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(54) Title: METHOD FOR REMOVING CONTAMINATION FROM A CHUCK SURFACE

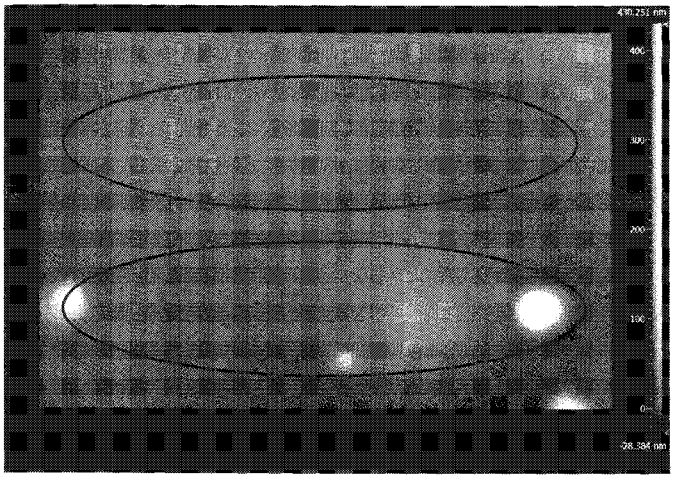

Fig. 1

(57) Abstract: A method for decontaminating support surfaces of a wafer chuck entails lightly passing a treatment tool having a nominally flat contacting surface over the regions of the chuck where contaminants are to be removed. The treatment tool and the chuck surface may have about the same hardness. The treatment tool may be constrained so that it may conform to the surface being processed. When the treatment tool is contacted to a flat surface, the area of contact may be in the form of a circle, ring or annulus. At application pressures, the treatment tool will abrade the chuck, which here is to be avoided, or at least minimized. Thus, the instant inventors have discovered that the same treatment tool that is used to engineer the elevation profile of the surface, and its roughness, at lower application pressures can be used to remove grinding debris and other contaminants from the surface.

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TITLE

Method for removing contamination from a chuck surface

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This patent document claims the benefit of United States Provisional Patent Application No. 62/205,349, entitled "Method for removing contamination from a chuck surface", filed on August 14, 2015 in the name of inventor Edward Gratrix. Where permitted, the entire contents of this provisional patent application are incorporated by reference herein.

STATEMENT REGARDING U.S. FEDERALLY SPONSORED RESEARCH

[0002] None.

TECHNICAL FIELD

[0003] This invention solves the problem for wafer handling tool cleaning and contamination removal in an in-situ manner, thus allowing a higher level of tool availability and lesser likelihood of cross contamination.

BACKGROUND ART

[0004] Semiconductor processes have inherent contamination in the forms of particulate and films which, although progress is continuously being made in reducing the level of particulate, is an omnipresent issue impacting device yield. Capital equipment feature tools and surfaces that serve for tens or hundreds of thousands of iterations; thus, the need for in-situ cleaning is critical. Contaminants can be particles, films or converted damage layers due to energetic bombardment (typical of plasma, ion, electron bombardment).

[0005] Often applied to clean these tools are mechanical and/or chemical processes that preferentially remove contaminants. Additionally, there are preventative measures to limit the impact of the contaminants during subsequent processes, such as scrubbers on the semiconductor wafer. One of the most challenging surfaces to decontaminate is the wafer chucking surface, which handles the wafers. These are the clamping tools that hold the wafers, and are exposed to rubbing and other friction processes that are the greatest contributors to particles being knocked off the wafer and/or the chuck.

[0006] Wafer handling tools, and pin chucks in particular, are extremely difficult to clean and decontaminate in-situ since they are not in chemical atmospheres where aqueous or dry chemical processes can be routinely used, but rather they operate in clean and dry conditions and are often swapped out or put on routine maintenance schedules.

[0007] A pin chuck consists of a rigid body with a plurality of pins on the surface on which the substrate to be processed (e.g., Si wafer) rests.

[0008] The use of pins on these devices is to provide minimum chuck-to-substrate contact. Minimum contact reduces contamination and enhances the ability to maintain high flatness. The pin tops need to have low wear in use to maximize life and precision. The pin tops also need to exhibit low friction so the substrate easily slides on and off, and lies flat on the pins. Furthermore, the pin tops should exhibit no metallic contamination.

[0009] The pins exist in many geometries, and go by many names including burls, mesas, bumps, proud lands, proud rings, etc.

[0010] The pin chuck by its very nature is a very low bearing area (<2% is typical); thus mechanical means such as foam, pad scrubbers or brushes are ineffective since the pins or mesa features will tear through the contact medium.

[0011] The instant invention addresses these issues, and provides a solution.

