(19) **United States**
(12) **Patent Application Publication**
Darras et al.
(10) **Pub. No.: US 2023/0154755 A1**
(43) **Pub. Date: May 18, 2023**

(54) **REMOVABLE STRUCTURE USED FOR THE TRANSFER OR MANIPULATION OF LAYERS, AND METHOD FOR TRANSFER OF A LAYER USING SAID REMOVABLE STRUCTURE**

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(21) Appl. No.: **17/995,547**

(22) PCT Filed: **Mar. 16, 2021**

(86) PCT No.: **PCT/FR2021/050435**

§ 371 (c)(1),
(2) Date: **Oct. 5, 2022**

(30) **Foreign Application Priority Data**

Apr. 1, 2020 (FR) FR2003263

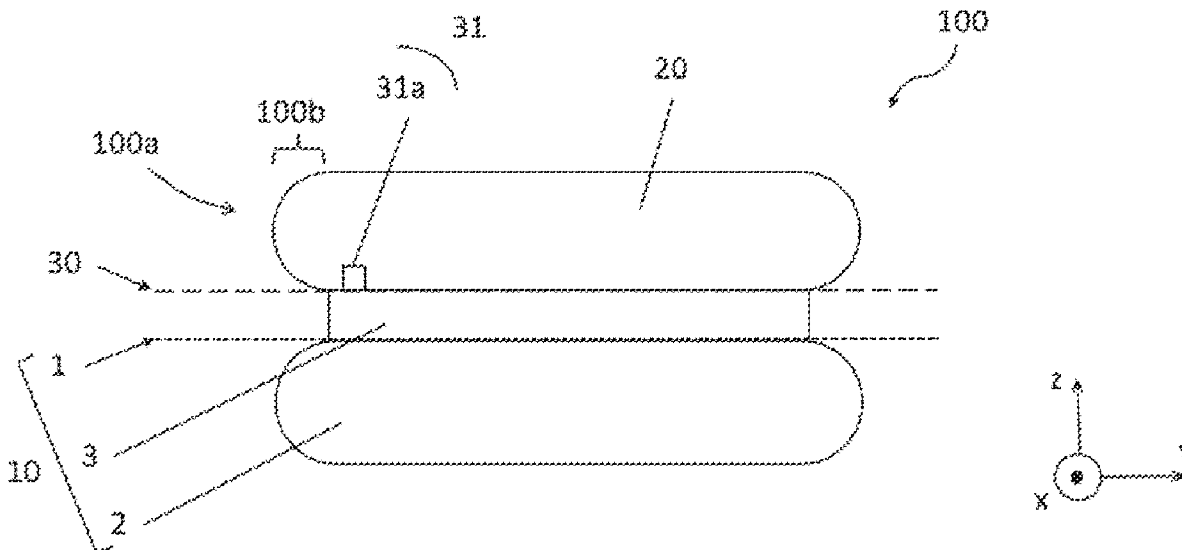
Publication Classification

(51) **Int. Cl.**
H01L 21/18 (2006.01)
H01L 21/02 (2006.01)
H01L 21/78 (2006.01)
H01L 21/304 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 21/187*** (2013.01); ***H01L 21/02002*** (2013.01); ***H01L 21/7806*** (2013.01); ***H01L 21/304*** (2013.01)

(57) **ABSTRACT**

A detachable structure comprises at least two interfaces including an assembly interface and a favored-detachment interface, a receiver substrate, and a donor substrate comprising a working layer that is to be transferred, arranged on an initial substrate. The favored-detachment interface is situated between the working layer and the initial substrate, and the assembly interface is situated between the working layer and the receiver substrate. The assembly interface has an assembly-interruption zone comprising at least one cavity present in the receiver substrate or in the working layer, and the assembly-interruption zone is located in a peripheral region of the detachable structure.



