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(54) Title: METHOD FOR PREVENTING DAMAGE TO WAFERS IN A SEQUENTIAL MULTIPLE STEPS POLISHING PROCESS

(57) Abstract: A method for preventing the drying of a residue on a wafer surface in a multiple stage polishing operation increases wafer processing throughput and extends the useful life of polishing pads used in a CMP operation. The method includes detecting a polishing endpoint for a wafer polished in a second polishing step following a first polishing operation for the wafer. Endpoint detection terminates polishing of another wafer in the first polishing operation and triggers overpolishing of the prior wafer in the second polishing operation. After a set period, overpolishing of the prior wafer in the second polishing operation ends. Finally each of the wafers moves to a subsequent processing operation, which may include a polishing operation or a buffing operation. One of the advantages of the invention is the maximization of total platen pad usage between platen pad changes since total processing time has been increased for the same polishing pads, thus permitting polishing of greater numbers of wafers between platen pad changes.

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Method for preventing damage to wafers in a sequential multiple steps polishing process

The present invention relates generally to semiconductor devices and their fabrication and, more particularly, to a method for preventing damage to wafers in a polishing process.

5

The semiconductor industry fabricates large numbers of devices for use in many products available to consumers. These devices include microprocessors that are fabricated on a semiconductor substrate material. The substrate material is most often composed of silicon that is produced in thin sections, commonly called wafers. Various electronic circuitry components are fabricated upon such wafers, with the wafers subdivided into dies or chips, each containing many circuitry components.

At various points in the fabrication process, the wafers may require processing to provide a planar surface on which to locate the electronic circuitry components of the semiconductor device. Such processing must provide a high degree of control in generating the substrate planar surface desired without damaging the wafer surface. Various polishing methods are employed to obtain a planar substrate surface. Chemical mechanical planarization (CMP) is one method that is used widely in the industry for wafer processing.

CMP is performed on a polishing device that has one or multiple platens for holding polishing pads and multiple heads for holding wafers. The polishing pads contain a particulate slurry that polishes a wafer held against the pad by a polishing head as the platen and pad rotate. When a wafer is polished in a multiple platen CMP device with multiple polishing heads, such as a device available from Applied Materials Mirra (Santa Clara, CA., USA), that particular wafer's entire polishing sequence is performed on the same polishing head. However, that head is rotated to different polishing platens. The first portion of the polishing sequence is performed on one platen ("Platen-1"). When the first portion of the polishing sequence is complete, the head and wafer move to a second polishing platen ("Platen-2") for the second portion of the polishing sequence. While the original wafer is on Platen 2- receiving the second portion of the polishing sequence, a second polishing head holding a second wafer performs the first portion of the polishing sequence on Platen-1.

When the first head ("Head-1") has completed the second portion of the polishing sequence at Platen-2 and the second head ("Head-2") has completed the first portion of the polishing sequence at Platen-1, the heads change platens again so that Head-1 moves to Platen-3, Head-2 moves to Platen-2 and Head-3 moves to Platen-1. In one common polishing device configuration, polishing (oxide film removal) is not performed on Platen-3. Instead, polishing occurs only on Platens-1 and 2, and Platen-3 is used for a post-CMP buffing operation ("buff") to remove chemical residue.

The CMP operation is controlled and the endpoint of polishing is detected using optical lasers and optical radiation detectors located in the polishing platens.

Transparent windows are embedded into the platen surface for radiation transmission. The polishing pad of each platen has a matching embedded pad of a material that allows transmission of the laser radiation ("windowed pad"). The windowed pad is aligned on the platen so that the radiation may be transmitted through the platen-window and through the pad window. The aligned platen-window and pad-window are referred to collectively as the "endpoint window." As the platen rotates, the endpoint window encounters the wafer once per rotation, allowing radiation to pass through the window and be reflected from the wafer back through the window to the detector.

During polishing of a transparent film that is coated over an opaque substrate (such as silicon dioxide over silicon), the intensity of the radiation at the detector displays a periodicity as the film is removed from the surface. The periodicity is governed by the equation $d = \lambda / (2n \cos \theta)$, where d is the distance through the film between peak maxima, n is the refractive index of the film for the radiation wavelength, θ is the collection angle, and λ is the radiation wavelength. A plot of the reflected light intensity versus polishing time yields an interferometry curve that may be used for polishing endpoint detection. The curve is referred to as an "endpoint trace". The signature of the endpoint trace is characteristic of the film thickness and the polishing rate. From knowledge of relationships between the trace signature, polishing rate and film thickness to be provided, the polishing "endpoint" can be determined at or near a particular node in the trace.

