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(54) **POLISHING PAD SURFACE ON HOLLOW POSTS**

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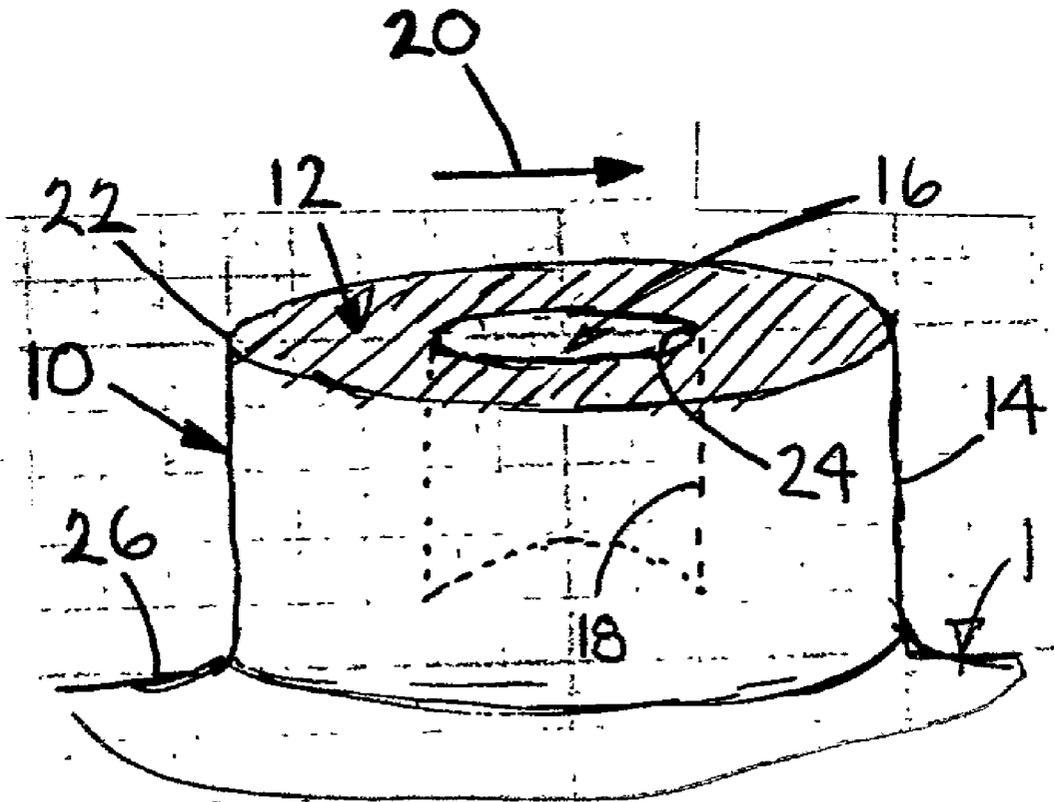
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(57) **ABSTRACT**

A polishing pad comprising: a base from which extends multiple posts having top surfaces that collectively provide a polishing surface on the polishing pad, and each of the top surfaces being recessed with an opening to provide a second cutting edge on the post, and the opening providing a reservoir for polishing fluid.

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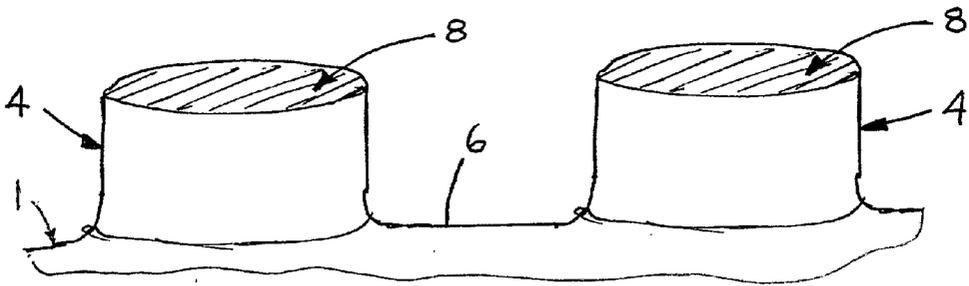


FIG. 1

(PRIOR ART)

