[0090] For these configurations and for purposes of the specification, the bias angle θ equals the average angle of the curved biased grooves in relation to the bisect line represented by a dashed line. One method for measuring bias angle as seen in Figure 8 is to draw an imaginary line 8-8 that connects adjacent radial feeder grooves 820 and 830 along a single curved biased groove, then measure the angle of intersection (θ) or bias angle with dashed bisect line B_8. Similarly, for Figure8A, imaginary line 8a-8a connects adjacent radial feeder grooves 870 and 872 along a single curved bias groove, then measuring the angle of intersection with dashed bisect line B_{8a} equals the bias angle, θ. It is important that at least a majority of each curved bias segment have either an inward or outward angle. Advantageously, a majority of the bias grooves have the same bias. This is because having an inward biased groove portion with an outward biased groove portion will tend to cancel each other out with respect to removal rate. Advantageously, all the bias segments have either an inward or outward bias.

[0091] Referring to Figures 9, polishing pad 900 has curved radial feeder grooves 910, 912, 914 and 916. The feeder grooves 910, 912, 914 and 916 curve counter counterclockwise to improve fluid flow for clockwise rotation of polishing pad 900. This shape accelerates outward flow of the polishing fluid to improve polishing fluid distribution to outer bias grooves 920 during clockwise rotation and decelerates outward flow to decrease polishing fluid distribution to outer bias grooves 920 during counterclockwise rotation. Alternatively, the radial feeder grooves could curve in a clockwise direction (not shown) for the opposite impact. This shape decelerates outward flow of the polishing fluid to improve polishing fluid distribution to outer bias grooves 920 during counterclockwise rotation and accelerates outward flow to decrease polishing fluid distribution to outer bias grooves 920 during clockwise rotation.

[0092] Measuring bias angle for Figure 9 having curved radial feeder grooves 914 and 916, requires drawing of dashed radial lines Ra and Rb with imaginary bisect line B_9 that bisects dashed radial lines Ra and Rb. This illustrates the bias angle θ for outward bias groove 930 that intersects bisect line B_9. Chords Ra_1 and Rb_1 have equal length and are parallel radial lines Ra and Rb, respectively. A dashed line Ra_1 –Rb_1 connects ends of chords Ra_1 and Rb_1 and intersects with bisect line B_9 at bias groove 930. The bias angle for groove 930 is the angle between bisect line B_9 and groove 930 or θ. This embodiment has a constant θ along each bias groove and throughout the entire polishing region.

[0093] Referring to Figure 10, polishing pad 1000 includes curved radial feeder grooves 1010, 1012, 1014 and 1016 combined with outward biased curved grooves 1020. In

CLAIMS

1. A polishing pad suitable for polishing or planarizing a wafer of at least one of semiconductor, optical and magnetic substrates, the polishing pad comprising the following:

a polishing layer having a polymeric matrix and a thickness, the polishing layer including a center, an outer edge and a radius extending from the center to the outer edge of the polishing pad and wherein the polishing layer is configured for polishing or planarizing a wafer of at least one of semiconductor, optical and magnetic substrates, including atomic scale polishing for removing a single monatomic layer at a time and wherein the polishing pad is a polyurethane CMP polishing pad;

radial feeder grooves in the polishing layer separating the polishing layer into polishing regions, the radial feeder grooves extending at least from a location adjacent the center to a location adjacent the outer edge of the polishing pad, the polishing regions having a series of biased grooves with a bias for adjusting residence time under the wafer, the bias having a bias angle θ between a bisect line bisecting polishing regions and the biased grooves connecting adjacent feeder grooves, the bias angle θ being either an inward bias angle θ sloped inward toward the center of the polishing pad or an outward bias angle θ sloped outward toward the outer edge of the polishing pad, a majority of the biased grooves sweeping under the wafer in the same direction for cumulative improving of removal rate; and

each polishing region including a series of spaced non-isosceles trapezoid groove structures, the trapezoid groove structures having biased grooves of parallel base segments connecting two adjacent radial feeder grooves to form leg segments, the base segments intersecting each of the leg segments at different angles, the series of non-isosceles trapezoid groove structures extending from adjacent the outer edge toward the center of the polishing pad with the perimeter of the series of trapezoid structures also being a trapezoid wherein the rotation of the polishing pad moves polishing fluid through a majority of the base segments and the leg segments toward the outer edge of the polishing pad and away from the wafer depending upon inward bias or outward bias and direction

of rotation of the polishing pad for increasing residence time of polishing fluid under the wafer with outward flow of the polishing fluid in the series of biased grooves in the circular sectors and wherein non-alignment of base segments between adjacent polishing regions facilitates polishing fluid flow down the radial feeder grooves for improved slurry distribution.