The endpoint traces from each of the polishing platens visited by a single wafer during processing may be electronically stitched together into a virtual single trace for the wafer. If a buffing step is performed on Platen-3, as described above, then only endpoint traces from Platens-1 and 2 are collected and stitched. In a two step polishing sequence, the polishing time for a wafer is divided into roughly equal portions, with approximately half the

total polishing time performed on platen-1 and approximately half the total polishing time performed on Platen-2. This division is achieved by either of the following strategies.

In the single-platen endpoint mode, the endpoint trace is collected from both Platen-1 and Platen-2 and both are stitched together into one virtual trace. However, the trace is used to trigger the polishing endpoint only on the second platen. Polishing time on Platen-1 is fixed at approximately half of the expected polishing time, based on knowledge of the polishing rate and film thickness to be removed. Polishing time on Platen-2 is then determined by optical endpoint analysis.

In the dual-platen endpoint mode, the endpoint trace is collected from both Platen-1 and Platen-2 and both are stitched together into one virtual trace. The trace is used to trigger the polishing endpoint on both polishing platens. Polishing time on the first platen is determined by detection of a particular feature in the trace that is determined to be approximately halfway through the polishing time, based on knowledge of relationships between endpoint trace and thickness removed. Polishing time on Platen-2 is again determined by optical endpoint analysis.

When the portion of the polishing sequence for a particular platen is complete, the head is lifted from the platen and the wafer is held by vacuum to the head, suspended above the polishing pad until the sequences are completed for all of the other stations of the device. For example, when the polishing endpoint is reached for a wafer on Platen-2, the head lifts the wafer from the platen and holds the wafer above the platen until the polishing sequences for the other heads are also complete. When all heads have satisfied their part of the polishing sequence and all wafers are lifted from the platens, the heads are all rotated to the next station in the polishing sequence. While the wafers are held suspended above the polishing platens, some slurry residue may be present on the wafer surface. Should the slurry residue dry during such idle times after polishing on Platen-2 or buffing on Platen-3, it can cause deleterious scratching of the wafer surface during subsequent processing operations.

Introduction of a water mist in the area of the heads and wafers during idle time may prevent slurry drying on the wafer surface. However, adding water to the polishing system can impact polishing performance and further complicates the process.

The present invention is directed to a method and system for addressing the above and other needs in connection with preventing damage to wafers in a sequential multiple steps polishing process by preventing the polishing slurry from drying on a wafer

surface between polishing steps. The present invention is exemplified in a number of implementations and applications, some of which are summarized below.

According to one aspect of the invention, a method for preventing drying of residue on a wafer surface in a sequential multiple steps polishing operation has been discovered. The method includes detecting a polishing endpoint for a first wafer polished in a second polishing operation following a first polishing operation of the first wafer. Endpoint detection terminates polishing of a second wafer in the first polishing operation and then the first wafer in the second polishing operation is overpolished. After a predetermined time period, overpolishing of the first wafer in the second polishing operation terminates. Finally each of the wafers are moved to a subsequent wafer processing operation, which can include a buffing operation, an additional polishing operation or simply continues on the wafer processing line. In a related application, the first wafer is polished and moved to the second polishing location before both wafers are polished simultaneously in each of two polishing locations. The polishing operation at the first location is terminated as a function of the time when the endpoint is reached in the first wafer being polished in the second location.

According to another aspect of the invention, a method for extending wafer polishing pad useful life in a multiple polishing pad device has been discovered. The method includes providing at least a first and second polishing pad and polishing a second wafer with the first polishing pad and polishing a first wafer with the second polishing pad. The polishing of the second wafer with the first polishing pad is then terminated upon detecting a polishing endpoint for the first wafer. The first wafer is then overpolished with the second polishing pad and then the overpolishing operation is terminated. Each of the wafers is then

Fig. 1 is an example of a two platen polishing system, including two heads and two polishing pads, in accordance with one embodiment of the invention;

Fig. 2 is a flowchart of the manner in which the polishing pads are controlled to prevent drying of a residue on wafers and to conversely extend the life of the polishing pads on the polishing device;

Fig. 3A is a summary table for processing a batch of 24 wafers utilizing the single platen endpoint mode and a fixed polishing time for the initial polishing operation; and

Fig. 3B is a summary table for processing a batch of 24 wafers in accordance with an example embodiment of the present invention.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not necessarily to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

The present invention is generally directed to a method and system for preventing drying of residue on a wafer surface in a polishing operation. The invention is also suited for extending the useful life of multiple polishing pads that are simultaneously used for polishing multiple wafers. While the present invention is not necessarily limited to a wafer processing application the invention will be better appreciated using a discussion of exemplary embodiments in such a specific context.

