(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 July 2014 (17.07.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/109928 A1

(51) International Patent Classification:
C09K 3/14 (2006.01) *H01L 21/304* (2006.01)

(21) International Application Number:
PCT/US2013/078310

(22) International Filing Date:
30 December 2013 (30.12.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/751,543 11 January 2013 (11.01.2013) US

(71) Applicant: **APPLIED MATERIALS, INC** [US/US]; 3050 Bowers Avenue, Santa Clara, CA 95054 (US).

(72) Inventors: **HARDIKAR, Vishwas, V.**; 108 Chalet Woods Circle, Campbell, CA 95008 (US). **WANG, Zhihong**; 1710 Wright Ave., Sunnyvale, CA 94087 (US). **GAGE, David, Maxwell**; 809 Auzerais Avenue, Unit 346, San Jose, CA 95126 (US). **GARTNER, Thomas, E.**; 1444 7th Ave. #206, San Francisco, CA 94122 (US).

(74) Agents: **DUGAN, Brian, M.** et al.; Dugan & Dugan, PC, 245 Saw Mill River Road, Suite 309, Hawthorne, NY 10532 (US).

(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, LT, 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, 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).

Published:

— *with international search report (Art. 21(3))*

(54) Title: CHEMICAL MECHANICAL POLISHING PROCESS AND SLURRY CONTAINING SILICON NANOPARTICLES

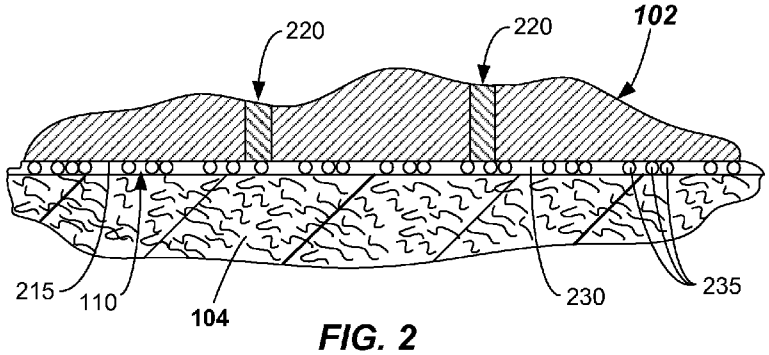


FIG. 2

(57) Abstract: In one aspect, a substrate chemical mechanical polishing (CMP) method for substrates is disclosed. The CMP method includes providing a substrate having a surface of silicon and copper (such as through silicon via regions containing copper), and polishing the surface with a slurry containing very small silicon nanoparticles (e.g., having an average diameter less than 8 nanometers). CMP systems and slurries for CMP are provided, as are numerous other aspects.

WO 2014/109928 A1

CHEMICAL MECHANICAL POLISHING PROCESS AND SLURRY CONTAINING SILICON NANOPARTICLES

RELATED APPLICATIONS

[0001] The present application claims priority to US Provisional Application 61/751,543 filed January 11, 2013, and entitled "CHEMICAL MECHANICAL POLISHING PROCESS AND SLURRY CONTAINING SILICON NANOPARTICLES" which is hereby incorporated herein for all purposes.

FIELD

[0002] The present invention relates generally to semiconductor device manufacturing, and more particularly to chemical mechanical polishing using abrasive slurries.

BACKGROUND

[0003] Within semiconductor substrate manufacturing, a planarization process may be used to remove various layers or films, such as silicon dioxide, silicon nitride, copper, or the like from a substrate (e.g., a patterned wafer). Planarization may be accomplished using a chemical mechanical polishing (CMP) process by instituting an abrasive slurry between a polishing pad and the substrate surface to be polished (e.g., planarized). The substrate is received in a holder that applies pressure against a side (e.g., front side or backside) of the substrate to force the substrate against the polishing pad. Both the holder and the polishing pad may be rotated to facilitate the material removal. Further, the holder may oscillate

the substrate back and forth across the surface of the polishing pad.

[0004] During certain planarization processes, although adequate material removal may be accomplished with existing processes and slurries, other problems may be encountered. Accordingly, improved polishing methods and slurries are sought.

SUMMARY

[0005] In a first aspect, a chemical mechanical polishing method of processing a substrate is provided. The chemical mechanical polishing method of processing a substrate includes providing a substrate having a surface containing silicon and copper, and polishing the surface with a slurry containing silicon nanoparticles.