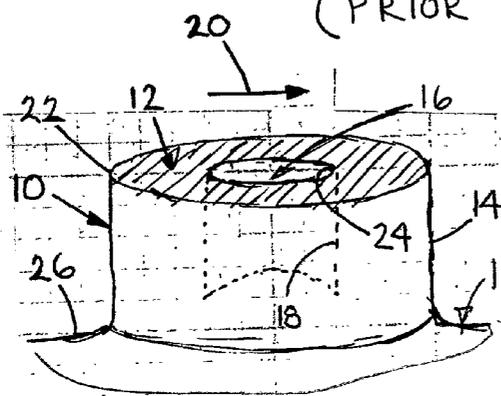


FIG. 2

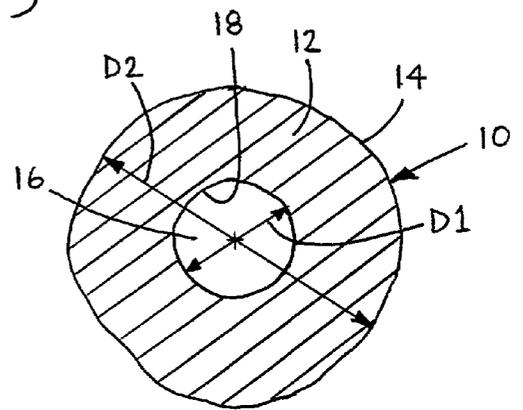


FIG. 3

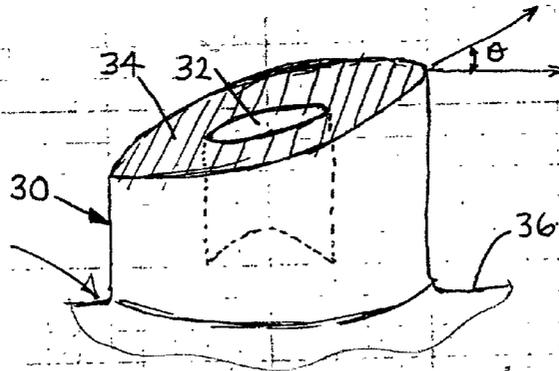


FIG. 4

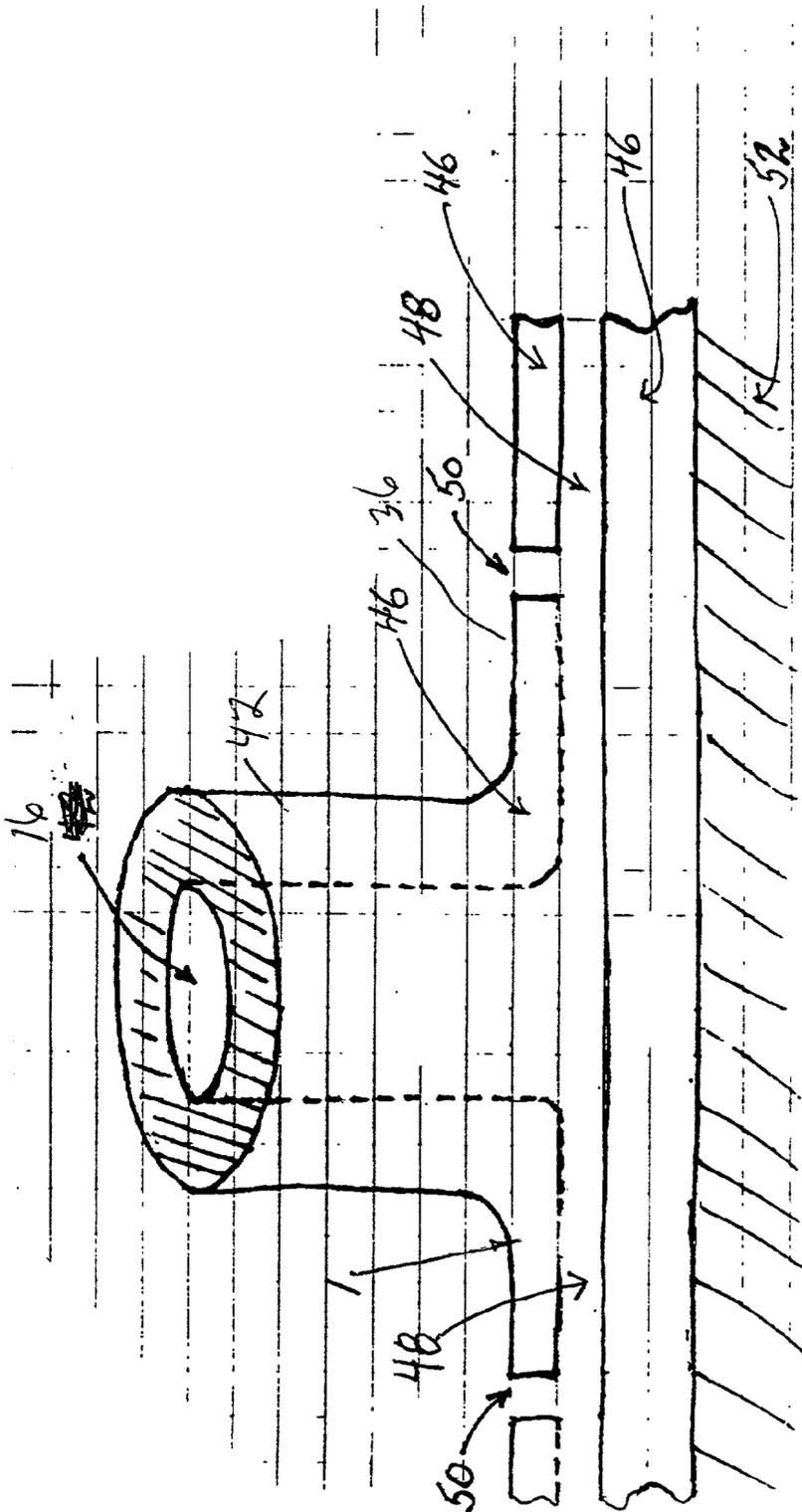


FIG. 5

## POLISHING PAD SURFACE ON HOLLOW POSTS

### CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of provisional application Ser. No. 60/185,619 filed Feb. 29, 2000.

### BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention relates to a polishing pad for polishing a semiconductor substrate, in which the pad has raised posts that provide a polishing surface.

[0004] 2. Discussion of Related Art

[0005] Polishing of a semiconductor substrate is further known as, polishing by chemical mechanical polishing or chemical mechanical planarization, CMP. Such polishing by CMP removes a layer of metal from an underlying barrier film of metal, and further removes the barrier film from an underlying dielectric layer on the semiconductor substrate, which leaves a smooth, planar polished surface on the dielectric layer serving as a substrate on which successive layers of material are fabricated, and further which leaves electrical circuit interconnects of precise dimensions, which interconnects are imbedded in trenches that are flush with the polished surface.

[0006] A known polishing pad, includes multiple posts extending upwardly from a base surface on the pad. Each of the posts has a top surface, which top surfaces collectively provide a polishing surface for the polishing pad. FIG. 1 discloses two of such posts 4 extending from a base surface 6 on a polishing pad. The posts 4 are made from a polishing medium that includes abrasive particles in a solid phase suspension medium. Such a pad having abrasive particles is also known as a fixed abrasive pad. The posts 4 have top surfaces 8 that collectively form the polishing surface on the polishing pad. The polishing surface has a topography of peaks, as provided by the projecting posts 4, and valleys formed by spaces among the posts 4. The topography transports and distributes polishing liquid or polishing fluid along the surface of a wafer which is being polished. A disadvantage of the invention is that the topography provides a single cutting edge on each post, which limits the rate at which material is removed from the semiconductor substrate by each post. A further disadvantage is that the polishing topography of the known posts is inefficient to distribute polishing fluid. Otherwise, frictional forces between the wafer and the polishing pad become excessively high. The topography is periodically renewed by a process of conditioning wherein a conditioning abrasive is passed across the topography by sweeping motions, which trims away worn portions of the posts, and trims the posts of uneven heights to a level, common height.