In an example embodiment, a method of preventing the drying of residue on a wafer surface and increasing wafer throughput on a multiple stage polishing device is described herein. In particular, in a polishing device that includes three polishing platens, Platen-1 and Platen-2 and a third buffing platen (Platen-3), the polishing endpoint detection program is altered to prevent idle time for the head and wafer located at Platen-2 after the polishing step on that platen is complete. When the polishing endpoint is detected on Platen-2, such as by analysis of an endpoint interferometry curve, this simultaneously triggers events on Platen-1 and Platen-2. Polishing of a wafer on Platen-1 is terminated and a short duration overpolishing step on Platen-2 is triggered. Overpolishing after detection of the polishing endpoint compensates for within-wafer polishing rate non-uniformity. The overpolishing duration allows sufficient time for the head and wafer at Platen-1 to retract from the polishing

pad. In this manner, the wafers are not suspended over Platen-2 during an idle time while waiting for completion of the fixed polishing time on Platen-1. Thus, slurry drying on the wafer surface due to idle time before the buffing step is minimized which in turn reduces deleterious scratching of the wafer on the buffing Platen-3. There is no Platen-2 endpoint
5 detection for the first wafer in a batch polished at Platen-1. However the polishing time on Platen-1 is simply fixed to approximately half of the expected total polishing time based upon knowledge of the polishing rate and amount of film to be removed from each wafer.

Referring now to the figures, Fig. 1 illustrates a polishing system 100 arranged in accordance with one embodiment of the invention. In this example, system 100 includes
10 two polishing pads 102A and 104A, disposed on separate platens, 102B and 104B, having a polishing slurry 106 disposed thereon. Above each of the pads is located polishing heads 108 and 112 that are holding a pair of wafers 110 and 114 that are to be polished. Platen 104B and pad 104A are aligned and have an embedded endpoint window 116 that is optically coupled to a device 118. Device 118 communicates with a computer arrangement 124 that is
15 coupled to both polishing heads 108 and 112 and that controls their movement up and down towards the polishing pads. In another embodiment, an optional endpoint window 122 and corresponding device 124 is provided in order to more accurately detect an endpoint in polishing the first wafer of a batch. Once the endpoint is detected at the first wafer 114 at head 112, this information is communicated via device 118 to computer 120 to signal head
20 108 to pull wafer 110 from polishing pad 102A.

Referring to Fig. 2, a flowchart 200 illustrates an example of the flow of operations of polishing multiple wafers in accordance with an embodiment of the present invention. At 202, the CMP polishing operation commences with the batch of wafers being presented to the polishing device. At 204, a first wafer is placed in the first polishing location
25 (for instance, head 108) for a predetermined time. In this example, the time is set for about half the total expected polishing time for the wafer. At 206, a second wafer is polished at the first polishing location and the first wafer is moved to the second polishing location for polishing. At this point, both wafers are polished simultaneously at both locations. At 208, the polishing of the second wafer terminates at the first polishing location as a function of the
30 time when the polishing endpoint of the first wafer is detected.

As the assembly at the first polishing location is winding down and the head and wafer is lifted from the polishing pad, the second polishing location performs an overpolishing operation on the first wafer at 210 for a predetermined time. In this example, the predetermined time is about 5 seconds, however the time is usually calculated as 5% of

the total polishing time at both platens. Once both polishing heads are lifted from the platens the wafers are moved to the another wafer processing operation as depicted at 212. In this example, the first wafer is moved to the third platen for buffing while the second wafer is moved to the second polishing location and a third wafer is moved into the first polishing
5 location. Once all of the wafers in the batch have completed their polishing sequence they are placed back in the cassette and moved to the next operation on the wafer processing line at 214.

In another embodiment of the present invention there is provided a method of extending the useful life of the polishing pads on the polishing device. This is accomplished
10 by reducing the difference in the total polishing time between two polishing platens, thereby reducing the difference in pad wear between the platens. After a certain amount of wear, pad performance degrades and the polishing rate drops, resulting in excessive within-wafer nonuniformity.

The dual-platen endpoint mode described above utilizes optical endpoint
15 analysis for controlling polishing on both Platen-1 and Platen-2. The single-platen endpoint mode, also described above, sets the polishing time on Platen-1 to approximately half the total polishing time while the polishing time on Platen-2 is determined by optical endpoint analysis. To ensure there is no idle time after polishing on Platen-2, the polishing time on Platen-1 is for a fixed duration that is significantly less than half the expected total polishing
20 time. This approach over time leads to more wear of the pad on Platen-2 than the pad on Platen-1, causing performance of the Platen-2 pad to degrade sooner than if the polishing time were split evenly between the two pads. Thus, the Platen-2 pad requires changing after polishing fewer wafers and due to the significant equipment down time required to change and requalify polishing pads, the pads on both platens are changed at the same time. If both
25 platen-1 and 2 pads must be changed when only the pad on Platen-2 has reached the end of its useful life, then some potential use of Platen-1 pad is lost. The net result is more frequent pad changes and higher pad usage rates for the same number of wafers processed.

