



(43) International Publication Date
15 September 2016 (15.09.2016)

(51) International Patent Classification:

B22F 7/00 (2006.01) *H01L 21/683* (2006.01)
B32B 15/04 (2006.01) *B24B 37/27* (2012.01)
B32B 15/14 (2006.01)

(21) International Application Number:

PCT/EP2016/054436

(22) International Filing Date:

2 March 2016 (02.03.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

15158637.7 11 March 2015 (11.03.2015) EP

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a
patent (Rule 4.17(ii))
- of inventorship (Rule 4.17(iv))

Published:

- with international search report (Art. 21(3))

(54) Title: CARRIER FOR TEMPORARY BONDED WAFERS

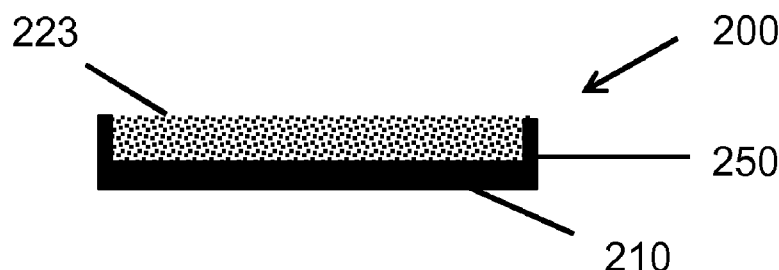


Fig. 2

(57) Abstract: A carrier is disclosed onto which a wafer can be temporarily bonded. The carrier comprises a plate shaped laminate. The plate shaped laminate comprises a first layer. The first layer comprises a foil, a sheet or a plate. The plate shaped laminate comprises a second layer. The second layer comprises a porous metal medium with three-dimensional open pores. The porous metal medium comprises metal fibers. The first layer is permanently bonded to the porous metal medium thereby closing the pores of the porous metal medium at the side where the first layer is located. The side edges of the porous metal medium are permanently sealed so that no open pores are present at the side edges of the porous metal medium.

Carrier for temporary bonded wafers

Description

Technical Field

[0001] The invention relates to the field of carriers for wafers. The carrier can be used for the temporary bonding of wafers during their processing, e.g. in wafer thinning.

Background Art

[0002] The use of temporary bonding of wafers onto a carrier to allow processing of the wafer is well known. A challenge is the subsequent debonding of the wafer from the carrier. Different carriers have been described that allow debonding by means of a solvent. In such processes, the adhesive used for the temporary bonding is chemically dissolved.

[0003] US2009/197070A describes a support plate that bonds to a substrate so as to support the substrate. In the support plate, a plurality of openings penetrate through from a bonding surface to a non-bonding surface. The bonding surface faces the substrate, and the non-bonding surface faces the bonding surface. A porous region, which includes a first region and a second region surrounding the first region, is formed on the bonding surface; and the first region has an opening ratio greater than that of the second region. This way, it is possible to realize a support plate that can be easily peeled off from a semiconductor wafer with a solvent, but does not easily come off from a substrate during a processing operation on the semiconductor wafer.

[0004] US2005/0173064A1 provides a supporting plate that has a structure in which a solvent can be supplied to an adhesive layer between the supporting plate and a substrate - such as a semiconductor wafer - in a short period of time after the substrate is thinned. The document also discloses a method for stripping the supporting plate. The supporting plate may have a larger diameter than the semiconductor wafer, and penetrating holes are formed in the supporting plate. The outer peripheral portion of the supporting plate is a flat portion in which no penetrating hole is formed. When alcohol is poured from above the supporting plate, the alcohol

reaches the adhesive layer through the penetrating holes, dissolves and removes the adhesive layer.