[0006] In a first aspect, a chemical mechanical polishing method of processing a substrate is provided. The chemical mechanical polishing method includes providing a substrate having a backside surface of silicon and through silicon via regions containing copper, and polishing the backside surface with a slurry containing silicon nanoparticles.

[0007] In another aspect, a chemical mechanical polishing system is provided. The chemical mechanical polishing system includes a substrate held in a substrate holder, the substrate having a surface of silicon and copper, a polishing pad, and a slurry containing silicon nanoparticles inserted between the substrate and the polishing pad.

[0008] In another aspect, a chemical mechanical polishing system is provided. The chemical mechanical polishing system includes a substrate held in a substrate holder, the substrate having a backside surface of silicon and through silicon via regions of copper, a polishing pad, and a slurry containing silicon nanoparticles inserted between the substrate and the polishing pad.

[0009] In another aspect, a slurry composition adapted to chemical mechanical polishing of a wafer is provided. The improved slurry composition includes a liquid carrier, and silicon nanoparticles having an average particle size of less than about 8 nanometers, and in an amount between about 0.01 weight % and about 0.1 weight % wherein the pH of the composition is between about 9 and about 12.

[00010] Other features and aspects of the present invention will become more fully apparent from the following detailed description of example embodiments, the appended claims, and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[00011] FIG. 1 illustrates a partial side plan of a chemical mechanical polishing system according to embodiments.

[00012] FIG. 2 illustrates a cross-sectioned partial side view of a backside of a substrate (including through silicon via regions) being polished by a slurry comprising nanoparticles according to embodiments.

[00013] FIG. 3 illustrates a micrograph view of a portion of a backside surface of a substrate after a first expose polishing step wherein the through silicon via is exposed illustrating deposited copper/copper oxide particles according to embodiments.

[00014] FIG. 4 illustrates a micrograph view of a backside surface of a substrate after a second polishing step wherein some or all of any deposited copper/copper oxide around the through silica via is removed according to embodiments.

[00015] FIG. 5 illustrates a flowchart of a chemical mechanical polishing method of processing a substrate according to embodiments.

DETAILED DESCRIPTION

[00016] Embodiments described herein relate to systems, slurries, and methods adapted to polish a surface of a substrate. In particular, chemical mechanical polishing methods and slurries adapted to provide through silicon via processing to expose backside via are provided. In particular, the method and slurries are used to prevent poisoning the silicon backside surfaces with copper.

[00017] In particular, when a polishing step using abrasives is carried out to expose the through silicon via, copper and/or copper oxide particles are deposited on the silicon surfaces around the peripheries of the through silicon via (See FIG. 3). This poisons the transistors. To avoid this poisoning of the silicon backside, prior methods have used a multistep process of stopping short of breaking through to the copper vias on the backside, and then performing further deposition and zoned etching to expose the regions of copper through silicon vias. Thus, although prior systems have avoided copper contamination, simpler methods are desired.

[00018] In one or more embodiments, a chemical mechanical polishing method of processing a substrate is provided. The method includes providing a substrate having a backside surface of silicon and exposed through silicon via regions of copper thereon. The backside surface is then polished with a slurry containing silicon nanoparticles. The silicon nanoparticles are extremely small so that they possess large surface area which can effectively bind to free copper removed by the small particles. Also, a chemical mechanical polishing system is

provided having a substrate holder, the substrate having a backside surface of silicon and through silicon via regions of copper, a polishing pad, and a slurry containing silicon nanoparticles inserted between the substrate and the polishing pad. CMP slurries including the silicon nanoparticles are provided, as are other aspects.

[00019] These and other aspects of embodiments of the invention are described below with reference to FIGs. 1-5 herein.

[00020] FIG. 1 illustrates a partial side view of a chemical mechanical polishing (CMP) system 100 and components thereof. The CMP system 100 is adapted to hold a substrate 102 in relationship to a polishing pad 104 and is used to carry out a polishing process in accordance with another aspect of the invention. The substrate may be a wafer, such as a patterned wafer including partially- or fully-formed transistors thereon. The polishing pad 104 may be mounted on a conventional platen 106 that may be rotated by a suitable motor (not shown) coupled to the platen by shaft 107. Polishing pad 104 may comprise any suitable porous material, such as a soft porous polymer material. Polishing pad 104 may have a shore A hardness of about 50 or less, about 40 or less, about 30 or less, and between about 8 and about 22 in some embodiments. The polishing pad 104 may have a pore size between about 30-40 microns, and a pore rate of between 20% and 40%, for example. A POLYPAS polishing pad model H7000 from FUJIBO available from Marubeni America Corporation of Santa Clara, CA, may be used. Other polishing pads may be used. Disc-shaped platen 106 may be rotated at between about 10-200 RPM. Other rotational speeds may be used. The