The present invention controls the wear rate on the various polishing pads by creating an interrelationship between them. Instead of polishing the wafer in the first
30 polishing location for a fixed time, the polishing time is controlled by the detection of the endpoint of the wafer in the second or proximate polishing location. In an example embodiment, a CMP device having four heads and four platens was used to process two 24-wafer batches. The wafers require a polishing time sufficient to remove 4850 Å of oxide film. The polishing endpoint was set to remove 4650 Å of oxide film from each wafer with an

overpolishing duration on Platen-2 of 5% of total polishing time of Platen-1 and Platen-2 (e.g. platens 102B and 104B of Fig. 1). The polishing rate on head 1 (e.g. head 108) is about 40 Å/sec., head 2 (e.g. head 112) is about 39 Å/sec., head 3 (not shown) is about 42 Å/sec., and head 4 (not shown) is about 40 Å/sec.

5 Fig. 3A provides a summary table for CMP processing of a batch of 24 wafers utilizing the single platen endpoint mode with a first polishing step (fixed time duration) of about 55 seconds and a second polishing step to the optical endpoint plus 5 seconds of overpolishing. The difference in average polishing time per wafer for Platen-1 vs. Platen-2 is 10.25 seconds (65.25 sec. vs. 55.00 sec.). The cumulative difference in pad wear time from
10 Fig. 3A is 246 seconds. In the single platen endpoint mode, a fixed time of 55 seconds was chosen for Platen-1. Increasing the Platen-1 time to 56 seconds causes an undesirable idle time on Platen-2. Decreasing the Platen-1 time to less than 55 seconds reduces the throughput and increases the difference in wear between the pads of Platen-1 and Platen-2.

In this example, both platen polishing operations are of about the same
15 duration, until the overpolishing operation performed by Platen-2. Fig. 3B provides another summary table for CMP processing of a batch of 24 wafers utilizing the endpoint mode of the present invention. The endpoint mode includes 5 seconds of overpolishing on Platen-2. The difference in average polishing time per wafer for Platen-1 vs. Platen-2 is now 7.25 seconds (63.75 sec. vs. 56.50 sec.). The cumulative difference in pad wear time from Fig. 3B is now
20 174 seconds, an improvement of 72 seconds over the single platen endpoint mode illustrated in Fig. 3A.

Typically, 300 wafers are processed between pad changes. In the processing of wafers involving a mixture of high-volume and low-volume ASIC design chips, the lot sizes vary from as few as 4 to as many as 24 wafers per lot, with most of the lots having 24 wafers.

25 The examples in Figs. 3A and 3B, illustrate that polishing a 24-wafer lot according to the teachings of the present invention reduces the difference in pad wear time by approximately 72 seconds, with total wear time on Platen-2 pad reduced by 36 seconds. Thus, processing twelve lots of 24 wafers results in a total wear time saved on Platen-2 pad of 432 seconds. The wear time saved is sufficient to processing an additional 6-wafer lot requiring 384
30 seconds of wear time on the Platen-2 pad before the pads need to be changed. Consequently, if the total platen pad usage between platen pad changes is specified in total processing time rather than the total number of wafers processed, the teachings of the present invention permit polishing of an extra 6-wafer lot between pad changes for every twelve lots of 24 wafers processed.

While the present invention has been described with reference to several particular example embodiments, those skilled in the art will recognize that many changes may be made thereto without departing from the spirit and scope of the present invention, which is set forth in the following claims.

CLAIMS:

1. A method for preventing drying of residue on a wafer surface in a sequential multiple step polishing operation, the method comprising:
 - detecting a polishing endpoint for a first wafer (114) polished in a second polishing operation following a first polishing operation of the first wafer (114);
 - 5 terminating polishing of a second wafer (110) in the first polishing operation and overpolishing the first wafer in the second polishing operation;
 - terminating overpolishing of the first wafer (114) in the second polishing operation; and
 - moving each of the wafers (114, 110) to a subsequent wafer processing
 - 10 operation.
2. The method of claim 1, wherein polishing the second wafer (110) in the first polishing step and polishing the first wafer (114) to an endpoint in the second polishing step are of about equal duration.
- 15 3. The method of claim 1, wherein detecting the polishing endpoint includes determining a film thickness on the surface of the first wafer (114).
4. The method of claim 1, wherein detecting the polishing endpoint includes
- 20 analyzing an endpoint trace from a detection device (118, 120).
5. The method of claim 1, wherein detecting the polishing endpoint includes analyzing an interferometry curve from a detection device (118, 120).
- 25 6. The method of claim 1, wherein detecting the polishing endpoint includes analyzing a laser beam reflected from the surface of the first wafer (114).
7. The method of claim 1, wherein overpolishing the first wafer (114) in the second polishing step occurs for a selected time period.