DISCLOSURE OF THE INVENTION

[0012] A method for decontaminating at least the support surfaces of a chuck, such as a wafer chuck, entails lightly passing a treatment tool having a contacting surface over the regions of the chuck where contaminants are to be removed. The treatment tool and the chuck surface may have about the same hardness. The treatment tool may be minimally constrained so that it may conform to the surface being processed. When the treatment tool is contacted to a flat surface, the area of contact may be in the form of a circle, ring or annulus. At higher application pressures, the treatment tool will abrade the chuck, which here is to be avoided, or at least minimized. Thus, the instant inventors have discovered that the same treatment tool that is used to engineer the elevation or profile of the surface, and its roughness, at lower application pressures can be used to remove grinding debris and other contaminants from the surface.

[0013] The contacting or treatment surface of the treatment tool may be nominally, or appear visually, flat, but may in reality feature turn-up edges such that the treatment surface assumes a slight toroidal shape.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Figure 1 is an interferometer map of a region on the surface of an optically flat substrate, such as a silicon wafer, that is clamped to a pin chuck. The lower circled area is before cleaning, and the upper circled area is after cleaning.

[0015] Figure 2 is an interferometer map of a region on the surface of an optically flat substrate, such as a silicon wafer, that is clamped to a pin chuck. The area in the upper oval was treated with a 37-gram-loaded tool, and the area in the lower oval region was treated with a 187-gram-loaded tool.

[0016] Figures 3A and 4A show an interferometer map of the surface elevation of a wafer chuck before and after a debris removal treatment, respectively, with a treatment tool in physical contact with the chuck surface.

[0017] Figures 3B and 4B show a trace of surface elevation along the chords indicated in Figures 3A and 4A.

MODES FOR CARRYING OUT THE INVENTION

[0018] In accordance with the instant invention, a method for decontaminating at least the support surfaces of a chuck such as a wafer chuck, entails lightly passing a treatment tool having a flat contacting surface over the regions of the chuck where contaminants are to be removed. The chuck support surface may feature pins or mesas. Other areas of the chuck may contain recesses. The flat surface of the treatment tool that contacts the chuck may be in the form of a ring or annulus, or preferably a toroid. The treatment tool may be attached to, or

supported by a fixture, and the attachment or support may be one of minimal constraint, such as a ball-and-socket joint. The treatment tool may have a similar hardness to that of the chuck, or at least of the surfaces to be processed (decontaminated). The contact pressure that the treatment tool makes with the chuck is maintained at a level below that pressure that would significantly alter the elevation or roughness of the chuck material during the decontamination process. The size, effective diameter, or cross-section of the treatment tool is less than the diameter of the chuck. This treatment tool size can be made quite small, in which case the treatment tool can process recessed areas on the chuck, such as the area for the vacuum seal, or for the areas between wafer support pins.

EXAMPLES

[0019] The invention will now be further described with reference to the following Examples.

Example 1: Cleaning versus Profiling

[0020] This example demonstrates the difference between the use of the treatment tool of the instant invention in a cleaning mode versus a profiling mode. This example is made with reference to Figures 1 and 2.

[0021] Figure 1 is an interferometer "map" showing the effect on surface elevation of a treatment tool in "cleaning" mode. Both the treatment tool and the surface being processed have about the same hardness and each is fabricated from reaction bonded SiC (RBSC). The surface being processed is a pin chuck, which is resolved by clamping an optically flat wafer on the pin chuck and

imaging in an interferometer. The scale on the right of the map shows elevation change by changes in brightness.

[0022] The lower oval-shaped area in Figure 1 is before cleaning, and the upper oval-shaped area is after cleaning. Contamination on the pin chuck and under the wafer is seen as white high points. The debris is stuck on the pin tops under the wafer on seen in the lower oval area, which was not cleaned. The upper oval area shows where the pin chuck was cleaned after 100 cycles of treatment by a tool in physical contact with the substrate.

[0023] The absence of the white spots in the upper oval-shaped area indicates that the cleaning operation removed this debris. However, the fact that the area inside the oval regions has about the same shade of gray as areas outside indicates that the cleaning treatment did not change the elevation of the pin tops; it did not remove pin material.

[0024] The treatment tool is 27 mm in diameter. By outward appearance, it is a disc having a flat contacting surface, but in reality it has a slight toroidal shape so that when it is brought into contact with a flat surface, the area of contact is not that of a disc but instead is a circle or annulus. (The modification to form the toroidal shape is very slight, and may involve deviations from "flat" that are less than a micron.) A dead weight loading of 37 grams is applied to the treatment tool. The tool is moved across the surface to be treated at a velocity of 30 mm/sec. Every point on the surface treated was processed by the tool 100 times (100 cycles of cleaning).

