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(54) **Title:** CARRIER FOR TEMPORARY BONDED WAFERS

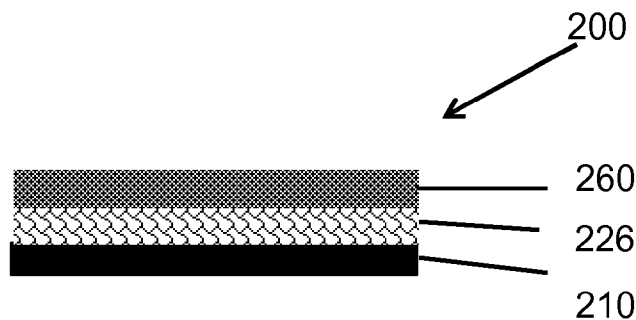


Fig. 2

(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 comprising a porous metal medium with three-dimensional open pores. 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 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.



WO 2016/142239 A1

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 and further processed, while 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 comprising a porous metal medium with three-dimensional open pores. 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 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.

[0011] Preferably, the carrier has the shape of a disk deviating 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.

- [0012] The carrier has the benefit that debonding solvent can flow through the three-dimensional open pores of the porous metal medium, from the side edges of the carrier adhesively bonded onto a wafer, through the whole volume of the porous metal medium. This way, the debonding solvent can reach the adhesive layer attaching the wafer to the carrier fast. 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 this inventive carrier that the presence of dimples on the thinned wafer is reduced or even completely eliminated. It is believed that this surprising beneficial effect is created by the powder particles being present in the pores between the fibers in the contact layer, thereby reducing the pore size, resulting in lower surface roughness of the contact layer. It is a further benefit of the carrier of the invention that less adhesive is consumed for bonding the wafer onto the carrier; which also results in faster debonding.
- [0013] In a preferred embodiment, the first layer comprises or consists out of metal, or glass, or silicon or ceramic.
- [0014] In a preferred embodiment, the porous metal medium comprises an additional porous layer. The additional porous layer is provided between the first layer and the contact layer. The additional porous layer comprises metal fibers, metal powder, or metal foam. Specific examples of the additional porous layer include sintered or welded metal fiber nonwovens, sintered powders, and metal foam.
- [0015] 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.

- [0016] 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.
- [0017] In a preferred embodiment, the first layer comprises metal and 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).
- [0018] 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.
- [0019] Preferably, the carrier has a thickness between 650 μm and 750 μm .
- [0020] Preferably, the first layer has a thickness between 20 μm and 650 μm , more preferably between 150 μm and 650 μm .
- [0021] Preferably, the porous metal medium has a thickness between 50 μm and 150 μm , more preferably between 50 μm and 150 μm .
- [0022] Preferably, the porosity of the porous metal medium is more than 20% and more preferably more than 30%, more preferably more than 40%, even more preferably more than 50%, even more preferably more than 55%. And preferably the porosity is less than 80%, more preferably less than 60%. Such embodiments synergistically add to improve the mechanical properties of the carrier, so that the wafer can fulfil the requirements of dimensional characteristics after its processing while being bonded onto the carrier.

- [0023] Preferably, 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%.
- [0024] Preferably, the equivalent diameter of the metal fibers in the contact layer 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.
- [0025] Preferably, the metal powder in the contact layer has a diameter 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 .
- [0026] In a preferred embodiment, 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 . 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.
- [0027] In a preferred embodiment, the porous metal medium comprises 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. 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 and the second porous layer comprises metal fibers of a second equivalent diameter. In an even more preferred

embodiment, the first equivalent diameter is larger than the second equivalent diameter.

[0028] In a preferred embodiment, 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.

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, 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 sealing 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.

When a temporary bonded wafer is to be debonded from a carrier with permanently sealed edges, initially no wicking of the debonding liquid occurs in the porous metal medium. Initial debonding happens on the thin layer of adhesive between the carrier and the wafer. When this thin adhesive layer is broken down, the debonding speed increases by having increased wicking of the debonding liquid in the porous metal medium through the openings created by dissolving the glue layer at the edge.