8. The method of claim 7, wherein overpolishing the first wafer (114) for a selected time period includes a duration sufficient for the second wafer (110) in the first polishing step to prepare for movement to a subsequent polishing operation.

5

9. The method of claim 1, wherein moving each wafer (114, 110) to a subsequent operation includes a subsequent polishing step.

10. The method of claim 1, wherein moving each wafer (114, 110) to a subsequent operation includes a subsequent buffing operation.

10

11. The method of claim 1, wherein terminating polishing of the second wafer (110) in the first polishing operation is a function of the time when the endpoint of polishing the first wafer (114) in the second polishing operation.

15

12. A method of preventing drying of residue on a wafer surface in a multiple stage polishing operation, the method comprising:

simultaneously polishing a second wafer (110) at a first polishing location and a first wafer (114) at a second polishing location;

20

terminating polishing of the second wafer (110) at the first polishing location as a function of the time when a polishing endpoint is detected for the first wafer (114) at the second polishing location; and

overpolishing the first wafer (114) at the second polishing location for a predetermined period of time.

25

13. The method of claim 12, prior to the simultaneously polishing, further including the step of polishing the first wafer (114) in the first polishing location for a predetermined time period.

30 14. A system for preventing drying of residue on a wafer surface in a sequential multiple steps polishing process, the system comprising:

means (108, 112, 120) for simultaneously polishing a second wafer (110) at a first polishing location (108) and a first wafer (114) at a second polishing location (112);

means (120) for terminating polishing of the second wafer (110) at the first polishing location (108) as a function of the time when a polishing endpoint is detected for the first wafer (114) at the second polishing location (112); and

means (112) for overpolishing the first wafer (114) at the second polishing
5 location (112) for a predetermined period of time.

15. A method for extending useful wafer polishing pad life in a multiple polishing pad device, the method comprising:

providing at least first and second polishing pads (104A, 102A);
10 polishing a second wafer (110) with the first polishing pad (104A) and
polishing a first wafer (114) with the second polishing pad (102A);
terminating polishing of the second wafer (110) with the first polishing pad
(104A) and overpolishing the first wafer (114) with the second polishing pad (102A) upon
detecting a polishing endpoint for the second wafer (110);
15 terminating overpolishing of the first wafer by the second polishing pad
(102A);
and
moving each of the wafers (110, 114) to a subsequent wafer processing
operation.

20

16. The method of claim 15, further including the step of polishing the first wafer (114) with the first polishing (104A) pad for a predetermined duration.

17. The method of claim 16, wherein the step of overpolishing with the second
25 polishing pad (102A) continues for a predetermined duration.

18. The method of claim 17, wherein the polishing with the first polishing pad (104A) and polishing with the second polishing pad (102A) to an endpoint are of about equal duration.

30

19. The method of claim 15, further including the step of tracking the difference in cumulative wear time between the at least two polishing pads (102A, 104A).

20. The method of claim 15, wherein the step of detecting the polishing endpoint includes analyzing an endpoint trace from a detection device (120).

