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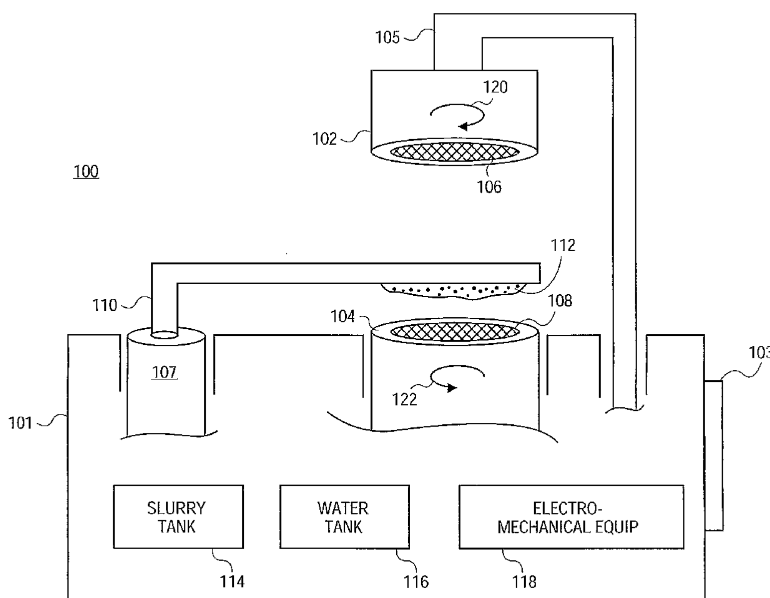
(54) Title: DIAMOND CONDITIONING OF SOFT CHEMICAL MECHANICAL PLANARIZATION/POLISHING (CMP) POLISHING PADS



(57) Abstract: Conditioning of chemical mechanical planarization (CMP) using conventional diamond-embedded abrasive strips are well suited to condition conventional "hard" polishing but not soft polishing pads because the diamonds not only remove waste material, but they also damage the polishing surface of the pad. Embodiments of the present invention condition soft polishing pads using diamond strips without damaging the soft polishing pad (108).

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DIAMOND CONDITIONING OF SOFT CHEMICAL MECHANICAL PLANARIZATION/POLISHING (CMP) POLISHING PADS

BACKGROUND

1. Field

[0001] Embodiments of the present invention relate to chemical mechanical planarization/polishing (CMP) and, in particular, to conditioning of CMP polishing pads.

2. Discussion of Related Art

[0002] Chemical mechanical planarization/polishing (CMP) is a process technology first developed in the mid-1980s to enable production of integrated circuits on substrates or wafers. CMP processes are used prepare wafers and to fabricate semiconductor devices or structures on the wafers. A CMP process may be used to planarize (*i.e.*, make flat) a semiconductor layer on a wafer, an insulating layer on the semiconductor layer, and a conductive layer on the insulating layer in predetermined patterns.

[0003] A typical CMP system includes a wafer carrier and a platen mounted in a housing. A polishing pad is secured to the platen and the wafer to be polished is secured in the wafer carrier. A typical CMP process operates as follows. The wafer carrier rotates the wafer and/or the platen rotates the polishing pad. Chemical slurry is applied to the surface of the polishing pad and the wafer is brought into contact with the polishing pad and is polished (or planarized). The combination of applying the chemical slurry and the mechanical rotation leads to the term "chemical-mechanical planarization."

[0004] As the wafer is polished, the chemical slurry and materials removed from the wafer tend to glaze the surface of the polishing pad, making the polishing pad slick and reducing the polishing rate and efficiency. It is thus important that the polishing pad surface be clean and free of surface irregularities. The process of cleaning the polishing pad is sometimes referred to a "conditioning" or "refreshing."

