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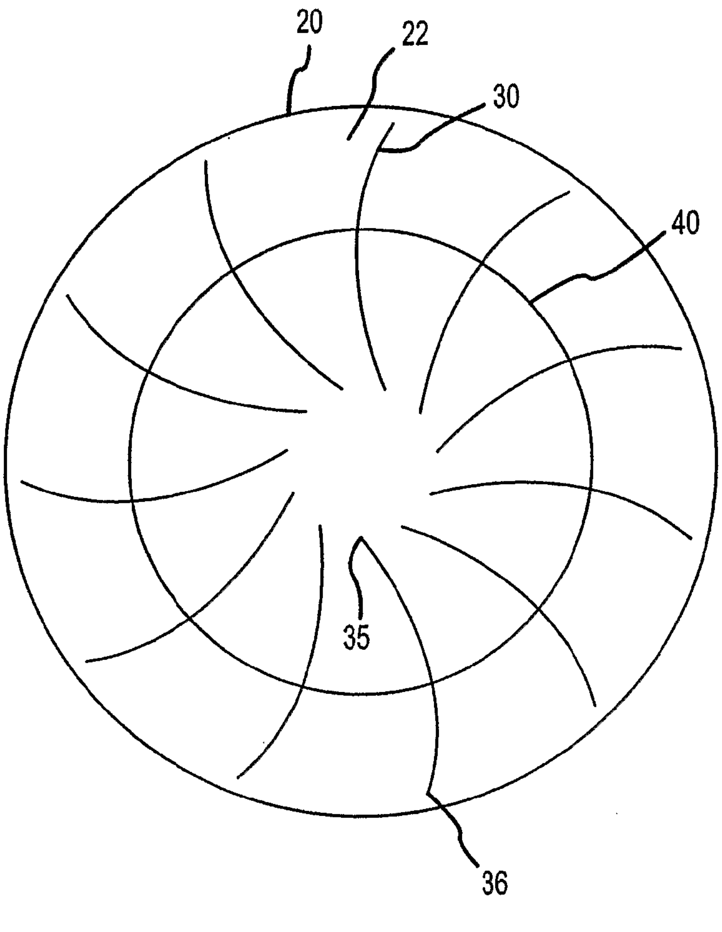
(54) Title: POLISHING PAD FOR USE IN POLISHING WORK PIECES



(57) Abstract: A polishing/lapping pad for use in CMP and other polishing and lapping operations is presented that comprises multiple channels designed to facilitate in the manipulation of slurry into specific locations on the wafer being planarized.

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POLISHING PAD FOR USE IN POLISHING WORK PIECES

Field of Invention

The present invention relates, generally, to an improved polishing/lapping pad for use in polishing various substrates, for example, during chemical mechanical planarization (CMP) of work piece surfaces. More particularly, the present invention relates to an improved channel design on polishing pads to improve the distribution of slurry during the CMP process.

Background of the Invention

The production of integrated circuits begins with the creation of high-quality semiconductor wafers. During the wafer fabrication process, the wafers may undergo multiple masking, etching, and dielectric and conductor deposition processes. In addition, metallization, which generally refers to the materials, methods and processes of wiring together or interconnecting the component parts of an integrated circuit located on the surface of a wafer, is critical to the operation of a semiconductor device. Typically, the "wiring" of an integrated circuit involves etching trenches and "vias" in a planar dielectric (insulator) layer and filling the trenches and vias with a metal.

In the past, aluminum was used extensively as a metallization material in semiconductor fabrication due to the leakage and adhesion problems experienced with the use of gold, as well as the high contact resistance which copper experienced with silicon. Other metallization materials have included Ni, Ta, Ti, W, Ag, Cu/Al, TaN, TiN, CoWP, NiP and CoP. The semiconductor industry has recently renewed its focus on copper metallization due to alloying and electromigration problems that are seen with aluminum. When copper is used as the trench and via filling material, typically a barrier layer of another material is first deposited to line the trenches and vias to prevent the migration of copper into the dielectric layer. After filling, planarization is typically conducted to remove the extra metal down to the dielectric surface. Planarization leaves the trenches and vias filled and results in a flat, polished surface.

