# Method for producing a Semiconductor-On-Insulator structure

The invention relates to the manufacturing of Semiconductor-On-Insulator (SeOI) structures for electronics or optoelectronics, like SOI structures (for "Silicon-On-Insulator" structure), having a high thermal conductivity.

A SeOI structure comprises a substrate, a dielectric layer and a top semiconductor layer, the dielectric layer electrically insulating the top layer from the substrate.

SeOI structures are usually manufactured by wafer bonding via the said dielectric layer which acts both as an electric insulator and as a bonding layer between the top layer and the substrate.

The said SeOI structures that are highly thermal conductor are especially used for dissipating the heat released from components to be manufactured in the top layer of the SeOI. It is particularly useful for components able to release a large quantity of heat, like high power frequency components.

To this end, it is known to provide a substrate with material(s) having good thermal conductivity, like monocrystalline or polycrystalline SiC.

For these kinds of structures, it would be also appreciated having a dielectric layer that is a good conductor of thermal energy.

For this purpose, it is known to provide a dielectric nitride layer, like $Si_3N_4$ or $Si_xN_yO_z$ between the substrate and the top layer.

However, the manufacturing of these SeOI structures by wafer bonding is difficult due to the fact that nitride materials have bad bonding properties.

$SiO_2$ has better bonding properties, but it has a low thermal conductivity.

Accordingly, there is a need for manufacturing SeOI structures with high thermal conductivity while implementing a bonding of good quality.

In order to reach these goals and to overcome the drawbacks of the prior art, the invention proposes, according to a first aspect, a process of treating a

structure for electronics or optoelectronics, the structure comprising successively:

- a substrate,
- a dielectric layer having a thermal conductivity substantially higher than the thermal conductivity of an oxide layer made of an oxide of a semiconductor material,
- an oxide layer made of an oxide of the said semiconductor material,
- a thin semiconductor layer made of said semiconductor material,

characterized in that it comprises a heat treatment of the structure in an inert or reducing atmosphere with a temperature value and a duration chosen for inciting an amount of oxygen of the oxide layer to diffuse through the semiconductor layer so that the thickness of the oxide layer decreases by a determined value.

In a second aspect, the invention proposes a process of manufacturing a structure for electronics or optoelectronics, characterized in that it comprises the following steps:

(a)providing a semiconductor layer having a determined thickness, the semiconductor layer is of a semiconductor material;

(b)providing a receiving wafer comprising successively a substrate and a top dielectric layer made of a dielectric material having a thermal conductivity higher than an oxide layer made of an oxide of the said semiconductor material;

(c)bonding the thin semiconductor layer to the receiving wafer such that the said dielectric layer is sandwiched between the thin semiconductor layer and the substrate, this bonding step comprising the forming of an oxide layer at the bonding interface made of an oxide of the said semiconductor material; it is thus formed a structure comprising successively the said substrate, the dielectric layer, the oxide layer and the thin semiconductor layer;

(d)heat treating the said structure in an inert or reducing atmosphere with a temperature value and a temperature duration chosen for diffusing an

amount of oxygen of the oxide layer through the thin semiconductor layer so that the thickness of the oxide layer decreases by a determined value.

Thanks to the configuration of the structure, the function of bonding (ensured by the oxide layer) is separated from the function of electrical insulating (ensured by the dielectric layer).

Accordingly, it is possible to manufacture a SeOI with a dielectric layer that has a very good thermal conductivity while ensuring a bonding of good quality, i.e. a bonding similar to the bonding via an oxide layer. Indeed, once the oxide layer was used for ensuring a bonding of good quality between the semiconductor layer and the substrate, it is dissolved during the heat treatment (step (d)), for leaving the dielectric layer as the sole dielectric layer of the SeOI.