- [0005] US8882096B2 discloses a perforated support plate for supporting a surface of a wafer by interposing an adhesive layer. The perforated support plate has penetration holes. Solvent to dissolve the adhesive with which the perforated support plate is adhered to a wafer penetrates through the perforations of the support plate. The perforated support plate comprises a reinforcing part for deflection prevention.
- [0006] US2004/0231793A1 discloses the use of a porous sintered metal as temporary carrier for wafers. The carrier can be released by solvent passing through the thickness of the temporary carrier through its pores in order to dissolve the adhesive used to adhere the wafer to the temporary carrier.
- [0007] US2009325467A describes a process wherein a wafer can be thinned without occurrence of dimples. A support plate has a number of through holes. A circuit forming surface of a wafer is adhered to one surface of the support plate by an adhesive member, and a dimple prevention member having a thickness of 100 μm or more and having an adhesive layer on one face is adhered to the other surface. Thus the openings at both ends of the through holes are blocked. The support plate is vacuum adsorbed to a support table through the dimple prevention member, and the wafer is ground/ polished to thin the wafer. The dimple prevention member is stripped off, and a solvent is penetrated into the adhesive member through the through holes to detach the wafer from the support plate.
- [0008] US2001005043A discloses a technique which performs the thinning of a wafer and the separation thereof from a support substrate with high yields and in a short time. A hole-free support substrate is bonded to a second surface of a support substrate having holes with an adhesive layer melted by heating so as to block the holes. A wafer is bonded to a first surface of the support substrate having the holes with an adhesive layer melted by solvent. The wafer is thinned by grinding and etching. The adhesive layer is melted by heating and the support substrate having the holes is slid with respect to the hole-free support substrate to thereby separate the support substrate having the holes from the hole-free support substrate. The

adhesive layer is then dissolved by solvent through the holes defined in the support substrate having the holes. Thereby the wafer is separated from the support substrate having the holes. As no load is put on the wafer, wafer damage is prevented.

Disclosure of Invention

[0009] It is an objective of the invention to provide a carrier for temporary wafer bonding. It is the objective to provide such a carrier with improved properties. It is an objective of the invention to provide a carrier that allows easy debonding of the wafer by dissolving the adhesive using a solvent percolating through the pores of the carrier. It is an objective of the invention to provide a carrier that allows that wafers can be thinned thereby obtaining the required quality specifications.

[0010] The first aspect of the invention is a carrier onto which a wafer can be temporarily bonded, e.g. to allow wafer thinning. The carrier comprises a plate shaped laminate. The plate shaped laminate comprises a first layer. The first layer comprises a foil, a sheet or a plate. The plate shaped laminate comprises a second layer. The second layer comprises a porous metal medium with three-dimensional open pores. The porous metal medium comprises or consists out of metal fibers. The first layer is permanently bonded to the porous metal medium thereby closing the pores of the porous metal medium at the side where the first layer is located. The side edges of the porous metal medium are permanently sealed so that no open pores are present at the side edges of the porous metal medium. Preferably, the sealing of the side edges is fully provided by metal.

[0011] The first layer is permanently bonded to the porous metal medium such that during and after debonding a wafer temporarily bonded to the carrier, the first layer remains bonded to the porous metal medium.

[0012] Preferably, the carrier has the shape of a disk, possible wherein the disk deviates from a circular circumference by a linear side. The linear side is present in order to match the shape of a wafer to be bonded to the work

carrier. Preferably the diameter of the circular section of the disk is suited for 6 inch, for 8 inch, or for 12 inch wafers. This means that the diameter of the disk is equal or slightly larger than the diameter of the wafer.

[0013] The carrier has the benefit that, once bonded to a wafer by means of a suitable adhesive, no processing fluid penetrates into the pores of the porous metal medium. A wafer bonded to the carrier can be debonded fast and in a reliable manner, by using an appropriate solvent for dissolving the adhesive with which the carrier is bonded to a wafer. The dissolving solvent dissolves first adhesive in the bond between wafer and carrier at the edges of the carrier. Subsequently, the solvent can penetrate into the porous metal medium in which it wicks easily and fast through the three-dimensional open pores. This way it accesses the whole adhesive layer between carrier and wafer in a short period of time, for fast and reliable debonding. The carrier has sufficient stiffness to transport the bonded wafer through the different process steps without the occurrence of bending or other mechanical deformation nor stresses. The carrier has the further benefit that it has sufficient mechanical properties, e.g. stiffness, in order to allow to reach the required dimensional properties of the thinned wafer, such as total thickness variation (TTV), bow and warp. It is a further benefit of the invention that the carrier can be used multiple times. It is a further benefit of the invention that the carrier can be re-used multiple times.