[0029] 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.

[0030] 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 contact layer. Preferably, the adhesive is an adhesive that can be removed by means of contacting a suitable debonding liquid to the adhesive.

[0031] A third aspect of the invention is a method for the processing of wafers, comprising 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;
- 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

[0032] 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

- [0033] 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.
- [0034] Figure 2 shows a cross section of an exemplary carrier 200 according to the invention. The carrier 200 comprises a first layer 210, wherein the first layer is a metal foil or a metal sheet. The carrier 200 further comprises an additional porous layer 226, e.g. a sintered nonwoven metal fiber web. The carrier comprises a contact layer 260 consisting out of a mixture of metal powder particles and metal fibers, sintered to each other at contacting points. Preferably, the metal foil or metal sheet, the metal fibers and the metal powder are out of the same metal or alloy. The different layers are permanently bonded to each other by means of sintering or by means of welding (e.g. capacity discharge welding). Instead of the nonwoven metal fiber web as additional layer, sintered porous metal powder layers and/or metal foam layers can be used. 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 porous metal layers (the additional porous layer and the contact layer) are bonded to each other by means of metallic bonds, e.g. sintering and the bonding with the first layer can then be done by means of an adhesive, e.g. epoxy.
- [0035] 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 described for figure 2. A temporary adhesive layer 370 is applied onto the porous metal medium of the carrier 200, and a wafer is 380 is temporarily bonded to the carrier 200 via this adhesive layer 370.
- [0036] As an example, a carrier has been made for an 8" wafer. As first layer, a titanium foil of 200 μm thickness has been used. On top of the titanium foil,

a nonwoven titanium fiber web (22 μm equivalent diameter of the titanium fibers) of thickness 500 μm and porosity 56% has been applied. The combination of the titanium foil and the nonwoven titanium fiber web has been sintered together. A titanium powder slurry has been prepared. The slurry comprises 20 % by weight of 20 μm diameter titanium powder, in water, with addition of a small amount of a suitable dispersing agent. A uniform slurry layer has been applied onto the nonwoven titanium fiber web side of the sintered fiber web/ titanium plate combination. The application can be done by means of screen printing, with a screen having a uniform distribution of openings over its surface. A volume of 200 mg/cm^3 (the volume is based on the porous nonwoven fiber medium) was applied. The powder slurry penetrates into the nonwoven titanium fiber web, and creates a mixture of titanium powder and fibers, thereby creating a contact layer of the carrier, whereby the contact layer comprises a mixture of titanium fibers and titanium powder. The product was dried at 180°C for 30 minutes followed by a sintering step at 800°C in vacuum condition for 1 hour, thereby creating sinter bonds between contacting titanium powder particles and titanium fibers. The sintering has been performed under conditions wherein the thickness of the carrier remains the same. Before and after applying and sintering the titanium powder slurry to the carrier, the pore size distribution was measured with a Porometer (Porolux 100). Before applying the titanium powder, the average pore size of the porous part was 55-65 μm and after applying the titanium powder mixture, the average pore size was decreased to 45 μm .

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 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 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.
2. Carrier as in claim 1, wherein the first layer comprises metal, or glass, or silicon or ceramic.
3. Carrier as in any of the preceding claims, wherein the first layer comprises metal;
and wherein the first layer is provided out of the same metal or alloy as the porous metal medium.
4. 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.
5. Carrier as in any of the claims 1 - 4, wherein the first layer comprises metal;
and
wherein the first layer is permanently bonded to the porous metal medium by means of metallic bonds.