Some other characteristics of this process of manufacturing a structure are:

- the oxide layer of step (c) is formed on the dielectric layer;
- alternatively, the oxide layer of step (c) is formed on the thin semiconductor layer;
- alternatively, the oxide layer of step (c) is made on the dielectric layer and on the semiconductor layer;
- step (a) comprises the providing of a donor wafer having the said semiconductor layer within, the process further comprises, between step (c) and step (d), a reduction of the donor substrate for only keeping the semiconductor layer bonded to the said substrate;
- the process further comprises, before step (a), a step of implanting atomic species in the donor wafer for forming a weakness zone beneath the semiconductor layer, and the said reduction of the donor wafer comprises a supplying of energy for detaching the semiconductor layer from the donor wafer at the weakness zone;
- the said temperature is firstly chosen according to a determined profile, and then the said determined thickness is chosen for determining the said duration or the said duration is chosen for determining the said determined thickness,

these choices are made for reducing the thickness of the oxide layer by a determined value;

- the said temperature is between 1100°C and 1250°C, such as around 1200°C;
- the determined thickness and temperature are chosen for having a mean reduction rate of the oxide layer during step (d) of at least about 0.5 angstroms per minute;
- the thickness of the semiconductor layer is between around 250 angstroms and around 5000 angstroms, the temperature is about 1200°C and the duration is between around 5 minutes and 5 hours;
- the oxide layer has a thickness between around 100 angstroms and around 500 angstroms;
- the heat treatment is processed so that substantially the whole oxide layer is removed;
- a part of the oxide layer is left after the heat treatment;
- the dielectric layer has a thickness sufficient for, after step (d), electrically insulating the semiconductor layer from the substrate, considering the components to be manufactured in the semiconductor layer;
- the said dielectric layer is made of a nitride material, diamond, alumina ($Al_2O_3$), aluminum nitride (AlN), sapphire;
- the dielectric layer comprises $Si_3N_4$;
- the dielectric layer has a thickness in the range of 1000 to 5000 Å;
- the substrate is made of a material having high thermal conductivity, like SiC.

BRIEF DESCRIPTION OF THE FIGURES

Other characteristics, objects, and advantages of the invention will appear clearer in reading the description below, which is illustrated by the following figures:

Figure 1 shows a schematic cross-section view of structure according to the invention.

Figure 2A to 2E show the different steps of a process of manufacturing the structure.

Figures 3 and 4 are schematic cross-section views of the structure, illustrating the diffusion phenomena.

Figure 5 is a graph showing distribution of oxygen inside the said structure after a heat treatment according to the invention.

Figure 6 shows difference of the BOX thickness of a heat-treated BOX in a SOI wafer after a heat treatment according to the invention, along the whole area of the BOX, measured by ellipsometry.

DETAILED DESCRIPTION OF THE INVENTION

Referring to figure 1, a structure 60 from which the treatment according to the invention will be processed, is shown.

The structure 60 comprises a substrate 10, a dielectric layer 30, an oxide layer 40, and a thin semiconductor layer 50.

The dielectric layer 30 is made of a material having a higher thermal conductivity than those of an oxide layer made of an oxide of the said semiconductor material. This dielectric layer 30 may be made of a nitride material or of diamond, alumina ($Al_2O_3$), aluminum nitride (AlN), sapphire.

This structure 60 is aimed to be heat treated for dissolving the oxide layer 40, and obtaining then a SeOI structure comprising the substrate 10, the dielectric layer 30 and a semiconductor layer 50'. Preferably, the semiconductor layer 50' comprises the de-oxidized oxide layer 40 and the said thin semiconductor layer 50 (see figure 2E). Alternatively, the SeOI structure comprises the substrate 10, the dielectric layer 30 and a semiconductor layer 50' which comprises a very thin oxide layer coming from the partial dissolution of the oxide layer 40, and the said thin semiconductor layer 50.

The substrate 10 stiffens the whole structure 60. To this aim, it has a sufficient thickness, typically of hundreds of micrometers.

