METHOD FOR OBTAINING A THIN LAYER BY IMPLEMENTING CO-IMPLANTATION AND SUBSEQUENT IMPLANTATION

The present invention relates to a method for producing a structure comprising a thin layer of semiconductor material on a substrate, comprising the steps of:

- carrying out implantation of species under a face of a donor substrate from which the thin layer must be made, so as to create an embrittlement zone in the thickness of the donor substrate,
- placing the face of the donor substrate into close contact with a support substrate, after it has undergone implantation,
- detaching the donor substrate at the level of the embrittlement zone, so as to transfer a part of the donor substrate onto the support substrate and form the thin layer on the latter.

The invention relates more precisely to the above-mentioned implantation step.

SMARTCUT™ type processes, for which more ample details can be found in the document 'Silicon-On-Insulator Technology: Materials to VLSI, 2nd Edition', by Jean-Pierre Colinge from Kluwer Academic Publishers, pp. 50 and 51, are an example of methods of the type mentioned hereinabove and correspond to a preferred embodiment of the invention

Such processes advantageously produce structures comprising a thin layer of semiconductor material, such as SeOI (Semiconductor On Insulator) structures and the like.

The resulting structures from such processes are used for applications in the field of microelectronics, optics and/or optronics.

Implantation of species is conventionally understood to mean any bombardment of atomic or ionic species, likely to introduce these species onto the material of the implanted donor substrate, with a maximum concentration of the implanted species situated at a preset depth from the substrate relative to the bombarded surface.

But as it will be stated hereafter, within the context of the invention, implantation of species is not limited to the here above mentioned conventional bombardment implantation method but also extends to any method suitable for introducing species into the donor substrate, and in particular extends to the exposure of the donor substrate to a plasma containing the implantation species.

The above mentioned implantation step can be implemented by bombarding the donor substrate and co-implanting within its thickness two different atomic species. A common advantage of this co-implantation technique is the reduction by a factor of 2 to 3 approximately of the implanted dose relative to the implantation of a single type of species.

For instance, it is established in the article by Aditya Agarwal, T. E. Haynes, V. C. Venezia, O. W. Holland, and D. J. Eaglesham, "Efficient production of silicon-on-insulator films by co-implantation of He+ with H+", Applied Physics Letters, vol. 72 (1998), pp. 1086-1088, that the co-implantation of hydrogen H and helium He enables thin layer detachment at a much lower total implantation dose than that required when either hydrogen or helium alone is implanted.

This reduction translates by reduction in the implantation time, and finally in costs associated with production of structures comprising a thin layer on a support substrate, in particular by means of a transfer process of the SMARTCUT™ type.

However co-implantation presents the major drawback that blisters may form at the bonding interface between the face of the implanted donor wafer under which implantation has been carried out and the face of the support wafer.

Certain operations (such as thermal treatment) carried out, for instance during a transfer process of the SMARTCUT™ type, may effectively lead to the degradation of the bonding interface, this degradation coming from the appearance of blisters at the bonding interface.

Hence, when a SMARTCUT™ type process is carried out, blisters at the bonding interface may disturb the structural properties of the thin layer which has been detached. Blisters may even cause a detachment at the level of the blisters sites, that is at the level of the bonding interface and not at the level of the embrittlement zone, thus creating "non transferred" zones and introducing roughness and structural defects to the transferred thin layer.

It is mentioned here that when a SeOI structure is to be produced, the donor substrate may comprise on its top a superficial oxide layer which is to be placed, after the implantation step, into close contact with the support substrate so as to form the buried oxide layer of the final SeOI structure. In this case blisters may form at the bonding interface between the oxide layer and the support substrate.

Structures presenting non-transferred zones are usually rejected from the production line, and hens decrease the production yield.

In addition, blisters and voids have also been observed to some extent in the case of an implantation step carried out by implanting a single atomic species only. This problem is for instance encountered when producing a SOI structure comprising a thin or very thin layer of buried oxide (thickness below 500 angstroms; refer for instance to the applicant's French patent application filed on June, 6 2003 under n° 03 06843 which identifies this problem in relation to a H only implantation and proposes a solution different from that of the present invention) or when direct Si-Si bonding takes place (for instance when no superficial oxide layer is present for acting as a bonding layer between the Si donor and support substrates).

Let's consider a donor substrate made of silicon Si which has undergone co-implantation of He and H atoms. As He atoms may diffuse in the Si matrix more easily than H atoms, it is believed that the risk of blisters formation increases if He is implanted close to the bonding interface.