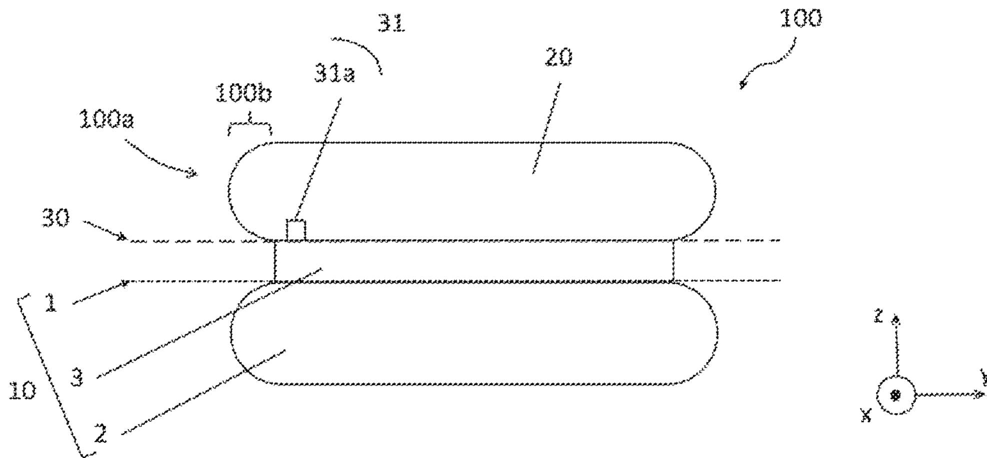


FIG. 1A

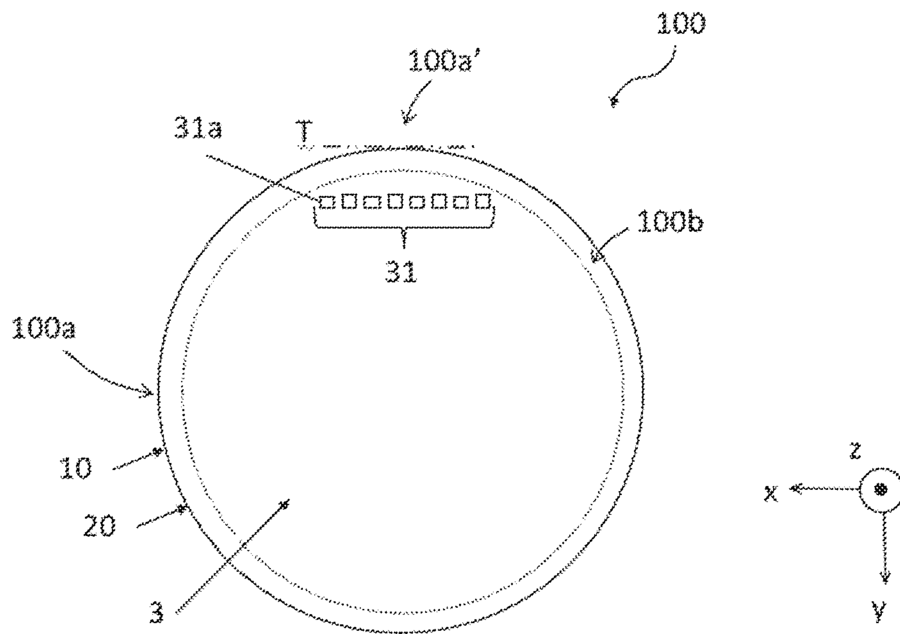


FIG. 1B

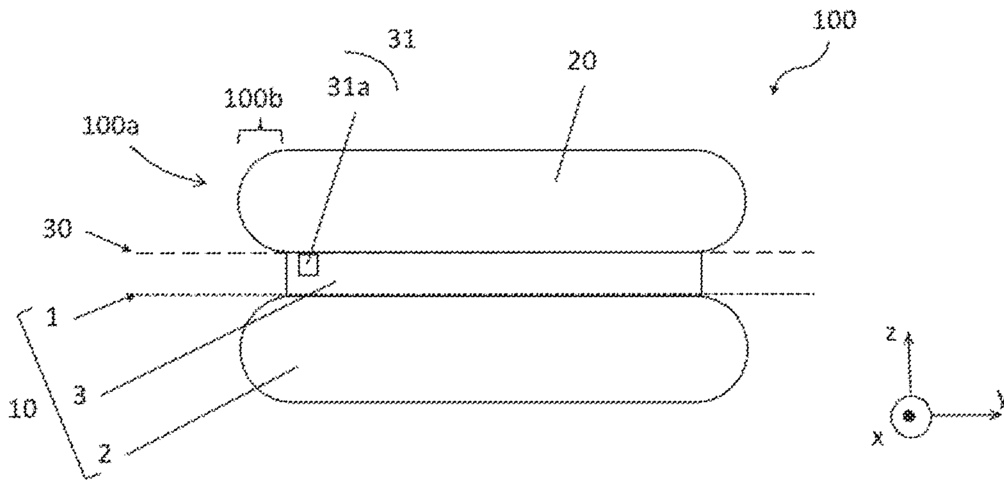


FIG. 2A

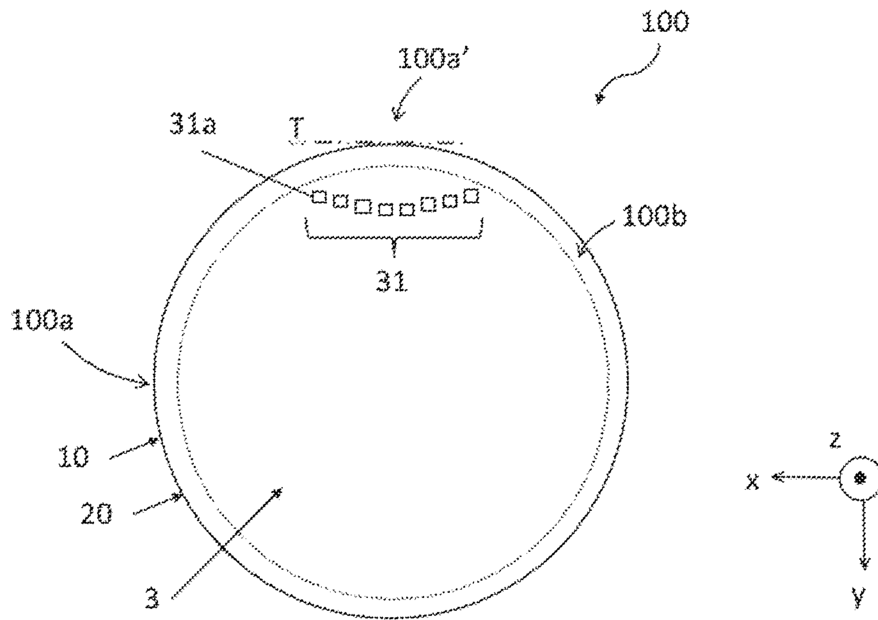


FIG. 2B

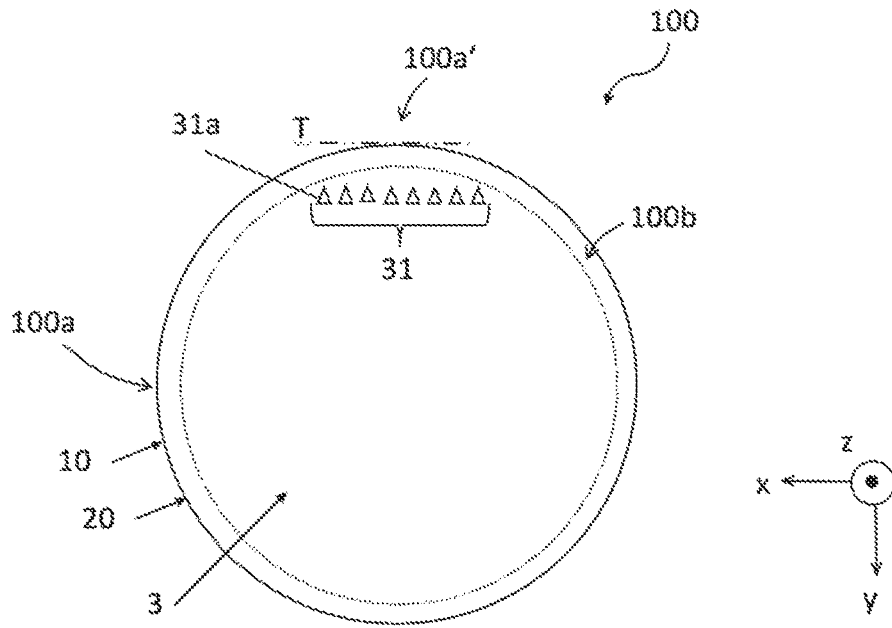


FIG. 2C

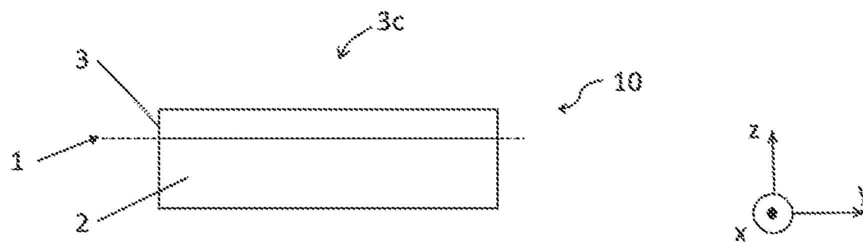


FIG. 3A

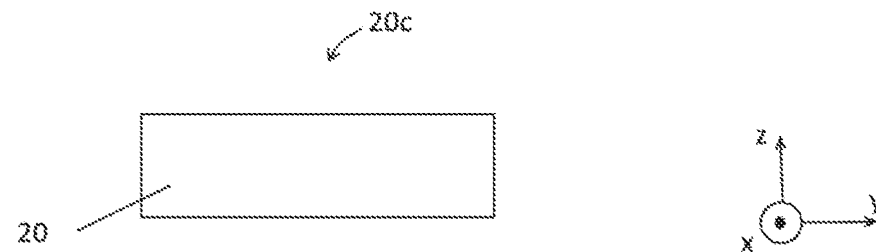


FIG. 3B

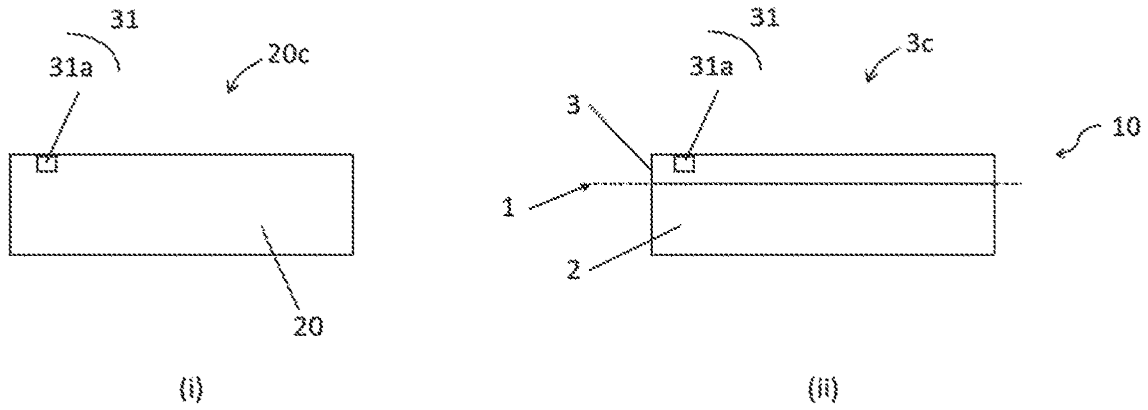


FIG. 3C

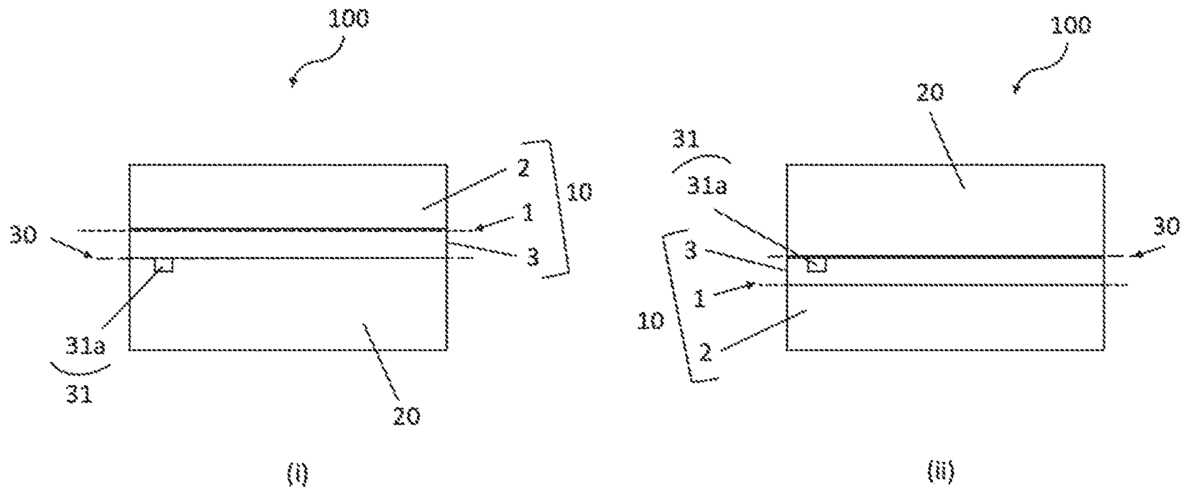


FIG. 3D

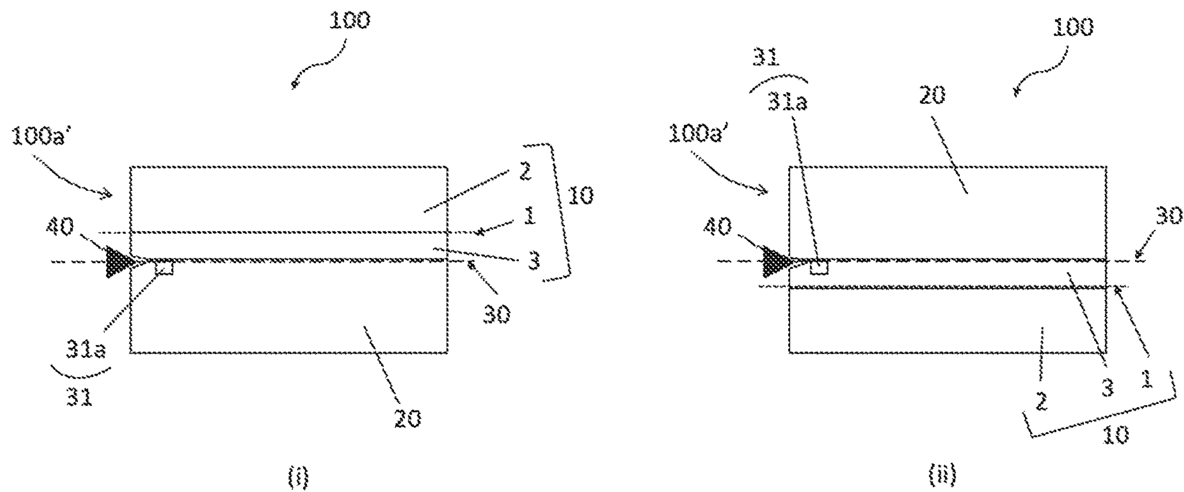


FIG. 3E

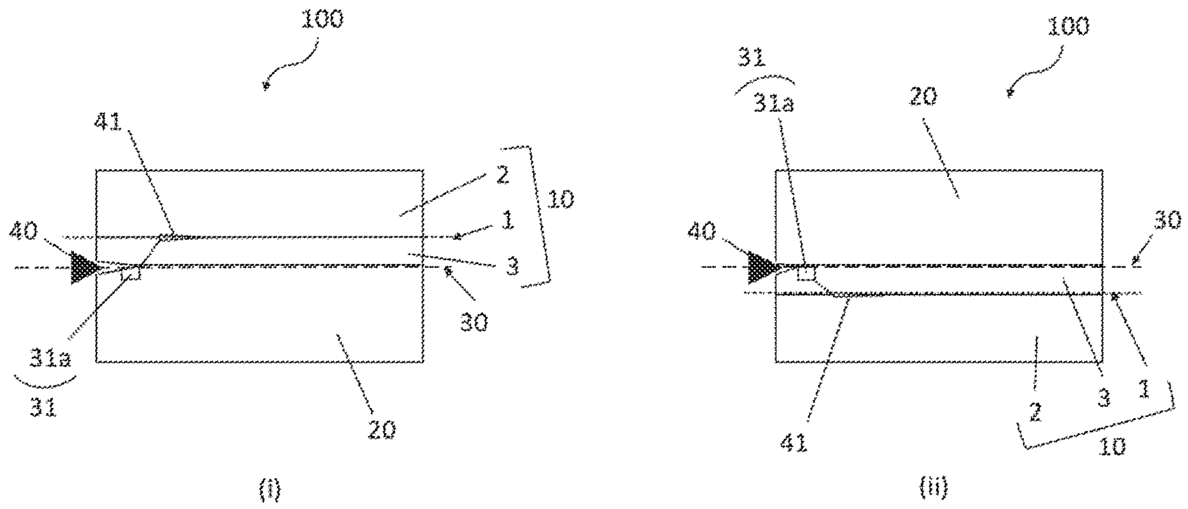


FIG. 3F

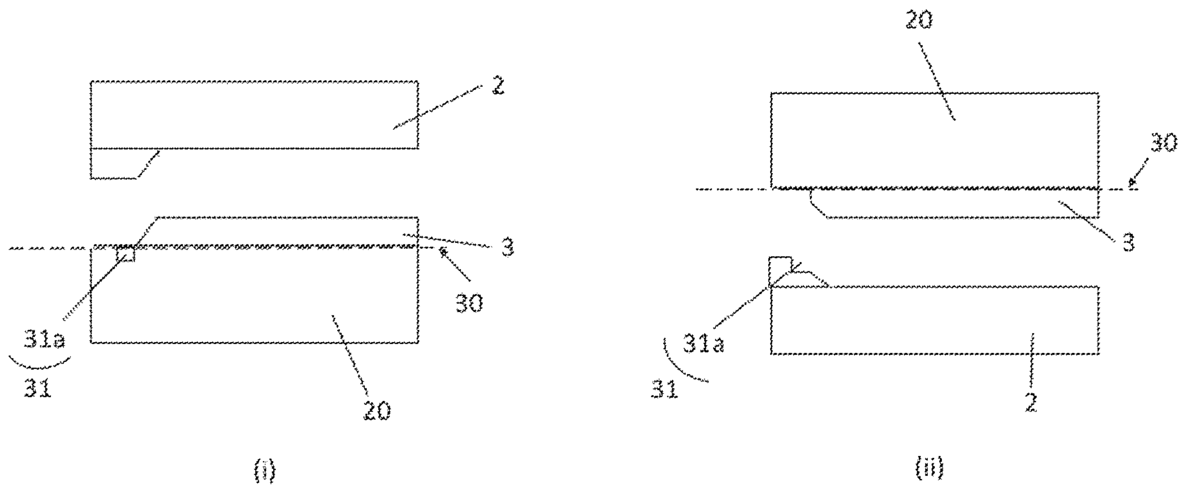


FIG. 3G

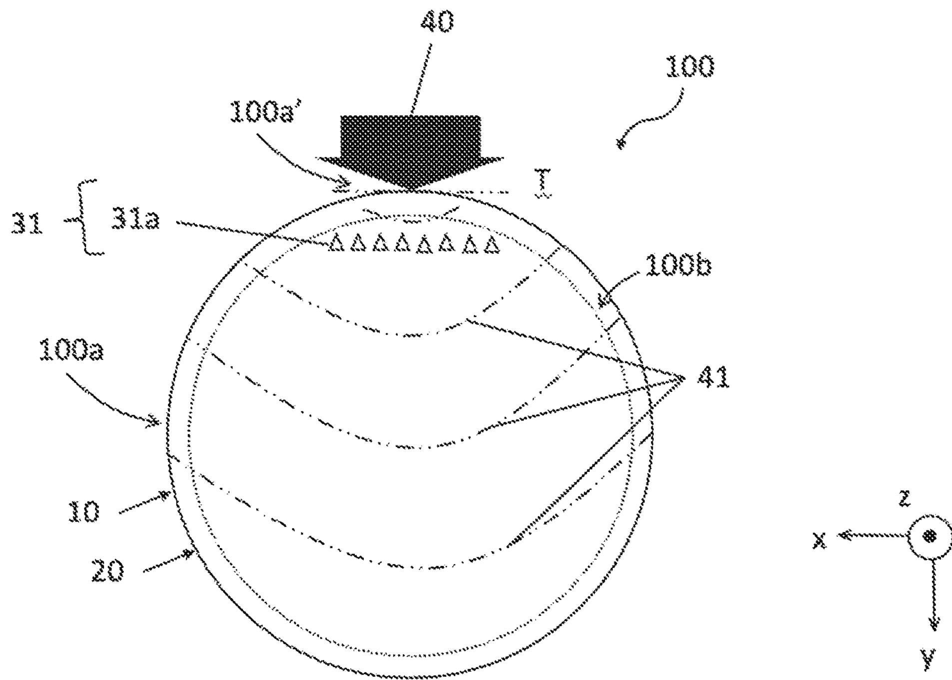


FIG. 4A

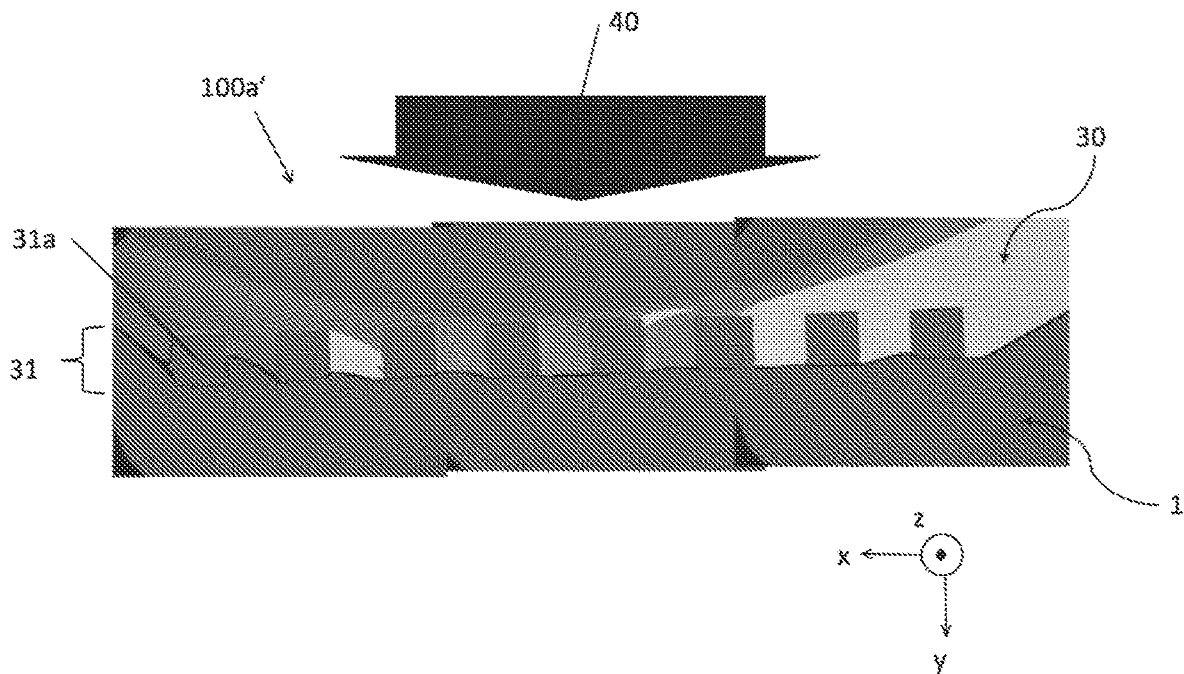


FIG. 4B

REMOVABLE STRUCTURE USED FOR THE TRANSFER OR MANIPULATION OF LAYERS, AND METHOD FOR TRANSFER OF A LAYER USING SAID REMOVABLE STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a national phase entry under 35 U.S.C. § 371 of International Patent Application PCT/FR2021/050435, filed Mar. 16, 2021, designating the United States of America and published as International Patent Publication WO 2021/198576 A1 on Oct. 7, 2021, which claims the benefit under Article 8 of the Patent Cooperation Treaty to French Patent Application Serial No. FR2003263, filed Apr. 1, 2020.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of transferring thin layers for applications in microelectronics, optics, microsystems, etc. It relates, in particular, to a detachable structure that may be used to transfer or to handle thin layers.

BACKGROUND

[0003] Numerous applications, in particular, in the fields of microelectronics, optics or microsystems, require thin layers (potentially incorporating components) that are arranged on specific substrates (thin, flexible, metal, insulating, etc., substrates). These specific substrates are not always compatible with the processes for fabricating thin layers and/or the processes for adding components to the layers.