The substrate 10 may be formed of a single bulk material, like Si, Ge, SiC, GaN, sapphire, glass, quartz, or other materials. Preferably, the substrate 10 is made of a material having good thermal conductivity, like monocrystalline or polycrystalline SiC.

Alternatively, the substrate 10 is a composite structure formed of at least two materials, stacked one onto the other.

The semiconductor layer 50 is of at least one semiconductor material.

The semiconductor layer 50 may be of Si, SiC, Ge, SiGe, SiGeC, a III-V material, a II-VI material or another semiconductor material. The semiconductor layer 50 may alternatively be a combination of or a superposition of at least two of these materials and/or a superposition of several sub-layers.

The semiconductor material is monocrystalline, polycrystalline or amorphous. It may be doped or non-doped, porous or non-porous.

The semiconductor layer 50 is advantageously formed for receiving electronic or optoelectronic components.

According to the invention, the semiconductor layer 50 is advantageously thin. Its thickness is advantageously less than about 5000 angstroms, and in particular less than 2500 angstroms. For example, the semiconductor layer 50 may have a thickness between around 250 angstroms and 2500 angstroms, or between around 250 angstroms and 1200 angstroms. Especially, the thickness of the semiconductor layer 50 may be chosen between 500 and 1000 angstroms, for speeding up the oxygen diffusion.

The said oxide layer 40 is buried in the structure 60, located between the dielectric layer 30 and the semiconductor layer 50.

The oxide layer 40 is of an oxide of the said semiconductor material. If the semiconductor layer 50 is constituted of several semiconductor sub-layers, the oxide layer 40 is of an oxide of the semiconductor material of the adjacent sub-layer.

For example, if the semiconductor layer 50 is of Si, the oxide layer 40 is of $SiO_2$.

This oxide layer 40 is configured for having adhesive properties. It is to be noticed that this oxide layer 40 is not configured for having electrical insulating properties in order to electrically insulate the electronic or optoelectronic components to be formed in the semiconductor layer 50 from the substrate 10.

The oxide layer 40 may be thin.

Its thickness may be chosen less than 500 angstroms or less than this thickness. For example, this thickness may be between around 100 angstroms and around 500 angstroms or between around 200 angstroms and around 500 angstroms.

A thickness chosen between 350 and 500 angstroms may be considered as optimum if the semiconductor layer 50 was initially transferred by bonding (via the oxide layer 40) by the Smart Cut® technology, and if a heat treatment is further implemented for densifying the oxide layer 40. Indeed, this thickness may be chosen for both ensuring a Smart Cut® technology of good quality (i.e. so as to capture water at the interface) and for allowing a dissolution of the oxide layer 40 in a relatively short time.

The dielectric layer 30 is buried in the structure 60, located between the substrate 10 and the oxide layer 40.

The dielectric layer 30 is made of a dielectric material having a high thermal conductivity, like a nitride of the said semiconductor material, like $Si_3N_4$, $Si_xO_yN_z$, diamond, alumina ($Al_2O_3$), aluminum nitride (AlN), or sapphire.

A dielectric layer 30 is considered having high thermal conductivity when its thermal conductivity is higher than those of the oxide layer 40, or, more particularly, when its thermal conductivity is greater than 10 $W.cm^{-1}.K^{-1}$ at room temperature.

This dielectric layer 30 may be thin.

This dielectric layer 30 is configured for having electrical insulating properties in order to at least partly electrically insulate the electronic or optoelectronic components to be formed in the semiconductor layer 50 from the substrate 10. It is to be noticed that this dielectric layer 30 is not configured for further having adhesive properties.

Additionally, the dielectric layer 30 is configured for conducting a determined amount of heat.

If the dielectric layer 30 is made of a nitride material (like $Si_3N_4$), diamond, alumina ($Al_2O_3$), aluminum nitride (AlN), sapphire, its thickness may be similar to or lower than 5000 angstroms, like in the range 1000-5000 angstroms. Also, this thickness may be between around 100 angstroms and around 1000 angstroms or between around 200 angstroms and around 500 angstroms. Its thickness may also be of a few angstroms.