The following methods are thus usually carried out in order to avoid blisters formation.

A first method consists in implanting He atoms deeper than H atoms within the donor substrate (starting from the donor substrate's face under which implantation is carried).

A second method consists in increasing the H dose to be implanted, typically by a couple of 10^{15} H atoms/cm^2.

Of course both these methods can be implemented jointly.

The effect of these methods is illustrated by the table Table 1 here below which represents the average number of blisters detected as a co-implantation of He and H atoms has been carried out according to the following co-implantation conditions:

- a dose of He atoms of 12.10^{15}/cm^2;
- a He implantation energy as indicated along the Y axis (in keV);
- a dose of H atoms implanted as indicated along the X axis (in 10^{15}/cm^2);
- a H implantation energy of 27 keV.

Table 1

Y			
46	1	0	0
40	1	0	0
34	0.67	0.67	0
	9	**12**	**15**

X

In the lowest row, corresponding to the smallest He implantation energy and thus to the shallowest He implantation depth, blisters formation is observed. However as He implantation energy increases (He being thus implanted deeper), less blisters formation is observed. In other words, the deeper He is implanted, the less blisters formation is observed.

In the left-hand side column, corresponding to the lowest H dose, blisters formation is observed. However, as H dose increases (see centre and right hand side columns), blisters formation decreases. In other words, the higher the H dose is, the less blisters formation is observed.

In both methods, the H implanted region is regarded as acting as a gettering region or barrier making it possible to block the diffusion of He towards the bonding interface.

As mentioned above, the donor substrate is detached at the level of the embrittlement zone created in its thickness by the implantation step so as to transfer a part of the donor substrate onto the support substrate and to form the thin layer on the latter.

The specifications of the surface state of the structures obtained thanks to a transfer process such as the SMARTCUT® process are generally very strict. The surface roughness and the thickness uniformity of the thin layer are indeed parameters which to a certain extent condition the quality of the components which will be created on the structure.

There is thus a need for limiting as much as possible the surface roughness of the thin layer, and thus to carry out the implantation step under conditions making it possible to limit the roughness.

This need also extends to implantation conditions that allow obtaining a thin layer which thickness uniformity is suitable for the aimed applications, that is to conditions that allow making the thickness of the thin layer as much uniform as possible.

The table Table 2 here below shows the surface roughness measured after the detachment step has been carried out and the resulting structure has been subjected to a RTA (Rapid Thermal Annealing) adapted for gumming out certain roughnesses by surface reconstruction.

The co-implantation conditions are the same as those exposed in relation with Table 1, and as for Table 1, the Y axis represents the He implantation energy (in keV) and the X axis represents the H dose (in $10^{15}/cm^2$).

The surface roughness has more precisely been measured on a surface of 10 x 10 μm^2 swept by the point of an atomic force microscope AFM and is expressed by an average quadratic value known as RMS (Root Mean Square).

Table 2

Y			
46	4,28	5, 01	8,48
40	3,59	5,62	10,5
34	4,63	5,76	7,12
	9	**12**	**15**

X

It is apparent from this table that the two conditions limiting the roughness are those underlined on the upper part of the left hand side column. However these conditions result, as shown in Table 1, in blisters formation.

On the other hand, conditions resulting to zero blisters formation are conditions which does not limit roughness.

Hence, as the comparison of Table 1 and Table 2 makes it clear, certain implantation conditions that result in the best roughness may lead to the undesired blisters formation, and reciprocally conditions that avoid blisters formation may result in poor roughness.

It thus appears that surface roughness, uniformity and blisters formation cannot be controlled separately. Hence a compromise has to be made between the best conditions (implantation energies and doses) for avoiding blisters formation and the best conditions for both limiting the resulting surface roughness and obtaining a suitable thickness uniformity.

But by carrying out such a compromise, one understands that it is then impossible to produce a structure having an optimal surface roughness and uniformity for which at the same time blisters formation is optimally avoided.

There is thus a need for a method for producing a high quality structure comprising a thin layer of semiconductor material on a substrate without a compromise being made in particular between the implantation conditions

for avoiding blisters formation and the implantation conditions for both limiting the resulting surface roughness and obtaining a suitable thickness uniformity.

In other words, there is a need for a method for producing a structure comprising a thin layer of semiconductor material on a substrate which presents at the same time a limited blisters formation, an optimal low surface roughness and an optimal thickness uniformity.

