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PROCESS FOR SEPARATING LAYERS OF MATERIAL

The present invention generally relates to the processing of materials, and more particularly to substrates for electronics, optics or optoelectronics.

More precisely, the invention relates to a process for detaching two layers of material according to an embrittlement surface defined between the two layers, said process comprising thermal annealing of a structure comprising said layers, the annealing bringing the temperature from a starting annealing temperature to a final annealing temperature.

Processes of the type mentioned above are already known.

In particular it is known to apply such known processes for detaching two layers of material coming from the same substrate, between which an embrittlement surface has been previously defined by implantation of species in the substrate.

The implanted species can be ions or atoms. It is thus known to implant a substrate of a semiconductor material such as silicon with a species such as hydrogen or helium.

And the embrittlement surface is determined as a function of the nature of the material, the nature of the implanted species and the implantation energy (this embrittlement surface typically being a plane parallel to the implantation face of the substrate).

It is also possible to produce the embrittlement surface by any other means known per se, for example by constructing an intermediate region of porous material between two regions of dense material, by constituting a layer of oxide embedded in a substrate (for example a substrate of SOI type), or even by bonding together two layers, the bonding zone then corresponding to the embrittlement surface.

Such detachment of two layers detached by an embrittlement surface can be used to create thin layers (whose thickness can be between a fraction of a micron and several microns), as is described for example in patent document FR 2 681 472.

This document describes a process known under the generic name of SMARTCUT®, the aim of which is to manufacture structures of SOI type (Silicon On Insulator according to accepted English terminology). The major steps in this process are the following:

- oxidation of a so-called upper plate of silicon to create a layer of oxide (which corresponds to the embedded layer of oxide of the SOI structure),
- ionic implantation of hydrogen in this upper plate so as to create the embrittlement surface, and to delimit the SOI structure by this surface on the one hand (situated to the side of the embedded oxide), and on the other hand a silicon heel,
- adhering the upper plate onto a support plate

called a stiffener (which can be made of silicon, but also from another material),

- annealing with a view to detachment to first obtain an SOI structure comprising the support plate, the embedded oxide layer and the layer of silicon placed between the embedded oxide and the embrittlement surface, and then silicon heel located on the other side of the embrittlement surface.

In this respect it is specified that this annealing can :

> either completing the detachment, with the SCI and the heel effectively exiting from the annealing oven unstuck,

> or, if the thermal budget is not sufficient to complete the annealing, to aid only in effecting splitting between the SOI and the heel. The splitting corresponds to a state preceding detachment in which the SOI and the heel are still attached by Van der Waals force type bonds, or again by a simple suction effect of the two parts to be detached.

In this case, detachment is finalised after annealing, for example by a contribution of mechanical energy (introduction of a projecting element such as a blade at the level of the embrittlement surface, etc.),

- complementary processing designed to reduce the roughness of the surface of the SOI which originates from splitting and detachment. It is usual to find roughness specifications not exceeding 5 Angstroms in rms value (corresponding to the English acronym root mean square).

It is specified that the measures of roughness are generally made by an atomic force microscope (AFM according to the acronym corresponding to the English

term Atomic Force Microscope).

With this type of instrument roughness is measured on surfaces swept by the points of the AFM microscope, ranging from 1 x 1 μm^2 to 10 x 10 μm^2 and less frequently 50 x 50 μm^2, even 100 x 100 μm^2.

It is also possible to measure the surface roughness by other methods, in particular by the bias of a haze measurement, in keeping with accepted English terminology.

This method has the particular advantage of enabling rapid characterisation of the uniformity of roughness on the whole surface.

This haze, measured in ppm, originates from a method utilising the properties of optical reflectivity of the surface to be characterised, and corresponds to an optical base noise diffused by the surface, in terms of its microroughness.

An example of tie between the haze and the roughness is shown in Figure 1, in the case of an SOI surface.

The SMARTCUT® process can also be used to constitute structures other than SOI, for example SOA (Silicon On Anything as per accepted English terminology : silicon on any material), or even AOA (Anything On Anything according to accepted English terminology any material on any material).

The known processes of detachment by annealing generally use annealing inducing the structure comprising the two layers to be unstuck from a relatively low starting annealing temperature, which may be for example of the order of 350°C, to a higher detachment temperature though not exceeding a value of the order of 500°C, with a temperature evolution in the annealing oven according

to a substantially constant increase of the order of 10°C per minute.