[0025] Now compare this Figure 1 with Figure 2. Figure 2 is an interferometer map of a region on the surface of an optically flat substrate, such as a silicon

wafer ,that is clamped to a pin chuck. The top section (area in the upper oval) was treated with 100 cycles of a 37 gram tool showing no measurable change while the lower section (area in the lower oval) was given 100 cycles of treatment by a 187-gram–loaded tool in physical contact with the substrate. The area inside the upper oval region has about the same shade of gray as areas outside, again indicating that the cleaning treatment did not change the elevation of the pin tops. In distinct contrast, the area inside the lower oval region is much darker than the area outside the lower oval region, as well as darker than the area inside the upper oval region, indicating a change in elevation, namely, a reduction in elevation. This indicates that the treatment tool operated under these conditions was digging into and removing material from the wafer chuck.

[0026] Thus, this example demonstrates that a certain threshold pressure must be reached before the treatment tool of about the same hardness as the surface being treated will remove material from that surface. It also shows that a treatment tool that is used for profiling (change of surface elevation by removing material of the work piece) can be used for cleaning of debris without removing work piece material, and that such may be accomplished by reducing the applied loading (dead weight) on the treatment tool.

Example 2: Cleaning a wafer chuck surface

[0027] This Example demonstrates how the treatment tool of the instant invention may be used in "cleaning" mode to remove debris from the surface of a wafer chuck, and is made with reference to Figures 3 and 4.

[0028] Figure 3A shows an interferometer map showing a highly magnified surface topography of an essentially optically flat wafer clamped to a wafer

chuck. The wafer chuck features a shallow circular groove machined into this top surface near the periphery of the image. The white chord in this Figure 3A indicates the scan of the surface elevation measuring device that gives rise to the surface elevation plot in Figure 3B. This particular wafer chuck has been in testing for wear properties whereby the groove was generated that is typical of the wear of a pin chick during normal use. The result is that some debris remains in the region of the worn groove, thus contaminating the wafer chuck. Arrow 31 shows the surface elevation of the wafer chuck surface in the middle of the chord, away from the machined groove. Arrow 33 shows the lower elevation of the machined groove. Arrow 35 shows one of a pair of peaks or "humps" adjacent and on opposite sides of the machined groove. These peaks correspond to debris, and suggest that debris preferentially accumulates adjacent the groove.

[0029] The wafer chuck support surface was then treated with the treatment tool in "cleaning mode", that is, under conditions similar to that described for cleaning in Example 1. Figures 4A and 4B show the resulting interferometer map and elevation trace along a similar chord following this cleaning treatment. Arrow 41 shows the surface elevation of the wafer chuck surface in the middle of the chord, away from the machined groove. Arrow 43 shows the lower elevation of the machined groove. Arrow 45 points to the elevation just outside of the circular groove. The peaks or humps have been noticeably reduced, and are not much higher than the balance of the wafer chuck surface, suggesting that the debris has been removed to a large extent from the regions just inside and outside the machined groove.

[0030] Thus, this example shows that the treatment tool can be used to remove debris from the surface of a wafer chuck, and without modifying the profile of the chuck through removal of chuck material.

INDUSTRIAL APPLICABILITY

[0031] Although much of the forgoing discussion has focused on articles and devices for chucking semiconductor wafers, one of ordinary skill in the art will recognize other related applications where the techniques and articles disclosed in the instant patent application will be useful, for example, in other areas or industries where a surface has to be finished to a desired shape or degree of flatness, and/or having a certain degree of texture (roughness/smoothness).

[0032] According to an embodiment of the instant invention, what is proposed is to remove contaminate(s) from the surface by hard mechanical contact with a material that is more or less the same hardness as the wafer handling tool. The purpose of the similar hardness is to minimize the particulate generation by wear of a soft tool or wear of the wafer handing chuck by a harder material.

[0033] Additionally, since there are wafer handing tools that have stringent control of flatness and to pins or mesas this tool is proposed to be ring or annular or toroidal shape such that it conforms to the natural surface flatness and may be moved over the surface in a manner that does not damage the flatness.

[0034] An unique property is to control the weight such that the two materials are not just run together but lightly travel with a minimal amount of pressure.

By that is meant sufficient applied pressure to remove contaminate(s) or debris but not enough applied pressure to significantly alter the flatness or roughness of the chuck.

[0035] An artisan of ordinary skill will appreciate that various modifications may be made to the invention herein described without departing from the scope or spirit of the invention as defined in the appended claims.