In order to fill the above mentioned need, the invention proposes, according to a first aspect, a method for producing a structure comprising a thin layer of semiconductor material on a substrate, comprising the steps of:

- carrying out implantation of species under a face of a donor substrate from which the thin layer must be made, so as to create an embrittlement zone in the thickness of the donor substrate,
- placing the face of the donor substrate into close contact with a support substrate, after it has undergone implantation,
- detaching the donor substrate at the level of the embrittlement zone, so as to transfer a part of the donor substrate onto the support substrate and form the thin layer on the latter,

characterised in that the implantation step comprises :

- a first implantation operation consisting in carrying out an implantation of species so as to create said embrittlement zone at a first depth in the thickness of the donor substrate,
- a second implantation operation consisting in carrying out an implantation of species according to second implantation conditions chosen to create:
  - at a second depth different from said first depth so as not to affect the detachment that has to take place at the level of the embrittlement zone at said first depth,
  - a gettering region preventing the diffusion of species implanted during said first implantation operation towards said face of the donor substrate under which implantation is carried out, thus limiting blisters formation.

Preferred but non restrictive forms of the method according to the invention are as follows.

- the first implantation operation can be performed before or after the second implantation condition;
- the first implantation operation can be carried out according to first co-implantation conditions chosen in order to limit the surface roughness and to obtain a suitable thickness uniformity of the thin layer to be formed onto the support substrate, independently of considerations relating to implantation conditions allowing to limit blisters formation;
- the second implantation conditions can be chosen to create said gettering region at said second depth different from said first depth so as not to affect the roughness limitation sought by said first implantation conditions;
- the second implantation operation can be performed either by bombarding the donor substrate with the species to be implanted or by exposing the donor substrate to a plasma containing said species.
- the shift between said first and second depths can advantageously be comprised between 50 nm and 150 nm;
- the second depth may be lower than said first depth;
- the method may further comprise a thinning step adapted for removing a part of the thin layer comprising the gettering region and /or an annealing step adapted for curing the gettering region;
- the first implantation operation can comprise the co-implantation of at least two different species, such as the Hydrogen and Helium species;
- Helium can be implanted before Hydrogen during said first implantation operation;
- the first implantation operation can comprise the implantation of a single species, such as the Hydrogen species.
- the second implantation operation may comprise the implantation of only the Hydrogen or the Argon species;

Of course, the invention also relates, according to a second aspect, to the structures, and in particular to SeOI structures, which can be obtained thanks to the method according to the first aspect of the invention.

Other characteristics, purposes and advantages of the invention will appear to the reading of the following detailed description, with respect to the annexed drawings, given as non restrictive examples, in which:

- figure 1 represents the concentration repartition of the species implanted in the thickness of the donor substrate according to a first preferred embodiment of the invention;
- figures 2 and 3 provide an example illustrating the improvement brought by the first preferred embodiment of the invention.

As it has already been exposed, the invention relates to the implantation step carried out during the production of structures comprising a thin layer of semiconductor material on a support substrate, the thin layer being obtained by detachment at the level of a donor substrate previously embrittled by implantation of species.

The invention can aid in improving the quality of a structure obtained by utilising a transfer process of the SMARTCUT™ type.

The structure can, in general, be any type of structure comprising a thin layer of a semiconductor material on a surface exposed to the external environment (free surface).

In a non restrictive way, the thin layer of semiconductor material can be silicon Si, silicon carbide SiC, germanium Ge, silicon-germanium SiGe, gallium arsenide AsGa, GaN, etc.

The substrate support can be made of silicon Si, quartz, etc.

A layer of oxide can also be intercalated in between the support substrate and the thin layer, the structure therefore formed being a SeOI (Semiconductor On Insulator) structure, and in particular a SOI (Silicon On Insulator) structure.

The implantation step according to the invention comprises a first operation consisting in carrying out an implantation of species so as to

create the embrittlement zone at a first depth in the thickness of the donor substrate.

The first implantation operation can be performed by implanting a single species or by co-implanting at least two different species.

The first implantation operation can be performed conventionally by submitting the upper face of the donor substrate to an ionic or atomic bombardment, or by any other means suitable for introducing species into the donor substrate.

In accordance with a first preferred embodiment of the method according to the invention, the Hydrogen and Helium species are co-implanted in order to form the embrittlement zone.

Preferably, though not exclusively, co-implantation is carried out by sequentially implanting Helium then Hydrogen.

In accordance with a second preferred embodiment of the method according to the invention, only the Hydrogen species is implanted in order to form the embrittlement zone.

