monocrystalline silicon covered with an oxide layer of about 1500 Å thick, whereby the chemical treatment prior to bonding, employing hydrochloric species, had been carried out at a temperature of 50°C or 80°C.

The number of blisters is shown up the ordinate.

The temperature is shown along the abscissa.

The overall results of the set of measurements carried out on a sample of SOI structures obtained after Smart-Cut™ which had undergone hydrochloric treatment at 80°C produced a mean number of blisters of about 7.

The overall results of the measurements carried out on a sample of structures obtained following Smart-Cut™ and which had undergone a hydrochloric treatment at 50°C gave a mean number of blisters of about 0.5.

Thus, the Applicant has clearly identified that, under the experimental conditions, the use of hydrochloric species during cleaning prior to bonding increases the bonding energy when carried out at 50°C rather than at 80°C.

The explanation which can be provided for the influence of temperature on the reduction in the number of surface blisters (and thus the increase in bonding energy) lies in the deleterious effect of the chemical action of HCl on surface hydrophilicity.

Hydrochloric acid has an acidic pH (of about 2) and thus comprises a high concentration of H_3O^+ ions in solution. Those ions will thus interact with water on the surface of the wafer and with the surface SiOH terminations, reducing the number of the latter.

The reduction in those bonds then tends to reduce the number of bonding sites and the quality of the surface wafer, degrading the hydrophilic character of the surface.

However, better hydrophilicity of the surfaces to be bonded results in a higher bonding energy between the wafers, which would seal the particles imprisoned at the surface more strongly (the origin of blisters) and close the micro-defects around them. Then, on detachment, there would be fewer pressurized cavities that could deform the surface to form blisters therein.

Thus, a reduction in temperature would reduce the deleterious effect of hydrochloric acidity on the hydrophilicity of the bonding surfaces and thus not reduce the bonding energy by too great an extent.

Thus, the Applicant has been able to demonstrate that a temperature of 50°C during hydrochloric treatment will increase the bonding energy by about 30% with respect to the conventionally implemented hydrochloric treatment (which is typically done at 80°C or more), for a constant treatment duration.

The Applicant also clearly identified that reducing the temperature during the hydrochloric treatment, below 50°C, increases the bonding energy, for a treatment duration less than about 10 minutes, preferably about 3 minutes.

However, it has been previously explained that a major purpose of carrying out a hydrochloric treatment such as a SC2 treatment is to decontaminate the surface to be bonded, and that the efficiency of contaminant removal (primarily metals) changes from about 95% to about 99% depending on whether the temperature is in the range from ambient temperature to about 90°C respectively, and that the depth of action, directly linked to the diffusion length of chlorine ions into the oxide at the treatment temperature, can vary from about 1 Å to about 10 Å between ambient temperature and about 90°C. It is to be noticed that the decontamination has to be particularly efficient in the case of a plasma activation step previously processed (as previously described). Indeed, the plasma activation tends to contaminate the surface.

It can thus be seen that:

- to preserve a sufficient hydrophilicity (obtained from previous SC1 treatment) of the surface to be bonded for good bonding quality, the temperature during the hydrochloric treatment should be reduced, and that:

- to decontaminate the bonding surface sufficient, the temperature should be increased during that hydrochloric treatment.

Thus, a compromise can be found between hydrophilicity and metal decontamination.

To this purpose, the temperature can be adapted to maximize the bonding energy.

After cleaning of at least one of the said two oxidised bonding surfaces of two wafers to be bonded, these two wafers are brought into close contact with each other at the level of this (or these) cleaned surface(s).

Oxidised wafer cleaning thus makes it possible to restrict a sizeable number of large-size particles and thus to avoid having defects that downgrade

the wafers, wafers being downgraded when the bonding energy is not sufficient to obtain non-defective final structures.

With reference to the figure 1c and 1d, said detachment of a thin film 16 at the level of an embrittlement area 15 in order to form a structure 30, carried out after bonding, may be carried out imperfectly with non-transferred areas.

These defects are reduced as far as possible by the cleaning steps according to the invention implemented prior to bonding, the chemical treatment SC1 having been carried out in conditions and in accordance with treatment parameters adjusted so as to reduce to the maximum the number of isolated particles at the bonding interface, while reducing interfacial roughness as far as possible, and taking into account the particular sensitivity to etching of an oxidised surface that has been subject to an implantation.

Then the SC2 treatment was implemented such that metallic contaminants are efficiently removed and the hydrophily obtained with SC1 treatment stays high for a better bonding.