substrate 102 may be held in a substrate holder 108 of conventional construction. Substrate holders (also referred to as retainers or carrier heads) are described in US Pat. Nos. 8,298,047; US 8,088,299; US 7,883,397; and US 7,459,057, issued to the present assignee, for example. Substrate holder 108 may be rotated and may also be scanned (e.g., oscillated) back and forth across the surface of the polishing pad 104 as the polishing pad 104 is being rotated in contact with the substrate 102. The holder oscillation rate may between about 0.1 mm/s and 5 mm/s. Other oscillation rates may be used. Substrate holder 108 may be rotated at between about 10-200 RPM and under a pressure of between about 0.1 and 1 psi, for example. Other rotational speeds and pressures may be used. The scanning back and forth may take place between a center and a radial side of the polishing pad 108.

[00021] A slurry 110 may be instituted and inserted between the polishing pad 104 and the substrate 102 by a distributor 112 and be used in the polishing process. Distributor 112 may be coupled to a slurry supply 114, such as by one or more suitable conduits. A pump 116 or other liquid conveying or transfer mechanism may supply a metered amount of the slurry 110 to the surface of the pad 104. In the depicted embodiment, the slurry 110 may be dispensed onto the surface of the polishing pad 104 ahead of the substrate 102 by the distributor 112 so that the slurry 110 is received in front of the substrate 102 and is drawn between the polishing pad 104 and the substrate 102 by the rotation of the pad 104 and is used to facilitate the polishing process. In the depicted embodiment, the slurry 110 comprises silicon

nanoparticles. The silicon nanoparticles may be provided in a suitable carrier liquid.

[00022] Accordingly, the CMP system 100 is useful for polishing a surface of a substrate 102 as will be apparent from the following description. According to embodiments, the CMP system 100 and slurry 110 containing silicon nanoparticles is especially adapted for use in polishing a backside 215 of a substrate 102 after a previous polishing step exposing a plurality of through silicon via 220 (See FIG. 2). Through silicon via 220 generally comprise cylindrical copper pillars internal to the silicon structure of the substrate 102 and are used to establish electrical connections between stacked chips in their final form. During a previous expose polishing process, wherein the through copper vias 224 are exposed, i.e., the silicon backside 215 is removed by polishing/planarization down to the depth of the through copper vias 224, some of the removed copper is believed to be involved in a reduction reaction, which causes copper particles and/or copper oxide particles 225 (a few shown in circles) to be re-deposited onto the backside silicon surface 215 of the substrate 102 surrounding the copper vias 224.

[00023] In particular, as shown in FIG. 2, a partial view of a substrate 102 is shown. The backside 215 of the substrate 102 is polished by utilizing a previous polishing process, and then is subjected to polishing method according to embodiments of the invention where a fine slurry 110 is instituted between the backside 215 of the substrate 102 and the polishing pad 104. The slurry 110 has a composition that is adapted to chemical mechanical polishing of a substrate (e.g., wafer). In one or more embodiments, the slurry composition comprises a

liquid carrier 230 and silicon nanoparticles 235 (a few labeled). The silicon nanoparticles 235 may be generally spherical in shape and may have an average particle size (e.g., diameter) of less than about 8 nanometers, less than about 6 nanometers, and between about 8 nanometers and about 3 nanometers, or even between about 6 nanometers and about 4 nanometers in some embodiments. These very small nanoparticles (e.g., being less than about 8 nanometers) provide a very large surface are is accessible for the copper reduction reaction. The silicon nanoparticles 235 may be provided in an amount of less than about 1 weight %, between about 1 weight % and about 0.01 weight %, or even between about 0.01 weight % and about 0.1 weight % in some embodiments. In accordance with another aspect, a pH of the slurry 110 may be between about 9 and about 12. Hydroxide or other source of hydroxyl ions may be added in an effective amount to bring about suitably basic conditions. For example, the Potassium hydroxide may be provided in an amount between about 0.01 weight % and about 1 weight %. In another example, hydrogen peroxide may be provided in an amount between about 0.1 weight % and about 2 weight %. The liquid carrier 230 may comprise de-ionized water. Other suitable carrier liquids may be used. Other additives and components may be added in combination with the silica nanoparticles, such as etchant chemicals and/or other sizes and types of abrasives. For example, an larger average size particle size abrasive such as silica having a weight % of between 2 weight % to about 13 weight % may be added. An etchant or other chemical may be added to control a copper removal rate. Weight % as used herein is

based upon the total weight of the composition according to the formula:

Weight% = (component weight/ total slurry weight) x 100%

[00024] One example embodiment of a slurry 110 in accordance with an aspect of the invention is shown in Table 1.