### SUMMARY OF THE INVENTION

[0007] The invention provides a post with a second cutting edge that serves to increase the polishing rate, which is the rate at which material is being removed by each post. Further, the invention provides a post that is recessed to provide an opening, the opening providing a reservoir for polishing fluid. The opening provides a second cutting edge on the post.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention will now be described by way of example with reference to the accompanying drawings wherein:

[0009] FIG. 1 is an isometric view of part of a polishing pad having posts;

[0010] FIG. 2 is an isometric view of part of a polishing pad and a post according to the invention;

[0011] FIG. 3 is a cross section the post shown in FIG. 2;

[0012] FIG. 4 is an isometric view of another embodiment of part of a polishing pad and a post; and

[0013] FIG. 5 is a section view of another embodiment of part of a polishing pad and post.

### DETAILED DESCRIPTION

[0014] A fixed abrasive polishing pad 1 comprises a polishing medium including a plurality of finely divided abrasive particles which are fixedly dispersed in a suspension medium. Suitable materials for use as a suspension medium include, but are not limited to, urethanes and acrylates, as disclosed in U.S. Pat. No. 5,250,085, hereby incorporated by reference herein. The abrasive particles are small, hard particles which are capable of abrading the surface of a semiconductor wafer. Suitable materials for the abrasive particles include, but are not limited to, aluminum oxides, silicon oxides, cerium oxides, carbides and industrial diamonds.

[0015] The polishing medium of the fixed abrasive polishing pad 1 has an external surface which defines a plurality of posts 10, only one of which is shown in FIGS. 2 and 3. Each of the posts 10 has a top surface 12 which is at a height of approximately 40 microns above a base surface 26 of the polishing pad. The top surface of each post is approximately 200 microns across the largest dimension. For example, each of the posts 10 has a cylindrical outer wall 14 with a diameter of approximately 200 microns. The posts 10 are spaced apart from one another by approximately 200 microns.

[0016] According to one embodiment of the invention, each post 10 has an opening 16 provided by a recess that extends through the top surface 12 to a depth of approximately 30 microns below the top surface as shown in FIG. 2. The opening 16 is bounded by a cylindrical continuous inner wall 18. The cylindrical outer and inner walls 14, 18, are one within the other, and define therebetween a cross section of the post 10 around the recess and the opening 16.

[0017] Although the outer and inner walls 14, 18 are preferably cylindrical, it should be recognized that each of the outer and inner walls may have some other shape such as square, triangular, or other regular or irregular polygon shape.

[0018] The top surfaces 12 of the posts 10 define a polishing surface for the fixed abrasive polishing pad 1. Diameter D1 of the inner wall 18 and diameter D2 of the outer wall 14 can be selected during manufacture, in conjunction with the population density of the posts 10, to provide a desired surface area for the polishing surface of the polishing pad. Preferably, the size and population density of the posts is such that the top surfaces 12 have a surface area

which is between about 10 percent to 40 percent, more preferably about 25 percent, of the available surface area of the polishing pad 1.

[0019] During a polishing operation, a semiconductor wafer is urged into contact with the polishing surface of the polishing pad 1 and is swept by the polishing surface due to relative lateral motion between the wafer and the polishing pad. Assuming relative motion of the wafer in the direction of arrow 20 in FIG. 2, each post 10 has a first cutting edge 22 that is continuous along the top of its exterior wall 14, which makes first contact with a portion of the wafer as it sweeps over the post 10, or is moved relative to the post 10. Each post 10 has a second cutting edge 24 that is continuous along the top of the inner wall 13, which makes second contact with a portion of the wafer that passes over the opening 16. The second cutting edge 24 is continuous along the edge of the opening 16. No matter whether the motion of the pad 1 is rotating, orbital or linear, the second cutting edge 24 increases the cutting action or polishing activity of the pad 1.

[0020] As shown in FIG. 4, another embodiment of a post 30 according to the invention has an opening 32 in a top surface 34 providing a second cutting edge 24. The top surface 34 is inclined at an angle  $\theta$  with respect to a base surface 36 of the polishing pad 1 from which each post 10 projects. The angle  $\theta$  is preferably within a range of 0° to about 10°. The inclined top surfaces 34 of multiple posts 30 are preferably inclined in the same direction.