Because of the high degree of precision required in the production of integrated circuits, an extremely flat surface is generally needed on at least one side of the semiconductor wafer to facilitate the fabrication process, as well as to enhance the accuracy and performance of the microelectronic structures created on the wafer surface. As the size of the integrated circuits continues to decrease and the density of microstructures on an integrated circuit increases, the need for precise wafer surfaces becomes more important. Therefore, between each processing step, it is often desirable to polish or planarize the surface of the wafer to obtain the flattest surface possible.

Chemical mechanical planarization (CMP) is a technique conventionally used for planarization of semiconductor wafers. Typically, a CMP machine includes a wafer carrier configured to hold, rotate, and transport wafers during the process of polishing or planarizing the wafer. During a planarization operation, a pressure applying element (e.g., a rigid plate, a bladder assembly, or the like) that may be integral to the wafer carrier, applies pressure to hold the wafer against an opposing polishing surface with a desired amount of force. The carrier and the polishing surface are rotated, typically at different rotational velocities, to produce relative lateral motion between the polishing surface and the wafer to promote uniform planarization.

Polishing pads can be formed of various materials, depending on the nature of the work piece and the process environment, and are available commercially. For example, a polishing pad may be blown polyurethane, felt, or stone. The hardness and density of the polishing pad depend on the material that is to be polished. An abrasive slurry may also be applied to the polishing surface. The abrasive slurry acts to chemically weaken the molecular bonds at the wafer surface so that the mechanical action of the polishing pad can more effectively liberate the undesired material from the wafer surface.

Presently known CMP processes are deficient in several respects. For example, asymmetrical or otherwise non-uniform distribution of slurry over the wafer surface, significant slurry run-off, and maintaining uniform proportionate temperature control across the wafer surface during the CMP process are common problems.

The slurry may be introduced to the CMP system in any desired manner, for example, at the center of the rotating pad. The centrifugal forces associated with the rotating pad force the slurry towards the outer edges of the pad. The slurry, if unimpeded, will continue to move beyond the outer edge of the wafer and pad, exiting the system. It is often impractical to reuse this slurry if, for example, it becomes contaminated. It is therefore economically advantageous to reduce the amount of slurry run-off.

Presently known CMP processes are also deficient in controlling the asymmetrical or otherwise non-uniform distribution of slurry across the surface of the wafer being planarized. For example, as the slurry migrates to the outer edges of the pad, a much larger pad surface area must be covered with a decreasing amount of slurry. Many pad designs contain grooves or channels cut into the surface of the pad that are intended to guide the slurry during the CMP process. Presently known designs, however, have not effectively directed the slurry to specific areas of the pad/work piece.

During CMP, different locations on a wafer can also get hotter than other points on the wafer. Therefore, some areas on the wafer will need more slurry to help regulate the temperature over the surface of the wafer. As the temperature increases, the reaction rate between the slurry and wafer generally increases, due to an increase in the rate constant of the reaction. Therefore, when there is an increase in temperature at one position of the wafer, the reaction rate increases, which can cause an asymmetrical planarization on the wafer. These areas are referred to as "hot spots."

Therefore, a need exists for a polishing pad for improving the planarization of wafers or other work pieces (such as, for example, LCD glass, optical glass, glass wafers, and float glass products) during CMP and other polishing processes. More preferably, a need exists to guide the flow of slurry during CMP, thereby maximizing the planarization of a wafer or similar work piece.

Summary of the Invention

These and other aspects of the present invention will become more apparent to those skilled in the art from the following non-limiting detailed description of preferred embodiments of the invention taken with reference to the accompanying figures.

In accordance with an exemplary embodiment of the present invention, a polishing pad for planarizing a surface of a work piece is provided. More preferably, a polishing pad that can be used during CMP is provided.

As described in greater detail below, each pad comprises a "pad circle" at each particular radius of the pad. The pad circle associated with any given point on a pad may be defined as a circle that has its center at the center of the polishing pad, and a radius which corresponds to the radius of the polishing pad at that given radius. Stated another way, a pad circle is a construct or conceptual tool, wherein each pad circle has the rotational, vertical axis of the pad as its center and a pad circle radius of any arbitrary value less than or equal to the radius of the pad.

The pad comprises channels that are cut into the pad. These channels are designed to guide the flow of the slurry used during CMP. The channels are used to help prevent slurry run-off, provide a symmetrical distribution of slurry throughout the wafer, and to direct slurry to specific areas on the wafer where it may be needed, such as, for example, at a "hot spot."

Another aspect of one embodiment of the present invention comprises channels that are substantially orthogonal to any given pad circle.