The detachment temperature for these detachment annealings of the prior art corresponds to the final annealing temperature.

Therefore, the known detachment annealings are performed with temperature evolution according to a substantially constant temperature ramp, the gradient of this ramp being of the order of 10°C/min.

But it is often noticed that the surfaces originating from detachment (that is, the surfaces of the two layers opposite both sides of the embrittlement surface) exhibit a relatively heightened roughness.

And relatively important specific processing can be made necessary to attain the desired surface state for surfaces originating from detachment.

For example, in the event of detachment of the layers of a plate of material such as silicon for constituting a SOI, completion of detachment generally results in roughness of the order of 80 Angstroms rms (in AFM measure on a field of 10*10 microns).

The principal aim of the invention is thus to allow to perform detachment annealings producing an improved state surface of the surfaces resulting from detachment.

As a function of the above, according to a first particular aspect the aim of the invention is more particularly to reduce the roughness of the surfaces resulting from detachment, relative to known processes.

In addition, with the known detachment annealing processes, degradation of the peripheral structure of the structures to be detached is also observed.

Figure 2 illustrates the typical result of

microscopic observation of the peripheral edge of the surface of an SOI after its detachment by annealing according to the prior art, said peripheral region being called crown.

This observation shows up numerous structural irregularities in the SOI crown.

This figure illustrates degradation of the SOI crown, said degradation being consequent to the detachment annealing (applicable to structures of types other than SOI).

The object of the invention is also to prevent, or at least reduce, such degradation noticed as a consequence of annealing detachment.

To achieve these aims the invention proposes according to a first aspect a process of detaching two layers of material according to an embrittlement surface defined between the two layers, the process comprising thermal annealing of a structure 10 comprising said layers, the annealing bringing the temperature from a starting annealing temperature to a final annealing temperature, characterised in that during the thermal annealing the annealing temperature evolves according to a first phase to a transition temperature, then according to a second phase during which the rise in temperature per unit of time is stronger than during the first phase.

Preferred, though non-limiting, aspects of this process are the following :

- the transition temperature corresponds to initial detachment,
- the first phase is an initiation phase of detachment, and the second phase is a surface-finishing phase,

- the second phase is followed by a heating stage at a substantially constant temperature,
- said substantially constant temperature corresponds to the final annealing temperature,
- during the first phase the temperature rises in accordance with a slow average gradient, up to around 10°C/min,
- during the second phase the temperature rises according to a rapid average gradient, greater than around 15°C/mm,
- the starting annealing temperature is less than or equal to 350°C,
- the final annealing temperature is of the order of 500°C to 800°C,
- the final annealing temperature is of the order of 600°C,
- the transition temperature between the two phases is of the order of 430°C to 450°C.

According to a second aspect the invention also proposes application of a process according to one of the abovementioned aspects to detach two layers of material delimited by an embrittlement surface, said embrittlement surface having been produced within the scope of a process of the SMARTCUT® type.

Preferred, though non-limiting, aspects of such an application are the following:

- the two layers of material comprise a silicon layer,
- the two layers of material are two layers of silicon, one of the two layers corresponding to an SOI, the other layer corresponding to a silicon heel.

Other aspects, aims and advantages of the invention

will emerge clearly from reading the following description of an embodiment of the invention, with reference to the accompanying diagrams in which, with the exception of Figures 1 and 2 which have already been mentioned in reference to the prior art :

- Figure 3 diagrammatically illustrates an annealing oven used to carry out the invention,
- Figure 4a illustrates the spatial distribution of haze on the surface of an SOI having undergone detachment annealing according to the prior art,
- Figure 4b is a graph representing overall the distribution of haze on the surface of the SOI for the surface of which Figure 4a illustrates the spatial distribution of haze, with the graph of Figure 4b specifically identifying the average haze of the surface in question,
- Figure 5 graphically represents the evolution of temperature during detachment annealing carried out according to the prior art, and the same type of evolution for two detachment annealings undertaken according to the present invention,
- Figure 6 illustrates highly diagrammatically the bonding of a layer of oxidised and implanted silicon, and a stiffener, in a SMARTCUT® type process,
- Figures 7a, 8a and 9a visually represent the spatial distribution of the haze on the surface of three SOIs following their detachment by annealing, the SOI of Figure 7a having undergone standard detachment annealing, the two SOIs of Figures 8a and 9a having undergone detachment annealings according to the present invention carried out according to different modalities,
- Figures 7b, 8b and 9b are graphs similar to

those of Figure 4b overall showing the distribution of haze for the SOI and respective of Figures 7a, 8a and 9a (Figure 7b corresponding as does Figure 4b to SOI annealing according to a known technique),

- Figures 10 to 12 are three similar representations of observation by microscope of the peripheral edge of three respective SOIs which have undergone detachment annealing,

o Figure 10 corresponding to a SOI having undergone standard annealing (similar to Figure 2),

o Figures 11 and 12 correspond to the respective SOIs of Figures (8a, 8b) and (9a, 9b).