Moreover, this dielectric layer 30 is preferably formed for having a uniform thickness. The obtained uniformity value may be of +/- 3% or lower.

The manufacturing of this structure 60 may be done by a wafer bonding technique, as illustrated on figure 2A to 2E, between a first wafer 70 and a second wafer 80.

Especially, with reference to figure 2A, the manufacturing can be firstly implemented by providing a first wafer 70 with the said substrate 10 and the said dielectric layer 30, the dielectric layer 30 being a top layer.

In a preferred embodiment, the dielectric layer 30 is formed on the substrate 10.

The purpose of this dielectric formation is to provide a buried dielectric layer with a predetermined thickness for forming, after bonding, the insulator part of a SeOI structure highly conductive of thermal energy, the insulator part of this structure being the dielectric layer 30.

The dielectric layer 30 may be a nitride layer formed by nitridation of the top of the substrate 10.

For example, if the substrate 10 has a superficial layer made of Si or SiGe, a $Si_3N_4$ layer 20 may be formed at the surface by nitridation.

Alternatively, the dielectric layer 30 may be formed by deposition (e.g. CVD) of aggregates made of the dielectric material.

For example, $Si_3N_4$ or Diamond aggregates may be deposed.

The parameters of the dielectric formation (like temperature, gas flows) are controlled such that the dielectric layer 30 is a dielectric barrier between the components to manufacture in the semiconductor layer 50 and the substrate 10.

Particularly, the material, the thickness, and eventually the intrinsic structure, of it are chosen to this end.

It is to be noticed that this dielectric layer 30 is not aimed to be a bonding layer, like in the prior art. Accordingly, no defaults are trapped at a bonding interface, and its quality is better.

Additionally, the dielectric formation parameters can be chosen for improving the interface with the substrate 10, lowering the defaults at the interface, and for having a good thickness homogeneity.

The thickness of the dielectric layer 30 may then be lower than a standard thickness of a bonding layer.

Advantageously according to the invention, the dielectric layer 30 is thin. For example, the dielectric layer 30 has a thickness, after bonding, between around 1000 and 5000 angstroms, or between around 200 angstroms and around 500 angstroms, or between 350 and 500 angstroms.

Of course, the dielectric layer 30 has also to be sufficiently thick for conducting the determined amount of thermal energy.

With reference to figure 2B, a second step consists of providing the said second wafer 80 with the semiconductor layer 50 within, the semiconductor layer 50 lying at the surface of the second wafer 80 defining a front layer.

The second wafer 80 may be of a single bulk material, the semiconductor layer 50 being then in the bulk material or grown on it.

Alternatively, the second wafer 80 may be a composite wafer comprising a holder substrate and a multilayer structure (not shown). In particular, the second wafer 80 can include a buffer structure between the holder substrate and the semiconductor layer 50 arranged for adapting the lattice parameter between these two elements and/or for confining defaults. For example, the second wafer 80 comprises a Si holder substrate, a SiGe buffer layer with a Ge concentration continuously increasing in thickness from the holder, and a SiGe or Ge and/or a strained Si semiconductor layer 50 over it. Some Carbon can be added in these materials.

Advantageously, the semiconductor layer 50 has been epitaxially grown.

Crystalline growth of the epitaxial layer may have been obtained using the known techniques of LPD (or more specifically LPCVD), CVD and MBE (respectively Liquid Phase Deposition, Chemical Vapour Deposition, and Molecular Beam Epitaxy).

With reference to figure 2C, a third step consists of bonding the first wafer 70 to the second wafer 80 such that the semiconductor layer 50 faces the dielectric layer 30.

