

Masking a zone at the edge of a donor substrate during an ion implantation step

The present invention relates to the field of fabricating semiconductor-on-insulator (SeOI) substrates and, more particularly, to the ion implantation step carried out on a donor substrate to produce a predetermined separation zone inside said donor substrate.

A semiconductor-on-insulator (SeOI) substrate may be obtained by means of a SmartCut process. In this type of process, a layer is transferred from a donor substrate onto a carrier substrate by propagating a fracture wave along an interface in the donor substrate, which interface is embrittled beforehand by ion implantation, during a thermal annealing operation. During fracturing, micrometre-sized particles are created, in particular at the edge of the SeOI substrate.

It thus subsequently becomes necessary to clean the SeOI substrate and/or the remainder of the donor substrate using RCA cleaning processes. This therefore represents a loss of time and of resources.

Embodiments of the invention seek to overcome the drawbacks described above by providing a process making it possible to fabricate a donor substrate with a predetermined separation zone for transferring a layer from the donor substrate onto a carrier substrate, making it possible to decrease the level of particles produced in the step of detaching the carrier substrate with the transferred layer from the remainder of the donor substrate.

An aspect of the present invention provides a process for forming a predetermined separation zone inside a donor substrate. The process comprises a first atom and/or ion implantation step that is carried out such that an implantation dose in a zone of an edge of the donor substrate is lower than an implantation dose in a central zone of the donor substrate, and a second atom and/or ion implantation step carried out over the entire surface of the donor substrate with an implantation dose that is lower than in the first implantation step.

Thus, the zone at the edge of the donor substrate, where there may be an absence of bonding with the carrier substrate, is less damaged by the implantation step than the central zone of the donor substrate.

Due to the lower concentration of the co-implant, the creation of particles during a thermal annealing operation may be avoided or at least decreased.

According to an embodiment, the first implantation step may be an implantation of helium ions and the second implantation step may be an implantation of hydrogen ions.

According to an embodiment, the implantation dose in the zone at the edge of the donor substrate may be lower than $1\text{e}16\text{ at/cm}^2$, in particular comprised between $0.5\text{e}16\text{ at/cm}^2$ and $7\text{e}16\text{ at/cm}^2$. For such implantation doses in the zone of the edge of the donor substrate, the creation of particles during a thermal annealing operation may be avoided or at least decreased.

Another aspect of the present invention provides a donor substrate for transferring a layer onto a carrier substrate, comprising a central zone and a zone of an edge, wherein a predetermined separation zone is formed in the donor substrate by a first implantation and a second implantation, wherein, in the first implantation, an implantation dose in the zone of the edge of the donor substrate is lower than an implantation dose in the central zone of the donor substrate, wherein the second implantation is carried out over the entire surface of the donor substrate with an implantation dose that is lower than in the first implantation, and wherein implanted species are present both in the central zone and the zone of the edge. The advantage is that, with such a substrate, a decrease in the level of particles produced in the detachment step of the layer transfer process may be obtained.

Another aspect of the present invention provides a process of transferring a thin layer from a donor substrate onto a carrier substrate, comprising the steps of a) attaching a donor substrate described above to a carrier substrate and b) carrying out a detachment operation at the site of the predetermined separation zone to detach a remaining portion of the donor substrate from the transferred layer to the carrier substrate. With this process using the donor substrate as described, a layer may be transferred while creating fewer particles.

According to one variant of the process, step b) may comprise a thermal annealing.

There is also disclosed a device for limiting an implantation region to a central zone of a donor substrate,

wherein the device includes a means suitable for carrying out the implantation such that an implantation dose towards a zone of an edge of the donor substrate is lower than an implantation dose in the central zone of the donor substrate.

Thus, it is possible to control the siting of the implantation zones on a substrate, in particular to delimit an implantation zone to a central zone of the substrate, to be able to decrease the creation of particles in a layer transfer process such as described above.