[0005] One method of conditioning polishing pads is to abrade them with a conventional diamond-embedded abrasive disk or strip. Although conventional diamond-embedded abrasive strips are well suited to condition "hard" polishing pads used for rough polishing,

they are not well suited to condition "soft" polishing pads used for fine polishing. When a soft polishing pad is conditioned with a diamond-embedded abrasive disk, the diamonds not only remove waste material, but they also damage the polishing surface of the pad.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0006] In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally equivalent elements. The drawing in which an element first appears is indicated by the leftmost digit(s) in the reference number, in which:

10 **[0007]** Figure 1 is schematic diagram of a chemical mechanical planarization/polishing (CMP) polishing system according to an embodiment of the present invention;

[0008] Figure 2 is a flowchart illustrating a process performed by a CMP polishing system in according to embodiments of the present invention;

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[0009] Figure 3 illustrates an example soft polishing pad according to an embodiment of the present invention;

[0010] Figure 4 illustrates operation of a conditioning arm according to an embodiment

20 of the present invention; and

[0011] Figure 5 illustrates a diamond conditioner according to an embodiment of the present invention.

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DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0012] Figure 1 is schematic diagram of a chemical mechanical planarization (CMP) polishing system 100 according to an embodiment of the present invention. The CMP polishing system 100 includes a housing 101, a polishing head 102, a control panel 103, a platen 104, a spindle 105, a wafer 106, a base 107, a soft polishing pad 108, a conditioning

30 arm 110, a diamond (or artificial diamond) conditioner 112, a slurry tank 114, a spindle 115, a water tank 116, and electromechanical equipment 118. The slurry tank 114 and/or the water tank 116 may be located in or separate from the housing 101. The electromechanical equipment 118 may include vertical drivers, rotational drivers,

controllers, or other equipment generally used to operate arms, motors, and other devices in CMP polishing systems.

[0013] The platen 104 is mounted in the housing 101 and may be rotated by a motor (not shown) in the electromechanical equipment 118. The polishing head 102 is mounted on the spindle 105 and may be rotated by a motor (not shown) in the electromechanical equipment 118. The wafer 106 is mounted with the surface to be polished face down and away from the polishing head 102. The soft polishing pad 108 mounted to the platen using an adhesive. During polishing of the wafer 106, the polishing head 102 may be rotated in a direction opposite to the rotation of the polishing pad 108 may be, as shown by arrows 120 and 122. Alternatively, the polishing head 102 may rotate while the platen 104 remains stationary. Alternatively still, the polishing head 102 may be stationary while the platen 104 rotates. The slurry tank 114 delivers slurry to the surface of the soft polishing pad 108 during wafer 106 polishing.

[0014] The conditioning arm 110 pivots in its base 107 when conditioning the soft polishing pad 108. A motor (not shown) in the electromechanical equipment 118 may move the conditioning arm 110. The water tank 116 may dispense a rinsing solution, such as potable water or de-ionized (DI) water, to the surface of the soft polishing pad 108 during conditioning of the soft polishing pad 108.

[0015] Figure 2 is a flowchart illustrating a process 200 performed by the CMP polishing system 100 according to embodiments of the present invention. A machine-readable medium with machine-readable instructions thereon may be used to cause a processor to perform the process 200. Of course, the process 200 is only an example process and other processes may be used. The example process 200 may be used to remove metal, oxides, glass, silicon, etc. Although the example process 200 is described with reference to wafers, the example process 200 may be used for semiconductors, memory disks, or other suitable objects requiring smoothness, planarity, fine polishing, etc., such as lenses and mirrors.

[0016] In a block 202 the head 102 holds the wafer 106 and rotates the wafer 106 against the soft polishing pad 108 as slurry from the slurry tank 114 is applied to the surface of the

soft polishing pad 108 and the platen 104 applies a force to the wafer 106. In a block 204, the head 102 disengages the wafer 106 from contact with the soft polishing pad 108 and the slurry stops flowing to the surface of the soft polishing pad 108.