Previous to the following description, in this case of structures such as multilayer substrates comprising, as above, a SOI (or SOA, or even AOA) and a layer of a heel of material (silicon in the case of SOI), the shape of the structure is generally that of a very fine crust designated by the term wafer according to accepted English terminology.

And the wafers are thus arranged vertically in the oven, as shown in Figure 3 (the wafers to be splitted being designated by reference numeral 10, the oven being designated by reference numeral 20).

This vertical arrangement of the wafers aims to prevent the risks of the two detached layers of each wafer shifting, relative to one another, at the end of detachment in the oven or especially during handling operations when the detached wafers are removed from the oven.

Hereinabove it has been seen that specifications of the surface state were, in certain cases, drastic (in particular for a SOI) ; so it is necessary to prevent any

relative shifting of the two detached layers so as to avoid the risks of any scratching on the surfaces of the two detached layers.

It is also noted, as illustrated in Figure 4a, that the surface roughness of a SOI 11 resulting from detachment annealing exhibits dissymmetry.

In fact, this figure shows a zone of the SOI surface (situated between 9 and 10 o'clock) in which the haze, and consequently the roughness, are increased.

Such divergence results from the presence of hot points in the annealing oven. In the case of an oven such as illustrated in Figure 3, it is more precisely about the translation of the vertical temperature gradient (the wafers to be detached being placed in the oven at an orientation of 90° relative to the representation of Figure 4a).

With reference now to Figure 4b, this shows the overall distribution of haze on the surface of the SOI of Figure 4a.

It will be recalled that this SOI has undergone detachment annealing according to a process known in the prior art.

Figure 4b illustrates that the value of the average haze on the whole SOI is of the order of 87 ppm.

This value is directly associated with an average roughness value of this SOI, and thus represents a reference value for measuring SOI roughness, characterised by the haze measurement.

This haze measurement, as well as similar measurements to be specified hereinbelow, are made according to the same protocol and using the same instrument, in this case by an instrument of the KLA

Tencor Surfscan SPI type (trade mark applied for).

With reference now to Figure 5, the evolution of the temperature prevailing in the annealing oven, during three detachment annealings, as a function of time, has been diagrammatically illustrated.

More precisely, this figure comprises three curves 51, 52, 53 which correspond to three different types of annealing.

The start of the temperature evolution during these three annealings is identical, comprising an entry stage at 350°C (corresponding to the annealing entry temperature), followed by a rising ramp of a temperature having a gradient of the order of 10°C per minute (or less), as is known from the prior art.

In the right part of the figure it is noticed that over time the temperatures of the three annealings evolve differently.

More particularly, the curve 51 illustrates the evolution of a detachment annealing according to the prior art.

In such annealing, after having been maintained at the entry level of 350°C for a first stage the temperature evolves according to the known gradient ramp of the order of 10°C per minute, up to a detachment annealing temperature and final temperature of the order of 500°C.

It is nevertheless specified that the so-called detachment start temperature, from which the beginning of detachment can be observed, may have a value of the order of 430°C to 450°C.

The entry annealing temperature may have a value of less than 350°C (this will also be the case for

annealings according to the present invention, illustrated by the curves 52 and 53).

The end of this annealing comprises a second stage, at this final annealing temperature.

In the case of this known annealing, the temperature therefore evolves according to a ramp.

The curve 52 represents the temperature evolution of annealing carried out according to the present invention, in a first embodiment.

It is noticed in this case that after having followed a part of the standard ramp having a gradient of the order of 10° per minute (or less), once the temperature has been brought to a transition value of the order of 430°C a 450°C, temperature evolves according to a second ramp whereof the gradient is different to that of the first ramp.

The two ramps are illustrated substantially linear.

More precisely, the second ramp has a gradient substantially greater than that of the first ramp, the gradient of this second ramp being of the order of 16°C per minute.