CLAIMS

What is claimed is:

1. A method for removing contamination from the support surface of a chuck, comprising:

(a) providing a treatment tool comprising a treatment surface configured to contact and pass lightly over said support surface, said treatment surface shaped such that when said treatment surface is brought into contact with a flat surface, an area of contact is a circle, ring or annulus;

(b) contacting said flat surface to said support surface;

(c) moving said treatment tool over at least a portion of said chuck support surface containing contamination, wherein at least during said moving, the force applied by said treatment tool against said support surface is maintained at a level of light pressure; and

(d) continuing said moving for a time or a number of passes over the contaminated surface sufficient to remove said contamination, and

(e) wherein a diameter of said support surface is greater than the size of said treatment surface.

2. The method of claim 1, wherein said treatment tool is minimally constrained, thereby permitting said treatment tool to conform to the support surface of said wafer chuck.

3. The method of claim 1, wherein a contact area between said treatment tool and said support surface is shaped as an annulus.

4. A method for removing contamination from the support surface of a chuck, comprising:

(a) providing a treatment tool comprising a surface configured to contact and pass over said support surface, said treatment tool surface shaped such that when said treatment tool surface is contacted to a flat surface, an area of contact is in the form of a circle, ring or annulus;

(b) contacting said treatment tool surface to said support surface;

(c) moving said treatment tool over at least a portion of said chuck support surface containing contamination, wherein at least during said moving, the force applied by said treatment tool against said support surface is maintained at a level of light pressure; and

(d) continuing said moving for a time or a number of passes over the contaminated surface sufficient to remove said contamination, and

(e) wherein a diameter of said support surface is greater than the size of said treatment tool; and

(f) further wherein said surface of said treatment tool and said support surface of said chuck have about the same hardness.

5. A method for removing contamination from the support surface of a chuck, comprising:

(a) providing a treatment tool comprising a surface configured to contact and pass over said support surface, said treatment tool surface configured such that a contact area of said treatment tool surface and a flat surface is circular, ring-shaped or annular-shaped;

(b) contacting said treatment tool surface to said support surface;

(c) moving said treatment tool over at least a portion of said chuck support surface containing contamination, wherein at least during said moving,

the force applied by said treatment tool against said support surface is maintained at a level of light pressure; and

(d) continuing said moving for a time or a number of passes over the contaminated surface sufficient to remove said contamination, and

(e) wherein a diameter of said support surface is greater than the size of said flat surface; and

(f) further wherein said treatment tool has a small cross-section, thereby enabling said treatment tool to process areas on said chuck that are recessed relative to said support surface of said chuck.

6. The method of claim 5, wherein one recessed area comprises a ring-shaped region for a vacuum seal.

7. The method of claim 5, wherein said support surface of said chuck comprises a plurality of pins distributed over a surface of said chuck, and a recessed area of said chuck comprises a region between adjacent pins.

8. The method of claim 7, wherein said treatment tool is minimally constrained, thereby permitting said treatment tool to conform to the support surface of said wafer chuck.

9. The method of claim 7, wherein said treatment tool is free to conform to the support surface of said wafer chuck.

10. The method of claim 7, wherein said treatment tool is held in such a manner that the pressure applied minimizes erosion of said chuck and tool.

11. The method of claim 7, wherein a contact area between said treatment tool and said support surface is shaped as an annulus.

12. The method of any of claims 1, 4 or 5, wherein said surface of said treatment tool is shaped as a toroid.

13. The method of any of claims 1, 4 or 5, wherein a loading on said treatment tool is equivalent to loading a 27mm diameter treatment tool with a dead weight loading of 5-50 grams.

14. The method of any of claims 1, 4 or 5, wherein said treatment tool is moved over said support surface at a velocity in a range 5-30 mm/sec.