5 **[0017]** In a block 206, the soft polishing pad 108 is conditioned using the diamond conditioner 112. In one embodiment of the present invention, the platen 104 rotates the soft polishing pad 108, rising solution from the water tank 116 rinses the soft polishing pad 108, e.g., by supplying DI water to the surface of the soft polishing pad 108, and the conditioning arm 110 with the diamond conditioner 112 sweeps across (e.g., back and 10 forth) the soft polishing pad 108. Although polishing of the soft polishing pad 108 may be described in some embodiments as being performed *ex situ* (between wafer 106 polishings), polishing of the soft pat 108 in other embodiments may be performed *in situ* (while wafers 106 are being polished), or some combination of both. Of course, the soft polishing pad 108 may be conditioned according to embodiments of the present invention 15 prior to polishing any wafers 106.

[0018] One or a combination of the following process parameters may be modified to improve the process for soft pad 108 conditioning using the diamond conditioner 112 to ensure that the conditioning arm 110 with the diamond conditioner 112 do not destroy or 20 significantly reduce the lifetime of the soft polishing pad 108. In fact, according to embodiments of the present invention, the lifetime of the soft polishing pad 108 is significantly increased. Increased soft polishing pad 108 lifetime results in reduced labor costs and costs of parts, as well as improved processes, (*e.g.*, soft polishing pads 108 do not have to be changed as often).

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[0019] In one embodiment, the conditioning arm 110 applies approximately 0.25 psi to the soft polishing pad 108 through the diamond conditioner 112 as opposed to approximately three psi applied using conventional hard polishing pad techniques..

30 **[0020]** In known soft polishing pad conditioning methods, the platen and thus the soft polishing pad does not rotate. In embodiments of the present invention, the rotational speed of the platen 104 and thus the soft polishing pad 108 may be approximately one hundred revolutions per minute 100 (rpm)

[0021] In known soft polishing pad conditioning methods, there may be no DI water flowing to the soft conditioning pad. In one embodiment of the present invention, the volumetric flow rate of DI water from the DI water tank 116 may may be one gallon per minute (gpm). Alternatively, the volumetric flow rate may be anywhere from zero to approximately seven gallons per minute.

[0022] In known soft polishing pad conditioning methods, there is no diamond conditioner used, thus no down force applied to a soft polishing pad In one embodiment, the down force applied to the soft polishing pad by the diamond conditioner 112 may be 0.25 psi.

[0023] In known soft polishing pad conditioning methods, no diamond conditioner is used. n known hard polishing pad conditioning methods, the diamond conditioner makes at least ten sweeps. In one embodiment, the diamond conditioner 112 makes one sweep across the soft polishing pad.

[0024] Figure 3 illustrates the example soft polishing pad 108 according to an embodiment of the present invention. The example soft polishing pad 108 includes several pores 302 and may be made from napped poromerics-porous urethane layers on a mylar or compressible urethane substrate. In an alternative embodiment, the example soft polishing pad 108 may be a soft pad made with tangled polyester fibers coated with polyurethane. In another embodiment, the example soft polishing pad 108 may be a felt sheet of fibers impregnated with micro porous elastomer. Alternatively still, the example soft polishing pad 108 may be a porous thermoplastic resin matrix, typically polyurethane, reinforced with a fibrous network such as a felted mat of polyester fibers. An example of a suitable soft pad includes any of the Politex® Series polishing pads available from Rodel Holdings in Wilmington, Delaware.

[0025] The soft polishing pads 108 according to embodiments of the present invention are to be distinguished from known hard polishing pads, which include micro porous polyurethane polishing pads that are relatively hard and not as compressible when compared to other types of polishing pads and polyurethane impregnated felt polishing

pads. Examples of hard pads include the SUBA 1000 Series polishing pads and the SUBA® Pads available from Rodel in Phoenix, Arizona.