During the first implantation operation, the implantation conditions (called first co-implantation conditions) are adapted for optimally obtaining a good quality thin layer (that is notably by limiting the surface roughness and obtaining a suitable thickness uniformity of the thin layer) to be formed onto the support substrate (for instance as indicated in Table 2 here above), independently of considerations relating to implantation conditions which help lowering or avoiding blisters formation.

In relation with the first preferred embodiment, one thus profits from the effect exposed in the applicant's French patent application filed on July, 29 2003 under n° 0309304, according to which co-implantation of (a low dose of) Helium and Hydrogen results, when combined with a finishing step comprising a rapid thermal annealing (RTA) of the structure obtained post-detachment, in the transfer of thin layers with a reduced level of roughness relative to the transfer following implantation of (a higher dose of) hydrogen alone.

However, as no compromise has been made for the implantation conditions of this first implantation operation, there is, as mentioned previously, a risk that blisters may form, for instance under the action of atoms (for instance He atoms) diffusing, under thermal activation, towards the superficial region of the implanted donor wafer.

In order to avoid this blisters formation, the implantation step according to the invention comprises a second implantation operation.

This second implantation operation may be performed by carrying out a conventional implantation, the donor wafer being subjected to a bombardment of species.

This second implantation operation may also be performed by carrying out a plasma implantation wherein the donor substrate is exposed to a plasma containing the species. This exposure may also improve and facilitate bonding.

The second implantation operation is realized under implantation conditions (called second implantation conditions) chosen to create, at a second depth different from said first depth, a gettering region preventing the diffusion of species implanted during the first implantation operation towards said face of the donor substrate under which implantation is carried out, thus avoiding blisters formation.

As the second selected depth is different from the first selected depth, the desired detachment (at the level of the embrittlement zone at said first depth) specification and thus the expected surface roughness and thickness uniformity of the thin layer are not affected by this second implantation operation.

In other words, this second implantation operation does not affect the roughness limitation and thickness uniformity sought by the implantation conditions of the first implantation operation.

The implantation energy of this second implantation operation is advantageously adapted for said gettering region at said second depth to be close to said embrittlement zone at said first depth.

The implantation dose of this second implantation operation is advantageously a low dose (for instance typically lower than 1.10^{16} atoms/cm² for Hydrogen) but enough for generating defects within the donor substrate in a sufficient density for said gettering region to act as a gettering site for the diffusing species implanted during the first implantation operation.

These implantation conditions (energy, dose) thus allow the blocking of the blisters-formative species diffusion.

In such a configuration, the gettering region can be seen as acting as a barrier preventing the diffusion of species towards the superficial region of the implanted donor substrate.

In accordance with a preferred embodiment of the method according to the invention, only Hydrogen is implanted during said second implantation operation. Preferably, Hydrogen is implanted at a dose lower than 5.10^{16}/cm².

It has however to be noted that the invention is not limited to the implantation of Hydrogen; other species such as Argon may indeed be implanted during said second implantation operation (preferably, Argon is implanted at a dose substantially comprised between 1.10^{14}/cm² and 1.10^{16}/cm²).

According to an advantageous embodiment of the invention, the second depth is selected to be lower than the first depth so that the gettering region is located in the thickness of the donor substrate in between the face of the donor substrate under which implantation is carried and the embrittlement zone.

Returning to the description of the first preferred embodiment of the method according to the invention, some Helium atoms tend, under thermal activation, to diffuse. Those He Atoms are gettered at the defect sites caused by the Hydrogen implantation carried out during said second implantation operation.

Hence as the H-only implantation region at a second selected depth is close enough to the embrittlement zone, and the implanted H dose creates defects in a sufficient manner for acting as a gettering site for the He atoms, it is believed that He diffusion towards the face of the donor substrate under which implantation is carried out is prevented and blisters formation is limited.

As mentioned above, the H-only gettering region is advantageously located, relatively to the embrittlement zone, on the side of the face of the donor substrate under which implantation is carried, so that said gettering region effectively acts as a barrier.

Returning to the description of the method according to the invention, once the thin layer has been formed onto the support substrate, the gettering region remains within the donor substrate if said second depth is larger than said first depth or is located within the thin layer formed on the support substrate if said second depth is lower than said first depth.

The method according to the invention may further comprise, after transfer, a thinning step adapted for removing a part of the thin layer comprising said gettering region, so that the quality of the final structure is not influenced by said gettering region.

