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(54) **WAFER POLISHING WITH
COUNTERACTION OF CENTRIFUGAL
FORCES ON POLISHING SLURRY**

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(57) **ABSTRACT**

Polishing slurry consumption in the wafer polishing process can be reduced by using a polishing pad structure that directs portions of the slurry flow towards the center of the polishing pad.

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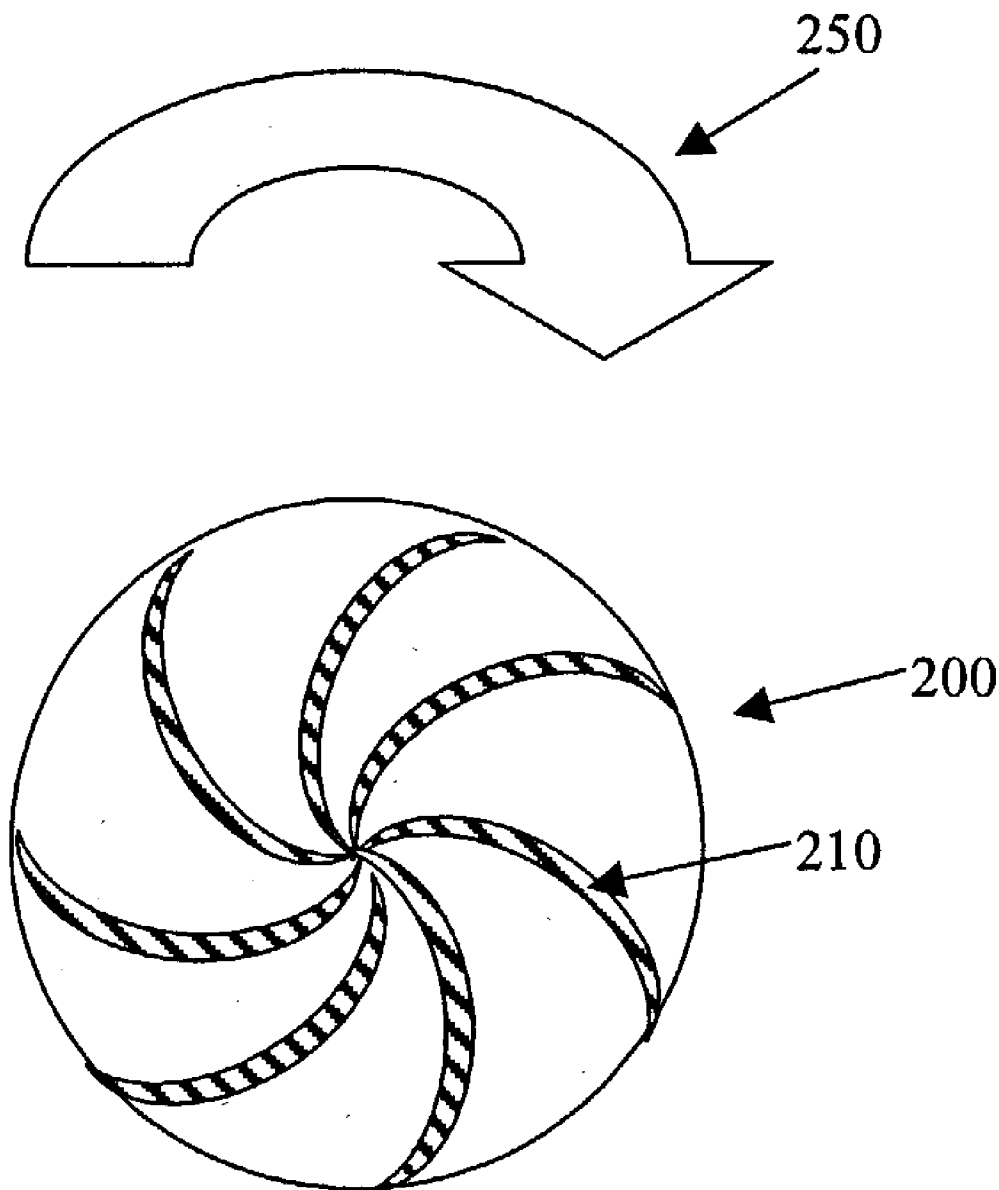