FIG. 1

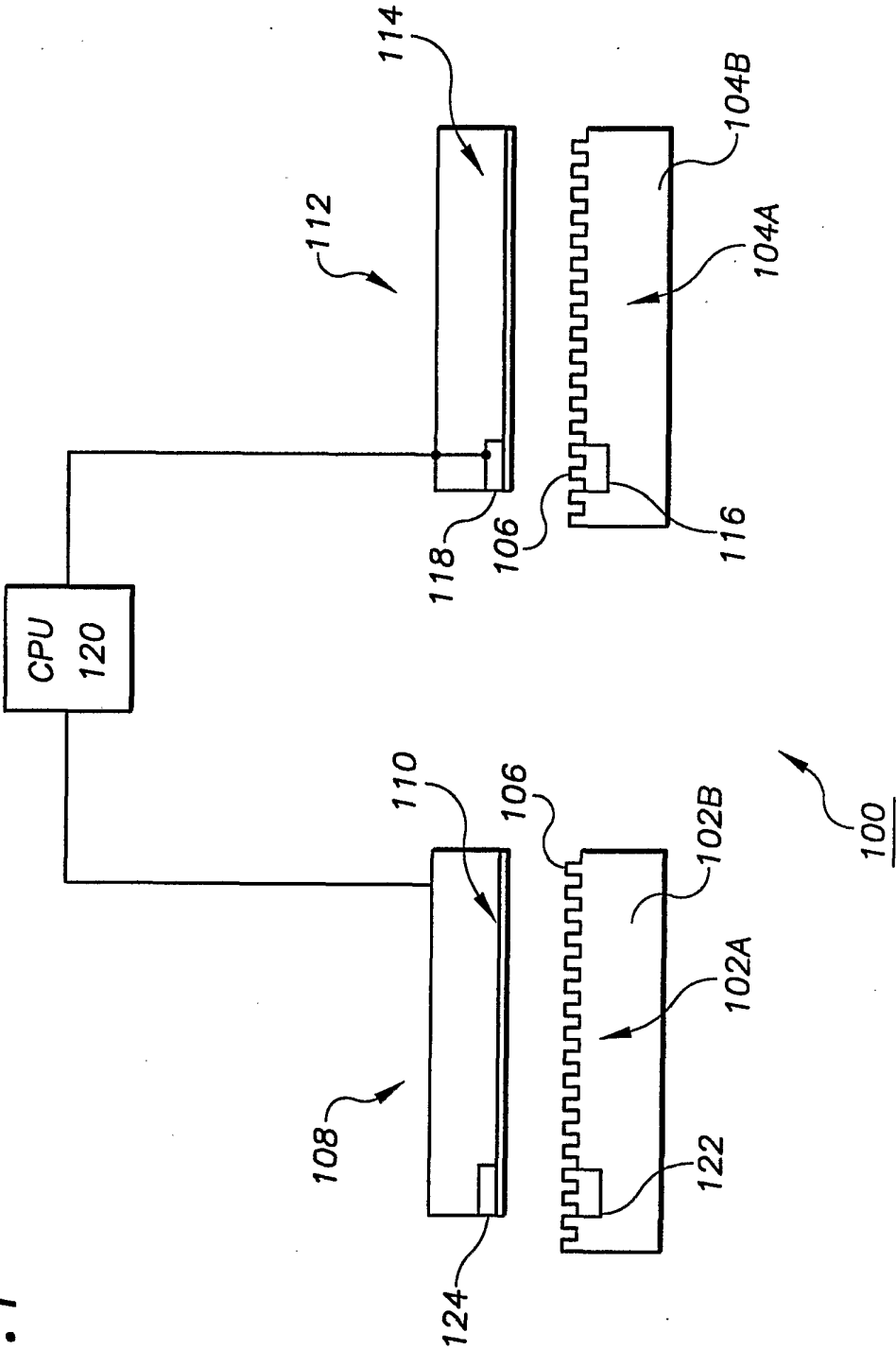
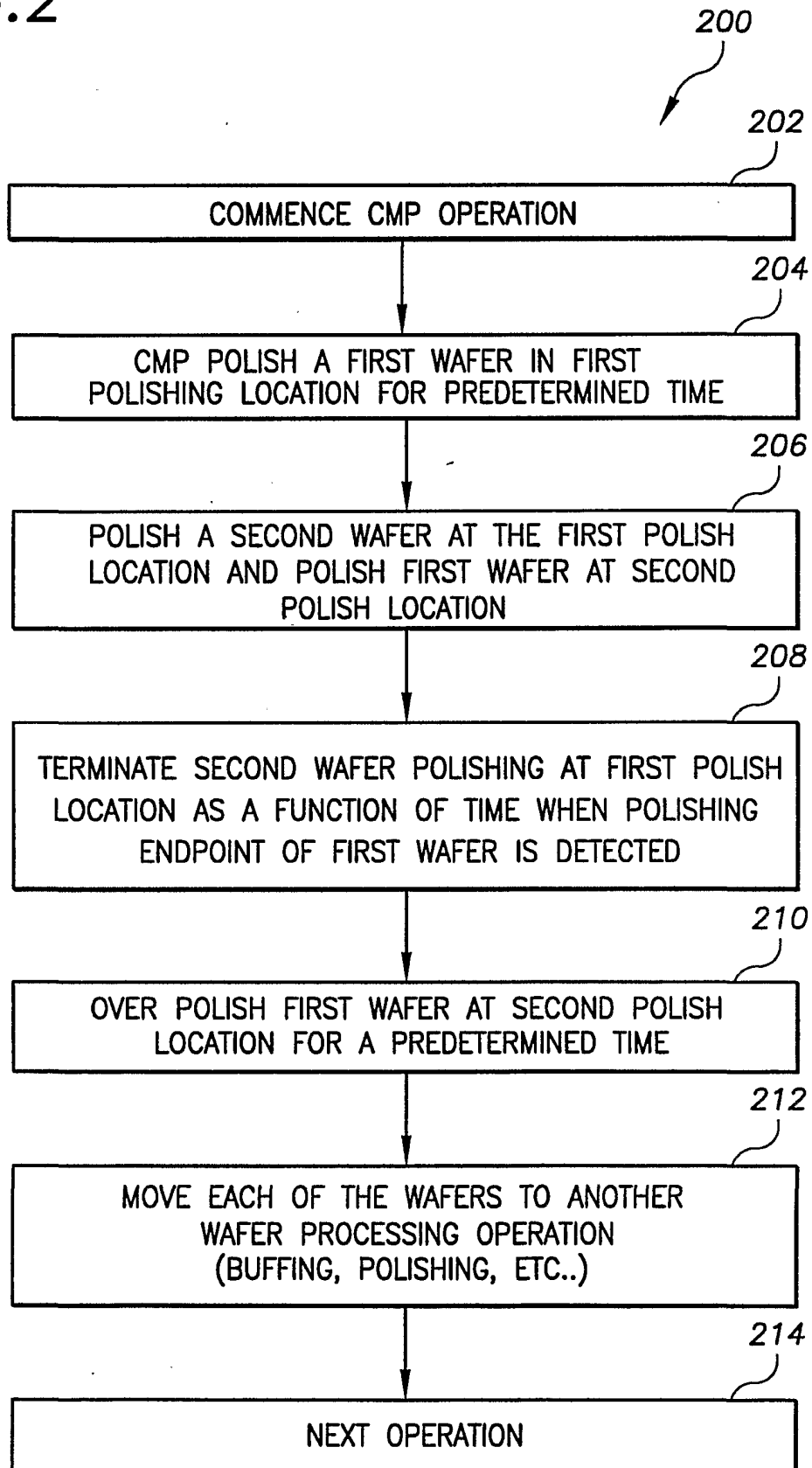