Table 1 – Example Slurry Composition

Component	Weight%
DIW	86.04%
KOH	0.20%
Silicon nanoparticles (5 nm APS)	0.01%
Colloidal silica particles (80 nm APS)	13.00%
BTA (Benzotriazole)	0.15%
Glycine	0.60%
Total	100.00%

APS = Average particle size

[00025] FIG. 5 illustrates a chemical mechanical polishing method 500 adapted to process a substrate (e.g., substrate 102), and in particular a method of polishing a substrate (e.g., substrate 102) after undergoing a previous planarization or other polishing process that has exposed the copper vias 220 on the backside 215 of the substrate (herein an “expose process”). However, the present method may be used on any substrate 102 having a surface (frontside or backside) having a combination of silicon and copper.

[00026] The method 500 includes, in 502, providing a substrate having a backside surface (e.g., backside surface 215) of silicon and through silicon via regions containing copper (220), and in 504 polishing the backside surface with a slurry (e.g., slurry 110) containing

silicon nanoparticles (e.g., silicon nanoparticles 235). Prior to the polishing step according to embodiments of the present invention, an expose process has taken place on the backside 215 of the substrate 102 to remove silicon, Copper from the through silica via regions 220, and a diffusion barrier 240 prior to the polishing of the backside surface 215. The expose process may be completed on a previous platen of a multi-step CMP system.

[00027] After this preliminary expose process is completed on the backside, the polishing method 500 with the slurry containing silicon nanoparticles according to embodiments of the invention may commence. In accordance with one or more embodiments, the polishing of the backside surface 215 with the slurry 110 containing silicon nanoparticles 235 may occur for 10 seconds or more. The slurry 110 containing silica nanoparticles 235 comprises silicon nanoparticles having an average particle size of less than about 8 nanometers. In some embodiments, the polishing of the backside surface 215 with the slurry 110 containing silicon nanoparticles 235 occurs for between about 10 seconds and about 90 seconds. Other time periods may be used. Without being bound to theory, the slurry 110 containing silicon nanoparticles 235 is believed to function as a reducing agent to deposit copper onto the surface of the silicon nanoparticles 235. The polishing method 500 including the slurry 110 of nanoparticles 235 functions as a reducing agent to remove copper particles surrounding the through silicon via 220 to the extent where only particles of less than 20 nanometers remain, if any. Thus, the method 500 provides defect reduction for Cu/Si TSV CMP.

[00028] In the more general case, a chemical mechanical polishing method of processing a substrate is provided. The method includes providing a substrate having a surface containing silicon and copper; and polishing the surface with a slurry containing silicon nanoparticles. The method may be carried out by a chemical mechanical polishing (CMP) system. Embodiments of the present system may be used whenever both Cu and silicon are exposed during CMP, regardless if the exposure is the substrate "frontside" or "backside" and regardless if the regions of Cu at issue extend completely through the silicon-containing substrate or not.

[00029] For example, copper defects may exist when processing Si/Cu on a wafer frontside, and even in the case where the copper regions only extend partially (not fully through) the silicon substrate. The system includes a substrate held in a substrate holder, the substrate having a surface containing silicon and copper, a polishing pad, and a slurry containing silicon nanoparticles inserted between the substrate and the polishing pad. The silicon nanoparticles may have an average particle size of less than about 8 nanometers. Other suitable slurry components may be used such as DIW, a pH control agent (e.g., OH or KOH), other abrasives such as larger colloidal silica particles (e.g., > 50 nanometers), inhibitors and/or complexing agents. For example, the slurry may contain colloidal silica particles of up to 13 weight %. These particles may have an average particle size of greater than 50 nm, or even about 80 nanometers. The slurry may have up to about 0.15 wt% of an inhibitor, such as BTA (Benzotriazole). Further, the

slurry may have up to about 0.6 wt% of a complexing agent, such as Glycine. Other additives may be included.

[00030] FIG. 4 illustrates a micrograph of through silica via 420 with the copper particles being removed around the via after undergoing the CMP method 500 at 1 psi pressure applied to the substrate 102 and with silicon nanoparticles 235 having a average particle size of 5 nanometers and weight percent of about 1.5 weight% for 30 seconds according to an embodiment of the invention.

