

concentric grooves having a first center of concentricity, and (b) a second plurality of concentric grooves having a second center of concentricity, wherein (1) the first center of concentricity is not coincident with the second center of concentricity, (2) the axis of rotation of the polishing pad is not coincident with at least one of the first center of concentricity and the second center of concentricity, (3) the plurality of grooves does not consist of a continuous spiral groove, and (4) the polishing surface does not comprise a mosaic groove pattern, and wherein the polishing pad further comprises a central channel, and the depth of the central channel is greater than the depth of the plurality of grooves.

[0007] A second aspect of the present invention provides a method of chemical-mechanically polishing a substrate, which method comprises, (a) contacting a substrate with a chemical-mechanical polishing composition and a polishing pad, (b) moving the polishing pad relative to the substrate with the chemical-mechanical polishing composition therebetween, and (c) abrading at least a portion of the substrate to polish the substrate, wherein the polishing pad comprises an axis of rotation, a polishing surface, and a plurality of grooves set into the polishing surface, wherein the plurality of grooves is composed of at least (a) a first plurality of concentric grooves having a first center of concentricity, and (b) a second plurality of concentric grooves having a second center of concentricity, wherein (1) the first center of concentricity is not coincident with the second center of concentricity, (2) the axis of rotation of the polishing pad is not coincident with at least one of the first center of concentricity and the second center of concentricity, (3) the plurality of grooves does not consist of a continuous spiral groove, and (4) the polishing surface does not comprise a mosaic groove pattern, and wherein the polishing pad further comprises a central channel, and the depth of the central channel is greater than the depth of the plurality of grooves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 illustrates a polishing pad according to an embodiment of the invention. FIG. 1 is a view of the polishing surface of the polishing pad from a perspective perpendicular to the polishing surface. The polishing pad of FIG. 1 is a mirror image of the polishing pad of FIG. 2. FIG. 1 contains a virtual x-axis and a virtual y-axis for ease of reference.

[0009] FIG. 2 illustrates a polishing pad according to an embodiment of the invention. FIG. 2 is a view of the polishing surface of the polishing pad from a perspective perpendicular to the polishing surface. The polishing pad of FIG. 2 is a mirror image of the polishing pad of FIG. 1. FIG. 2 contains a virtual x-axis and a virtual y-axis for ease of reference.

CLAIM(S):

1. A polishing pad comprising an axis of rotation, a polishing surface, and a plurality of grooves set into the polishing surface, wherein the plurality of grooves is composed of at least (a) a first plurality of concentric grooves having a first center of concentricity, and (b) a second plurality of concentric grooves having a second center of concentricity, wherein

(1) the first center of concentricity is not coincident with the second center of concentricity,

(2) the axis of rotation of the polishing pad is not coincident with at least one of the first center of concentricity and the second center of concentricity,

(3) the plurality of grooves does not consist of a continuous spiral groove, and

(4) the plurality of grooves does not comprise a mosaic groove pattern, and wherein the polishing pad further comprises a central channel, and the depth of the central channel is greater than the depth of the plurality of grooves.

2. The polishing pad of claim 1, wherein, when the plurality of grooves is extended infinitely in the plane of the polishing surface, the first plurality of concentric grooves is symmetric with the second plurality of concentric grooves by way of a 180° rotation about an axis of symmetry perpendicular to the polishing surface.

3. The polishing pad of claim 1, wherein, when the plurality of grooves is extended infinitely in the plane of the polishing surface, the first plurality of concentric grooves is symmetric with the second plurality of concentric grooves by way of a first mirror plane that (a) is perpendicular to the polishing surface and (b) does not intersect with either the first center of concentricity or the second center of concentricity.

4. The polishing pad of claim 1, wherein, when the plurality of grooves is extended infinitely in the plane of the polishing surface, the first plurality of concentric grooves is symmetric with the second plurality of concentric grooves by way of a first mirror plane that is perpendicular to the polishing surface and a second mirror plane intersects with both the first center of concentricity and the second center of concentricity.

5. The polishing pad of claim 1, wherein at least a portion of the grooves in the plurality of grooves is an arc having a shape selected from the group consisting of substantially

circular, substantially semi-circular, substantially parabolic, substantially oval, and combinations thereof.

6. The polishing pad of claim 5, wherein the shape is substantially circular or substantially semi-circular, and each respective groove in the first plurality of concentric grooves has a substantially constant radius with respect to the first center of concentricity, and each respective groove in the second plurality of concentric grooves has a substantially constant radius with respect to the second center of concentricity.

7. The polishing pad of claim 1, wherein (a) the first plurality of concentric grooves does not cross the second plurality of concentric grooves, and (b) the polishing pad has a first region containing the first plurality of concentric grooves and a second region containing the second plurality of concentric grooves, wherein the first region is adjacent to the second region.

8. The polishing pad of claim 7, wherein one or more of the following conditions is satisfied:

(a) at least a portion of the first region abuts at least a portion of the second region at an interface,

(b) the first region abuts the second region at an interface,

(c) the first region is entirely separated from the second region by a third region, and

(d) the first region is entirely separated from the second region by the central channel.

9. The polishing pad of claim 8, wherein one or more of the following conditions is satisfied:

(a) at least one of the grooves in the first plurality of concentric grooves is aligned with at least one of the grooves in the second plurality of concentric grooves at the interface,

(b) the grooves in the first plurality of concentric grooves are aligned with the grooves in the second plurality of concentric grooves at the interface,

(c) none of the grooves in the first plurality of concentric grooves is aligned with the grooves in the second plurality of concentric grooves at the interface,

(d) the first center of concentricity is located in the first region and the second center of concentricity is located in the second region,

13. The polishing pad of claim 1, wherein the central channel has a rounding edge.

14. The polishing pad of claim 1, wherein (i) the polishing pad has a thickness T , (ii) each groove in the first plurality of concentric grooves has a first depth, a first width, and is separated from an adjacent groove by a first pitch, and (iii) each groove in the second plurality of concentric grooves has a second depth, a second width, and is separated from an adjacent groove by a second pitch, and wherein one or more of the following conditions is satisfied:

(a) the first depth and the second depth measured as a fraction of the thickness T of the polishing pad independently are $0.01 T$ to $0.99 T$ and can be the same or different, and the first depth, the second depth, or both, either is constant or varies within the first plurality of concentric grooves, the second plurality of concentric grooves, or both,

(b) the first width and the second width independently are 0.005 cm to 0.5 cm and can be the same or different, and the first width, the second width, or both, either is constant or varies within the first plurality of concentric grooves, the second plurality of concentric grooves, or both, and

(c) the first pitch and the second pitch independently are 0.005 cm to 1 cm and can be the same or different, and the first pitch, the second pitch, or both, either is constant or varies within the first plurality of concentric grooves, the second plurality of concentric grooves, or both.

15. The polishing pad of claim 14, wherein at least a portion of an area surrounding the first center of concentricity, the second center of concentricity, or both, does not comprise any grooves, wherein the area has a radius greater than at least one of the first pitch or the second pitch.

16. A method of chemical-mechanically polishing a substrate, which method comprises:

(a) contacting a substrate with a chemical-mechanical polishing composition and the polishing pad of claim 1,

(b) moving the polishing pad relative to the substrate with the chemical-mechanical polishing composition therebetween, and

(c) abrading at least a portion of the substrate to polish the substrate.

17. The method of claim 16, wherein a removal rate of the substrate is higher, as compared to an otherwise identical polishing pad that does not contain the plurality of grooves.

18. The method of claim 17, wherein the substrate is tungsten.

19. The method of claim 16, wherein the polishing pad comprises a thermoplastic polyurethane.