FIG. 2

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TO
FIG.
3A-2

FIG.3A-1

Pad wear and process time example for Single-Platen Endpoint Mode

even 1#	head # on plat-1	polish rate on plat-1	plat-1 pol time	head # on plat- 2	polish rate upon plat-2	plat-2 endpt time	plat-2 overpol time	plat-2 total pol time
	A/sec		sec	fixed in				
1	1	40	55	recipe	none	0	0	0
2	2	39	55	"	1	40	61	5 66
3	3	42	55	"	2	39	64	5 69
4	4	40	55	"	3	42	55	5 60
5	1	40	55	"	4	40	61	5 66

TO FIG. 3A-3

FIG. 3A-2

plat-2 time based on	total polishing time	total wear time on plat-1	total wear time on plat-2	difference in pad wear time	total polish+ post-rinse time	cum proc time due to pol + rinse
	sec	sec	sec	sec	sec	sec
endpt	55	55	0	55	61	61
endpt	121	110	66	44	72	133
endpt	124	165	135	30	75	208
endpt	115	220	195	25	66	274
endpt	121	275	261	14	72	346

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FROM
FIG.
3A-1

TO FIG. 3A-4

TO
FIG.
3A-4

FROM FIG. 3A-1

FIG.3A-3

6	2	39	55	"	1	40	61	5	66
7	3	42	55	"	2	39	64	5	69
8	4	40	55	"	3	42	55	5	60
9	1	40	55	"	4	40	61	5	66
10	2	39	55	"	1	40	61	5	66
11	3	42	55	"	2	39	64	5	69
12	4	40	55	"	3	42	55	5	60
13	1	40	55	"	4	40	61	5	66
14	2	39	55	"	1	40	61	5	66
15	3	42	55	"	2	39	64	5	69

TO FIG. 3A-5

FROM FIG. 3A-2

FIG. 3A-4

endpt	121	330	327	3	72	418
endpt	124	385	396	11	75	493
endpt	115	440	456	16	66	559
endpt	121	495	522	27	72	631
endpt	121	550	588	38	72	703
endpt	124	605	657	52	75	778
endpt	115	660	717	57	66	844
endpt	121	715	783	68	72	916
endpt	121	770	849	79	72	988
endpt	124	825	918	93	75	1063