[0021] FIG. 5 discloses an embodiment in which the opening 16 in each recessed post 42 provides a reservoir for polishing fluid. Flow of the polishing fluid to and from the reservoir is provided by providing horizontal, fluid conveying channels 48, one shown, in a bottom surface of a first layer 46 of the pad 1. The channels 48 are covered by a bottom layer 52 of the pad 1 that forms a subpad. Holes 50, one shown, in the base surface 26 extend in the top layer 46, and communicate with respective channels 48. Each reservoir opens into at least one of the respective channels 48, to enhance a flow of polishing fluid to and from the reservoir, and along corresponding channels 48, and along corresponding holes 50, which replenishes the reservoir with polishing fluid, and which enhances distribution of the polishing fluid over the polishing surface of the post 42 during polishing.

[0022] According to another feature of the invention each opening 16, 32 provided by a corresponding recess serves as a reservoir for polishing fluid that is dispensed during a polishing operation in a known manner, for example, as described by U.S. Pat. No. 5,664,990. The reservoirs distribute polishing fluid adjacent to the corresponding second cutting edge 24. Polishing uniformity on a wafer is controlled by selecting the openings 16, 32 to provide a selected ratio of, or dimensional difference between, the dimensions of the inner and outer walls, for example, as shown in FIG. 3 by dimensions D1 and D2. Polishing uniformity is further controlled by the population density of the posts 10, 30, 42. The provision of a second cutting edge on each of the posts 10, 30, 42 increases material removal, and enhances material removal uniformly by all areas of the pad 1, while minimizing scratches and uneven material removal. Furthermore, as the posts 10, 30, 42 wear down during polishing, the structure will change from partially hollow to solid, which is an indication to the user that the polishing pad should be replaced.

[0023] Thus, the invention provides a post 10, 30, 42 with a second cutting edge 24 that serves to increase the polishing rate, and uniformity of material removal, as compared to a post 10, 30, 42 that has a single cutting edge 22.

[0024] Thus, the invention provides a corresponding post 10, 30, 42 that is recessed to provide an opening 16, 32 that, in turn, provides a reservoir for polishing fluid. The opening 16, 32 further provides the second cutting edge 24.

[0025] In each embodiment of a post 10, 30, 42, the recess providing a corresponding opening 16, 32 is made by a process of machining, including, for example, but not limited to, boring, punching, embossing or milling. Alternatively, the opening 16, 32 is made by the same process that makes the post 10, 30, 42, including, for example, but not limited to, injection molding fluent material, sintering powdered material in a binder, casting fluent material, and brazing material onto the corresponding base surface 26, 36. The invention in the embodiments described above provides a fixed abrasive polishing pad 1 having partially hollow posts 10, 30.

[0026] Embodiments of the invention having been described, other embodiments and modifications of the invention are intended to be covered by the spirit and scope of the appended claims.

What is claimed is:

1. A polishing pad comprising: a base from which multiple posts extend, the posts having top surfaces that collectively provide a polishing surface on the polishing pad, a leading first cutting edge on each of the posts, and each of the top surfaces being recessed to provide a second cutting edge on each of the posts.
2. A polishing pad as recited in claim 1 wherein each of the top surfaces is recessed by an opening providing a reservoir for polishing fluid. A polishing pad comprising: a base from which extends multiple posts having top surfaces that collectively provide a polishing surface on the polishing pad, and each of the top surfaces being recessed to provide a reservoir for polishing fluid.
3. The polishing pad of claim 1 wherein the post has an annular cross-sectional shape.
4. The polishing pad of claim 1 wherein the top surface is inclined with respect to the base surface.
5. A polishing pad comprising: a base from which extends multiple posts having top surfaces that collectively provide a polishing surface on the polishing pad, a leading first cutting edge on each of the posts, and each of the top surfaces being recessed to provide a second cutting edge on each of the posts.
6. A polishing pad as recited in claim 5 wherein, each of the top surfaces is recessed to provide an opening providing a reservoir for polishing fluid.
7. A polishing pad comprising: a base from which extends multiple posts having top surfaces that collectively provide a polishing surface on the polishing pad, and each of the top surfaces being recessed to provide a reservoir for polishing fluid.

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