[0014] In a preferred embodiment, the side edges of the porous metal medium are permanently sealed by means of metallic bonds, e.g. by welded bonds, preferably welding without the use of filler material. An example is where the side edges of the porous metal medium are sealed by means of a welding operation, with or without the use of filler material during welding. Another example is where the porous metal medium is laser cut to size before or after bonding to the first layer, and wherein by the laser cutting the side edges are sealed by the heat generated in laser cutting.

[0015] In a preferred embodiment, the side edges of the porous metal medium are permanently sealed by means of upstanding side edges of the first

layer. The upstanding side edges of the first layer cover the side edges of the porous metal medium, thereby sealing the pores at the side edges of the porous metal medium. An example of such embodiment is where a plate, foil or sheet is machined to remove material, to make the plate, foil or sheet thinner except that upstanding side edges remain. The porous metal medium is then applied fitting in the so formed cup shape of the plate, foil or sheet and permanently bonded onto the plate, foil or sheet.

- [0016] Preferably, the carrier has a thickness between 650 μm and 750 μm .
- [0017] Preferably, the first layer has a thickness between 20 μm and 650 μm , more preferably between 150 μm and 650 μm .
- [0018] Preferably, the porous metal medium has a thickness between 50 μm and 150 μm , more preferably between 50 μm and 150 μm .

- [0019] Preferably, the porosity of the porous metal medium is between 30 and 80 %, more preferably between 50 and 80 %, more preferably between 60 and 80 %. Such embodiments synergistically add to improve the mechanical properties of the carrier, so that the wafer can fulfil the requirements in terms of dimensional characteristics after its processing while being bonded onto the carrier.
- [0020] Preferably, the first layer comprises or consists out of metal, or glass, or silicon or ceramic. In a preferred embodiment, the first layer consists out of metal, or out of glass or out of silicon or out of ceramic.
- [0021] Specific examples of the porous metal medium include sintered or welded metal fiber nonwovens.
- [0022] Preferably, the first layer comprises or consists out of metal. Preferably, the first layer comprises or consists out of a metal foil, a metal plate or a metal sheet. Preferably, the first layer comprises the same metal or alloy as the porous metal medium.
- [0023] Preferably, the porous metal medium comprises or consists out of stainless steel, titanium, palladium or tungsten; or comprises or consists out of an alloy comprising for more than 50% by weight of titanium, palladium or tungsten. More preferably, for embodiments where the first layer comprises or consists out of a metal foil, a metal plate or a metal

sheet, the first layer comprises the same metal or metal alloy as the porous metal medium.

- [0024] In a preferred embodiment wherein the first layer comprises or consists out of metal, the first layer is permanently bonded to the porous metal medium by means of metallic bonds, preferably by means of diffusion bonding, such as sintering, or by means of welding (and preferably by means of welding wherein no additional filler material is used in the welding process). An example of a welding process that can be used is capacity discharge welding (CDW).
- [0025] In a preferred embodiment, the first layer is permanently bonded to the porous metal medium by means of an adhesive. The adhesive can be selected from the wide range of adhesives that are not attacked by the debonding liquid used when debonding the temporarily bonded wafer from the carrier. Examples of suitable adhesives are adhesives based on epoxy.
- [0026] In a preferred embodiment, the equivalent diameter of the metal fibers is between 2 and 50 μm , more preferably between 2 and 40 μm , even more preferably between 2 and 25 μm . Even more preferably between 10 and 25 μm . With equivalent diameter is meant the diameter of the circle having the same area as the cross section of a fiber, cross sectional shape which can deviate from a circular shape.
- [0027] Preferably, the porous metal medium has a surface for being bonded onto a wafer, wherein this surface is parallel with the first layer. This surface is polished so that the carrier has a total thickness variation (TTV) less than 10 μm , more preferably less than 5 μm , even more preferably less than 2 μm . The total thickness variation (TTV) is measured by a drop gauge measurement on 5 points, selected randomly over the surface of the material. For the test method, the diameter of the drop gauge is 5.99 mm. The TTV is defined as the difference between the maximum thickness measured and the minimum thickness measured.