[00031] Accordingly, while the present invention has been disclosed in connection with example embodiments thereof, it should be understood that other embodiments may fall within the scope of the invention, as defined by the following claims.

CLAIMS

THE INVENTION CLAIMED IS:

1. A slurry composition adapted to chemical mechanical polishing of a wafer, the composition comprising:

a liquid carrier; and

silicon nanoparticles having an average particle size of less than about 8 nanometers and in an amount between about 0.01 weight % and about 0.1 weight %,

wherein the pH of the composition is between about 9 and about 12.

2. The slurry of claim 1, wherein the silica nanoparticles comprising an amount of the silicon nanoparticles of between about 0.01 weight % and about 0.1 weight %.

3. The slurry of claim 1, wherein the silica nanoparticles comprise an average particle size of between about 3 nanometers and about 8 nanometers.

4. The slurry of claim 1, comprising colloidal silica particles having an average particle size greater than 50 nanometers, an inhibitor, and a complexing agent.

5. A chemical mechanical polishing system, comprising:

a substrate held in a substrate holder, the substrate having a backside surface of silicon and through silicon via regions of copper;

a polishing pad;

a slurry containing silicon nanoparticles inserted between the substrate and the polishing pad.

6. The chemical mechanical polishing system of claim 5, wherein the polishing pad comprises a polymer having a durometer of less than about 50 shore A.

7. A chemical mechanical polishing method of processing a substrate, comprising:

providing the substrate having a backside surface of silicon and through silicon via regions containing copper; and

polishing the backside surface with a slurry containing silicon nanoparticles.

8. The method of claim 7, comprising polishing the substrate to remove silicon, Cu from the through silica via regions, and a diffusion barrier prior to the polishing of the backside surface with the slurry containing silicon nanoparticles.

9. The method of claim 7, wherein the slurry containing silica nanoparticles comprises silicon nanoparticles having an average particle size of less than about 8 nanometers.

10. The method of claim 7, wherein the slurry containing silica nanoparticles comprises silicon nanoparticles having an average particle size of less than about 6 nanometers.

11. The method of claim 7, wherein the slurry containing silicon nanoparticles functions as a reducing agent to deposit copper onto the surface of the silicon nanoparticles.

12. A chemical mechanical polishing method of processing a substrate, comprising:

providing a substrate having a surface containing silicon and copper; and

polishing the surface with a slurry containing silicon nanoparticles.

13. The chemical mechanical polishing method of claim 12 wherein the silicon nanoparticles have an average particle size of less than about 8 nanometers.

14. The chemical mechanical polishing method of claim 12 wherein the silicon nanoparticles are provided in an amount between about 0.01 weight % and about 0.1 weight %.

15. A chemical mechanical polishing system, comprising:

a substrate held in a substrate holder, the substrate having a surface of silicon and copper;

a polishing pad;

a slurry containing silicon nanoparticles inserted between the substrate and the polishing pad.