Advantageously, the bonding is firstly implemented by well-known bonding techniques (see, for example, "Semiconductor Wafer Bonding Science and Technology" by Q.-Y. Tong and U. Gösele – a Wiley Interscience publication, Johnson Wiley & Sons, Inc – for more details). Thus, for example, molecular bonding of hydrophilic surfaces or surfaces rendered hydrophilic may be done.

Well-known cleaning steps may be implemented just before bonding.

Optionally, a plasma treatment of one and/or the other of the two surfaces to be bonded, followed by conventional annealing or RTA treatment (rapid thermal annealing), is implemented.

With reference to figure 2C, the said oxide layer 40 was formed, before bonding, on the semiconductor layer 50 and/or on the dielectric layer 30, for being buried at the bonding interface after bonding.

This oxide layer 40 is formed by specific means on the semiconductor layer 50 and/or on the dielectric layer 30.

The oxide layer 40 may be formed by oxidation of the top part of the semiconductor layer 50.

For example, if the semiconductor layer 50 is of Si or SiGe, $SiO_2$ layer 40 may be formed at the surface by oxidation.

Alternatively, the oxide layer 40 may be formed by deposition of aggregates constituted of the oxide material on the semiconductor layer 50 and / or on the dielectric layer 30.

For example, $SiO_2$ aggregates may be deposited.

The parameters of the formation of the oxide are controlled such that the oxide layer 40 is a bonding layer sufficiently thick for ensuring a sufficient adhesivity between the first and second wafers 70-80.

Especially, if a Smart Cut® technology is planned to be processed in the first wafer 70, the oxide layer 40 has to be sufficiently thick for avoiding problems associated with water and particles captured at the bonding interface that can generate some interfacial defaults and/or bubbles in the semiconductor layer 50 during a subsequent heat treatment.

On the other hand, it is preferable that this thickness is not too high for avoiding that the dissolution heat treatment lasts too much time.

The oxide layer 40 may have a thickness below 600 angstroms, or below 500 angstroms, or between 200 and 500 angstroms. The preferred thickness is between 350 and 500 angstroms as previously explained.

With reference to figure 2C, the second wafer 80 and the first wafer 70 are bonded together such that the oxide layer 40 is located at the interface, as previously explained.

Optionally, at least one step of heating is additionally implemented for reinforcing the bonds at the interface.

Referring to figure 2D, the said structure 60 is obtained by reducing the second wafer 80 such that a rear portion is removed. Only the semiconductor layer 50 is kept.

Any technique of wafer reduction may be used, such as chemical etching technique, lapping then polishing, Smart Cut® technology which is known per se to the skilled person (see for example « Silicon-On-Insulator Technology : Materials to VLSI, 2nd Edition » from Jean-Pierre Colinge in « Kluwer Academic Publishers », p.50 et 51), taken alone or in combination.

In particular, if using the Smart Cut® technology, the second wafer 80 is implanted prior to bonding, with atomic species (such as hydrogen, helium or a combination of the them, and/or other atomic species) at energy and dose selected for producing within a zone of weakness at a depth close to the

thickness of the semiconductor layer 50. The implantation may be carried out before or after forming the oxide layer 40. Finally, once the bonding has been carried out, Smart Cut® technology comprises supplying suitable energy (like thermal and/or mechanical energy) for rupturing the bonds at the zone of weakness, and thus detaching the rear portion 60 from the semiconductor layer 50.

An optional step of finishing (by polishing, CMP, cleaning,...) may be implemented after the reduction step, in order to have a smooth and homogeneous semiconductor layer 50. This finishing step may be implemented prior to or after the heat treatment nextly described.

Other steps may also be provided, with no limitation according to the invention.

The obtained structure 60 comprises successively the substrate 10, the dielectric layer 30, the oxide layer 40, and the thin semiconductor layer 50.

A heat treatment according to the invention is then processed for reducing or removing the thickness of the oxide layer 40.

The heat treatment is implemented in an inert or reducing atmosphere, like argon or hydrogen atmosphere or a mixture of them.