2. The polishing pad of claim 1 wherein all polishing regions have the same bias.

3. The polishing pad of claim 1 including an inward bias for increasing polishing fluid residence time under a wafer during counterclockwise rotation of the polishing pad and the wafer.

4. The polishing pad of claim 1 wherein the polishing pad includes at least three radial feeder grooves.

5. The polishing pad of claim 1 wherein the series of spaced non-isosceles trapezoid groove structures connecting a pair of adjacent radial feeder grooves are parallel linear grooves.

6. The polishing pad of claim 1 wherein the parallel base segments step down into the radial feeder grooves.

7. A polishing pad suitable for polishing or planarizing a wafer of at least one of semiconductor, optical and magnetic substrates, the polishing pad comprising the following:

a polishing layer having a polymeric matrix and a thickness, the polishing layer including a center, an outer edge and a radius extending from the center to the outer edge of the polishing pad and wherein the polishing layer is configured for polishing or planarizing a wafer of at least one of semiconductor, optical and magnetic substrates, including atomic scale polishing for removing a single monatomic layer at a time and wherein the polishing pad is a polyurethane CMP polishing pad;

radial feeder grooves in the polishing layer separating the polishing layer into polishing regions, the polishing regions being circular sectors defined by two adjacent radial feeder grooves, a bisect line connecting the center to a midpoint of the perimeter arc bisecting the polishing regions, the radial feeder grooves extending at least from a location adjacent the center to a location adjacent the outer edge of the polishing pad, a majority of the polishing regions having a series of biased grooves with a bias for adjusting residence time under the wafer, the bias having a bias angle θ between a bisect line bisecting polishing regions and the biased grooves connecting adjacent feeder grooves, the bias angle θ being either an inward bias angle θ sloped inward toward the center of the polishing pad or an outward bias angle θ sloped outward toward the outer edge of the polishing pad, a majority of the biased grooves sweeping under the wafer in the same direction for cumulative improving of removal rate; and

each polishing region including a series of spaced non-isosceles trapezoid groove structures, the trapezoid groove structures having biased grooves of parallel base segments connecting two adjacent radial feeder grooves to form leg segments, the base segments intersecting each of the leg segments at different angles, the series of non-isosceles trapezoid groove structures extending from adjacent the outer edge toward the center of the polishing pad with the perimeter of the series of trapezoid structures also being a trapezoid wherein the rotation of the polishing pad moves polishing fluid through a majority of the base segments and the leg segments toward the outer edge of the polishing pad and away from the wafer depending upon inward bias at an angle of 20° to 85° from the bisect line or outward bias at an angle of 95° to 160° from the bisect line and direction of rotation of the polishing pad for increasing residence time of polishing fluid under the wafer with outward flow of the polishing fluid in the base segments in the circular sectors and wherein non-alignment of base segments between adjacent polishing regions facilitates polishing fluid flow down the radial feeder grooves for improved slurry distribution.

8. The polishing pad of claim 7 wherein all polishing regions have the same bias.

9. The polishing pad of claim 7 including an inward bias for increasing polishing fluid residence time under a wafer during counterclockwise rotation of the polishing pad and the wafer.

10. The polishing pad of claim 7 wherein the polishing pad includes at least three radial feeder grooves.

11. The polishing pad of claim 7 wherein the series of spaced non-isosceles trapezoid groove structures connecting a pair of adjacent radial feeder grooves are parallel linear grooves.

12. The polishing pad of claim 7 wherein the parallel base segments step down into the radial feeder grooves.