All the same it is noted that for this annealing according to the present invention, as well as for the annealing represented by the curve 53, the two linear ramps can be replaced by two non-linear ramps corresponding to the same general evolution in two phases detached by a transition temperature, where the second phase corresponds to a more rapid rise in temperature.

The annealing ends with a stage at the final annealing temperature of the order of 600°C.

The curve 53 illustrates a variant of the invention, in which the second ramp again has a gradient of the

order of 16° per minute after a transition to 430°C to 450°C.

In this instance, the second ramp continues up to a final annealing temperature at an even greater value of the order of 800°C.

Accordingly, the detachment annealings according to the invention which correspond to curves 52 and 53 are performed with a rise in temperature comprising two phases having different respective average ramps (these ramps can be linear, or not) :

- a "slow" phase, whose average ramp can have a relatively low average gradient of the order of 10°C/mm or less,
- followed by a "rapid" phase, having an increased average gradient (can be of the order of 15°C/min or more), this second phase being intended to finalise detachment and to end, as will be explained, on an improved surface state.

More precisely, the first phase corresponds to classic annealing detachment ramp.

The aim of this first phase, in the case of the invention, is to supply the wafer to be detached with thermal energy leading almost to detachment.

More precisely still, the first phase stops at a transition temperature corresponding to the onset of a detachment following the thermal energy supplied to the wafer during the first phase.

This onset of detachment is understood to mean the state in which a part of the embrittlement surface has effectively undergone detachment, but this detachment has not spread over the whole embrittlement surface.

This is accordingly a state in which the wafer

comprises a splitting "bubble", at the level of its embrittlement surface.

In classic annealing (such as that shown by the curve 51), the detachment ramp continues beyond this detachment beginning along the same average gradient to finalise detachment (in the situation where it is preferred to complete detachment during annealing).

In the case of the present invention however, the temperature evolution gradient is increased so as to continue annealing in a second phase corresponding to a second ramp, substantially greater than the gradient of the first phase.

It is specified that the transition temperature, which is, as we have seen, the temperature corresponding to the onset of detachment, will be adapted in terms of the nature and dimensions of the wafer to be detached; this adaptation could be made according to charts, or empirically.

In this respect, it should also be noted that the transition temperature corresponds more precisely to a thermal transition budget imparted to the wafer, which in turn corresponds to a state of the wafer in which onset of detachment takes place in the embrittlement surface of the wafer.

The aim of the second phase is to finalise detachment, by finishing up with a surface state (roughness especially) substantially improved relative to what is achieved from conventional methods.

The applicant has in fact observed that in continuing the first phase, after a transition temperature such as that defined and specified hereinabove, by a second phase of substantially increased

average gradient, the result is a surface state of the detached layers which is substantially improved relative to what is achieved in detachment annealing in the prior art.

It should also be pointed out that the second phase, apart from the fact that it has an increased average gradient, preferably also brings the wafer to a final annealing temperature likewise substantially increased relative to the final temperature of annealing detachment according to the prior art (which are of the order of 500°C, as illustrated by the curve 51).

This is illustrated by the final annealing temperatures of the curves 52 and 53.

And this characteristic, combined with the strong average gradient associated with the second phase, actually results in a particularly advantageous surface state, the surface roughness of the detached layers decreasing further still.

To initiate detachment at a specific point on the embrittlement surface of the wafer, the divergence in temperature prevailing inside the oven can be exploited (for example the presence of thermal gradients in an oven inside which the wafers are arranged vertically).

In the case where the wafer to be detached has been made up by bonding two layers having varying mechanical characteristics, the respective mechanical behaviour of the two bonded layers also influence detachment of the layers.

This is the case for example for SOIs shaped according to a process of the SMARTCUT® type, the SOIs being obtained by detachment, at an embrittlement surface (constituted by implantation), of the SOI and the silicon

heel.

In this respect in the event of detachment, then this detachment does not mean the operation consisting of undoing a bond which had been created by adhesion ("bonding" according to accepted English terminology).

Therefore, in the case of detachment of a wafer to constitute a SOI, a bonding interface is created by bonding (between the oxidised and implanted plate and the stiffener), and detachment takes place at the level of the embrittlement surface created by implantation, this embrittlement surface being distinct from the bonding interface, even if it is very close.