[0004] It is therefore advantageous to be able to transfer a thin layer (with or without incorporated components) from an initial substrate that is compatible with the processes mentioned above to a specific target substrate possessing the required properties for the target application.

[0005] There are several processes for transferring a thin layer, produced on an initial substrate, to a target substrate.

[0006] Some transfer processes involve attaching the thin layer (arranged on the initial substrate) to the target substrate, then in mechanically and/or chemically removing the initial substrate, thus transferring the thin layer to the target substrate. The main drawbacks of this approach are the costs related to the loss of the initial substrate and the limiting mechanical and chemical treatments that are liable to negatively affect the quality of the thin layer during transfer.

[0007] Other processes are based on separating the thin layer from the initial substrate by subjecting a layer or a weakened interface present between the two to mechanical stress or by applying a chemical treatment thereto; the thin layer, having previously been attached to the target substrate, is transferred thereto as the separation operation is performed. Such is notably the case with the processes described in French Patent Publications FR2748851, FR2823599 or FR2823596; detachable structures are usually described as having a layer or a weakened interface, in which separation can be performed in such a way as to free a thin surface layer and transfer it onto a target substrate.

[0008] One difficulty associated with these approaches is that detachment may sometimes occur at interfaces or layers other than the weakened one due to the potential difficulty in precisely localizing the mechanical stress and/or the chemical attack to the weakened interface or layer. The variabilities in the geometry of the edges of the substrates, the method used to apply the mechanical stress or the chemical etching solution used for detachment may cause the separation to begin at an interface other than the weakened one, even if this other interface has a mechanical integrity superior to that of the weakened interface.

[0009] In order to address this problem, it is conceivable to reinforce locally, notably at the edges of the substrates, the mechanical integrity of the interfaces other than the weakened one and/or to reduce still further the integrity of the weakened interface. Nevertheless, these measures are not always able to prevent separation from being initiated at an interface that is not the intended one.

[0010] French Patent Publication FR2995446 is concerned with detachable structures comprising at least two interfaces, including the weakened one at which separation is expected. It offers solutions for redirecting the separation front toward the weakened interface when this separation begins at the other interface.

BRIEF SUMMARY

[0011] The present disclosure provides an alternative solution that assists with localizing the detachment into the weakened interface of a detachable structure. One subject of the present disclosure is a detachable structure comprising at least two interfaces, of which one is the weakened interface or favored-detachment interface. The detachable structure is used for transferring or handling layers.

[0012] The present disclosure relates to a detachable structure for transferring or handling layers, comprising:

- **[0013]** at least two interfaces, an assembly interface and a favored-detachment interface,
- **[0014]** a receiver substrate, and
- **[0015]** a donor substrate comprising a working layer that is to be transferred, arranged on an initial substrate,

[0016] the favored-detachment interface being situated between the working layer and the initial substrate, and the assembly interface being situated between the working layer and the receiver substrate.