15. The method of any of claims 1, 4 or 5, wherein said treatment tool comprises SiC.

16. The method of any of claims 1, 4 or 5, wherein said treatment tool comprises reaction bonded SiC.

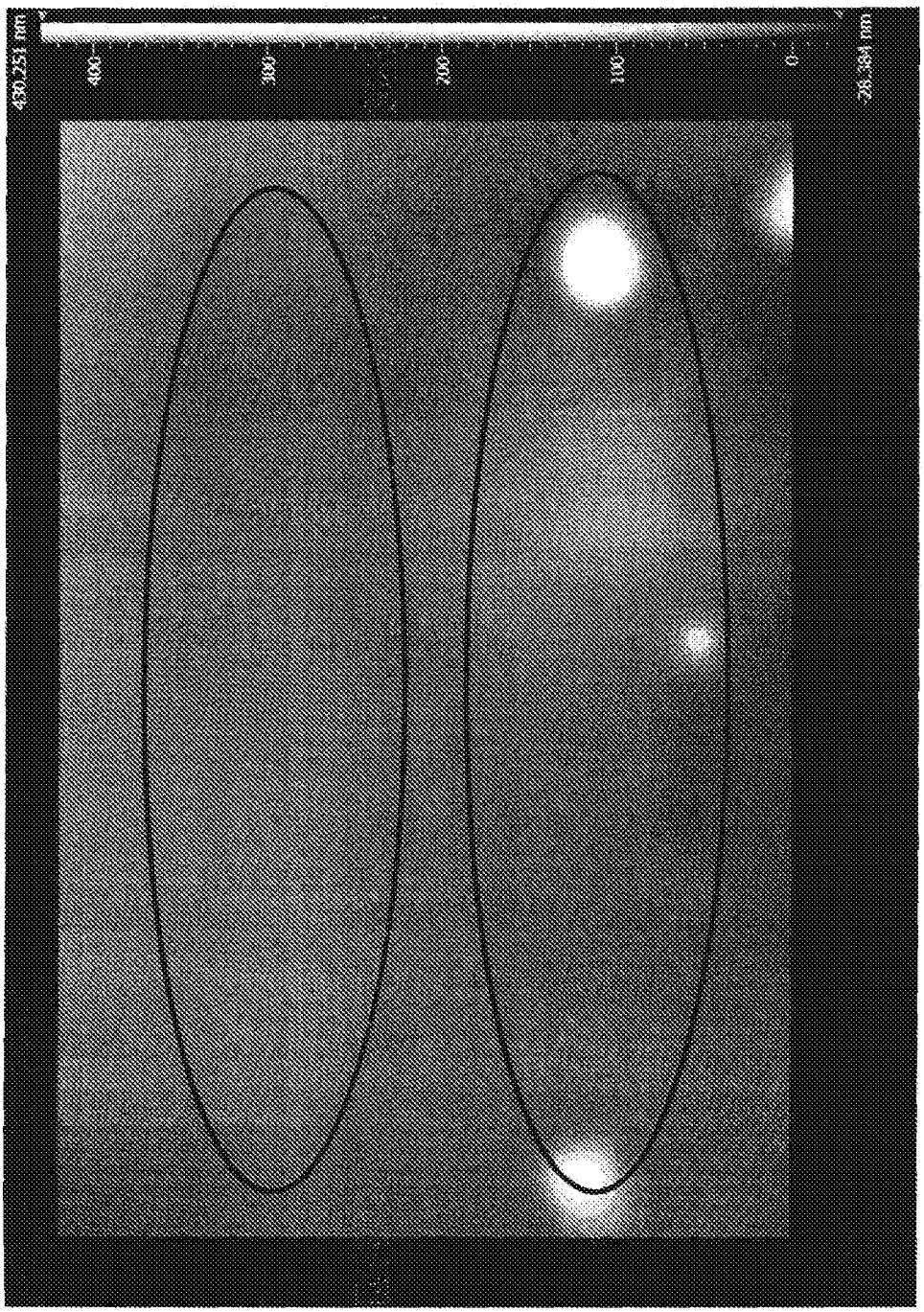


Fig. 1

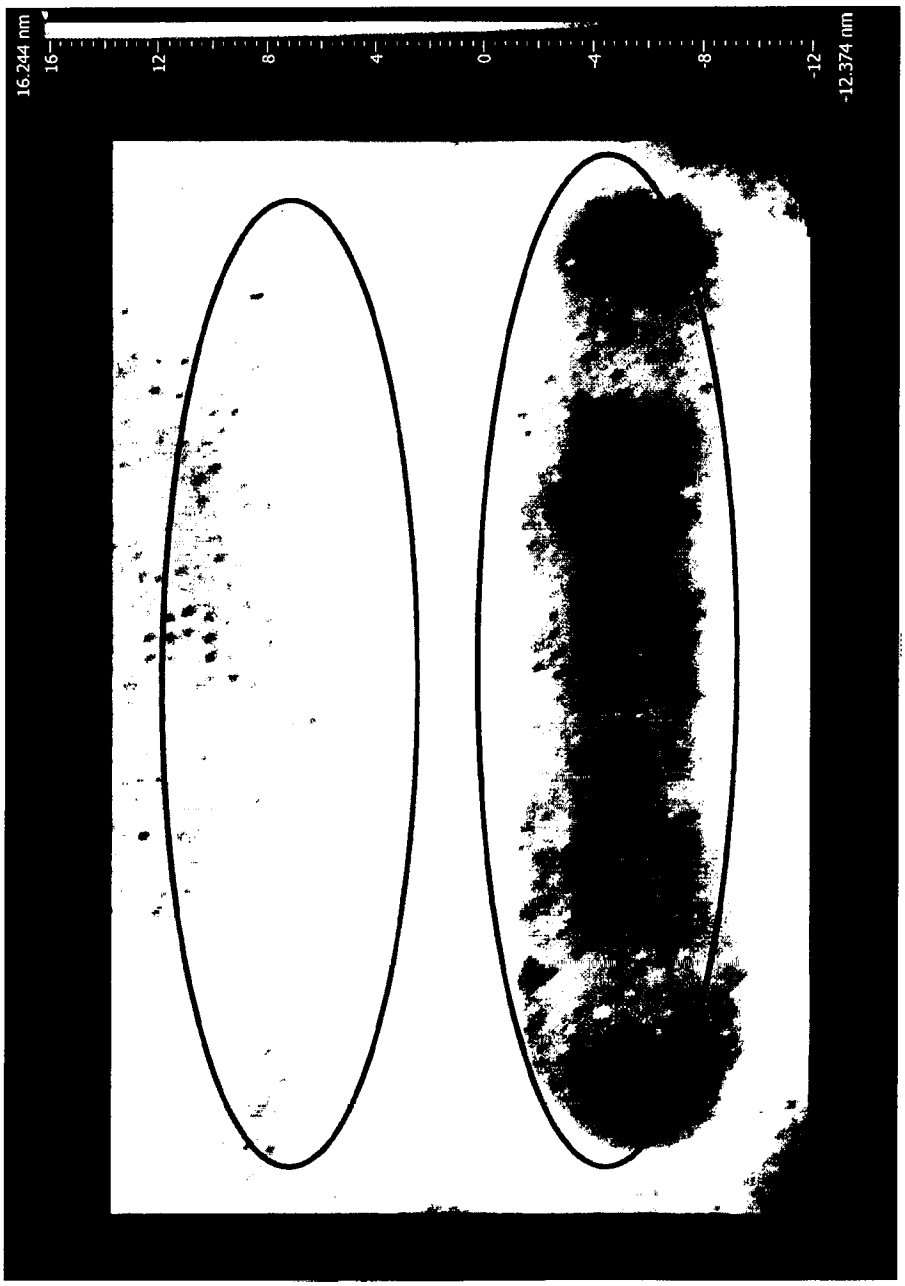
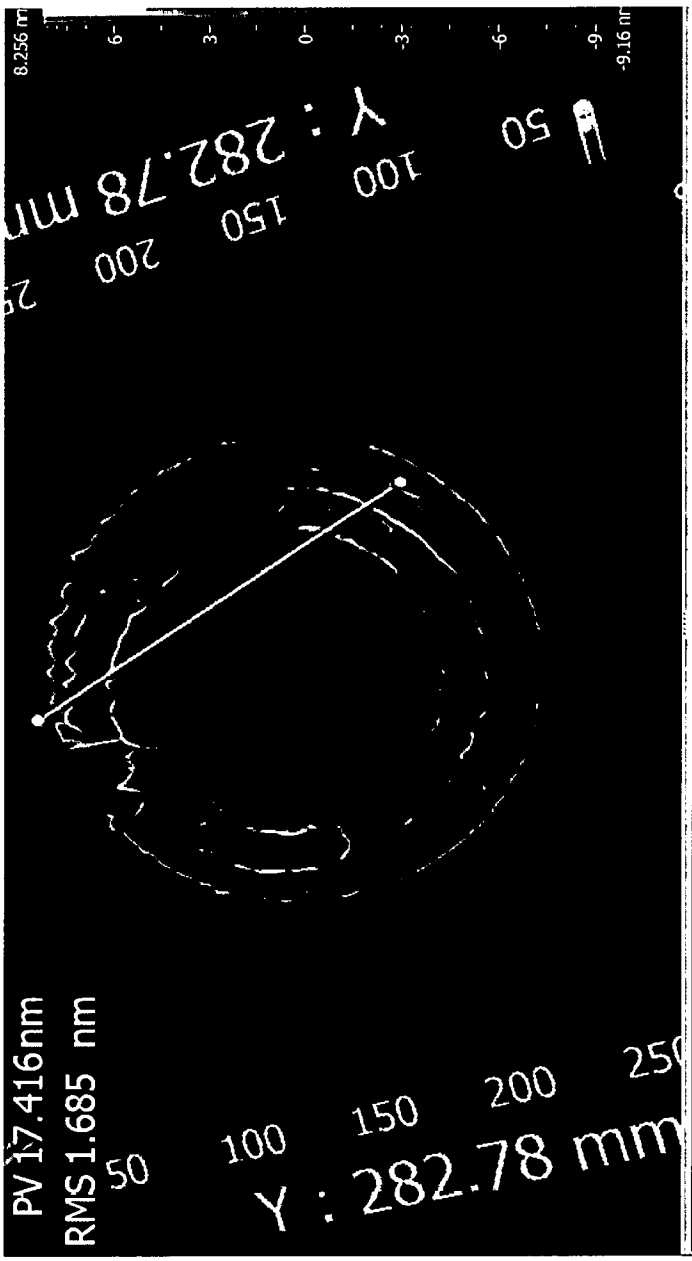