According to an embodiment, the means for limiting the implantation region to the central zone of the donor substrate may comprise a mask. According to another alternative, the mask may be a ring positioned on or above the donor substrate. According to one alternative, the mask may be configured to mask the zone of the edge of a donor substrate over a width comprised between 1 mm and 5 mm, in particular between 1 and 2 mm. Thus, the implantation profile in a substrate may be modified and predetermined in a straightforward manner to obtain implantation zones having various doses in one and the same substrate.

There is also disclosed an ion implanter for implanting ions into a donor substrate comprising a device such as described above. Thus, an ion implanter may provide greater possibilities with respect to controlling the siting of the implantation zones on a substrate, in particular of delimiting an implantation zone to a central zone of the substrate.

The invention may be understood by referring to the following description together with the appended figures, in which numerical references identify the elements of the invention.

Figures 1a to 1f schematically show the various steps of the process of transferring a thin layer from a donor substrate onto a carrier substrate according to the invention.

Figure 2a shows a diagram of masking the edge of a substrate in an implantation step according to one variant of the invention.

Figure 2b shows a schematic view from above of a mask used for masking a zone of the edge of a substrate during the implantation operation according to one variant of the invention.

Claims

1. Process for forming a predetermined separation zone inside a donor substrate, the process comprising:
 - a first atom and/or ion implantation step that is carried out such that an implantation dose in a zone of an edge of the donor substrate is lower than an implantation dose in a central zone of the donor substrate, and
 - a second atom and/or ion implantation step carried out over the entire surface of the donor substrate with an implantation dose that is lower than in the first implantation step.
2. Process according to Claim 1, wherein the first implantation step is carried out such that the implantation is limited to the central zone of the donor substrate.
3. Process according to Claim 1 or 2, wherein the zone of the edge of the donor substrate comprises or is limited to a chamfered zone on the edge of the donor substrate.
4. Process according to any one of Claims 1 to 3, wherein a width of the zone of the edge of the donor substrate is comprised between 1 mm and 5 mm.
5. Process according to Claim 4, wherein the width is comprised between 1 mm and 2 mm.
6. Process according to any one of Claims 1 to 5, wherein the first implantation step is carried out using a mask on or above the zone of the edge of the donor substrate.
7. Process according to any one of Claims 1 to 6, wherein the first implantation step is carried out by scanning the donor substrate with an ion beam such that the implantation dose towards the zone of the edge of the donor substrate is lower than the implantation dose in the central zone of the donor substrate, such that the implantation is limited to the central zone of the donor substrate.

8. Process according to any one of Claims 1 to 7, wherein the first implantation step comprises an implantation of helium ions (He) or a co-implantation of helium and hydrogen ions (He-H).

9. Process according to Claim 1, wherein the first implantation step is an implantation of helium ions and the second implantation step is an implantation of hydrogen ions.

10. Process according to any one of Claims 1 to 9, wherein the implantation dose in the zone of the edge of the donor substrate is lower than $1\text{e}16\text{ at/cm}^2$.

11. Process according to Claim 11, wherein the implantation dose in the zone of the edge of the donor substrate is comprised between $0.5\text{e}16\text{ at/cm}^2$ and $1\text{e}16\text{ at/cm}^2$.

12. Donor substrate for transferring a layer onto a carrier substrate, comprising a central zone and a zone of an edge, wherein a predetermined separation zone is formed in the donor substrate by a first implantation and a second implantation, wherein, in the first implantation, an implantation dose in the zone of the edge of the donor substrate is lower than an implantation dose in the central zone of the donor substrate, wherein the second implantation is carried out over the entire surface of the donor substrate with an implantation dose that is lower than in the first implantation, and wherein implanted species are present both in the central zone and the zone of the edge.

13. Process of transferring a layer of a donor substrate onto a carrier substrate comprising the steps of:

- a) attaching a donor substrate according to Claim 12 to a carrier substrate;
- b) carrying out a detachment operation at the site of the predetermined separation zone to detach a remaining portion of the donor substrate from the layer transferred to the carrier substrate.

14. Process according to Claim 13, wherein step b) comprises a thermal annealing operation.