In this case, the two "layers" to be detached are therefore both the SOI itself comprising the stiffener, the oxide and the fine slice of silicon, and also the silicon heel.

Given the extreme fineness of the oxide and the fine layer of silicon of the SOI, the SOI has mechanical characteristics which are assimilable to those of the stiffener, such that the two layers to be detached have the respective mechanical characteristics of silicon and of the stiffener (which can be different in nature, the stiffener capable of being made from silicon, but also of a wide range of materials, such as quartz).

From the point of view of the mechanical characteristics, each of the two layers to be detached from the SOI can be assimilated respectively into two layers, which were previously bonded together, to make up the wafer to be detached, (the silicon layer and the stiffener).

The following applies to detachment (that is, fracture of the previously created embrittlement

interface) of two layers which are assimilable in the same way into two layers previously bonded together, each of the two layers to be detached being essentially composed of the material of one of these two layers.

And with reference to the influence of the mechanical behaviour of the layers to be detached, the two layers to be detached from the SOI (the silicon heel and the SOI itself) can thus have different mechanical characteristics).

In addition, these two layers are obviously equivalent from the mechanical point of view to a layer of silicon, and to the stiffener (these two elements having been assembled by bonding).

The two such bonded layers are not exactly flat.

There are tolerances on the surface evenness of such layers.

And bonding the two layers (oxidised and implanted silicon S, and stiffener R, see Figure 6) together was done so that the concavities of the two respective layers face one another, as is shown diagrammatically in the figure.

In this figure the concavities of the two bonded layers have been shown much deeper than in reality, and do not correspond in any way to a realistic scale.

During such bonding the concavities of the two layers are flattened so as to bond the surfaces of the two layers together. The two layers of the resulting wafer (and consequently the two layers to be detached, given that it was seen that mechanically these two layers were equivalent to the two bonded layers) are thus slightly prestressed (especially in their central region).

These two layers will thus tend to move apart from one another as soon as detachment has been initiated in a movement of relaxing the constraints due to the abovementioned bonding.

This benefits continuing detachment after the initial detachment described above and achieved on completion of the first phase of annealing.

This relaxation phenomenon becomes useful for detachment according to the present invention of any wafer whereof the two layers to be detached can be assimilated into two slices which have previously been bonded together, by subjecting them to prestressing as they are adjusted to one another.

With reference to the process according to the present invention in general, it has been said that the final annealing temperatures are greater than the final annealing temperatures of the prior art.

More precisely, in a preferred variant of the invention beneficial results will be obtained with final annealing temperatures of the order of 500°C to 800°C.

And even more precisely, according to a preferred option for implementing the invention the final annealing temperature is of the order of 600°C.

The gradient of the second ramp known as the rapid ramp is not necessarily 16° per minute. This non-limiting value can be adapted; in any case it must be substantially greater than the value of the gradient of the first ramp in temperature rise.

Similarly, the final annealing temperature, if effectively selected preferably substantially higher than for classic detachment annealings, is not limited to the values described above which constitute preferred values

only.

Also, the profile of temperature rise in two rectangular ramps represented in the curves 52 and 53 constitutes only a particular mode of utilising the invention.

In fact, a general characteristic of such annealing carried into effect according to the present invention is that it comprises :

- A first phase during which the temperature is brought from a starting annealing temperature (which can have a value of less than 350°C, as has been mentioned) to a temperature corresponding to a starting detachment temperature for the wafer.

It is specified that the onset of detachment can for example be observed by following, using any means known in and of itself, the diameter of gaseous bubbles generated by the detachment annealing from an embrittlement surface defined by implantation, the gaseous bubbles originating from the combination of micro-cavities formed in the structure by implanted inserts.

This first phase corresponds to the first slow ramp of the curves 52 and 53,

- Followed by a second phase during which, instead of stabilising the temperature as in known detachment annealings, at a final annealing temperature corresponding to a temperature which is only slightly greater than the starting detachment temperature, not only is the rise in temperature continued, but even the growth in temperature is increased per unit of time.

It can be considered therefore that :

- the first phase corresponds to the mechanical

triggering of detachment,

- while the second intensive annealing phase allows :
  - not only finalising of this detachment,
  - but also obtaining (as will be explained in detail hereinbelow) a very good surface state, this second phase corresponding to a finishing phase.

The starting detachment temperature, which corresponds to the transition temperature between the two annealing phases, can vary in terms of the characteristics of the structure to be detached.