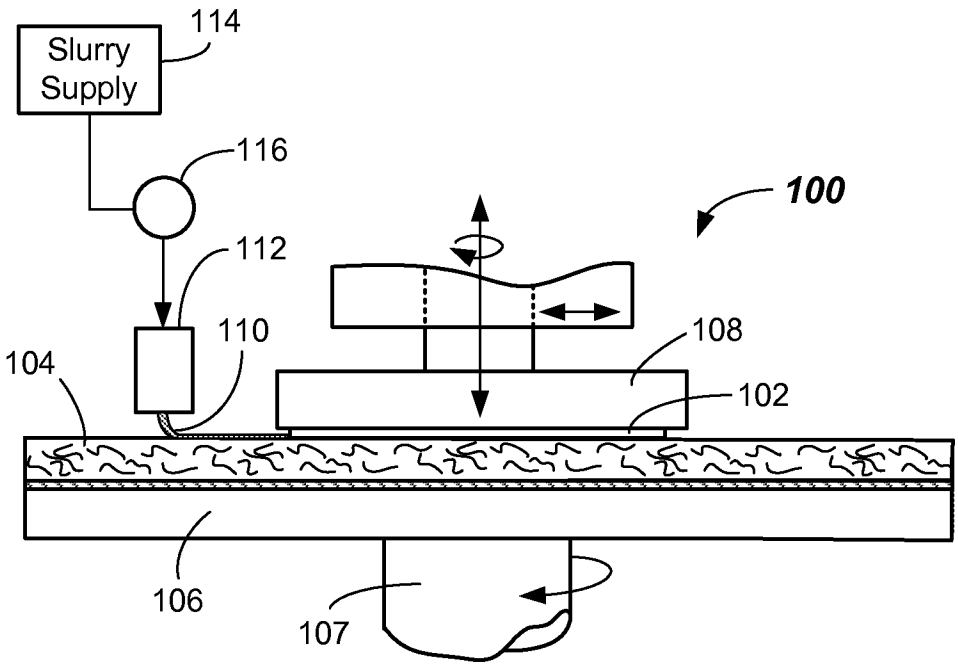

Slurry Supply
114
116
112
110
104
108
102
100
106
107

FIG. 1

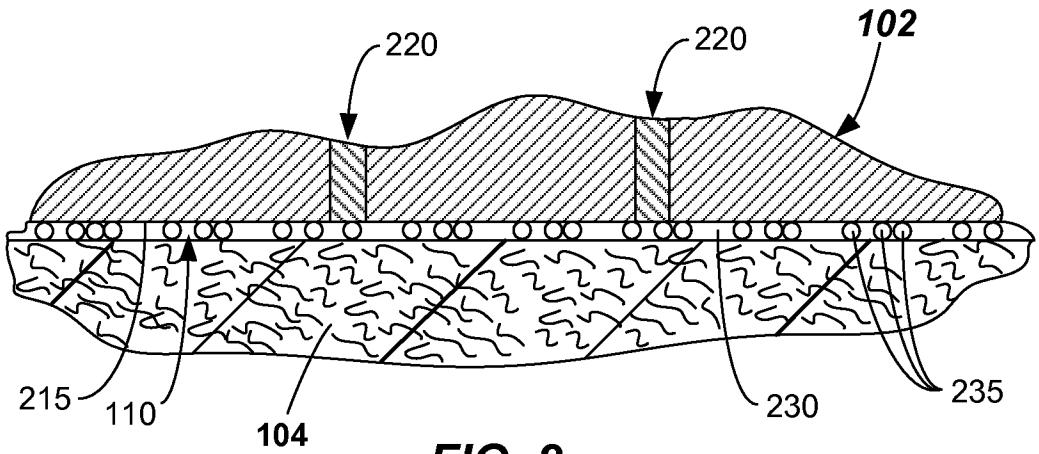

220
220
102
215
110
104
230
235

FIG. 2

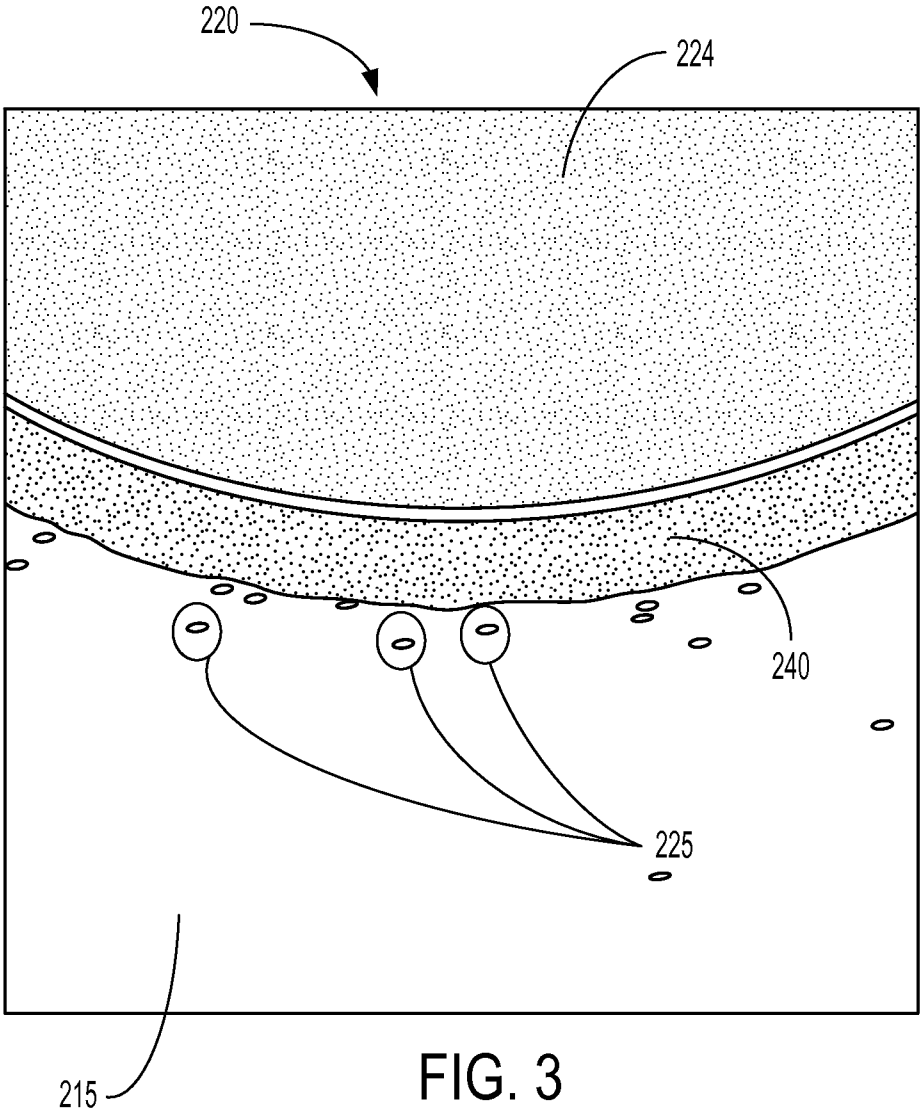


FIG. 3

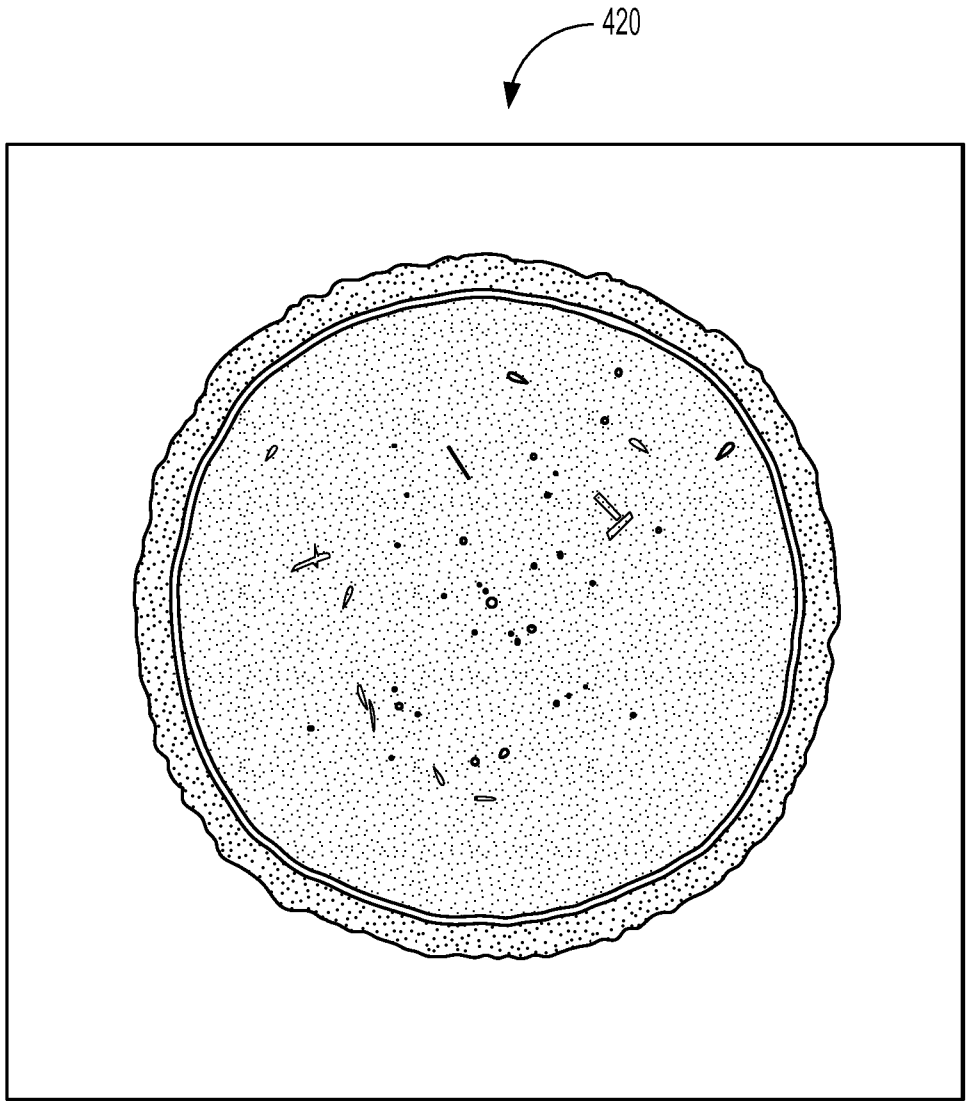


FIG. 4

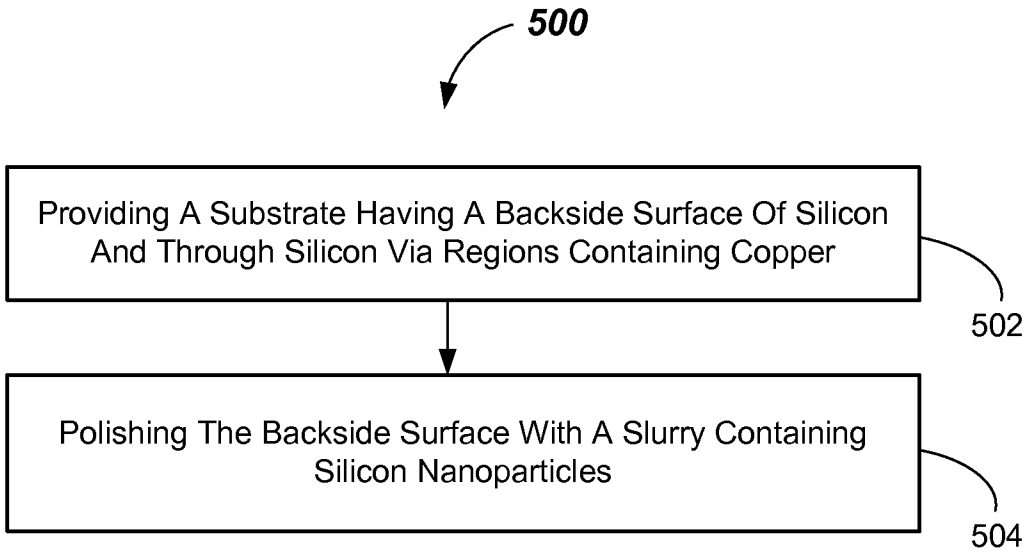

500
Providing A Substrate Having A Backside Surface Of Silicon And Through Silicon Via Regions Containing Copper
502
Polishing The Backside Surface With A Slurry Containing Silicon Nanoparticles
504

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/078310

A. CLASSIFICATION OF SUBJECT MATTER

C09K 3/14(2006.01)i, H01L 21/304(2006.01)i

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)
C09K 3/14; H01L 21/304; C09G 1/04; B24B 37/00; C09G 1/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: chemical mechanical polishing, silicon nanoparticle, through silicon via