Such a thinning step may be carried out according to classical techniques such as a chemical-mechanical polishing (CMP), a sacrificial oxidation, a (dry or wet) chemical etching, etc.

In a more general way, this thinning step may be applied after detachment to the transferred layer or to the donor substrate as exposed for instance in patent application US 6 720 640.

The method according to the invention may further comprise an annealing step performing a simple annealing (in a furnace or by performing a RTA at a temperature around 1,000°C) adapted for annealing out the slight crystalline defects induced by the second implantation condition, thus curing the gettering region.

Preferentially, the shift (which may be for instance defined as the distance between the H peaks) between the first and second depths is comprised between 50 nm and 150 nm, so that the gettering region profile does not advantageously overlap the layer region that will serve as the useful final thin layer.

The first preferred embodiment of the method according to the invention is schematically illustrated by Figure 1 which represents the concentration repartition within the thickness of the donor substrate of the different implanted species.

He and H atoms are co-implanted during the first implantation operation and are distributed in the thickness of the donor substrate according respectively to curve C1 and curve C2, so as to create an embrittlement zone represented by reference Ez at depth z.

H atoms are then implanted during the second implantation operation and are distributed in the thickness of the donor substrate according to curb C3.

Arrow A represents the diffusion of He atoms, under thermal treatment, towards the gettering site constituted by the second H-only implantation operation, so that diffusion of He atoms towards the zero depth region is avoided, blisters formation being thus prevented.

The description hereafter aims at providing examples illustrating the improvement brought by the method according to the invention.

In a first example, a first SOI structure S1 was produced with an implantation step consisting only of a co-implantation of He and H under implantation conditions known for resulting in the formation of blisters.

A second SOI structure S2 was produced accordingly to the first preferred embodiment of the invention, the implantation step consisting in:

- a co-implantation operation under the same conditions as the co-implantation operation of the first SOI structure and of
- a subsequent implantation operation of H only.

The following table Table 3 recapitulates the implantation conditions used for producing structures S1 and S2.

Table 3

		S1	S2
First implantation operation (He/H co-implantation)	He implantation	49 keV $1,5.10^{16}/cm^2$	
	H implantation	32 keV $10^{16}/cm^2$	
Second implantation operation (H only implantation)		None	20 keV $0,5.10^{16}/cm^2$

Structures S1 and S2 were furthermore subjected to a classical finishing step comprising an annealing treatment, for instance as described in the applicant's patent application FR 0309304 already mentioned above.

Figure 2 represents the number (along the vertical axis) of blisters (represented as circles) observed after structures S1 and S2 were subjected to a classical finishing step comprising an annealing treatment.

It is apparent from this figure 2 that the number of blisters are significantly lowered for structure S2 compared to structure S1. Indeed, whereas the mean number of observed blisters is 11, 2 for structure S1, the mean number of observed blisters is 4,4 only for structure S2 produced according to a possible embodiment of the invention.

Figure 3 represents roughness RMS values measured for structures S1 and S2 by a 10*10 μm^2 AFM scan. It is apparent from this figure 3 that the roughness of structure S2 is identical to that of structure S1. Indeed the mean roughness of structure S2 is 50.7 angstroms RMS while that of structure S1 is 49.8 angstroms RMS.

It is thus apparent from this first example that the roughness can be optimized by the implantation conditions of the first implantation step (in this case a He/H co-implantation) while the number of blisters may be limited thanks to the second implantation step (here notably by blocking the diffusion of He at the second H implanted region). The method according to the invention thus allows not having in particular to make the classical compromise between implantation conditions avoiding blisters and implantation conditions limiting the resulting surface roughness and obtaining a suitable thickness uniformity.

In a second example, a SOI structure having a thin layer of buried oxide was produced according to a method comprising a step of oxidizing a Si substrate for forming a 200 angstroms thick superficial oxide layer.

This SOI structure S3 was more precisely produced accordingly to the second preferred embodiment of the invention, the implantation step consisting in:

- a fist implantation operation of H only and of
- a subsequent second implantation operation of argon Ar only.

Table 4 hereafter recapitulates the implantation conditions used for producing structure S3.

Table 4

	S3
First implantation operation (H implantation)	37 keV $5.10^{16}/cm^2$
Second implantation operation (Ar implantation)	200 keV $5.10^{14}/cm^2$

After detachment, very few blisters were observed and a 10*10 μm^2 AFM scan revealed a roughness of approximately 60 angstroms RMS.