[0017] The detachable structure is notable in that the assembly interface has an assembly-interruption zone comprising at least one cavity present in the receiver substrate or in the working layer, in the latter instance, the depth of the cavity being strictly less than the thickness of the working layer. The assembly-interruption zone is located in a peripheral region of the detachable structure and allows a stress field at the head of the wave front of a separation wave to be modified when this wave is initiated in the assembly interface for the purposes of transferring or handling the working layer.

[0018] The modification of the stress field by the—at least one—cavity of the assembly-interruption zone allows the separation wave to be deflected from the assembly interface toward the favored-detachment interface, thus allowing the working layer to be moved over onto the receiver substrate.

[0019] According to advantageous characteristics of the present disclosure, taken alone or in any feasible combination:

- **[0020]** the assembly-interruption zone extends over a length, along the perimeter of the detachable structure, less than or equal to 20 mm;

[0021] the assembly-interruption zone is situated at less than 10 mm from the edges of the detachable structure;

[0022] the (at least one) cavity has lateral dimensions between a few microns and a few millimeters, preferably between 20 microns and 1 mm;

[0023] the (at least one) cavity has a depth between 0.5 micron and several tens of microns, typically 50 microns;

[0024] the (at least one) cavity has, in a plane parallel to the assembly interface, a perimeter that is square, rectangular, triangular, trapezoidal or rounded;

[0025] at least one rectilinear segment of the perimeter of the (at least one) cavity is parallel to a detachable edge of the detachable structure or to the tangent to a detachment edge of the detachable structure;

[0026] a rectilinear segment of the perimeter of the (at least one) cavity, which has the greatest lateral dimension, is parallel to a detachment edge of the detachable structure or to the tangent to a detachment edge of the detachable structure;

[0027] the assembly-interruption zone comprises a plurality of cavities spaced apart by a distance between 1 micron and 1 mm, typically between several microns and several hundred microns;

[0028] the percentage of contact zones, between the cavities of the assembly-interruption zone, is less than 80%, or even less than 50%;

[0029] the cavities are aligned along a straight line or along a curved line of which the convexity is directed toward the center of the detachable structure;

[0030] the assembly-interruption zone is situated at less than 8 mm from the edges of the detachable structure, or even at less than 3 mm;

[0031] the working layer has a thickness between a few hundreds of nanometers and several hundreds of microns, typically between 200 nm and 200 microns;

[0032] the favored-detachment interface has a first interfacial surface energy, the assembly interface has a second interfacial surface energy, and the difference in interfacial surface energy between the favored-detachment interface and the assembly interface is greater than or equal to 1000 mJ/m^2;

[0033] the favored-detachment interface is a bonding interface using molecular adhesion having a first bonding energy, and the assembly interface is a bonding interface using molecular adhesion having a second bonding energy, the first bonding energy being less than the second bonding energy; and

[0034] the difference in bonding energy between the favored-detachment interface and the assembly interface is at least on the order of 1000 mJ/m^2.

[0035] The present disclosure also relates to a process for transferring a working layer from a donor substrate to a receiver substrate, comprising the following steps:

[0036] a) the provision of a detachable structure as described hereinabove,

[0037] b) the application of a mechanical stress to a detachment edge of the detachable structure, the detachment edge being located as close as possible to the assembly-interruption zone and the mechanical stress being able to initiate a separation wave at the assembly interface or at the favored-detachment interface,

[0038] c) if the initiation of the separation wave occurs at the assembly interface, the deflection of the separation wave into the favored-detachment interface when the separation wave passes the assembly-interruption zone, and

[0039] d) the propagation of the separation wave at the favored-detachment interface to result in the complete separation of the detachable structure.

[0040] According to advantageous characteristics of the present disclosure, taken alone or in any feasible combination:

[0041] the mechanical stress is applied in such a way that the direction of propagation of the separation wave is perpendicular to at least one rectilinear segment of a perimeter of the (at least one) cavity of the assembly-interruption zone;

[0042] the mechanical stress is applied in such a way that the direction of propagation of the separation wave is perpendicular to a rectilinear segment of a perimeter of the (at least one) cavity that has the greatest lateral dimension; and

[0043] the mechanical stress is applied by inserting a bevel-edged tool between the edges of the receiver substrate and the edges of the donor substrate;

[0044] step a) comprises:

[0045] the provision of the donor substrate comprising the working layer arranged on the initial substrate, the favored-detachment interface being situated between the working layer and the initial substrate,

[0046] the provision of a receiver substrate,

[0047] the creation of at least one cavity opening onto a face that is to be assembled, belonging to the receiver substrate, or onto a face that is to be assembled, belonging to the working layer, in a peripheral region of the receiver substrate or of the working layer, and

[0048] the assembling of the working layer and of the receiver substrate at their respective faces that are to be assembled.

BRIEF DESCRIPTION OF THE DRAWINGS

[0049] Other features and advantages of the present disclosure will emerge from the following detailed description, with reference to the accompanying figures, in which:

[0050] FIGS. **1**A and **1**B, respectively, depict a view in cross section, and a plan view, of a detachable structure according to the present disclosure; in the plan view, the cavities have been rendered visible for a better understanding of their distribution and location even though they ought to be hidden because they are positioned between the working layer and the receiver substrate.

[0051] FIGS. **2**A-**2**C, respectively, depict a view in cross section, and two plan views, of a detachable structure according to the present disclosure; in the plan views, the cavities have been rendered visible for a better understanding of their distribution and location even though they ought to be hidden because they are positioned between the working layer and the receiver substrate.

[0052] FIGS. **3**A-**3**G show steps of the transfer process according to the present disclosure.

[0053] FIG. **4**A depicts a plan view of a detachable structure during the course of the step of applying a mechanical stress, which is a step in the transfer process according to the

present disclosure; FIG. **4**B depicts a photo, zooming in and around the assembly-interruption zone, of the moving of a working layer over onto a receiver substrate at the end of the transfer process according to the present disclosure.

DETAILED DESCRIPTION

[0054] In the descriptive section, the same references as in the figures may be used for elements of the same nature.

[0055] The figures are diagrammatic representations that, for the sake of readability, are not to scale. In particular, the thicknesses of the layers along the z-axis are not to scale with respect to the lateral dimensions along the x- and y-axes.

[0056] The present disclosure relates to a detachable structure **100** comprising at least two interfaces, an assembly interface **30** and a favored-detachment interface **1**. In FIG. **1**A, the two interfaces extend in planes parallel to the plane (x, y).

[0057] What is meant by a detachable structure is a structure **100** intended to be stressed mechanically in order to initiate a desired separation at the favored-detachment interface **1**; because of the presence of the second interface (assembly interface **30**), the separation wave propagates concurrently in the two interfaces **1**, **30**.

[0058] The detachable structure **100** comprises a donor substrate **10** including a working layer **3** that is to be transferred, which layer is arranged on an initial substrate **2**; the favored-detachment interface **1** is situated between the working layer **3** and the initial substrate **2**.

[0059] By way of example, the working layer **3** may be formed from a semiconductor material such as silicon, silicon carbide, germanium, a III-V compound, etc., and/or from an insulating, notably piezoelectric, material such as lithium tantalate or lithium niobate. Of course, this list is not exhaustive and any material in the form of a thin layer that it might be desirable to transfer from the donor substrate **10** to a receiver substrate **20** could make up the working layer **3**.

[0060] The working layer **3** may also comprise a plurality of films of different materials, and/or functional structurations (for example, cavities), particularly on its face that faces the receiver substrate **20**, and/or may fully or partially comprise microelectronic components. The adhesion between the various films or stacks of components is expected, of course, to be stronger than the integrity of the favored-detachment interface **1** of which the characteristics will be detailed later. In general, the characteristics of the working layer **3** are dependent on the intended application and on the desired functionalities.

[0061] The working layer **3** has a thickness between a few hundreds of nanometers and a few hundreds of microns, for example, between 200 nm and 200 microns, or preferably between 1 micron and 50 microns.

[0062] The initial substrate **2** is advantageously formed of a low-cost material affording good mechanical support for the handling of the working layer **3**. Although other materials can be envisaged, silicon is generally the material of choice because of its compatibility with any microelectronics manufacturing line.