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7097677 B2 (YOKOI, NORIAKI) 29 August 2006 See abstract; columns 1-2 and 4-6; claim 1; and figures 1A-4B.	1-15
A	LIU, ZIYU et al. `Copper chemical mechanical polishing and wafer thinning with temporary bonding for through silicon via interconnect.` in Proceedings of the 2012 13th International Conference on Electronic Packaging Technology and High Density Packaging (ICEPT-HDP), pages 488-493. See pages 488-491.	1-15
A	US 7247179 B2 (SIDDIQUI, JUNAID AHMED et al.) 24 July 2007 See column 5, lines 48-53; and claims 1-22.	1-15
A	JP 2009-289886 A (FUJIFILM CO., LTD.) 10 December 2009 See paragraph [0007]; and claims 1-10.	1-15
A	JP 2003-297777 A (SPEEDFAM CO., LTD.) 17 October 2003 See paragraph [0010]; and claims 1-8.	1-15
A	KR 10-2003-0068791 A (KOREA ELECTRONICS TECHNOLOGY INSTITUTE et al.) 25 August 2003 See page 2; claims 1-10; and figures 1-4.	1-15

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

☒ See patent family 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 application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 April 2014 (28.04.2014)	**28 April 2014 (28.04.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
HONG, Sung Ran
Telephone No. +82-42-481-5405

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/078310

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7097677 B2	29/08/2006	EP 1405889 A1	07/04/2004
		KR 10-2004-0080935 A	20/09/2004
		TW I257947 B	11/07/2006
		US 2004-0020132 A1	05/02/2004
		WO 03-070853 A1	28/08/2003
US 7247179 B2	24/07/2007	US 2004-0107650 A1	10/06/2004
		US 2005-0044803 A1	03/03/2005
		US 6893476 B2	17/05/2005
JP 2009-289886 A	10/12/2009	None	
JP 2003-297777 A	17/10/2003	None	
KR 10-2003-0068791 A	25/08/2003	None	