FIGURE 1

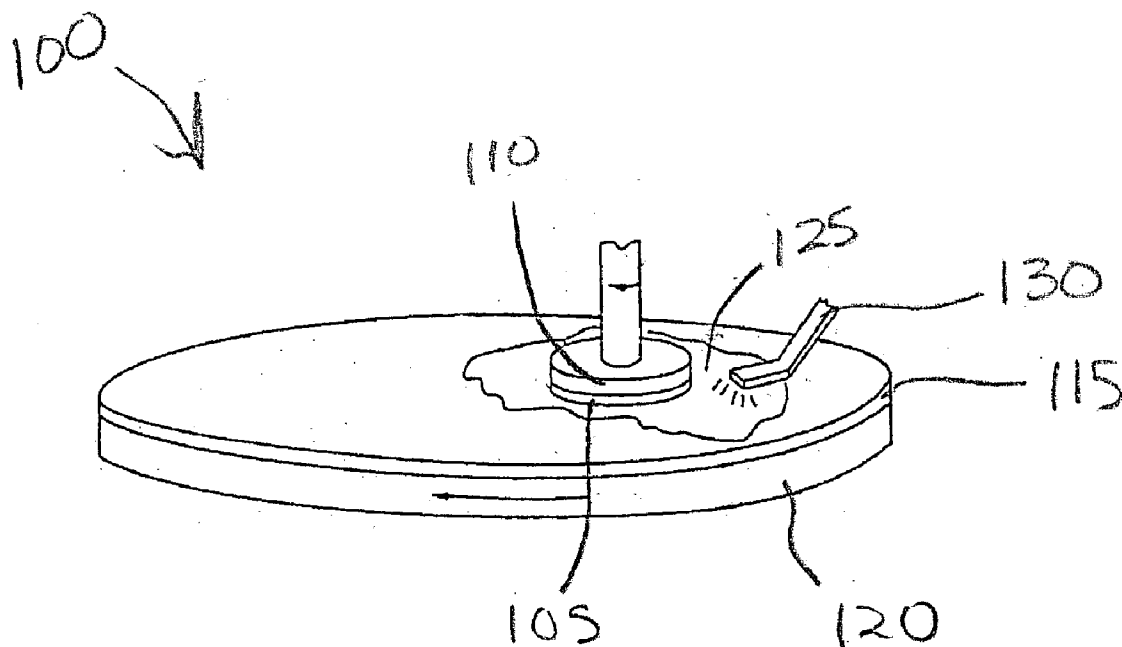


FIGURE 2

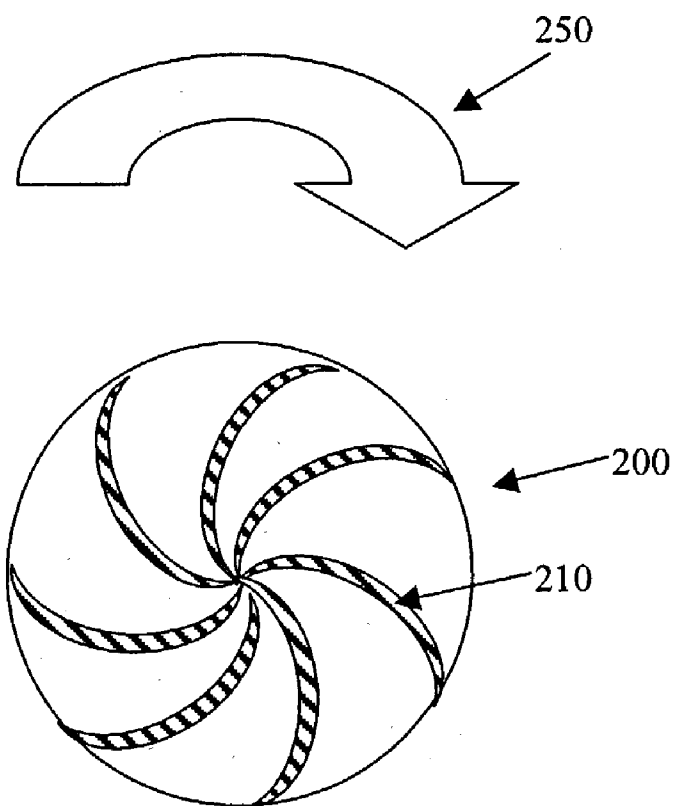


FIGURE 2A

