implantation have low fluxes and the ion implantation step would require a significant amount of time. Consequently, to implant the target doses (several $10^{16}cm^{-2}$), the method would be difficult to carry out (slow) and expensive. In addition, such equipment is not standard. As a result, the maximum lateral dimension of a cavity in this type of structure obtained using Smart-Cut cannot be more than a few tens of microns.

OBJECT OF THE INVENTION

The present invention aims to overcome all or some of the aforementioned drawbacks. It relates to a method for using Smart-Cut to transfer a membrane of piezoelectric nature to a substrate comprising at least one cavity of large size.

An aspect of the present invention provides a method for producing a device comprising a membrane of piezoelectric nature above at least one cavity, the method comprising the following steps:

a) providing a carrier substrate having a first face extending over a plane (x, y) and provided with a cavity opening out onto the first face, the cavity having a lateral dimension in the plane (x, y) that is larger than 30 µm,
b) providing a donor substrate made of silicon or of silicon carbide and provided with a buried weakened plane formed by implanting light species through a front face of the donor substrate, the weakened plane delimiting a surface layer,
c) depositing, on the front face of the donor substrate, a stiffening layer made of piezoelectric material having a thickness greater than 500 nm,
d) joining the carrier and donor substrates at a bonding interface arranged between the first face of the carrier substrate and the stiffening layer, and

e) splitting, after step d), the donor substrate at the buried weakened plane so as to transfer a membrane comprising the surface layer and the stiffening layer to the carrier substrate, the membrane being located above the cavity.

According to other advantageous and non-limiting features of this production method, which may be implemented alone or in any technically feasible combination:

- the carrier substrate is made of silicon,
- the donor substrate is made of silicon and the stiffening layer is deposited at a temperature lower than 450°C,
- the donor substrate is made of silicon carbide and the stiffening layer is deposited at a temperature lower than 850°C,
- the implanted light species are hydrogen ions and/or helium ions,
- a first electrically conductive layer is interposed between the stiffening layer and the carrier substrate, the first electrically conductive layer being directly in contact with the stiffening layer and configured to form a lower electrode of the device,
- a bonding layer is interposed between the stiffening layer and the carrier substrate, said bonding layer being directly in contact with the carrier substrate, the bonding layer preferably being made of silicon oxide,
- a second electrically conductive layer is formed on the stiffening layer, the second electrically conductive layer being configured to form an upper electrode of the device,
- the method comprises at least one mechanical grinding operation and/or at least one chemical-mechanical

polishing operation and/or at least one chemical etching operation on the surface layer after splitting step e),

- joining step d) comprises bonding by molecular adhesion between, on the one hand, the donor substrate provided with the stiffening layer and, on the other hand, the first face of the carrier substrate,
- a step of deposition on the free surface of the surface layer is performed after step e) so as to increase the thickness of the surface layer.

According to another aspect of the invention, the invention also relates to a donor substrate configured to transfer a membrane of piezoelectric nature to a carrier substrate provided with at least one cavity having a lateral dimension larger than 30 µm, the donor substrate being made of silicon or of silicon carbide and comprising:

- a weakened plane arranged in the donor substrate and delimiting a surface layer, and
- a stiffening layer made of piezoelectric material having a thickness greater than 500 nm arranged on the surface layer.

BRIEF DESCRIPTION OF THE FIGURES

Other features and advantages of the invention will become apparent from the following detailed description of the invention, which is given with reference to the appended figures, in which:

[Fig. 1]

[Fig. 2]

[Fig. 3]

[Fig. 4]

CLAIMS

1. A method for producing a device comprising a membrane of piezoelectric nature above at least one cavity, the method comprising:
   a) providing a carrier substrate having a first face extending over a plane and provided with a cavity opening out onto the first face, the cavity having a lateral dimension in the plane that is larger than 30 µm,
   b) providing a donor substrate made of silicon or of silicon carbide and provided with a buried weakened plane formed by implanting light species through a front face of the donor substrate, the weakened plane delimiting a surface layer,
   c) depositing, on the front face of the donor substrate, a stiffening layer made of piezoelectric material having a thickness greater than 500 nm,
   d) joining the carrier and donor substrates at a bonding interface arranged between the first face of the carrier substrate and the stiffening layer, and
   e) splitting, after step d), the donor substrate at the buried weakened plane so as to transfer a membrane comprising the surface layer and the stiffening layer to the carrier substrate, the membrane being located above the cavity.

2. The method according to Claim 1, in which the carrier substrate is made of silicon.

3. The method according to Claim 1, in which the donor substrate is made of silicon and the stiffening layer is deposited at a temperature lower than 450°C.

4. The method according to Claim 1, in which the donor substrate is made of silicon carbide and the stiffening layer is deposited at a temperature lower than 850°C.

5. The method according to one of the preceding claims, in which the implanted light species are hydrogen ions and/or helium ions.

6. The method according to one of the preceding claims, in which a first electrically conductive layer is interposed between the stiffening layer and the carrier substrate, the first electrically conductive layer being directly in contact with the stiffening layer and configured to form a lower electrode of the device.

7. The method according to one of the preceding claims, in which a bonding layer is interposed between the stiffening layer and the carrier substrate, said bonding layer being directly in contact with the carrier substrate.

8. The method according to claim 7, in which the bonding layer is made of silicon oxide.

9. The method according to one of the preceding claims, in which a second electrically conductive layer is formed on the stiffening layer, the second electrically conductive layer being configured to form an upper electrode of the device.

10. The method according to one of the preceding claims, comprising at least one mechanical grinding operation and/or at least one chemical-mechanical polishing operation and/or at least one chemical etching operation on the surface layer after splitting step e).

11. The method according to one of claims 1 to 6, in which joining step d) comprises bonding by molecular adhesion between, on the one hand, the donor substrate provided with the stiffening layer and, on the other hand, the first face of the carrier substrate.

12. The method according to one of the preceding claims, in which a step of deposition on the free surface of the surface layer is performed after step e) so as to increase the thickness of the surface layer.

13. A donor substrate configured to transfer a membrane of piezoelectric nature to a carrier substrate provided with at least one cavity having a lateral dimension larger than 30 µm, the donor substrate being made of silicon or of silicon carbide and comprising:

a weakened plane arranged in the donor substrate and delimiting a surface layer, and

a stiffening layer made of piezoelectric material having a thickness greater than 500 nm arranged on the surface layer.