Fig. 2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RMS 1.685 nm
50
100
150
200
Y : 282.78 mm

Fig. 3A

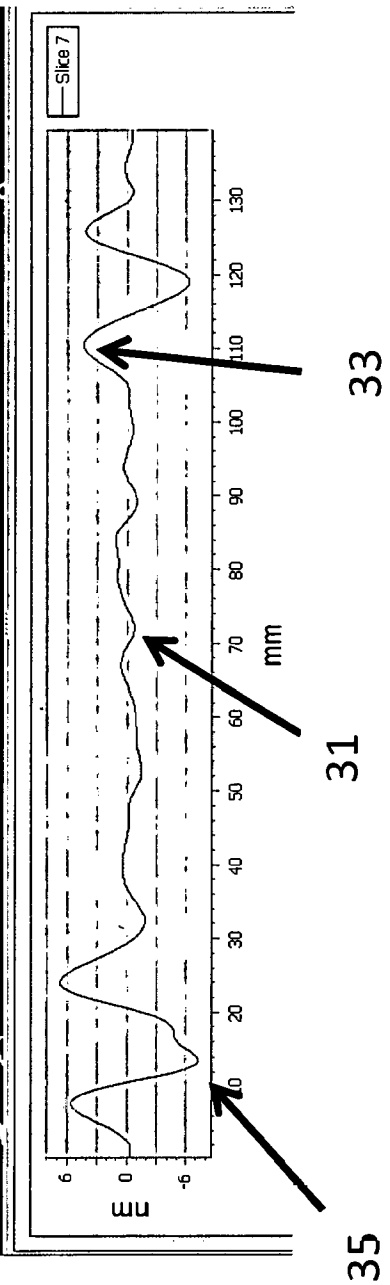
Slice 7
nm
mm
33
31
35

Fig. 3B

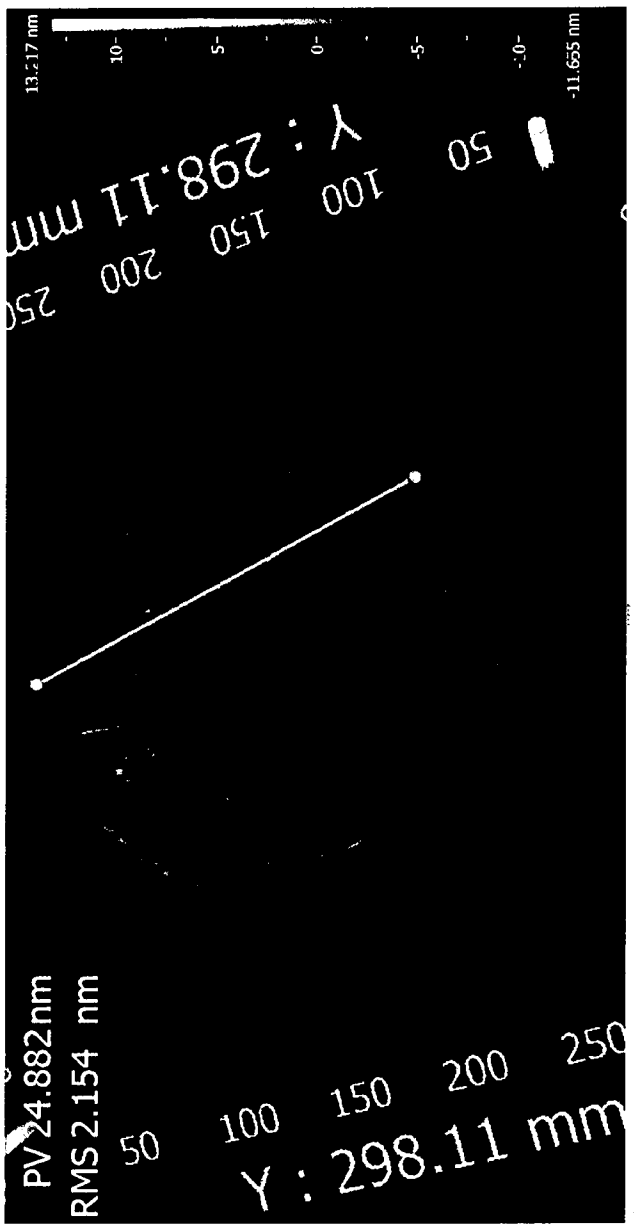
13.217 nm
10
5
0
-5
-10
-11.655 nm
PV 24.882nm
RMS 2.154 nm
50
100
150
200
250
Y : 298.11 mm