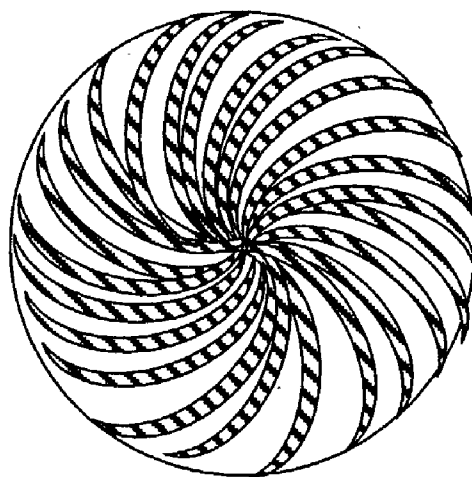


FIGURE 3

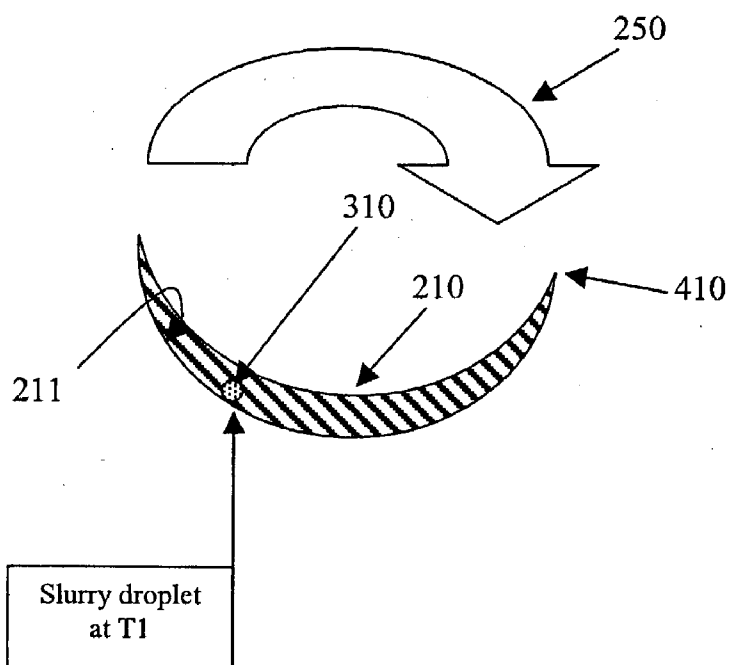
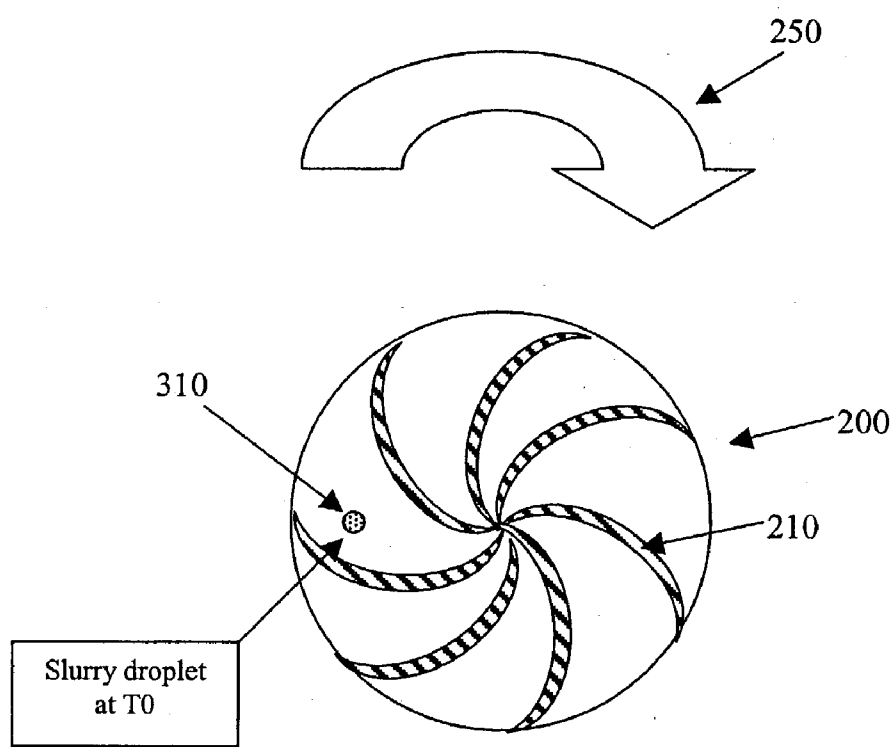


