

polishing pad, such as the polishing pad material, the surface topography of the polishing pad (e.g., micro- and macro- structures, such as perforations, pores, textures, grooves, depressions, etc.), and the like, in combination with the properties of the composition of the polishing slurry (e.g., reactivity, abrasiveness, etc.), can affect various aspects of the CMP process, including the polishing rate and the quality of the polished substrate (e.g., degree of planarity, and number and type of defects). The polishing rate, in particular, directly relates to the throughput of the CMP process, such that the polishing rate is important for cost-of-ownership considerations.

[0004] Attempts in the art to increase throughput by way of increasing the polishing rate have typically involved adjusting the physical and mechanical properties of the polishing pad material or the micro-structure of the polishing pad surface, e.g., using different materials and pad conditioning processes, often resulting in various undesirable tradeoffs, such as increased defects on the surface of the polished substrate and/or reduced life of the polishing pad. While employing macro-structures on the polishing pad surface, such as grooving patterns, has had some success in improving some characteristics of the polishing process, such as the lifetime of the polishing pad in some instances (see, for example, U.S. Patent 6,520,847 to Osterheld et al.), other properties of the polishing process, such as the polishing rate of the substrate, generally have not been adequately improved by conventional grooving patterns to sufficiently increase throughput, while still achieving a polished substrate with a high level of planarity and low defects. Moreover, many conventional grooving patterns are not adequate for retaining the polishing slurry on the polishing pad for a sufficient amount of time, thereby requiring a larger amount of polishing slurry to be used in a polishing process, which undesirably adds to the overall manufacturing costs.

[0005] Thus, there remains a need in the art for improved polishing pads that retain the polishing slurry for a sufficient amount of time and also achieve a commercially viable polishing rate, while at the same time producing a polished substrate having advantageous surface properties, such as high planarity and low defects.

BRIEF SUMMARY OF THE INVENTION

[0006] ~~The A first aspect of the present invention provides a polishing pad comprising, consisting essentially of, or consisting of 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, and 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.

[0007] ~~The invention also~~ A second aspect of the present invention provides a method of chemical-mechanically polishing a substrate, which method comprises, ~~consists essentially of, or consists of~~ (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, ~~consists essentially of, or consists of~~ 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, and 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.

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.