In accordance with another aspect of the present invention, the polishing pad contains a plurality of channels. Each of the channels is used to guide the slurry to, or maintain the slurry in, a particular location on the pad. In one embodiment, each of the channels has a first end and a second end, the second end having a greater radius than the first end.

In accordance with another aspect of the present invention, each channel has deviation in its radial and circular components. As you move along a channel from the center of pad the outer edge of the pad the radial component of the channel gets larger and larger. The circular component on the other hand, does not deviate as substantially as the radial component, and in some instances there may not be any change.

Brief Description of the Drawings

Exemplary embodiments of the present invention will hereafter be described in conjunction with the appended drawing figures, wherein like designations denote like elements, and:

Figure 1 is a schematic drawing of a chemical mechanical polishing apparatus;

Figure 2 is a top view of prior art polishing pads;

Figure 3 is a top view of prior art polishing pads;

Figure 4 is a cross-sectional view of a polishing pad in accordance with an exemplary embodiment of the present invention;

Figure 5 is a top view of a polishing pad in accordance with an exemplary embodiment of the present invention;

Figure 6 is a top view of a polishing pad in accordance with an exemplary embodiment of the present invention comparing the radial and circular deviations of a channel;

Figure 7 is a top view of polishing pad in accordance with another exemplary embodiment of the present invention;

Figure 8 is a top view of a polishing pad in accordance with another exemplary embodiment of the present invention;

Figure 9 is a top view of a polishing pad in accordance with an exemplary embodiment of the present invention;

Figure 10 is a top view of a polishing pad in accordance with an exemplary embodiment of the present invention; and

Figure 11 is a top view of a polishing pad in accordance with an exemplary embodiment of the present invention.

Detailed Description

The following description is of exemplary embodiments only and is not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the following description provides a convenient illustration for implementing exemplary embodiments of the present invention. Various changes to the described embodiments may be made in the function and arrangement of the elements described without departing from the scope of the invention as set forth in the appended claims.

With Reference to Figure 1, a wafer polishing apparatus 100 is shown. Typical polishing of a work piece involves pressing the work piece against a polishing pad 20. Preferably, pad 20 is rotating about its axis. It should be noted, however, that pad 20 may also move in a "back and forth" motion, or alternatively may comprise a continuous belt. In addition, it is preferable for a carrier element 124 to rotate the work piece around its axis. The carrier element 124 may also oscillate the work piece back and forth across the rotating pad. During CMP, slurry is added to the system between pad 20 and the work piece.

With reference to Figure 4, the exemplary polishing pad in accordance with the present invention has a top layer 11, an adhesive layer 12, and a bottom layer 13. The top layer is preferably made out of polyurethane, but can be any known or hereinafter developed material used to planarize a surface. The bottom layer may comprise polyurethane, polycarbonate, or some type of "soft" material, such as, for example, a felt pad. It should be noted that any material now known or hereinafter developed may be used to make the pad. For optimum planarization it is typical for a softer pad to be below a stiffer pad. This allows the stiffer pad to flex over global variations in the wafer, providing a more uniform surface over the work piece.

The adhesive layer 12 may comprise a heat sensitive or pressure sensitive adhesive. In one embodiment of the present invention the adhesive layer 12 comprises only a single layer of adhesive. In another embodiment of the present invention, adhesive layer 12 may comprise a Mylar film positioned between two adhesives layers on each side of the Mylar film.

Referring to Figures 4 and 5, an exemplary polishing pad in accordance with the present invention is shown. Preferably, channels 30 are cut into top layer 11 of pad 20. Multiple channels 30 are cut into the polishing surface 22 of pad 20. Each channel 30 has side walls 31 and a bottom wall 32. As shown in Figure 5, an exemplary embodiment of the present invention has walls substantially perpendicular to polishing surface 22, and a bottom wall that comprises a substantial circular shape. It should be noted however, that other geometries of channel 30 may be used. For example, the bottom wall 32 may be perpendicular to the side walls 31. In yet another embodiment, the channels are substantially cylindrical. In a further embodiment of the present invention, the channels may be substantially triangular. Stated in another way, the side walls 31 slant towards one another and there is a small bottom wall 32, or no bottom wall at all. Any geometry may be used for the channel shape.