[0026] Figure 4 illustrates operation of the conditioning arm 110 according to an embodiment of the present invention. When the soft polishing pad 108 is moving and a wafer 106 is being polished, the conditioning arm 110 (and the diamond conditioner 112) remain in the position 402 situated adjacent to the perimeter of the soft polishing pad 108. After a predetermined number of wafers have been polished by the soft polishing pad 108, or when the polishing rate has been decreased due to build up of slurry and other debris, the conditioning arm 110 is pivoted at one end by the base 107, lowered onto the soft polishing pad 108, and swept along an arc indicated by the arrows 408 from the position 402 across the surface of the soft polishing pad 108 (as shown by phantom lines) to a second position 406 adjacent to the other side of the perimeter of the soft polishing pad 108 (also shown by phantom lines).

[0027] Figure 5 illustrates the diamond conditioner 112 according to an embodiment of the present invention. The diamond conditioner 112 includes a base 502 having diamonds 504. The base 502 may be any suitable rigid substrate. The diamonds 504 may be synthetic diamonds, natural diamonds, etc.

[0028] The diamonds 504 may be placed on the base 502 using chemical vapor deposition (CVD). Alternatively, the diamonds 404 may be embedded in the base 502. For example, the diamond conditioner 112 may be formed by embedding diamond particles in nickel coated on the surface of a rigid substrate according to well-known or proprietary techniques.

[0029] Embodiments of the invention can be implemented using hardware, software, firmware, or a combination of hardware and software. In implementations using software, the software may be stored on a computer program product (such as an optical disk, a magnetic disk, a floppy disk, etc.) or a program storage device (such as an optical disk drive, a magnetic disk drive, a floppy disk drive, etc.).

[0030] The above description of illustrated embodiments of the invention is not intended

to be exhaustive or to limit the invention to the precise forms disclosed. While specific embodiments of, and examples for, the invention are described herein for illustrative purposes, various equivalent modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize. These modifications can be made to the
5 invention in light of the above detailed description.

[0031] In the above description, numerous specific details, such as particular processes, materials, devices, and so forth, are presented to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that
10 the embodiments of the present invention can be practiced without one or more of the specific details, or with other methods, components, etc. In other instances, well-known structures or operations are not shown or described in detail to avoid obscuring the understanding of this description.

15 **[0032]** Various operations have been described as multiple discrete operations performed in turn in a manner that is most helpful in understanding embodiments of the invention. However, the order in which they are described should not be construed to imply that these operations are necessarily order dependent or that the operations be performed in the order in which the operations are presented.

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[0033] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, process, block, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases "in one embodiment" or "in an
25 embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0034] The terms used in the following claims should not be construed to limit the
30 invention to the specific embodiments disclosed in the specification and the claims. Rather, the scope of embodiments of the invention is to be determined entirely by the following claims, which are to be construed in accordance with established doctrines of claim interpretation.

CLAIMS

What is claimed is:

1. A method of conditioning a chemical mechanical planarization (CMP) polishing pad, comprising:

    conditioning a soft polishing pad using diamond conditioner.

2. The method of claim 1, further comprising:

    rotating a soft polishing pad on a platen;
    rinsing the soft polishing pad; and
    passing a diamond conditioner over the soft polishing pad.

3. The method of claim 2, further comprising:

    applying zero pounds per square inch (psi) to the soft polishing pad from the platen.

4. The method of claim 1, wherein passing the conditioning arm having the diamond conditioner thereon over the soft polishing pad comprises passing the diamond conditioner over the soft polishing pad during wafer polishing.

5. The method of claim 1, wherein passing the conditioning arm having the diamond conditioner thereon over the soft polishing pad comprises passing the diamond conditioner over the soft polishing pad between wafer polishings.

6. The method of claim 1, further comprising rotating a wafer against the soft polishing pad.

7. The method of claim 6, further comprising applying a slurry to the surface of the soft polishing pad.

8. A chemical mechanical planarization (CMP) system, comprising:

a head mounted in a housing;

a wafer mounted to the head;

a platen mounted in the housing;

5 a soft polishing pad mounted to the platen;

a pad conditioning arm mounted in the housing; and

a diamond conditioner mounted to the pad conditioning arm.