[0028] Preferably, the surface of the second layer onto which the wafer will be temporarily bonded, has a surface roughness Ra less than 1 μm , more preferably less than 0.5 μm . As is known to the skilled person, Ra is the arithmetic mean of the deviations of the measured roughness points from their average.

[0029] In a preferred embodiment, the porous metal medium comprises or consists out of a first porous layer and a second porous layer. The first porous layer is provided between the first layer and the second porous layer. The porosity of the first porous layer is higher than the porosity of the second porous layer. Preferably, the second porous layer is provided for temporarily bonding a wafer onto it.

In a more preferred embodiment, the first porous layer is directly bonded to the first layer. In a further preferred embodiment, the second porous layer is directly bonded to the first porous layer. In a further embodiment, the second porous layer is provided for being bonded onto the wafer.

In a more preferred embodiment, the first porous layer comprises metal fibers of a first equivalent diameter (e.g. 22 μm) and the second porous layer comprises metal fibers of a second equivalent diameter (e.g. 14 μm).

In an even more preferred embodiment, the first equivalent diameter is larger than the second equivalent diameter.

[0030] In a preferred embodiment, the second layer comprises a contact layer for being bonded onto a wafer. The contact layer comprises a mixture of metal fibers and metal powder. The metal fibers and the metal powder are permanently bonded to each other at their contacting points. In a preferred such embodiment, the porosity of the porous metal medium is more than 20% and preferably more than 30%, more preferably more than 40%, even more preferably more than 50%, even more preferably more than 60%. And preferably the porosity is less than 80%, more preferably less than 60%.

In a preferred such embodiment, the porosity of the contact layer is more than 20% and preferably more than 30%. And preferably the porosity of the contact layer is less than 50%, more preferably less than 40%.

In a preferred embodiment, the porous metal medium comprises an additional porous layer, provided between the first layer and the contact layer. The additional porous layer can comprise metal fibers, metal powder, or metal foam. Specific examples of the additional porous layer include sintered or welded metal fiber nonwovens, sintered metal powders, and metal foam.

Preferably, the metal powder in the contact layer has a diameter within the range of within the range of 2 to 30 μm , preferably within the range of 2 to 20 μm , more preferably within the range of 2 to 10 μm .

[0031] Preferably, the carrier is provided such that when applying a pressure of 4 bar onto it, the permanent deformation of the carrier is less than 5 % of its original thickness before applying the pressure. This can be tested by measuring the thickness of the carrier before and after applying a pressure of 4 bar during a time period of 20 seconds. A carrier according to this embodiment can be made by prepressing the carrier or the porous metal layer or porous metal layers in it so that future permanent deformation is limited. Such embodiments surprisingly synergistically improve the properties of the wafer after its processing (e.g. thinning) while being temporarily adhered to the carrier.

[0032] A second aspect of the invention is an assembly (or stack) of a wafer and a carrier as in the first aspect of the invention. The wafer is bonded by means of an adhesive onto the second layer. Preferably, the adhesive is an adhesive that can be removed by means of contacting a suitable debonding liquid to the adhesive.

[0033] A third aspect of the invention is a method for the processing of wafers. The method comprises the steps of

- temporarily adhering a wafer to a carrier as in the first aspect of the invention by means of an adhesive;
- processing the wafer temporarily adhered to the carrier, e.g. thinning the wafer; and
- debonding the wafer from the carrier, by means of a debonding liquid

breaking up the temporary adhesive bond between the wafer and the carrier; wherein the debonding liquid penetrates into the porous metal medium from the side edges of the assembly of the wafer bonded by means of adhesive to the carrier.