With reference to figure 2E, the heat treatment is processed such that the oxide layer 40 reduces in thickness or is entirely dissolved, by oxygen diffusion through the semiconductor layer 50.

The final structure 100 is a SeOI structure, with an insulator part formed by the dielectric layer 30 and eventually by a thin remaining part of the oxide layer 40.

The semiconductor part 50' of the SeOI structure 100 is the semiconductor layer 50 and the de-oxidized part of the oxide layer 40. During the said heat treatment, it is to be noticed that a part of the semiconductor layer 50 may have been evaporated away by the inert gas treatment.

For illustrating the reduction of the oxide layer 40 due to oxygen diffusion, figures 3 and 4 show respectively a cross sectional view of the structure 60, one during diffusion and the other after diffusion.

The structure 60 contains two diffusion domains:

- left side (top semiconductor layer 50) and
- right side (substrate 10 – dielectric layer 30);

separated by the oxide layer 40 with a thickness $d_{ox}$.

It is assumed that the diffusion of oxygen is in one dimension – the diffusion equation is then:

$$\frac{\partial C(x,t)}{\partial t} = D(T)\frac{\partial^2 C(x,t)}{\partial x^2}$$

where: x-axis extends transversally to the layer planes, has its origin at the center of the oxide layer 40, and is pointed to the positive value in the semiconductor layer 50, and to the negative value in the bulk substrate 10.

C(x, t) is the oxygen concentration at time t and at x.

D(T) is the diffusion coefficient of the oxygen in the semiconductor (unit: $cm^2/s$).

Fig.5 schematically shows distribution of oxygen in the structure during a heat treatment.

If the top semiconductor layer 50 is sufficiently thin, some oxygen of the oxide layer 40 diffuses through it and evaporates in the atmosphere at the surface of it.

This diffusion is accelerated by the fact that the atmosphere is chosen inert, as it can be deduced from the boundary conditions.

In particular, the following reaction occurs at the surface of the semiconductor layer 50 if the inert atmosphere contains hydrogen and the layer is in silicon:

$$SiO_2 + H_2 \rightarrow H_2O + SiO\uparrow \text{ if atmosphere is } H_2$$

$$SiO_2 + Si \rightarrow 2SiO\uparrow \text{ if atmosphere is Ar}$$

For increasing the efficiency of this diffusion, a previous deoxidation of the surface of the semiconductor layer 50 may be done.

The dielectric layer 30 prevents from the diffusion through the substrate 10.

Then, after a determined time and if the thickness of the semiconductor layer 50 is small with respect to the oxygen diffusion length $(D*t)^{1/2}$, the applicant calculated that the diffusion time is acceptable.

In this last case, the determined time is about 100 s, at about 1200°C.

In such conditions the steady flux is defined as:

$$F = D(T)*C_0(T)/d_{Se}$$

where: $d_{Se}$ is the thickness of the semiconductor layer 50

where $C_0(T)$ is the equilibrium oxygen solubility in the semiconductor at annealing temperature.

Oxide dissolution time for decreasing the oxide layer 40 thickness $d_{ox}$ by a predetermined value $\Delta d_{ox}$, is:

$$time = \frac{d_{Se} * \Delta d_{ox}}{D(T) * C(T)} * N$$

where: N is the concentration of oxygen atoms in oxide.

For example, if the semiconductor layer 50 is of monocrystalline Si then N = 4.22e22, and the oxide layer 40 is of $SiO_2$, and if $d_{Se}$ = 1000 angstroms and $\Delta d_{ox}$ = 20 angstroms:

$$time = 1.86e\text{-}12 * \exp(4.04eV/kT)$$

The applicant demonstrated that the main parameter affecting the time is the anneal temperature and the thickness of the top semiconductor layer 50.