9. The system of claim 8, further comprising a slurry tank mounted in the housing.

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10. The system of claim 9, further comprising a water tank mounted in the housing.

11. The system of claim 8, further comprising electromechanical equipment mounted in the housing.

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12. A chemical mechanical planarization (CMP) apparatus, comprising:

a soft polishing pad adhered to a platen in a housing; and

a pad conditioning arm mounted in the housing, the pad conditioning arm having a diamond conditioner attached thereto.

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13. The CMP apparatus of claim 12, wherein the soft polishing pad comprises napped poromerics-porous urethane layers on a substantially compressible substrate.

14. The CMP apparatus of claim 13, wherein the soft polishing pad comprises napped

25 poromerics-porous urethane layers on a mylar substrate.

15. The CMP apparatus of claim 12, wherein the soft polishing pad comprises napped poromerics-porous urethane layers on a substantially compressible urethane substrate.

30 16. The CMP apparatus of claim 12, wherein the diamond conditioner comprises a diamond strip.

17. The CMP apparatus of claim 12, wherein the diamond strip comprises synthetic diamonds embedded in a base.

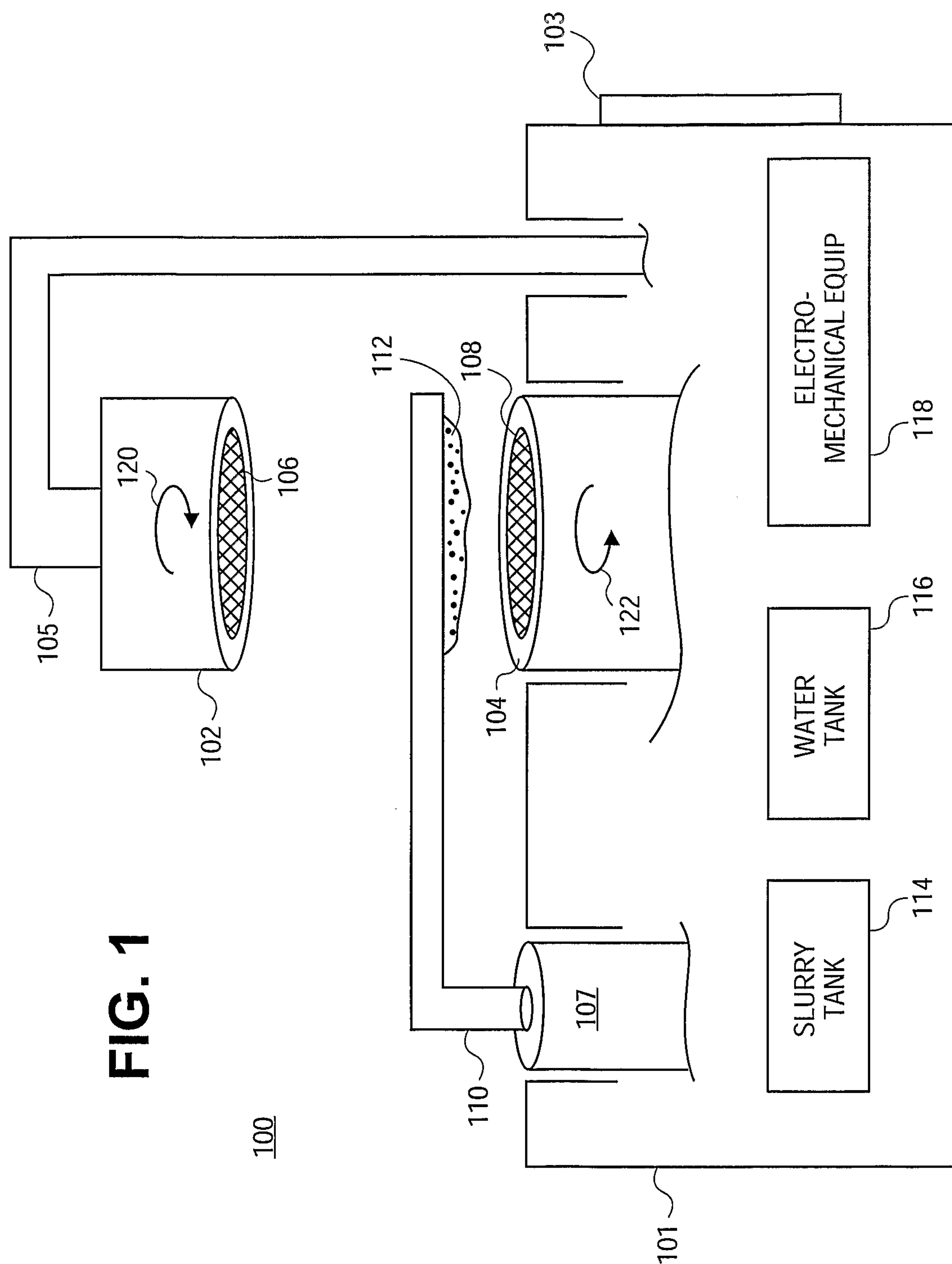
FIG. 1
100
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108
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114
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118
120
122
ELECTRO-
MECHANICAL EQUIP
WATER
TANK
SLURRY
TANK