FIGURE 4

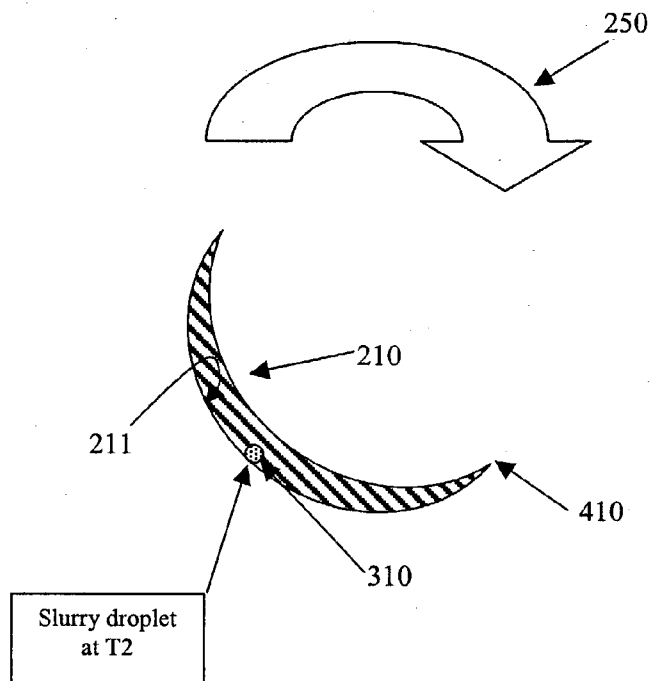


FIGURE 5

FIGURE 6