Preferably, channels 30 are cut into pad 20 with a technique that allows for incomplete penetration of top layer 11. This prevents the adhesive layer 12 from contacting slurry, water, or any other components used in polishing, lapping, or surfacing a work piece. Examples of such techniques include, but are not limited to, punching, laser, or CNC methods. It should be noted that any now known or hereinafter developed technique used to cut channels into the pads may be used. Upon completion of cutting the channels into pad 20, the top layer may be sanded down or treated.

Each channel has a width W_C and a depth D_C. In an exemplary embodiment of the present invention, W_C is from about 0.1 mm and 4 mm. More preferably, W_C is from about 0.3 mm to about 3 mm. Optimally, W_C is from about 0.5 to about 2 mm. DC is from about 0.2 mm to about 4 mm. More preferably, DC is from about 0.4 to about 3 mm. Optimally, DC is from about 0.5 to about 2 mm.

As demonstrated in Figure 5, it is preferable for a subset of channels 30 to have a first end 35 and a second end 36. Furthermore, as demonstrated in Figure 5, every channel 30 may have a first end 35 and a second end 36.

With reference to Figure 6, each channel has deviation in its "radial" and "circular" components. Radial refers to the directional component of a channel that moves directionally from the center of the pad towards the outer edge or vice versa. Circular, on the other hand, refers to the directional component of a channel that moves rotationally around the center axis of the pad. As a channel moves from one end to the other, the radial component of the channel will have a large deviation. The circular component on the other hand, does not deviate as substantially as the radial component, and in some instances there may be no deviation. For example, when comparing two separate points along channel 30, P_1 and P_2, each has a radial component RC and a circular component θ. RC_1 is going be less than RC_2. The difference between θ_1 and θ_2 will not be as great.

Another preferred aspect of the present invention is that the deviation of the circular component is related to the direction of rotation of pad 20. For example, with continued reference to Figure 6, pad 20 is rotating in direction 60. Therefore, arrow 65 shows the direction of deviation between the circular components of P_1 and P_2, which is in the same circular direction as arrow 60.

With reference to Figure 5, for each radius R of pad 20, there is a corresponding pad circle 40 that has a corresponding radius of R and has its center at the center of pad 20. Stated another way, a pad circle is a construct or conceptual tool, wherein each pad circle has the rotational, vertical axis of the pad as its center and a pad circle radius of any arbitrary value less than or equal to the radius of the pad.

In accordance with one aspect of the present invention, channel 30 is closer to being orthogonal to any pad circle as opposed to parallel to it. Furthermore, there is a substantial amount of deviation between pad circle 40 and channel 30. For example, as channel 30 extends along the surface of pad 20, there is a wide range of distances between any pad circle 40 and channel 30. On the other hand, with reference to Figure 2, the prior art has practically no deviation between a pad circle and the channel. Any particular channel of the prior art has a radius, and the pad circle for that particular radius deviates very little if at all from the channel.

With Reference to Figure 7, an exemplary embodiment of the polishing pad, more channels 30 can be placed on particular locations of the pad as needed. For example, due to non-uniformities of temperature across the surface of the work piece, it may be necessary to manipulate the slurry to the location on the work piece that has a higher temperature.

Figure 8 demonstrates another exemplary embodiment of the present invention. The pad contains sets of circular channels. Each circular channel 50 is within a group of circular channels that forms a circular channel set 55. Each of the circular channels 50 within an circular channel set 55 has a common center. Each circular channel set is surrounded by six other circular channel sets, except at the outer edges of the pad. Similar to prior embodiments described above, this embodiment helps prevent run-off of slurry. In addition, the embodiment depicted in Figure 8 manipulates slurry to locations on the work piece than may need additional slurry.

Figure 9 demonstrates yet another exemplary embodiment of the present invention. Wherever there is a greater need for slurry, a circular channel set 55 can be placed on the pad to help maintain the proper uniformity of temperature across the work piece surface. It should also be noted that shapes other than circles may be used to produce the same results. For example, Figure 10 shows hexagons, and Figure 11 shows pentagons. Any shape can be used in place of circles.

In the foregoing specification, the invention has been described with reference to specific embodiments. However, it may be appreciated that various modifications and changes can be made without departing from the scope of the present invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than restrictive sense, and all such modifications are intended to be included within the scope of the present invention.

CLAIMS

What is claimed is:

1. A polishing pad for use in supporting work in CMP and similar polishing and lapping operations, comprising channels cut into the surface to effect the flow of slurry and characterized by concentric pad circles having an axis at the axis of rotation of the rotating pad, improved wherein:

said multiple channels are substantially orthogonal to a first pad circle; and

the deviation of the radial component of any of said multiple channels is substantially greater than any deviation of the circular component as said channel extends from the center of the pad outward.