Structure S3 was furthermore subjected to a classical finishing step comprising an annealing treatment, for instance as described in the applicant's patent application FR 0309304 already mentioned above. A

10*10 μm^2 AFM scan revealed a roughness as low as a few angstroms RMS.

More generally speaking, the structures, in particular SeOI structures (such as structures S2 and S3), obtained thanks to the above described method, exhibit a small roughness, and particularly a roughness revealed by a 10*10 μm^2 AFM scan, substantially comprised between 35 and 60 angstroms.

THE CLAIMS

1. Method for producing a structure comprising a thin layer of semiconductor material on a substrate, comprising the steps of:

- carrying out implantation of species under a face of a donor substrate from which the thin layer must be made, so as to create an embrittlement zone in the thickness of the donor substrate,
- placing the face of the donor substrate into close contact with a support substrate, after it has undergone implantation,
- detaching the donor substrate at the level of the embrittlement zone, so as to transfer a part of the donor substrate onto the support substrate and form the thin layer on the latter,

characterised in that the implantation step comprises :

- a first implantation operation consisting in carrying out an implantation of species so as to create said embrittlement zone at a first depth in the thickness of the donor substrate,
- a second implantation operation consisting in carrying out an implantation of species according to second implantation conditions chosen to create:
  - at a second depth different from said first depth so as not to affect the detachment that has to take place at the level of the embrittlement zone at said first depth,
  - a gettering region preventing the diffusion of species implanted during said first implantation operation towards said face of the donor substrate under which implantation is carried out, thus limiting blisters formation.

2. Method according to claim 1, characterised in that the first implantation operation is performed before the second implantation operation.

3. Method according to claim 1, characterised in that the first implantation operation is performed after the second implantation operation.

4. Method according to any one of the preceding claims, characterised in that the first implantation operation is carried out according to first implantation conditions chosen in order to limit the surface roughness and to obtain a suitable thickness uniformity of the thin layer to be formed onto the support substrate, independently of considerations relating to implantation conditions allowing to limit blisters formation.

5. Method according to claim 4, characterised in that said second implantation conditions are chosen to create said gettering region at said second depth different from said first depth so as not to affect the roughness and uniformity limitation sought by said first implantation conditions.

6. Method according to claim 5, characterised in that said second implantation operation is carried out by bombarding the surface of the donor substrate with the species to be implanted.

7. Method according to claim 5, characterised in that said second implantation is carried out by exposing the donor substrate to a plasma containing the species to be implanted.

8. Method according to any one of the preceding claims, characterised in that the shift between said first and second depths is comprised between 50 nm and 150 nm.

9. Method according to any one of the preceding claims, characterised in that said first and second implantation conditions are chosen so that said second depth is lower than said first depth, the gettering region being thus located in the thickness of the donor substrate in between the face of the

donor substrate under which implantation is carried and the embrittlement zone.

10. Method according to claim 9, characterised in that it further comprises a thinning step adapted for removing a part of the thin layer comprising the gettering region.

11. Method according to any one of claims 9 or 10, characterised in that it further comprises an annealing step adapted for curing the gettering region.

12. Method according to any one of the preceding claims, characterised in that said first implantation operation comprises the co-implantation of at least two different species.

13. Method according to the preceding claim, characterised in that said first implantation operation comprises the co-implantation of the Hydrogen and Helium species.

14. Method according to the preceding claim, characterised in that Helium is implanted before Hydrogen during said first implantation operation.

15. Method according to any one of claims 1 to 11, characterized in that said first implantation operation comprises the implantation of a single species.

16. Method according to the preceding claim, characterized in that said first implantation operation comprises the implantation of Hydrogen only.

17. Method according to any one of claims 12 to 16, characterised in that said second implantation operation comprises the implantation of only the Hydrogen or only the Argon species.

18. Method according to claim 17, characterised in that Hydrogen is implanted during said second implantation operation at a dose lower than $5.10^{16}/cm^2$ or Argon is implanted during said second implantation operation at a dose substantially comprised between $1.10^{14}/cm^2$ and $1.10^{16}/cm^2$.

19. Structure, in particular Semiconductor On Insulator (SeOI) structure, obtained thanks to the method according to any one of the preceding claims, characterized in that the thin layer exhibits a small roughness, particularly a roughness measured by a 10 x 10 μm^2 AFM scan, substantially comprised between 35 and 60 angstroms RMS.

20. Intermediate Structure obtained just after the implantation step of the method according to any one of claims 1 to 9 or any one of claims 12 to 19.