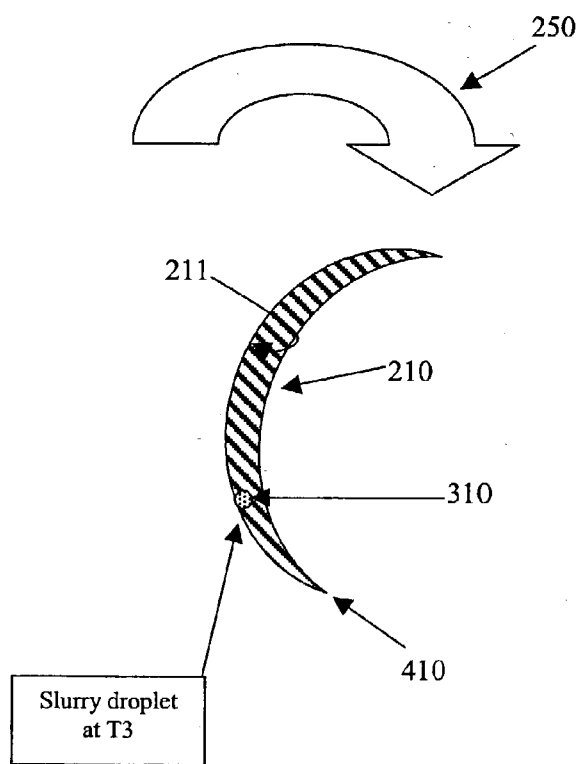
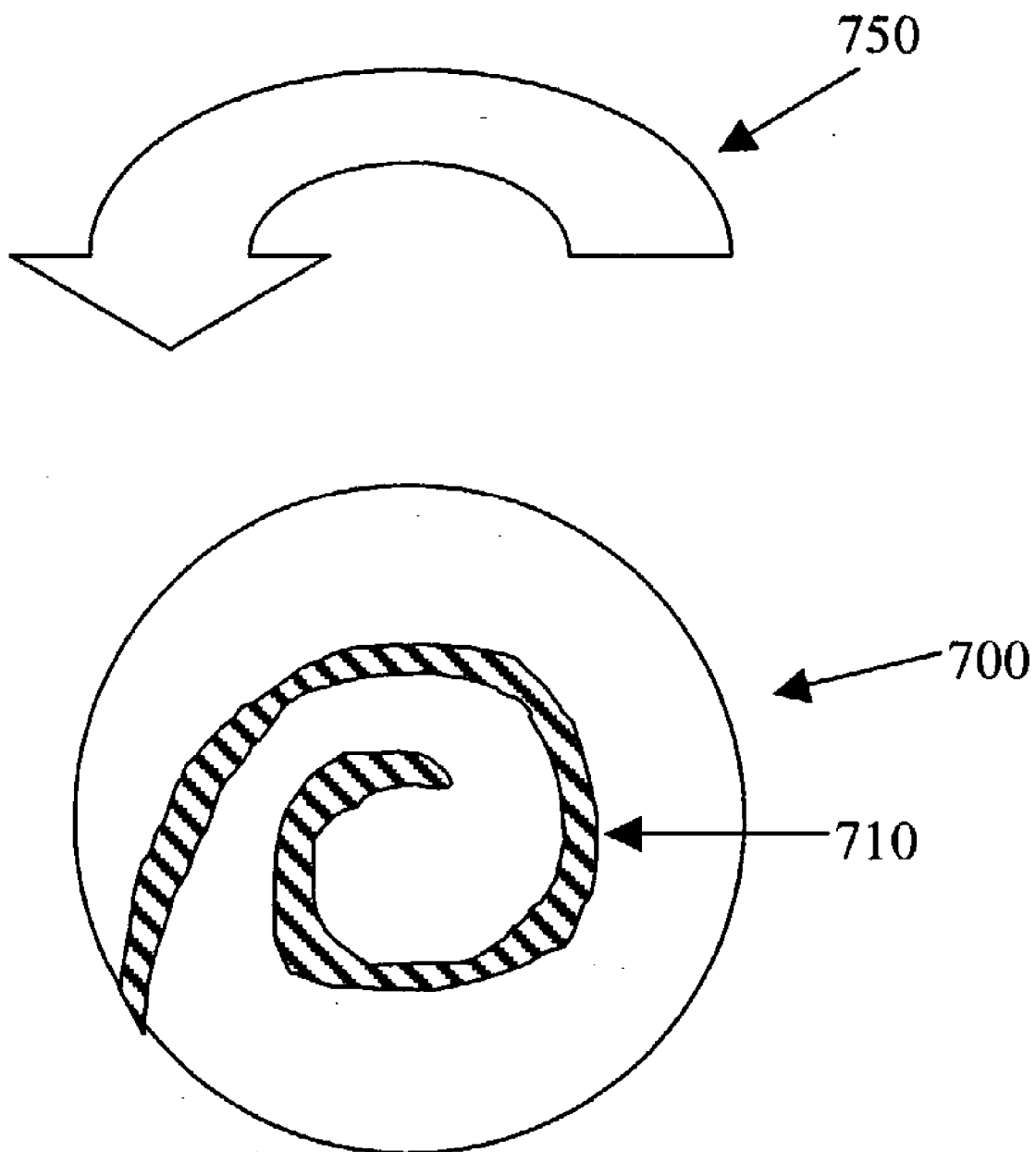