During and after debonding a wafer temporarily bonded to the carrier, the first layer remains bonded to the porous metal medium.

In a preferred method, the carrier is after debonding re-used one or more times for temporarily adhering another wafer onto it. Preferably, the carrier can be used at least 5 times, more preferably at least 10 times.

Brief Description of Figures in the Drawings

[0034] Figure 1 shows a top view of an exemplary carrier according to the invention.

Figure 2 shows the cross section of an exemplary carrier according to the invention.

Figure 3 shows an example of an assembly of a wafer temporarily bonded to an inventive carrier.

Mode(s) for Carrying Out the Invention

[0035] Figure 1 shows the top view of a carrier 100 according to the invention.

The carrier 100 has the shape of a disk deviating from a circular circumference (with diameter D) by a linear side 102. The linear side 102 is present in order to match the shape of a wafer to be bonded to the work carrier.

[0036] Figure 2 shows a cross section of an exemplary carrier 200 according to the invention. The carrier 200 comprises a first layer 210. The first layer is a metal foil or a metal sheet. The carrier 200 further comprises a metal porous metal medium 223 comprising metal fibers, e.g. a sintered metal fiber nonwoven web. The side edges 250 of the porous metal medium are permanently sealed so that no open pores are present at the side edges 250 of the porous metal medium 523. The side edges can be sealed by means of welding of the edges, or by means of laser cutting to size and shape operation of the porous metal medium 223, or by means of a

welding of the edges or by means of laser cutting operation to size and shape of the combination of the first layer and the second layer after bonding the first layer to the second layer.

An alternative method for creating the sealed edges is by machining a plate so that the upstanding edges are created, and the porous metal medium is inserted in the cup that is created by the machining, and subsequent bonding of the porous metal medium onto the first layer.

Instead of a metal foil or a metal sheet, e.g. a glass, ceramic or silicon sheet or plate can be used as first layer. The bonding of the porous metal medium with the first layer can then be done by means of an adhesive, e.g. epoxy.

[0037] Figure 3 shows an example of an assembly or stack 301 of a wafer temporarily bonded to a carrier, e.g. the carrier 200 of the example of figure 2. Same reference numbers as in figure 2 have the same meaning as in figure 2. A temporary adhesive layer 370 is applied onto the porous metal medium of the carrier 200, and a wafer 380 is temporarily bonded to the carrier 200 via this adhesive layer 370.

When the bonded wafer 380 is to be debonded from the carrier 200, initially no wicking of the debonding liquid occurs in the porous metal medium 223. Initial debonding happens on the thin layer of adhesive 370 between the carrier 200 and the wafer 380. When this thin adhesive layer is broken down at the edges of the stack 301, the debonding speed increases by having an increased wicking of the debonding liquid in the porous metal medium 223 through the openings created by dissolving the glue layer at the edges of the stack.

[0038] In a first example, a metal carrier was constructed by applying a first layer consisting out of a titanium metal foil of 200 μm thickness. A porous metal layer was sintered on the first layer, consisting out of a 500 g/m^2 nonwoven metal fiber web of 20 μm equivalent diameter titanium fibers and a thickness of 250 μm , resulting in a porosity of the porous metal layer of 56%. The material was produced in sheets of 450 mm by 600 mm. After sintering, 8" round discs with a straight line were cut out by means of laser cutting to match to an 8" silicon semiconductor wafer. By the laser cutting, the titanium fibers at the edges of the porous metal medium were molten

down, resulting in complete edge sealing of the porous metal medium, without any permeability at the sides of the porous metal medium.

By means of spin coating, a silicon based adhesive is applied at the porous side of the carrier and the device wafer is bonded at 25°C and at 0.8 bar pressure in 10 minutes. In the debonding step, immersing the bonded stack (the stack is the assembly of the carrier and the wafer temporarily bonded onto the carrier) in Daeclean 300 – a commercially available solvent system for removal of cured silicone - at 25°C it was shown that initial debonding occurred on the thin glue layer between the top layer of the carrier and the device wafer. When this thin glue layer was broken down, the debonding speed increased by having an increased wicking of the debonding liquid in the porous metal medium through the openings created by dissolving the glue layer at the edge. The device wafer was fully debonded in 6 minutes 30 seconds.