In effect, the value of 430°C to 450°C mentioned above is not strictly limiting: in terms of characteristics such as the material(s) of the structure, the dose of implantation energy utilised during the creation of the embrittlement surface (in the case where this surface has been created by implantation), this temperature may vary to a certain extent.

For example, if the embrittlement surface is created by implantation, then before the thermal budget is supplied to cause initial bubbling of detachment it has to be adapted when the implantation energy is modified.

Figures 7a to 9a illustrate the differences in spatial distribution of haze on the surface of three SOIs which have undergone detachment annealings according to three different modalities.

Figure 7a thus illustrates distribution of haze on the surface of a SOI which has undergone classic detachment annealing, corresponding to the curve 51 of Figure 5.

This figure is to be compared to Figure 7b, which, following the example of Figure 4b, illustrates global

distribution of haze on the surface of the SOI, and an average value of the order of 87ppm.

Figure 8a illustrates the spatial distribution of haze on the surface of a SOI which has undergone detachment annealing according to the invention, with a temperature evolution corresponding to the curve 52 of Figure 5.

This figure is to be compared to Figure 8b, from which an average haze value of the order of 73ppm on the surface of the SOI is deduced.

A substantial decrease is noticed in the value of average haze and, consequently, of roughness on the surface of the SOI resulting from detachment.

Figures 9a and 9b correspond to another SOI, having undergone detachment annealing according to a temperature evolution according to the curve 53 of Figure 5.

In this case, as shown more particularly in Figure 8b, the average value of haze on the surface of the SOI is of the order of 5ppm.

This corresponds to an extremely significant decrease in the surface roughness of the SOI.

Figures 10 to 12 illustrate the evolution of the state of the crown of three respective SOIs which have undergone detachment annealing according to the three respective modalities described above (corresponding to the three respective curves 51, 52, 53 of Figure 5).

These figures 10 to 12 illustrate a significant decrease in the peripheral degradation of the SOI structure (the most degraded structure corresponding to classic annealing, the best preserved structure corresponding to annealing done according to the present invention and corresponding to the curve 53 of Figure 5).

It is specified that although the abovementioned examples have been described in reference to detachment, thus generating a SOI, the invention applies to detachment of any other structure comprising embrittlement which effectively delimits the layers to be detached.

CLAIMS

1. A process of detachment of two layers of material according to an embrittlement surface defined between the two layers, the process comprising thermal annealing of a structure (10) comprising said layers, said annealing bringing the temperature from a starting annealing temperature to a final annealing temperature, characterised in that during the thermal annealing the annealing temperature is made to evolve according to a first phase up to a transition temperature, then according to a second phase during which the rise in temperature per unit of time is stronger than during the first phase.

2. The process as claimed in the preceding claim, characterised in that the transition temperature corresponds to the onset of detachment.

3. The process as claimed in any one of the preceding claims, characterised in that the first phase is a detachment initiation phase, and the second phase is a surface-finishing phase.

4. The process as claimed in any one of the preceding claims, characterised in that the second phase is followed by a heating stage at a substantially constant temperature.

5. The process as claimed in the preceding claim, characterised in that said substantially constant temperature corresponds to the final annealing temperature.

6. The process as claimed in any one of the preceding claims, characterised in that during the first phase the temperature rises according to a slow average

gradient, extending up to around 10°C/min.

7. The process as claimed in any one of the preceding claims, characterised in that during the second phase the temperature rises according to a rapid average gradient, greater than around 15°C/mm.

8. The process as claimed in any one of the preceding claims, characterised in that the starting annealing temperature is less than or equal to 350°C.

9. The process as claimed in any one of the preceding claims, characterised in that the final annealing temperature is of the order of 500°C to 800°C.

10. The process as claimed in the preceding claim, characterised in that the final annealing temperature is of the order of 600°C.

11. The process as claimed in any one of the preceding claims, characterised in that the transition temperature between the two phases is of the order of 430°C a 450°C.

12. Application of a process as claimed in any one or more of the preceding claims for detaching two layers of material delimited by an embrittlement surface, said embrittlement surface having been created within the scope of a process of the SMARTCUT® type.

13. The application as claimed in the preceding claim, characterised in that the two layers of material comprise a layer of silicon.

14. The application as claimed in any one of the preceding claims, characterised in that the two layers of material are two layers of silicon, with one of the two layers corresponding to a SOI, and the other layer corresponding to a silicon heel.