For examples, and based on numerical simulation, the minimum annealing conditions to dissolve 20 angstroms of interfacial $SiO_2$, with 1000 angstroms of top Si layer, in a Ar or $H_2$ atmosphere, are:

- 1 100°C for 2hr, or
- 1 200°C for 10 min, or

– 1 250°C for 4 min.

The temperature and the duration of the heat treatment are then chosen for inciting an amount of oxygen of the oxide layer 40 to diffuse through the semiconductor layer 50.

Then, the thickness of the oxide layer 40 decreases by a predetermined value.

Additionally, the thickness of the semiconductor layer 50 may also have been chosen, when forming it, for inciting the said diffusion.

Particularly, the thickness of the semiconductor layer 50 and the temperature of the heat treatment determine the mean reduction rate of the oxide layer 40. More the thickness less the rate. More the temperature more the rate.

For example, said thickness and temperature may be predetermined such that at least about 0.5 angstroms per minute of oxide layer 40 mean reduction rate is reached. To this purpose, for a temperature of about 1200°C, a thickness of a (110) Si monocrystalline layer 10 is chosen less than 2500 angstroms.

Only the duration of the heat treatment is then necessary to control for accurately reducing the thickness of the oxide layer 10 by a predetermined value.

Alternatively, the thickness of the semiconductor layer 50 has been chosen for reducing the oxide layer 40 by a predetermined value by implementing the heat treatment with a predetermined duration and a predetermined temperature.

The predetermined temperature may be chosen about 1000°C – 1300°C, and especially around 1100°C or 1200°C.

The thickness of the semiconductor layer 50 may be between around 250 angstroms and around 1000 angstroms, the predetermined temperature is about 1200°C and the predetermined duration is between around 5 minutes and 5 hours.

The heat treatment is processed for reducing the oxide layer 40 by a predetermined thickness.

By adjusting precisely the parameters of the heat treatment, it is then possible to control precisely the reduction of material in the oxide layer 40, for finally having an oxide layer 40 with a desired thickness.

According to the invention, it is then possible to control precisely the thickness of the oxide layer 40 of SeOI.

Particularly, it is possible to remove the whole oxide layer 40.

Alternatively, it is possible to leave a thin oxide layer (of about 10-100 angstroms) in order to improve the electrical properties at the interface (i.e. to decrease the Dit).

Additionally, the bonding between the semiconductor layer 50 and the substrate 10 can be done with an oxide layer 40 having a thickness greater than a limit thickness beyond which the deformation of the semiconductor layer 50 and bubbles are avoided.

Furthermore, as risks of deterioration of the semiconductor layer 50 are decreased, the thickness of the latter can also be decreased, while still respecting manufacturing specifications.

Thus, the components to be manufactured in the semiconductor layer 50 may be more miniaturized and have lower power consumption than the prior art.

A main advantage of the invention is that the dielectric layer 30 is maintained in its initial configuration, even if the diffusing heat treatment is implemented. Indeed, the dielectric layer 30 is not used for the bonding, and its initial dielectric and thermal properties can thus be maintained.

The dielectric properties of the dielectric layer 30 can then be initially calibrated very precisely, without taking account of the next heat treatment.

## CLAIMS

**1.** Process of treating a structure for electronics or optoelectronics, the structure comprising successively:

- a substrate,
- a dielectric layer having a thermal conductivity substantially higher than the thermal conductivity of an oxide layer made of an oxide of a semiconductor material,
- an oxide layer made of an oxide of the said semiconductor material,
- a thin semiconductor layer made of said semiconductor material,

characterized in that it comprises a heat treatment of the structure in an inert or reducing atmosphere with a temperature value and a duration chosen for inciting an amount of oxygen of the oxide layer to diffuse through the semiconductor layer so that the thickness of the oxide layer decreases by a determined value.