[0039] In a second example, a carrier was constructed starting from a 400 µm thick titanium foil. By a grinding tool, a 200 µm thick disc shape hole was ground, leaving – along the full circumference of the titanium foil - an upstanding ridge of 0.5 mm width and 200 µm height. Inside the disc shape opening, a nonwoven titanium fiber web of 200 µm thickness (22 µm fiber equivalent diameter – 400 g/m² and porosity 56%) was pressed; and afterwards the foil and porous metal medium are sintered together at 1100°C during 1 hour. By means of spin coating, a silicon based adhesive is applied to the porous side of the carrier and the device wafer is bonded at 25°C and at 0.8 bar during 10 minutes. In the debonding step, immersing the bonded stack (the stack is the assembly of the carrier and the wafer temporarily bonded onto the carrier) in Daeclean 300 – a commercially available solvent system for removal of cured silicone adhesives- at 25°C it was shown that initial debonding happened on the thin glue layer between the top layer of the carrier and the device wafer. When this thin glue layer was broken down, the debonding speed increased by having an increased wicking of the debonding liquid in the porous metal medium through the openings created by dissolving the glue layer at the edge. The device wafer was fully debonded in 6 minutes 30 seconds.

Claims

1. Carrier onto which a wafer can be temporarily bonded, wherein the carrier comprises a plate shaped laminate, the plate shaped laminate comprises:
 - a first layer, wherein the first layer comprises a foil, a sheet or a plate; and
 - a second layer comprising a porous metal medium with three-dimensional open pores; wherein the porous metal medium comprises metal fibers; wherein the first layer is permanently bonded to the porous metal medium thereby closing the pores of the porous metal medium at the side where the first layer is located; wherein the side edges of the porous metal medium are permanently sealed so that no open pores are present at the side edges of the porous metal medium.
2. Carrier as in claim 1, wherein the side edges of the porous metal medium are permanently sealed by means of metallic bonds.
3. Carrier as in claim 1, wherein the side edges of the porous metal medium are permanently sealed by means of upstanding side edges of the first layer, wherein the upstanding side edges of the first layer cover the side edges of the porous metal medium, thereby sealing the pores at the side edges of the porous metal medium.
4. Carrier as in any of the preceding claims, wherein the first layer comprises metal, or glass, or silicon or ceramic.
5. Carrier as in any of the preceding claims, wherein the first layer comprises metal; and wherein the first layer comprises the same metal or alloy as the porous metal medium.
6. Carrier as in any of the preceding claims, wherein said porous metal medium comprises stainless steel, titanium, palladium or tungsten; or comprises an

alloy comprising for more than 50% by weight of titanium, palladium or tungsten.

7. Carrier as in any of the claims 1 - 6,
wherein the first layer comprises metal; and
wherein the first layer is permanently bonded to the porous metal medium by means of metallic bonds.
8. Carrier as in any of the claims 1 – 6, wherein the first layer is permanently bonded to the porous metal medium by means of an adhesive.
9. Carrier as in any of the preceding claims, wherein the porous metal medium comprises metal fibers, and wherein the equivalent diameter of the metal fibers is between 2 and 50 μm .
10. Carrier as in any of the preceding claims, wherein the porous metal medium has a surface provided for being bonded onto a wafer, wherein this surface is parallel with the first layer; and wherein this surface is polished so that the carrier has a total thickness variation (TTV) less than 10 μm .
11. Carrier as in any of the preceding claims, wherein the porous metal medium comprises a first porous layer and a second porous layer,
wherein the first porous layer is provided between the first layer and the second porous layer; and wherein the porosity of the first porous layer is higher than the porosity of the second porous layer.
12. Carrier as in any of the preceding claims, wherein the second layer comprises a contact layer for being bonded onto a wafer,
wherein the contact layer comprises a mixture of metal fibers and metal powder,
wherein the metal fibers and the metal powder are permanently bonded to each other at their contacting points.