[0063] The initial substrate **2** may be in the form of a wafer having a diameter from 100 mm to 450 mm and a thickness between 250 and 850 microns, for example. Of course, the initial substrate **2** may alternatively take other forms (for example, square).

[0064] The detachable structure **100** further comprises a receiver substrate **20**, assembled on the donor substrate **10**: the assembly interface **30** is situated between the receiver substrate **20** and the working layer **3**.

[0065] The receiver substrate **20** may be made of an insulating, semiconductor or conducting material, and may be solid or comprise a plurality of layers or functional surface structurations (for example, cavities), or else again may fully or partially comprise active or passive components. The characteristics of the receiver substrate **20** are chiefly dependent on the intended application and the desired functionalities.

[0066] Like the initial substrate **2**, the receiver substrate **20** may be in the form of a wafer having a diameter from 100 mm to 450 mm and a thickness between 250 and 850 microns, for example.

[0067] The detachable structure **100** according to the present disclosure is intended to be separated, at the favored-detachment interface **1**, so that the working layer **3** can be transferred from the donor substrate **10** onto the receiver substrate **20**.

[0068] In general, the mechanical integrity of the favored-detachment interface **1** is therefore inferior, or even very much inferior, to the mechanical integrity of the assembly interface **30**, as is habitually the case in a detachable structure comprising two interfaces. Preferably, the aim will be to have a difference in mechanical integrity or in interfacial surface energy at least on the order of 1000 mJ/m^2 between the two interfaces **1**, **30**.

[0069] According to one advantageous embodiment, the favored-detachment interface **1** is a bonding interface using molecular adhesion having a first bonding energy E1. The assembly interface **30** may then be a direct-bonding interface, using molecular adhesion, thermocompression bonding, or some other technique, having a second bonding energy E2, the first bonding energy E1 being lower than the second bonding energy E2.

[0070] As is known per se, the difference between the first E1 and the second E2 bonding energies may be obtained by managing the surface roughnesses of the faces that are to be bonded, the materials brought into contact in order to achieve the molecular adhesion bonding, the chemical treatment (wet clean or plasma activation) applied to the faces prior to the bonding, etc. Materials such as silicon oxide, silicon nitride may be deposited on the faces that are to be bonded (in order to form the favored-detachment interface **1** or the assembly interface **30**), and may be treated (cleaned, polished, activated by plasma, etched, etc.) in such a way as to adjust the resultant interfacial surface energy of the molecular adhesion bonding of the faces.

[0071] Advantageously, as stated previously, the difference in bonding energy (E2-E1) between the two interfaces **1**, **30** is chosen to be at least on the order of 1000 mJ/m^2. By way of example, the first bonding energy E1 may be on the order of 2000 mJ/m^2, and the second bonding energy E2 may be greater than 3000 mJ/m^2. It will be recalled that, as is well known per se, a bonding energy may notably be evaluated by the Mazara blade measurement technique.

[0072] The detachable structure **100** according to the present disclosure is notable in that the assembly interface **30** has an assembly-interruption zone **31** comprising at least one cavity **31***a* present in the receiver substrate **20** or in the working layer **3**. The assembly-interruption zone **31** corresponds to a zone in which the assembly interface is inter-

rupted, namely where there is no contact between the receiver substrate **20** and the working layer **3**.

[0073] The assembly-interruption zone **31** is located in a peripheral region of the detachable structure **100**. As a preference, the assembly-interruption zone **31** is situated at less than 10 mm from the edges **100***a* of the structure **100**. Advantageously, the assembly-interruption zone **31** is even situated at less than 8 mm from the edges **100***a* of the detachable structure, or even at less than 5 mm or else even at less than 3 mm.

[0074] It is commonplace for the detachable structures **100** formed from assembling two wafers **10**, **20** of microelectronics grade to have a non-bonded peripheral exclusion zone **100***b*, connected with the edge geometry of the wafers (chamfer) or with the edge geometry of the working layer **3** present on one of the two wafers; this exclusion zone **100***b* rarely exceeds 1 mm to 2 mm. In the presence of this exclusion zone **100***b*, the assembly-interruption zone **31** is offset radially toward the inside of the detachable structure **100** with respect to the exclusion zone **100***b*, because it needs, by definition, to interrupt the assembly interface **30**, which places the receiver substrate **20** and the working layer **3** in contact. It may be positioned, for example, at 0.5 mm, 1 mm or 2 mm from the exclusion zone **100***b*.

[0075] Advantageously, the assembly-interruption zone **31** is highly localized, which is to say that it does not extend, in the peripheral region, along the entire perimeter of the detachable structure **100** but only over a length of a few hundreds of microns (typically 200 microns) to a few tens of millimeters (typically 50 mm to 100 mm), for example, between 1 mm and 20 mm, preferably between 5 mm and 15 mm. This offers the advantage of limiting the impact it has on the usable surface area of the working layer **3**.

[0076] As mentioned previously, the assembly-interruption zone **31** comprises at least one cavity **31***a* formed either in the receiver substrate **20** (as illustrated in FIG. **1**A) or in the working layer **3** (as illustrated in FIG. **2**A). It should be noted that, in instances in which the (at least one) cavity **31***a* is formed in the working layer **3**, its depth may vary, for example, between 5% and 95% of the thickness of the working layer **3**, this depth, of course, never exceeding the thickness of the layer **3**.

[0077] Advantageously, the assembly-interruption zone **31** comprises a plurality of cavities **31***a*.

[0078] The cavities **31***a* may be spaced apart, for example, by a distance between 1 micron and 1 mm, typically between several microns and several hundreds of microns, for example, 500 microns. They may be aligned on a straight line or on a line that is curved in the plane (x, y) parallel to the assembly interface **30**. The straight line is preferably parallel to the edge **100***a* of the detachable structure **100** or parallel to the tangent T to the edge **100***a* (FIGS. **1**B and **2**C). The curved line may have a convex curvature oriented toward the center of the detachable structure **100**; in other words, as can be seen in the example of FIG. **2**B, the curved line follows a curvature that is the opposite of that of the edges **100***a* of the detachable structure **100**.

[0079] Mention will be made hereinafter of a cavity **31***a*, it being appreciated that the features listed may apply to all the cavities **31***a* that make up the assembly-interruption zone **31**, if the latter comprises a plurality of same.

[0080] Advantageously, the cavity **31***a* has lateral dimensions between a few microns and a few millimeters, typically between 20 microns and 1 mm. It may moreover have a depth between 0.5 micron and several tens of microns, typically up to 20 microns, 50 microns, or even as much as 100 microns; for example, the cavity **31***a* may have a depth of 3 microns.

[0081] When the assembly-interruption zone **31** comprises a plurality of cavities **31***a*, the percentage of the zones of contact between the receiver substrate **20** and the working layer **3** (namely the percentage of the contact zones, between the cavities **31***a* of the assembly-interruption zone **31**) is preferably less than 80%, or even less than 50%.

[0082] The (at least one) cavity **31***a* of the assembly-interruption zone **31** may have, in a plane (x, y) parallel to the assembly interface **30**, a perimeter that is square, rectangular, triangular, trapezoidal or rounded.

[0083] As a preference, at least one rectilinear segment of the perimeter of the cavity **31***a* is parallel to a detachment edge **100***a*' of the detachable structure **100** or to the tangent T to a detachment edge **100***a*' of the detachable structure **100**.

[0084] According to another preferred aspect, a rectilinear segment of the perimeter of the cavity **31***a*, which has the greatest lateral dimension, is parallel to a detachment edge **100***a*' of the detachable structure **100** or to the tangent T to a detachment edge **100***a*' of the detachable structure **100**. For example, in the case of cavities that are rectangular, the long side of the cavities **31***a* in the plane (x, y) would run parallel to the tangent T.