The present invention relates to a preparation of the surface of oxidised wafers from any kind of material relating to the field of semiconductors, in other words a material belonging to atomic family IV such as silicon or a Silicon-Germanium alloy, but extending also to other types of alloy of the IV-IV, III-V or II-VI family.

It should be specified that these alloys may be binary, ternary, quaternary or of higher degree.

CLAIMS

1. Method for preparing an oxidised surface of a wafer for bonding with another wafer, the oxidised surface having been subject to an implantation of atomic species, the method including a first step of cleaning the oxidised surface by employing NH_4OH and H_2O_2, and a second step of cleaning by employing hydrochloric species (HCl), wherein the first step is implemented so as to etch from about 10 Å to about 120 Å, and wherein the second step is implemented at a selected temperature below around 50°C for a duration less than about 10 minutes.

2. Method for preparing an oxidised wafer surface according to the previous claim, wherein the etching of the first step is implemented so as to etch between about 10 angströms and about 60 angströms.

3. Method for preparing an oxidised wafer surface according to the previous claim, wherein the treatment parameters of the first step are chosen so as to remove from the surface isolated particles with an average diameter of more than about 0.1 micrometers.

4. Method for preparing an oxidised wafer surface according to one of the previous claims, wherein the treatment parameters of the first step are chosen so that the roughness after treatment is less than about 5 ÅRMS.

5. Method for preparing an oxidised wafer surface according to the previous claim, wherein the roughness after treatment of the first step is less than about 4 ÅRMS.

6. Method for preparing an oxidised wafer surface according to one of the previous claims, wherein the dosing per unit mass of NH_4OH/H_2O_2 is in the range from about 1/2 to about 4/4, the temperature at which this first step is processed is between from about 30°C to about 90°C.

7. Method for preparing an oxidised wafer surface according to one of the previous claims, wherein the percentage dosing per unit mass of NH_4OH/H_2O_2 is

about 1/2, the temperature of this mix is about 50°C, and the cleaning time of the first step is about 3 minutes.

8. Method for preparing an oxidised wafer surface according to one of the claims 1 to 6, wherein the percentage dosing per unit mass of NH_4OH/H_2O_2 is about 2/4, the temperature of this mix is about 70°C and the cleaning time of the first step is about 3 minutes.

9. Method for preparing an oxidised wafer surface according to one of the claims 1 to 6, wherein the dosing per unit mass of NH_4OH/H_2O_2 is about 3/4, the temperature of this mix is about 80°C, and the cleaning time of the first step is about 3 minutes.

10. A method for preparing an oxidised surface of a wafer according to the preceding claim, wherein the second step of cleaning is carried out so that about 95% to 99% of the metallic contaminants present on the wafer surface are removed.

11. A method for preparing an oxidised surface of a wafer according to any preceding claims, wherein the selected temperature at which the mixture of the second step is employed is about room temperature.

12. A method for preparing an oxidized surface of a wafer according to the preceding claim, wherein the selected temperature employed during the second step is greater than about 0°C.

13. A method for preparing an oxidized surface of a wafer according to the preceding claim, wherein the second step is implemented at a selected temperature below around 50°C for a duration less than about 10 minutes

14. Method for preparing an oxidized surface of a wafer according to one of the previous claims, wherein a step of plasma activation is implemented previously to the first step.

15. A method of removing a thin layer from a first wafer having a superficial oxide layer, comprising the following steps:

a) forming a zone of weakness in the first wafer at a depth close to the thickness of the thin layer to be formed;

b) preparing the oxide surface of the first wafer in accordance with a method according to one of the preceding claims;

c) bonding the first wafer to a second wafer at the surface prepared in step b);

d) supplying energy to detach the thin layer bonded to the second wafer, at the zone of weakness.

16. A method of removing according to the preceding claim, wherein a step of thermal oxidation of the surface to be prepared in step b) is carried out prior to step b).

17. A method of removing according to either one of the two preceding claims, wherein it further comprises preparing the bonding surface of the second wafer in accordance with a method according to one of claims 1 to 14.

18. A method of removing according to the preceding claim, wherein a step of thermal oxidation of the surface of the second wafer is carried out prior to preparing said surface.

19. A method of removing according to any one of the four preceding claims, wherein the zone of weakness formed during step a) is obtained by implanting atomic species to a depth close to that of the zone of weakness.

20. Use of the method of removing according to one of claims 15 to 19, for producing a semiconductor-on-insulator structure.