13. Assembly of a wafer and a carrier as in any of the preceding claims,
wherein the wafer is bonded by means of an adhesive onto said second layer.
14. Method for the processing of wafers, comprising the steps of
- temporarily adhering a wafer to a carrier as in any of the claims 1 - 12 by means of an adhesive,
 - processing the wafer temporarily adhered to the carrier, e.g. thinning the wafer;
 - debonding the wafer from the carrier, by means of a debonding liquid breaking up the temporary adhesive bond between the wafer and the carrier; wherein the debonding liquid penetrates into the porous metal medium from the side edges of the assembly of the wafer bonded by means of adhesive to the carrier.

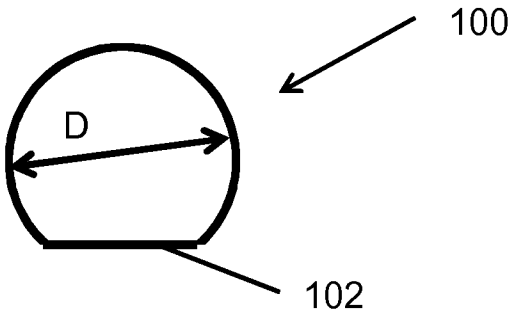


Fig. 1

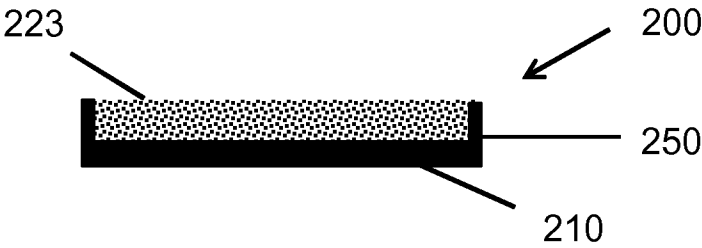


Fig. 2

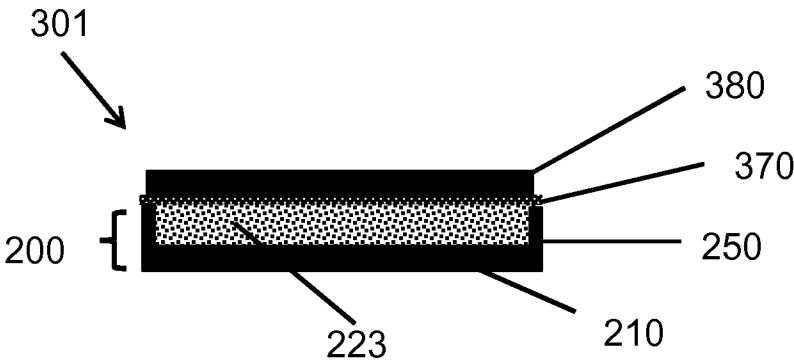


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/054436

A. CLASSIFICATION OF SUBJECT MATTER
INV. B22F7/00 B32B15/04 B32B15/14 H01L21/683 B24B37/27
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B22F B32B H01L B24B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 02/29856 A2 (MOTOROLA INC [US]) 11 April 2002 (2002-04-11)	1-8,13
Y	page 1, line 1 - page 2, line 3	11
A	page 3, line 1 - line 10	14
	page 4, line 4 - page 5, line 17	
	page 6, line 9 - page 7, line 17	
	claims; figures	

X	FR 2 835 242 A1 (KARL SUSS FRANCE [FR]) 1 August 2003 (2003-08-01)	1,2, 4-10,12, 13
Y	page 1, line 17 - page 2, line 20	11,14
	page 3, line 1 - line 7	
	page 3, line 28 - page 4, line 18	
	claims; figures	

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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

24 May 2016

Date of mailing of the international search report

01/06/2016

Name and mailing address of the ISA/

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Fax: (+31-70) 340-3016

Authorized officer

Ceulemans, Judy

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/054436

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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