Fig. 4A

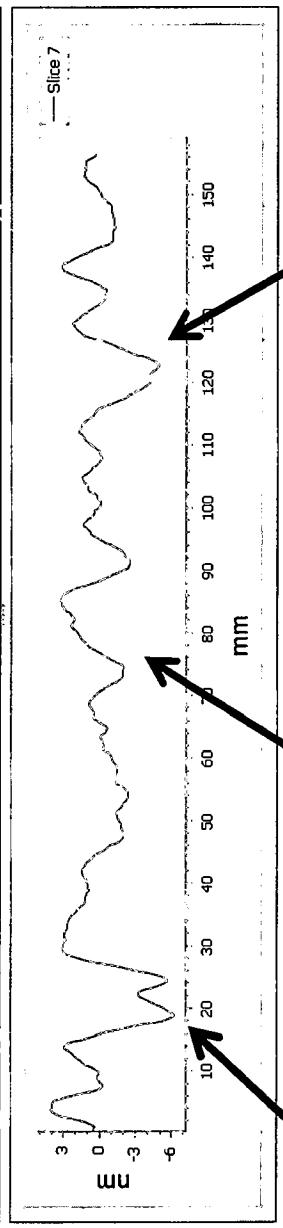
Slice 7
nm
mm
43
41
45

Fig. 4B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 16/46216

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B24B 1/00 (2016.01)
CPC - B24B 1/00
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 (8): B24B 1/00 (2016.01)
CPC: B24B 1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
-*- See Extra Sheet -*-

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase. Google (Web, Patent, Scholar)
-*- See Extra Sheet -*-

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,682,406 B2 (CHIOU) 27 January 2004 (27.01.2004) Figs. 1A-C; col 3 ln 35-47; col 5 ln 40-44, col 6 ln 40-44.	1-2, 5-9, (12-14)/(1, 5),
A		3-4, 10-11, (12-14)/(4), (15-16)/(1, 4, 5)
Y	US 5,740,580 A (LEU et al.) 21 April 1998 (21.04.1998) Figs. 1, 5; col 2 ln 27-31, 61-66.	1-2, 5-9, (12-14)/(1, 5)
A		3-4, 10-11, (12-14)/(4), (15-16)/(1, 4, 5)
Y	US 2006/0130767 A1 (HERCHEN) 22 June 2006 (22.06.2006) Figs. 1-2; paras [0021-3], [0027].	7-9
A		10, 11
A	US 2003/0200996 A1 (HIATT et al.) 30 October 2003 (30.10.2003) Figs. 1-3; paras [007-8]	1-16
A	US 6,635,844 B2 (YU) 21 October 2003 (21.10.2003) Figs. 1-2; col 3 ln 58 - col 4 ln 24	1-16

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

* 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
16 October 2016	28 OCT 2016
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

-*- Continuation of Page 5, Part B -*-

Documentation searched other than minimum:

IPC (8): B05C13/00, B08B1/00, B08B3/00, B08B3/02, B08B3/04, B08B5/00, B08B5/02, B08B5/04, B08B7/04, B08B9/00, B08B9/08, B08B9/093, B24B1/00, B24B53/017, B24B55/00, G03F7/20, H01L21/00, H01L21/027, H01L21/30, H01L21/304, H01L21/306, H01L21/683 (2016.01).

CPC: B08B1/00, B08B3/02, B08B5/02, B08B5/04, B08B9/00, B08B9/08, B08B9/093, B24B1/00, B24B53/017, B24B55/00, G03F7/707, G03F7/70866, H01L21/67028, H01L21/67046, H01L21/67051, H01L21/67057, H01L21/6708, H01L21/67092, H01L21/6833, H01L21/6838, H01L21/68735

USPC: 118/52, 134/140, 134/149, 134/153, 134/157, 134/158, 134/21, 134/22.1, 134/22.12, 134/22.18, 134/23, 134/25.4, 134/26, 134/32, 134/33, 134/34, 134/36, 134/42, 134/6, 134/61, 134/902, 134/94.1, 134/95.1, 134/99.1, 15/105, 15/210.1, 362/119, 362/91, 438/906, 451/444, 451/56

Search Terms Used: Abrasive, Annulus, Axes, Axis, Buff, Chuck, Circular, Cleaning, Cleaning, Contact, Contaminate, Cube, Debris, Decontaminate, Diameter, Disc, Electrode, Electrostatic, Etch, Face, Flat, Force, Grind, Hardness, Head, Lap, Lapidary, Light, Magnetic, Mechanical, Pad, Particle, Photolithography, Planar, Plane, Platen, Polishing, Press, Record, Resurface, Ring, Round, Scrape, Scrub, Semiconductor, Silicon, Steam, Surface, Technology, Tool, Touch, Treatment, Vacuum, Wafer, Wand, Wipe