FIGURE 7



WAFER POLISHING WITH COUNTERACTION OF CENTRIFUGAL FORCES ON POLISHING SLURRY

FIELD OF THE INVENTION

[0001] The invention relates generally to the manufacture of integrated circuit devices and, more particularly, to a wafer polishing pad.

BACKGROUND OF THE INVENTION

[0002] During integrated circuit ("IC") manufacturing, the various masking and processing steps typically result in the formation of topographical irregularities on the wafer surface. For example, topographical surface irregularities can be created after metallization, which includes the steps of blanketing the wafer surface with a conductive metal layer and then etching away unwanted portions of the blanket metal layer to form a metallization interconnect pattern on each IC. Surface irregularities are also exacerbated by the use of multilevel interconnects.

[0003] Photolithographic processes require highly planar surfaces in order to achieve the resolution needed to create maximum circuit density on each wafer. Consequently, maintaining wafer surface planarity during fabrication is important. Chemical-mechanical planarization ("CMP") processes are conventionally used as a preparation step in the fabrication of wafers to provide substantially planar surfaces.

[0004] FIG. 1 diagrammatically illustrates a conventional CMP polisher 100 in accordance with the known art. CMP typically requires that the wafer 105 be mounted in a wafer head or carrier 110, with the surface of wafer 105 to be polished exposed. The surface of wafer 105 that is to be polished is then placed against polishing pad 115 mounted on platen 120. Platen 120 may rotate (as suggested by the arrow on platen 120) in either direction. Carrier 110 holding wafer 105 may also rotate (as suggested by the arrow on carrier 110) in either direction, to provide additional motion between wafer 105 and the surface of polishing pad 115. Further, polishing slurry 125 (typically including an abrasive and at least one chemically reactive agent therein, which are selected to enhance the polishing of the topmost film layer of wafer 105) is supplied to pad 115 by slurry supply 130 to provide an abrasive chemical solution at the interface between pad 115 and wafer 105. Pressure may be applied between carrier 110 and platen 120 to effectuate polishing. In some CMP machines, wafer 105 rotates while polishing pad 115 is stationary, in others pad 115 moves while carrier 110 is stationary, and in yet another type both carrier 110 and pad 115 move simultaneously. Polishing pad 115 may be pre-soaked and continually re-wet with a slurry 125 that may have a variety of abrasive particles suspended in a solution of chemicals. Primary cost factors in the polishing process are labor, slurry and pads. The rotation of polishing platen 120 results in a loss of slurry 125 due to centrifugal forces that force slurry 125 towards the edge of polishing pad 115.

[0005] Conventional polishing pads are currently available in a variety of configurations, including smooth (without structures), perforated (round holes evenly distributed for better soaking of the pad), centered rings of differing diameters, and patterned with a chessboard/lattice-like design (both of which encourage uniform distribution of the slurry). Each of these configurations is directed towards the

distribution of slurry/chemicals and a quick exchange of consumables and by-products. Whenever a polishing pad is patterned, the pattern will modify the direction of the slurry flow. However, none of these conventional configurations control the slurry flow such that it is directed back towards the center of the polishing pad.