**2.** Process of manufacturing a structure for electronics or optoelectronics, characterized in that it comprises the following steps:

(a) providing a semiconductor layer having a determined thickness, the semiconductor layer is of a semiconductor material;

(b) providing a receiving wafer comprising successively a substrate and a top dielectric layer made of a dielectric material having a thermal conductivity higher than an oxide layer made of an oxide of the said semiconductor material;

(c) bonding the thin semiconductor layer to the receiving wafer such that the dielectric layer is sandwiched between the thin semiconductor layer and the substrate, this bonding step comprising the forming of an oxide layer at the bonding interface made of an oxide of the said semiconductor material; it is thus formed a structure comprising successively the said substrate, the dielectric layer, the oxide layer and the thin semiconductor layer;

(d) heat treating the said structure in an inert or reducing atmosphere with a temperature value and a temperature duration chosen for diffusing an amount of oxygen of the oxide layer through the thin semiconductor layer so that the thickness of the oxide layer decreases by a determined value.

**3.** Process of manufacturing a structure according to claim 2, wherein the oxide layer of step (c) is formed on the dielectric layer.

**4.** Process of manufacturing a structure according to claim 2, wherein the oxide layer of step (c) is formed on the thin semiconductor layer.

**5.** Process of manufacturing a structure according to claim 2, wherein the oxide layer of step (c) is made on the dielectric layer and on the semiconductor layer.

**6.** Process of manufacturing a structure according to one of claims 2 to 5, wherein step (a) comprises the providing of a donor wafer having the said semiconductor layer within, wherein the process further comprises, between step (c) and step (d), a reduction of the donor substrate for only keeping the semiconductor layer bonded to the said substrate.

**7.** Process of manufacturing a structure according to claim 6, further comprising, before step (a), a step of implanting atomic species in the donor wafer for forming a weakness zone beneath the semiconductor layer, and wherein the said reduction of the donor wafer comprises a supplying of energy for detaching the semiconductor layer from the donor wafer at the weakness zone.

**8.** Process of manufacturing a structure according to any of claims 2 to 7, wherein the said temperature is firstly chosen according to a determined profile, and then the said determined thickness is chosen for determining the said

duration or the said duration is chosen for determining the said determined thickness, these choices are made for reducing the thickness of the oxide layer by a determined value.

**9.** Process of manufacturing a structure according to claim 9, wherein the said temperature is between 1100°C and 1250°C, such as around 1200°C.

**10.** Process of manufacturing a structure according to claim 2 to 7, wherein the determined thickness and temperature are chosen for having a mean reduction rate of the oxide layer during step (d) of at least about 0.5 angstroms per minute.

**11.** Process according to any of claims 1 to 7, wherein the thickness of the semiconductor layer is between around 250 angstroms and around 5000 angstroms, the temperature is about 1200°C and the duration is between around 5 minutes and 5 hours.

**12.** Process according to any of claims 1 to 7, wherein the oxide layer has a thickness between around 100 angstroms and around 500 angstroms.

**13.** Process according to any one of the previous claims, wherein the heat treatment is processed so that substantially the whole oxide layer is removed.

**14.** Process according to any of claims 1 to 12, wherein a part of the oxide layer is left after the heat treatment.

**15.** Process according to one of the preceding claims, wherein the dielectric layer has a thickness sufficient for, after step (d), electrically insulating the semiconductor layer from the substrate, considering the components to be manufactured in the semiconductor layer.

**16**. Process according to any of claims 1 to 15, wherein the said dielectric layer has a thermal conductivity higher than 10 $W.cm^{-1}.K^{-1}$.

**17**. Process according to any of claims 1 to 16, wherein the said dielectric layer is made of nitride, diamond, alumina ($Al_2O_3$), aluminum nitride (AlN), or sapphire.

**18.** Process according to any one of the preceding claims, wherein the dielectric layer comprises $Si_3N_4$.

**19.** Process according to one of the two preceding claims, wherein the dielectric layer has a thickness in the range of 1000- 5000Å.

**20.** Process according to one of the preceding claims, wherein the substrate is made of a material having high thermal conductivity, like SiC.