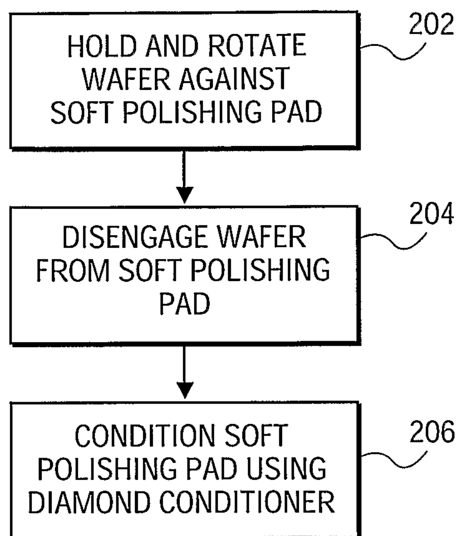

FIG. 2

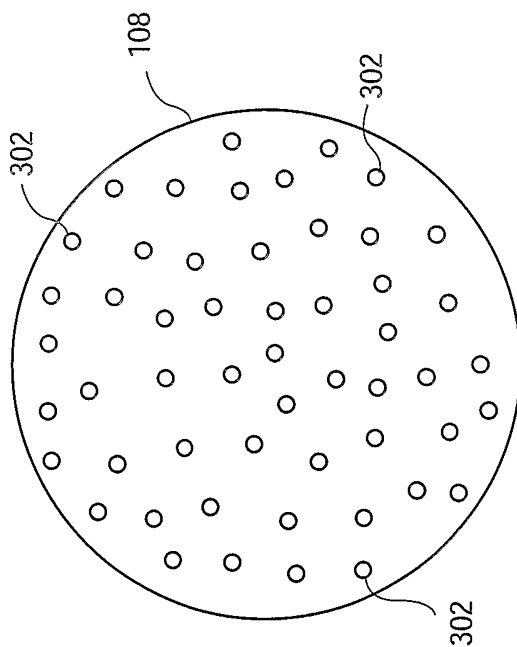

FIG. 3

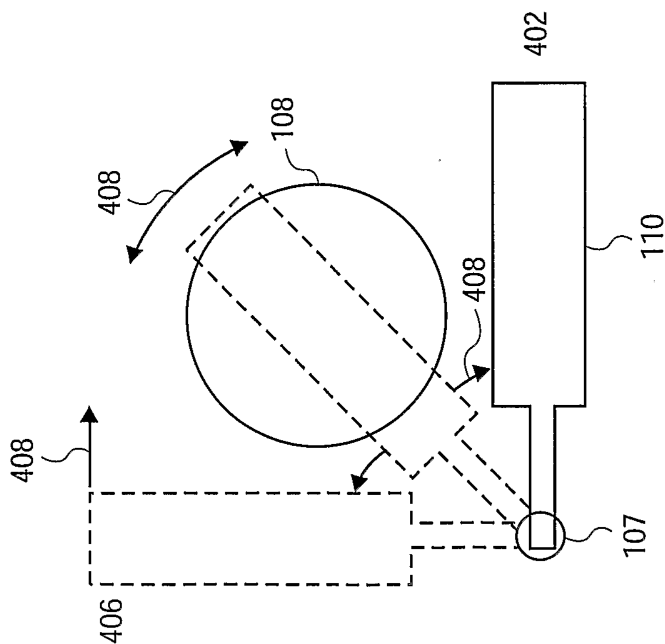

FIG. 4

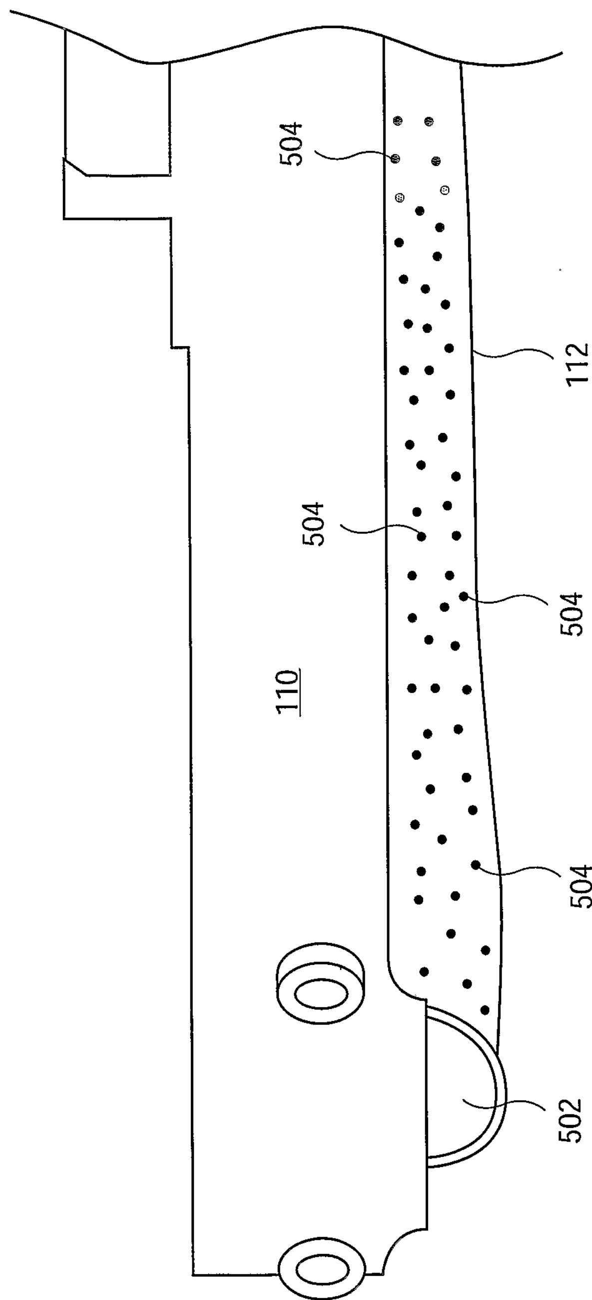

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/39969

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B24B37/04 B24B53/007

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)
IPC 7 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 practical, 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 2001/029155 A1 (LI JUI-LUNG ET AL) 11 October 2001 (2001-10-11) paragraphs '0034!,'0035!,'0043!; claim 1; figure 3	1-17
A	US 2002/137436 A1 (GOTKIS YEHIEL ET AL) 26 September 2002 (2002-09-26) paragraph '0024!; figure 5C	16,17

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 May 2004	25/05/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Do Huu Duc, J

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 03/39969

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