[0006] It is therefore desirable to provide a solution that decreases slurry consumption in the polishing process. Exemplary embodiments of the present invention provide a pad structure that directs portions of the slurry flow towards the center of the polishing pad, thereby reducing slurry consumption.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above and further advantages of the invention may be better understood by referring to the following description in conjunction with the accompanying drawings in which corresponding numerals in the different figures refer to the corresponding parts, in which:

[0008] FIG. 1 diagrammatically illustrates a conventional CMP polisher in accordance with the known art;

[0009] FIG. 2 diagrammatically illustrates exemplary embodiments of a polishing pad in accordance with the present invention;

[0010] FIG. 2A diagrammatically illustrates further exemplary embodiments of a polishing pad in accordance with the present invention;

[0011] FIG. 3-6 diagrammatically illustrate an exemplary movement over time of a slurry droplet across an exemplary embodiment of a polishing pad as illustrated in FIG. 2; and

[0012] FIG. 7 diagrammatically illustrates further exemplary embodiments of a polishing pad in accordance with the present invention.

DETAILED DESCRIPTION

[0013] While the making and using of various embodiments of the present invention are discussed herein in terms of chemical-mechanical planarization ("CMP"), it should be appreciated that the present invention provides many inventive concepts that can be embodied in a wide variety of contexts. The specific embodiments discussed herein are merely illustrative of specific ways to make and use the invention, and are not meant to limit the scope of the invention.

[0014] The present invention can decrease slurry consumption in the polishing process. Exemplary embodiments of the present invention can provide a pad structure that directs portions of the slurry flow towards the center of the polishing pad.

[0015] FIG. 2 diagrammatically illustrates exemplary embodiments of a polishing pad 200 in accordance with the present invention. A polishing surface of polishing pad 200 includes a pattern of curved grooves 210 that are shaped and located to induce the movement of slurry towards the center of pad 200. In some embodiments, the grooves extend from the outer peripheral edge of the polishing surface to a central point of the polishing surface. The exemplary embodiment illustrated in FIG. 2 can guide the slurry inside grooves 210 towards the center of pad 200 when pad 200 is rotated in the

direction indicated by arrow **250**. The exact movement of the slurry will be dependent on the shape of grooves **210**, the rotational speed of pad **200** and the slurry viscosity.

[0016] An exemplary movement over time of slurry droplet **310** across an exemplary embodiment of a polishing pad **200** is diagrammatically illustrated in **FIG. 3-6**. At time T0, slurry droplet **310** can be placed on a polishing pad, such as polishing pad **200**. As polishing pad **200** rotates (or undergoes relative rotation with respect to the wafer) in the direction indicated by arrow **250**, slurry droplet **310** moves from its position at time T0 in **FIG. 3** into one of grooves **210** in the position shown at time T1 in **FIG. 4**. As polishing pad **200** continues to rotate in the direction indicated by arrow **250** around a generally central point **410**, slurry droplet **310** next moves along an edge **211** (i.e., a sidewall of the groove) of one of grooves **210** to the position shown at time T2 in **FIG. 5** and then to the position shown at time T3 in **FIG. 6**. As seen by the exemplary movement of slurry droplet **310** across polishing pad **200** over time, as polishing pad **200** rotates in the direction indicated by arrow **250**, rather than losing slurry to centrifugal forces that tend to move the slurry radially outwardly, the slurry can be moved in a continuous, uninterrupted flow towards the center of polishing pad **200**. This is due to slurry travel along the continuously extending edge **211** of the groove **210**.

[0017] **FIG. 7** diagrammatically illustrates exemplary embodiments of a polishing pad **700** in accordance with the present invention. Groove **710** curves in a spiral that covers most of pad **700**. When rotated in the direction indicated by arrow **750**, groove **710** can move slurry towards the center of pad **700**.

[0018] In some exemplary embodiments, the depth of the grooves (or groove) can be modified such that the depth increases towards the edge of the pad to capture more slurry on the edges. In some embodiments, the plurality of grooves shown generally in **FIGS. 2 and 3** can be more numerous, such that the grooves cover a majority (see **FIG. 2A**) or substantially all of the polishing surface.