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FROM
FIG.
3A-3

TO FIG. 3A-6

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TO
FIG.
3A-6

FROM FIG. 3A-3

FIG.3A-5

16	4	40	55	"	3	42	55	5	60
17	1	40	55	"	4	40	61	5	66
18	2	39	55	"	1	40	61	5	66
19	3	42	55	"	2	39	64	5	69
20	4	40	55	"	3	42	55	5	60
21	1	40	55	"	4	40	61	5	66
22	2	39	55	"	1	40	61	5	66
23	3	42	55	"	2	39	64	5	69
24	4	40	55	"	3	42	55	5	60
25					4	40	61	5	66
AVERAGE		40.25	55			40.25	60.25	5	65.25

FROM FIG. 3A-4

FIG. 3A-6

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endpt	115	860	978	98	66	1129
endpt	121	935	1044	109	72	1201
endpt	121	990	1110	120	72	1273
endpt	124	1045	1179	134	75	1348
endpt	115	1100	1239	139	66	1414
endpt	121	1155	1305	150	72	1486
endpt	121	1210	1371	161	72	1558
endpt	124	1265	1440	175	75	1633
endpt	115	1320	1500	180	66	1699
endpt	121	1320	1566	246	72	1771

70.84

120.25

FROM
FIG.
3A-5

FIG. 3B-1

Pad wear and process time example for "Platen-2 endpoint triggers platen-1 polish time"

even 1#	head # on plat-1	polish rate on plat-1	plat-1 pol time based on	head # on plat-2	polish rate upon plat-2	plat-2 endpt time	plat-2 overpol time	plat-2 total time
					A/sec	sec	sec	sec

fixed (1st wfr) none

1	1	40	30					
2	2	39	86	1	40	86	5	91
3	3	42	33	2	39	33	5	38
4	4	40	77	3	42	77	5	82
5	1	40	39	4	40	39	5	44

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TO FIG. 3B-2

FIG. 3B-2

plat-2 time based on	total polishing time	total wear time on plat-1	total wear time on plat-2	difference in pad wear time	total polish+ post-rinse time	cum proc time due to pol + rinse
	sec	sec	sec	sec	sec	sec
		30	0	30	36	36
endpt	121	116	91	25	97	133
endpt	124	149	129	20	44	177
endpt	115	226	211	15	88	265
endpt	121	265	255	10	50	315

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FROM
FIG.
3B-1

TO FIG. 3B-4

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TO
FIG.
3B-4

FROM FIG. 3B-1

FIG. 3B-3

6	2	39	77	plat-2	1	40	77	5	82
7	3	42	42	plat-2	2	39	42	5	47
8	4	40	68	plat-2	3	42	68	5	73
9	1	40	48	plat-2	4	40	48	5	53
10	2	39	68	plat-2	1	40	68	5	73
11	3	42	51	plat-2	2	39	51	5	56
12	4	40	59	plat-2	3	42	59	5	64
13	1	40	57	plat-2	4	40	57	5	62
14	2	39	59	plat-2	1	40	59	5	64
15	3	42	60	plat-2	2	39	60	5	65

TO FIG. 3B-5

FROM FIG. 3B-2

FIG. 3B-4

endpt	121	342	337	5	88	403
endpt	124	384	384	0	53	456
endpt	115	452	457	5	79	535
endpt	121	500	510	10	59	594
endpt	121	568	583	15	79	673
endpt	124	619	639	20	62	735
endpt	115	678	703	25	70	805
endpt	121	735	765	30	68	873
endpt	121	794	829	35	70	943
endpt	124	854	894	40	71	1014

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FROM
FIG.
3B-3

TO FIG. 3B-6

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TO
FIG.
3B-6

FROM FIG. 3B-3

FIG. 3B-5

16	4	40	50	plat-2	3	42	50	5	55
17	1	40	66	plat-2	4	40	66	5	71
18	2	39	50	plat-2	1	40	50	5	55
19	3	42	69	plat-2	2	39	69	5	74
20	4	40	41	plat-2	3	42	41	5	46
21	1	40	75	plat-2	4	40	75	5	80
22	2	39	41	plat-2	1	40	41	5	46
23	3	42	78	plat-2	2	39	78	5	83
24	4	40	32	plat-2	3	42	32	5	37
25					4	40	84	5	89
AVERAGE		40.25	56.5			40.25	58.75		63.75

FROM FIG. 3B-4

FIG. 3B-6

endpt	115	904	949	45	61	1075	14/14
endpt	121	970	1020	50	77	1152	
endpt	121	1020	1075	55	61	1213	
endpt	124	1089	1149	60	80	1293	
endpt	115	1130	1195	65	52	1345	
endpt	121	1205	1275	70	86	1431	
endpt	121	1246	1321	75	52	1483	
endpt	124	1324	1404	80	89	1572	
endpt	115	1356	1441	85	43	1615	
endpt	121	1356	1530	174	95	1710	
120.25						69.75	

FROM
FIG.
3B-5