[0085] In addition, when the shape of the cavity **31***a* is not symmetrical, there is a preferred direction in which to orient the pattern of the cavity **31***a* with respect to the detachment edge **100***a*' (or the tangent T thereto) or, more specifically, with respect to the direction of propagation of the separation wave, as will be described with reference to the transfer process according to the present disclosure. It would appear to be more advantageous for the separation wave to pass through a segment of greatest dimension last. In the example of FIG. **2**C, if the cavities **31***a* in the assembly-interruption zone **31** have a triangular perimeter, it is therefore advantageous for these to be positioned in such a way that the vertex of the triangle points toward the detachment edge **100***a'*.

[0086] The present disclosure also relates to a process for transferring a working layer **3** from a donor substrate **10** to a receiver substrate **20**.

[0087] The process comprises first of all a step a) of providing a detachable structure **100** as described hereinabove.

[0088] According to one embodiment, step a) comprises the following sub-steps referenced a1) to a4).

[0089] First of all, a step a1) comprises the provision of the donor substrate **10**, which comprises the working layer **3** arranged on the initial substrate **2**, the favored-detachment interface **1** being situated between the working layer **3** and the initial substrate **2** (FIG. **3**A).

[0090] The working layer **3** of the donor substrate **10** may be produced using any known layer transfer technique, for example:

- **[0091]** by bonding followed by a mechanical/chemical thinning based on grinding, polishing, chemical etching and cleaning techniques; in which case the working layer **3** is derived from a working substrate bonded onto the initial substrate and then thinned down.
- **[0092]** using the Smart Cut® process to transfer a thin layer, typically of a thickness less than 2 microns; in

which case the working layer **3** is likewise derived from a working substrate implanted with lighter species, bonded to the initial substrate and then separated along the buried fragile plane defined by the implantation.

[0093] using the Smart Cut® process followed by a step of epitaxial growth or deposition aimed at thickening the working layer transferred.

[0094] The bondings mentioned in these various techniques result in the creation of the favored-detachment interface **1**. It is therefore necessary to tailor the bonding parameters (the materials in contact, the roughnesses of the surfaces that are to be bonded, the cleaning operations and chemical activation treatments of the surfaces that are to be bonded, etc.) so as to obtain a first bonding energy (or first interfacial surface energy) E1 within the desired range, after the donor substrate **10** has potentially undergone heat treatments. Such is notably the case when films are deposited, and/or when functional structurations are made, and/or when all or some of the components are created on or in the working layer **3** before it is transferred onto the receiver substrate **20**.

[0095] As a preference, the first bonding energy (or first interfacial surface energy) E1 is between 1000 mJ/m^2 and 3000 mJ/m^2. As mentioned previously, the aim will advantageously be to achieve an energy difference of 1000 mJ/m^2 at least between the favored-detachment interface **1** (energy E1) and the assembly interface **30**, which will be formed in a later step a4) of the process.

[0096] Step a2) of the process comprises providing the receiver substrate **20** the characteristics of which are dependent on the intended application and on the desired functionalities, as mentioned previously (FIG. **3**B).

[0097] The next step a3) involves forming one or more cavities **31***a* opening onto a face **20***c* that is to be assembled, belonging to the receiver substrate **20** (FIG. **3**C(i)) or onto a face **3***c* that is to be assembled belonging to the working layer **3** (FIG. **3**C(ii)), in a peripheral region of the receiver substrate **20** or of the working layer **3**, respectively. This (at least one) cavity **31***a* will enable the creation of the assembly-interruption zone **31** when the donor substrate **10** is assembled onto the receiver substrate **20**.

[0098] The assembly-interruption zone **31** is localized to a peripheral region of the donor substrate **10** or of the receiver substrate **20** at less than 10 mm from the edges. Advantageously, the assembly-interruption zone **31** is even situated at less than 8 mm from the edges of the substrates, at less than 5 mm, or even at less than 3 mm.

[0099] The assembly-interruption zone **31** is preferably highly localized, which is to say that it does not extend, in the peripheral region, along the entire perimeter of the donor substrate **10** or of the receiver substrate **20**, but only over a length of a few hundreds of microns to a few tens of millimeters.

[0100] The cavity **31***a* may be performed using conventional lithography and etching techniques. As mentioned previously, each cavity **31***a* preferably has lateral dimensions between a few microns and a few millimeters, a depth between 0.5 micron and a few tens of microns, and varying shapes in the plane (x, y).

[0101] Finally, a step a4) comprises assembling the working layer **3** and the receiver substrate **20** at their respective faces **3***c*, **20***c* that are to be assembled, so as to form the detachable structure **100** (FIG. **3**D(i) and (ii)).

[0102] As is well known per se, the assembling of the two substrates may be performed by direct bonding using molecular adhesion, by metallic bonding or by adhesive bonding, depending on the intended application and the compatibility of the bonding techniques.

[0103] The step a4) may involve, before bringing the substrates **10**, **20** into contact, sequences of cleaning, depositing of adhesion-promoting layers, surface activation or other surface preparations. The step a4) may involve, after the substrates **10**, **20** have been brought into contact, heat treatments for consolidating the assembly interface **30**, at a greater or lesser temperature according to the type of bonding and the nature of the materials assembled and that make up the substrates **10**, **20**.

[0104] The assembly interface **30** formed at the end of this step a4) has a bonding energy E2 greater than the bonding energy E1 of the favored-detachment interface **1**. In particular, the difference between the bonding energy E2 and the bonding energy E1 is on the order of 1000 mJ/m^2, or even higher.

[0105] At the end of step a), one particular embodiment of which has just been described, the method according to the present disclosure comprises a step b) comprising applying mechanical stress to a detachment edge **100***a*' of the detachable structure **100** (FIG. **3**E(i) and (ii)).

[0106] The detachment edge **100***a*' is located as close as possible to the assembly-interruption zone **31** and the mechanical stress is able to initiate a separation wave in the assembly interface **30** or in the favored-detachment interface **1**. By way of example, the mechanical stress may be applied by inserting a bevel-edge **40** between the edges of the assembled donor substrate **10** and receiver substrate **20**. Alternatively, it may be applied by injecting a liquid or gaseous fluid between these same edges, or by any other suitable technique.

[0107] Typically, the direction of the propagation wave is in the plane (x, y) and perpendicular to the detachment edge **100***a*' or to the tangent T to the detachment edge **100***a'*.

[0108] As mentioned previously, it is commonplace for a detachable structure **100** to have a peripheral exclusion zone, because of the edge geometry of the donor substrate **10** and receiver substrate **20**. Note that, for the sake of simplicity, this exclusion zone is not depicted in FIGS. **3**A to **3**G.

[0109] When a mechanical stress is applied, for example, by inserting a bevel-edge **40**, it is possible that the separation wave **41** may start at the assembly interface **30**, this being despite the lower mechanical integrity of the favored-detachment interface **1**. This starting of the separation wave **41** in the assembly interface **30** is notably encouraged by the presence of the exclusion zone, which provides direct access to the interface **30**.

[0110] For that reason, the method according to the present disclosure continues with step c) during which, if the separation wave **41** has initiated at the assembly interface **30**, the separation wave is deflected into the favored-detachment interface **1** as the separation wave **41** passes the assembly-interruption zone **31** (FIG. **3**F(i) and (ii)). Effectively, the cavities **31***a* of the assembly-interruption zone **31** allow the stress field at the head of the wave front of the separation wave **41** to be modified, encouraging it to be deflected toward the lowest-energy interface, in this instance the favored-detachment interface **1**.

[0111] It is advantageous for the mechanical stress to be applied in such a way that the direction of propagation of the

separation wave **41**, parallel to the axis y in the figures, is perpendicular to at least one rectilinear segment of a perimeter of the cavity (or cavities) **31***a* of the assembly-interruption zone **31** (FIG. **4**A).

[0112] According to another advantageous embodiment, the mechanical stress is applied in such a way that the direction of propagation of the separation wave **41** is perpendicular to a rectilinear segment of a perimeter of the cavity **31***a* that has the greatest lateral dimension. This scenario may be encountered, for example, when the cavity (or cavities) **31***a* has (or have) a rectangular shape. The longest dimension of the rectangle (the length) will preferably be oriented in such a way as to be perpendicular to the direction of propagation of the separation wave **41**.