[0019] Although exemplary embodiments of the present invention have been described in detail, it will be understood by those skilled in the art that various modifications can be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. An apparatus for polishing a wafer used to manufacture integrated circuits, comprising:

a pad body having a polishing surface; and

said polishing surface having formed therein a groove, said groove defining a continuous edge which extends continuously from a first location adjacent an outer peripheral edge of said polishing surface to a second location adjacent a central point of said polishing surface, said continuous edge extending across a majority of a distance between said outer peripheral edge and said central point.

2. The apparatus of claim 1, wherein said continuous edge of said groove directs slurry toward said central point of said polishing surface when said pad body is rotated relative to the wafer in a predetermined direction to polish the wafer.

3. The apparatus of claim 2, wherein said continuous edge opens concavely toward said predetermined direction.

4. The apparatus of claim 2, wherein said continuous edge spirals around said central point of said polishing surface.

5. The apparatus of claim 1, wherein said continuous edge extends continuously from said outer peripheral edge of said polishing surface to said central point of said polishing surface.

6. The apparatus claim 5, wherein said continuous edge has a generally curved configuration.

7. The apparatus of claim 5, wherein said continuous edge spirals around said central point of said polishing surface.

8. The apparatus of claim 1, wherein said continuous edge has a generally curved configuration.

9. The apparatus of claim 8, wherein said groove increases in depth from said second location toward said first location.

10. The apparatus of claim 1, wherein said continuous edge spirals around said central point of said polishing surface.

11. The apparatus of claim 10, wherein said groove increases in depth from said second location toward said first location.

12. The apparatus of claim 1, wherein said groove increases in depth from said second location toward said first location.

13. The apparatus of claim 1, wherein said polishing surface includes a plurality of said grooves defining a respectively corresponding plurality of said continuous edges.

14. The apparatus of claim 13, wherein said plurality of grooves cover a majority of said polishing surface.

15. The apparatus of claim 13, wherein each of said continuous edges directs slurry toward said central point of said polishing surface when said pad body is rotated relative to the wafer in a predetermined direction to polish the wafer.

16. The apparatus of claim 15, wherein each of said continuous edges opens concavely toward said predetermined direction.

17. The apparatus of claim 13, wherein each of said continuous edges extends from said outer peripheral edge of said polishing surface to said central point of said polishing surface.

18. An apparatus for polishing a wafer used to manufacture integrated circuits, comprising:

a pad body having a polishing surface;

said polishing surface having formed therein a groove, said groove defining a continuous edge which extends continuously from a first location adjacent an outer peripheral edge of said polishing surface to a second location adjacent a central point of said polishing surface, said continuous edge extending across a majority of a distance between said outer peripheral edge and said central point;

a holding apparatus having said pad body mounted thereon; and

said holding apparatus for holding the wafer in contact with said polishing surface of said pad body while effecting relative rotation between the wafer and said pad body.

19. The apparatus of claim 18, wherein said polishing surface includes a plurality of said grooves defining a respectively corresponding plurality of said continuous edges.

20. The apparatus of claim 18, wherein said continuous edge of said groove directs slurry toward said central point of said polishing surface when said pad body is rotated relative to the wafer in a predetermined direction to polish the wafer.

21. The apparatus of claim 20, wherein said continuous edge opens concavely toward said predetermined direction.

22. The apparatus of claim 20, wherein said continuous edge spirals around said central point of said polishing surface.

23. A method for directing slurry flow while polishing a wafer used to manufacture integrated circuits, comprising:

effecting relative rotation between a polishing surface and the wafer; and

during said relative rotation, the polishing surface directing a continuous flow of slurry from a first location adjacent an outer peripheral edge of the polishing surface to a second location adjacent a central point of the polishing surface and across a majority of a distance between said outer peripheral edge and said central point.

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