6. Carrier as in any of the claims 1 – 4, wherein the first layer is permanently bonded to the porous metal medium by means of an adhesive.
7. Carrier as in any of the preceding claims, wherein the porosity of the porous metal medium is between 20 and 80 %.
8. Carrier as in any of the preceding claims, wherein the porosity of the contact layer is more than 20%.
9. Carrier as in any of the preceding claims, wherein the equivalent diameter of the metal fibers in the contact layer is between 2 and 50 μm .
10. Carrier as in any of the preceding claims, wherein the metal powder in the contact layer has a diameter within the range of 2 to 10 μm .
11. Carrier as in any of the preceding claims, wherein the porous metal medium has a surface 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 .
12. 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.
13. Carrier as in any of the preceding claims, 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.
14. 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 contact layer.

15. Method for the processing of wafers, comprising the steps of
- temporarily adhering a wafer to a carrier as in any of the claims 1 – 13, by means of an adhesive;
 - processing the wafer temporarily adhered to the carrier;
 - 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.

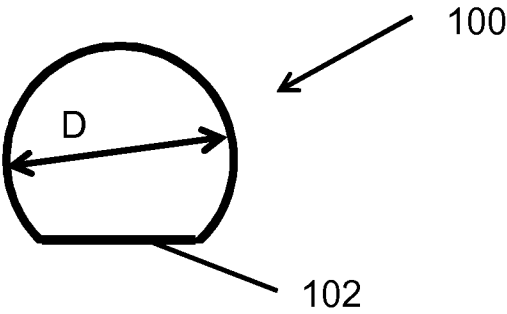


Fig. 1

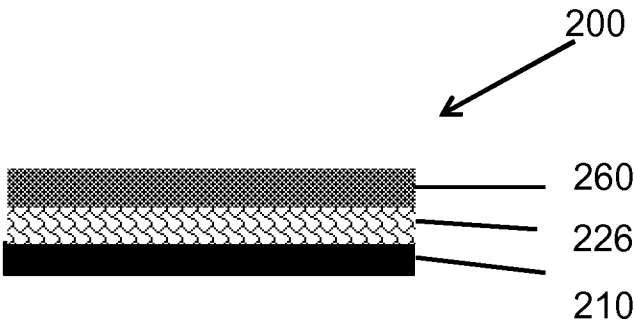


Fig. 2

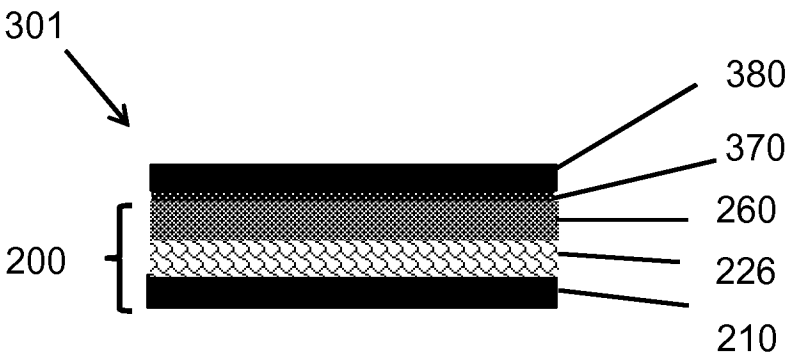


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER

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ADD. B24B37/27 B32B15/04

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)

H01L B24B B32B

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/009631 A1 (JOSHI SHAILESH N [US]) 8 January 2015 (2015-01-08) claims; figures 8-10	1-10
X	----- CN 102 430 752 A (NW INST NON FERROUS METAL RES) 2 May 2012 (2012-05-02) claims	1-5,7-10
A	----- US 2009/197070 A1 (MIYANARI ATSUSHI [JP]) 6 August 2009 (2009-08-06) cited in the application abstract	1-15
A	----- US 2007/110975 A1 (SCHNEWEIS STEFAN [DE]) 17 May 2007 (2007-05-17) claims	1-15
	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

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27/05/2016

Name and mailing address of the ISA/

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Gori, Patrice

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/054435

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005/173064 A1 (MIYANARI ATSUSHI [JP]) 11 August 2005 (2005-08-11) cited in the application abstract -----	14,15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/054435

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