[0113] As mentioned previously, it is also advantageous, in the case of a cavity **31***a* of triangular shape, for the vertex of the triangle to point toward the detachment edge **100***a*; in other words, it is preferable for the separation wave initiated at the detachment edge **100***a'* to pass through the base of the triangle last (FIG. **4**A).

[0114] It should be noted that, when the separation wave **41** is initiated directly in the favored-detachment interface **1** in step b), the passage of the wave at the assembly-interruption zone **31** does not modify its location: after crossing through the assembly-interruption zone **31**, the separation wave **41** continues to propagate along the favored-detachment interface **1**.

[0115] This transfer process next comprises a step d) of propagation of the separation wave at the favored-detachment interface **1**, to result in the complete separation of the detachable structure **100** (FIGS. **3**G(i) and **3**G(ii)).

[0116] Once it has been deflected into the correct interface, the separation wave **41** easily propagates along the favored-detachment interface **1**, of lower mechanical integrity, either spontaneously, if the mechanical stress applied to initiate the separation wave **41** was enough to cause the separation wave to propagate, or by the mechanical stress being maintained continuously or applied intermittently.

[0117] FIG. **4**B shows a photograph of a view from above of a working layer **3** (made of silicon) transferred onto a receiver substrate **20** (made of silicon) from a detachable structure **100** according to the present disclosure. The photograph, in particular, zooms in around the assembly-interruption zone **31**, which is formed in the receiver substrate **20**. It is possible to see the deflecting of the separation wave between the assembly interface **30** (direct bonding of the oxide SiO2/silicon type) upstream of the assembly-interruption zone **31**, and the favored-detachment interface (direct bonding of SiO2/SiO2 type) downstream of the assembly-interruption zone **31**. Downstream of the cavities **31***a*, the working layer **3** is transferred onto the receiver substrate **20**. In the example of FIG. **4**B, the eight cavities **31***a* that form the assembly-interruption zone **31** are square in shape, having lateral dimensions of 500 microns×500 microns, and a depth of 3 microns. They are situated approximately 3 mm from the edge.

[0118] The transfer process applied to the detachable structure **100** according to the present disclosure allows the separation wave **41** to be deflected effectively from the assembly interface **30** of the detachable structure **100** toward the favored-detachment interface. It is thus possible to maximize the surface area of the working layer **3** transferred onto a receiver substrate **20** and to transfer a working layer **3** of high quality.

[0119] Needless to say, the present disclosure is not limited to the embodiments described and implementation variants may be applied thereto without departing from the scope of the present disclosure as defined by the claims.

[0120] Although the preferred embodiments of the detachable structure **100** describe a favored-detachment interface **1** based on direct bonding using molecular adhesion, the present disclosure is equally applicable to other types of interface.

[0121] For example, the favored-detachment interface **1** could comprise a buried fragile plane obtained by the implantation of lighter species, the formation of a layer of porous material (for example, porous silicon) or else the formation of multilayer deposits of which one interface has a low energy (for example, as described in French Patent Publication FR3082997). With reference to this last option, mention may, for example, be made of a multilayer involving a layer of silicon oxide or silicon nitride on a layer of a noble metal (Au, Pt, Ag, etc.), the interface between these layers having a low interfacial surface energy.

[0122] In general, the present process is applicable as long as the detachable structure **100** comprises two interfaces **1**, **30** exhibiting a sufficient difference in interfacial surface energy, in particular, an energy difference greater than or equal to 1000 mJ/m^2.

1. A detachable structure for transferring or handling layers, comprising:

at least two interfaces including an assembly interface and a favored detachment interface;

a receiver substrate;

a donor substrate comprising a working layer to be transferred, the working layer disposed on an initial substrate;

the favored-detachment interface being situated between the working layer and the initial substrate, and the assembly interface being situated between the working layer and the receiver substrate;

wherein:

the assembly interface has an assembly-interruption zone comprising at least one cavity present in the receiver substrate or in the working layer, if in the working layer, the depth of the cavity being strictly less than a thickness of the working layer

the assembly-interruption zone is located in a peripheral region of the detachable structure and allows a stress field at a head of a wave front of a separation wave to be modified when this wave is initiated in the assembly interface to transfer or handle the working layer.

2. The detachable structure of claim **1**, wherein the assembly-interruption zone is situated at less than 10 mm from the edges of the detachable structure.

3. The detachable structure of claim **1**, wherein the assembly-interruption zone extends over a length, along the perimeter of the detachable structure, less than or equal to 20 mm.

4. The detachable structure of claim **1**, wherein the at least one cavity has a depth between 0.5 micron and 50 microns.

5. The detachable structure of claim **1**, wherein the at least one cavity has, in a plane parallel to the assembly interface, a perimeter that is square, rectangular, triangular, trapezoidal or rounded.

6. The detachable structure of claim **5**, wherein at least one rectilinear segment of the perimeter of the at least one

cavity is parallel to a detachment edge of the detachable structure or to a tangent to a detachment edge of the detachable structure.

7. The detachable structure of claim **5**, wherein a rectilinear segment of the perimeter of the at least one cavity which has a greatest lateral dimension, is parallel to a detachment edge of the detachable structure or to a tangent to a detachment edge of the detachable structure.

8. The detachable structure of claim **1**, wherein the assembly-interruption zone comprises a plurality of cavities, the cavities being spaced apart by a distance between 1 micron and 1 mm.

9. The detachable structure of claim **8**, wherein a percentage of contact zones, between the cavities of the assembly-interruption zone, is less than 80%.

10. The detachable structure of claim **8**, wherein the cavities are aligned along a straight line or along a curved line of which a convexity is directed toward a center of the detachable structure.

11. The detachable structure of claim **1**, wherein the assembly-interruption zone is positioned at less than 8 mm from the edges of the detachable structure.

12. The detachable structure of claim **1**, wherein the working layer has a thickness between 200 nm and 200 microns.

13. The detachable structure of claim **1'**, wherein:

the favored-detachment interface has a first interfacial surface energy;

the assembly interface has a second interfacial surface energy;

a difference in interfacial surface energy between the favored-detachment interface and the assembly interface is greater than or equal to 1000 mJ/m^2.

14. The detachable structure of claim **1**, wherein the favored-detachment interface is a molecular adhesion bonding interface having a first bonding energy, and the assembly interface is a molecular adhesion bonding interface having a second bonding energy, the first bonding energy being less than the second bonding energy.

15. The detachable structure of claim **14**, wherein the difference in bonding energy between the favored-detachment interface and the assembly interface is at least on the order of 1000 mJ/m^2.

16. A process for transferring a working layer from a donor substrate to a receiver substrate, comprising:

providing a detachable structure according to claim **1**;

applying a mechanical stress to a detachment edge of the detachable structure, the detachment edge located as close as possible to the assembly-interruption zone, the mechanical stress being sufficient to initiate a separation wave at the assembly interface or at the favored-detachment interface;

wherein, if the initiation of the separation wave occurs at the assembly interface, deflecting the separation wave into the favored-detachment interface when the separation wave passes the assembly-interruption zone; and

propagating the separation wave at the favored-detachment interface to result in complete separation of the detachable structure.

17. The process of claim **16**, further comprising applying the mechanical stress in such a way that the direction of propagation of the separation wave is perpendicular to at least one rectilinear segment of a perimeter of the at least one cavity of the assembly-interruption zone.

18. The process of claim **16**, further comprising applying the mechanical stress in such a way that the direction of propagation of the separation wave is perpendicular to a rectilinear segment of a perimeter of the at least one cavity having the greatest lateral dimension.

19. The process of claim **16**, further comprising applying the mechanical stress by inserting a bevel-edged tool between the edges of the receiver substrate and the edges of the donor substrate.

20. The process of claim **16**, wherein providing the detachable structure comprises:

providing the donor substrate comprising the working layer disposed on the initial substrate, the favored-detachment interface being disposed between the working layer and the initial substrate;

providing a receiver substrate;

forming at least one cavity opening onto a face to be assembled, belonging to the receiver substrate, or onto a face to be assembled, belonging to the working layer, in a peripheral region of the receiver substrate or of the working layer; and

assembling the working layer and the receiver substrate together at their respective faces to be assembled.

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