2. The polishing pad of claim 1, wherein at least a subset of said multiple channels comprise a first end and a second end.

3. The polishing pad of claim 1, wherein at least a portion of the length of at least one of said multiple channels extends along the surface of said pad at varying distances from said pad circle.

4. The polishing pad of claim 1, wherein said at least one of said multiple channels circular component deviates outwardly in the same direction said pad rotates.

5. The polishing pad of claim 1, further comprising extra channels to compensate for hotter temperatures on the wafer.

6. A polishing pad comprising:

multiple channels;

wherein said channels are positioned in groups of like shapes having common centers; and

wherein said groups are adjacent to at least one other of said groups, wherein each group has a separate common center.

7. The polishing pad of claim 6, wherein said shapes are circles.

8. The polishing pad of claim 7, wherein each of said groups is adjacent to six other said groups, except at the edges of said pad.

9. The polishing pad of claim 8, wherein each of said groups is adjacent to at least three other of said groups

10. The polishing pad of claim 6, wherein said shapes are hexagons.

11. The polishing pad of claim 6, wherein said shapes are pentagons.

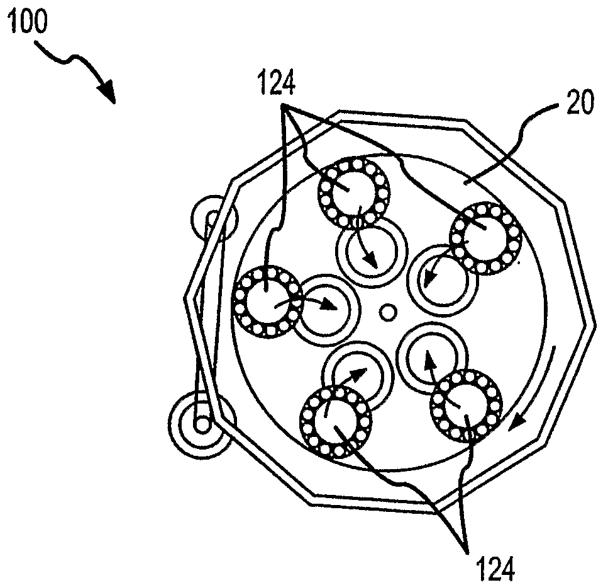

FIG.1

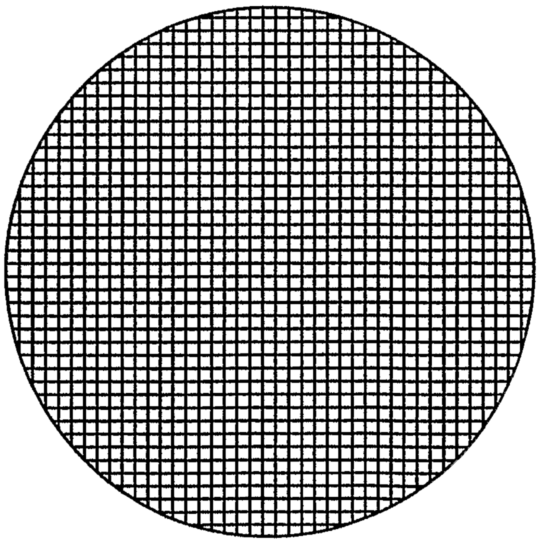

FIG.2
PRIOR ART

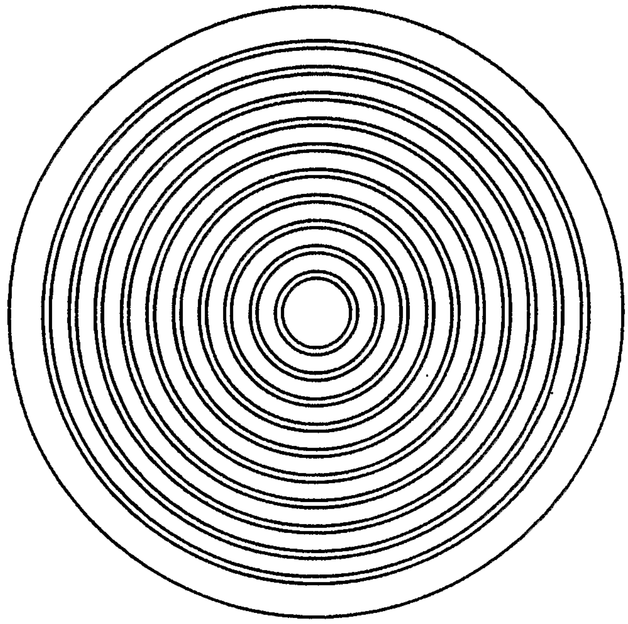

FIG.3
PRIOR ART

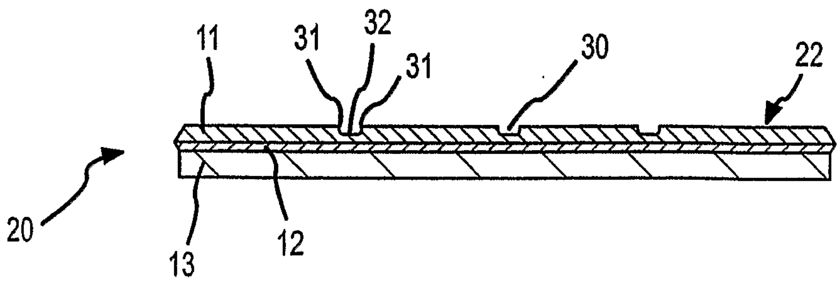

FIG.4

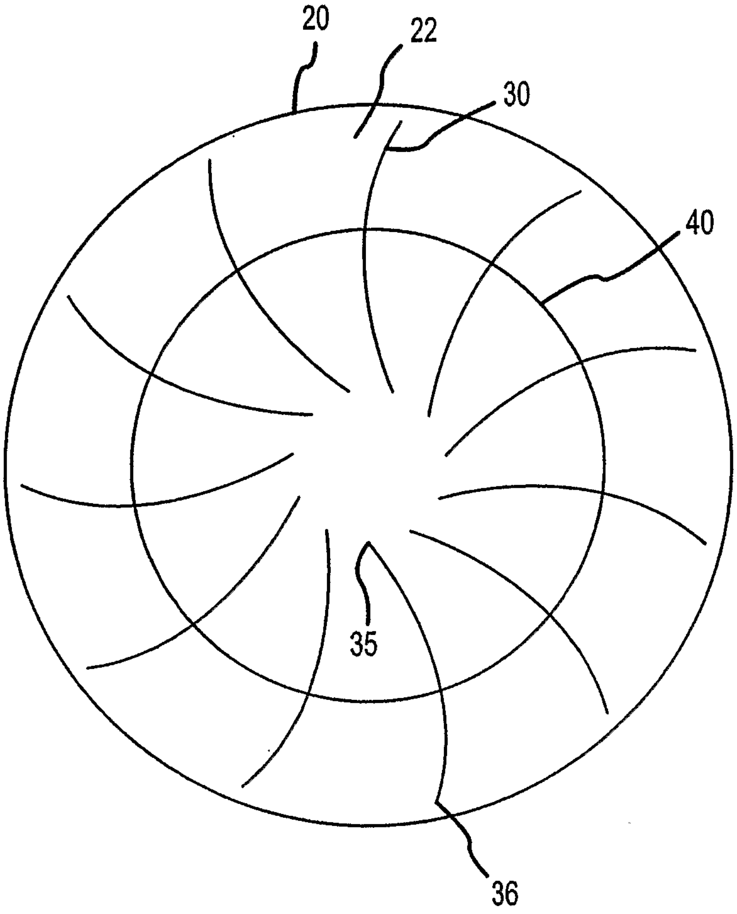

FIG.5

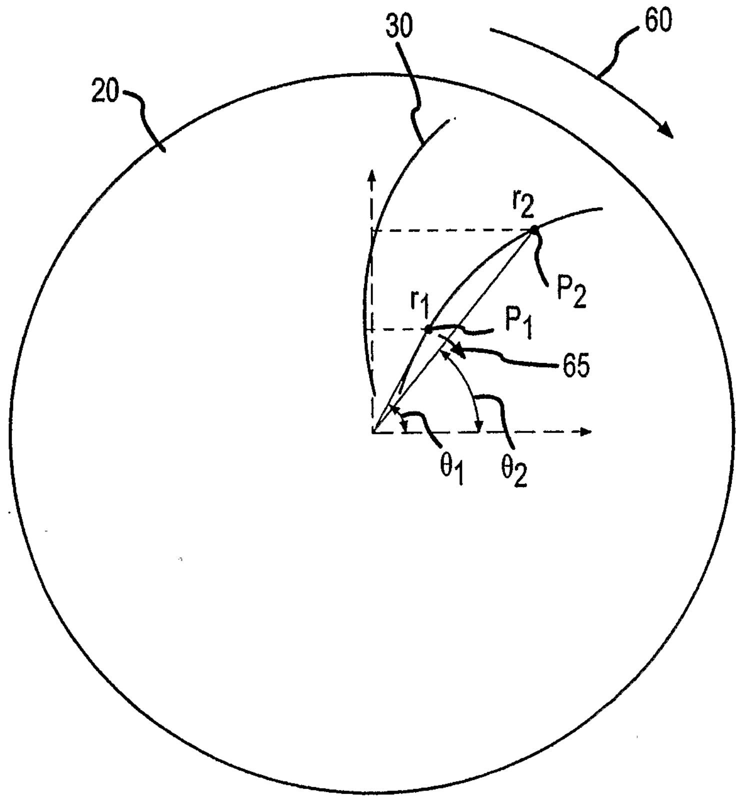

FIG.6

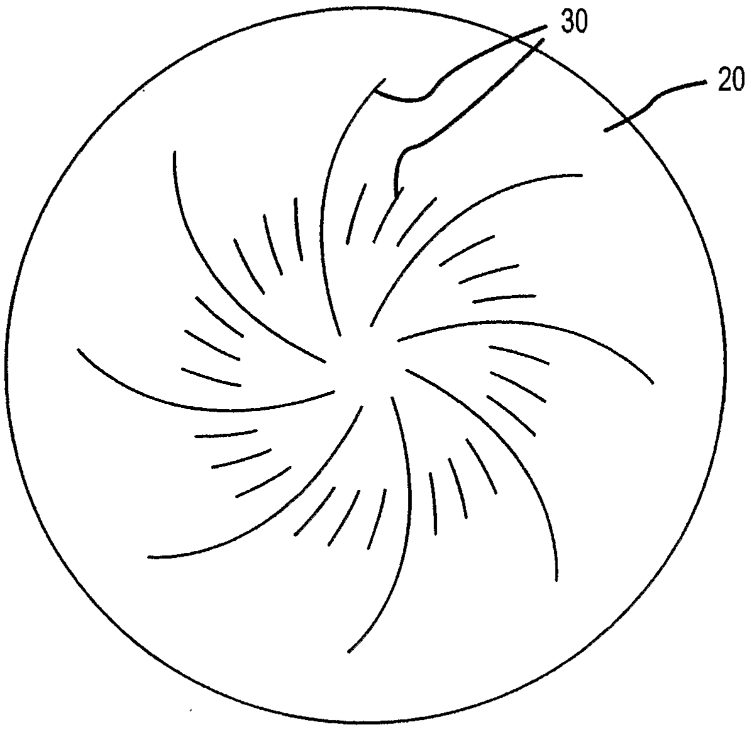

FIG.7

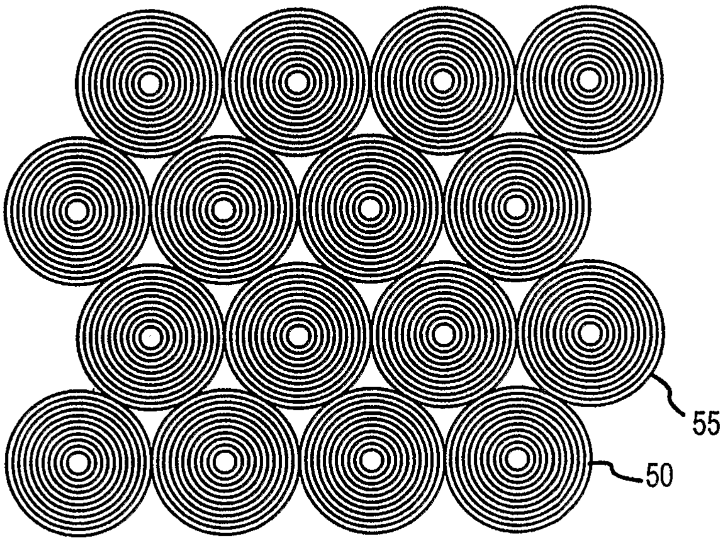

FIG.8

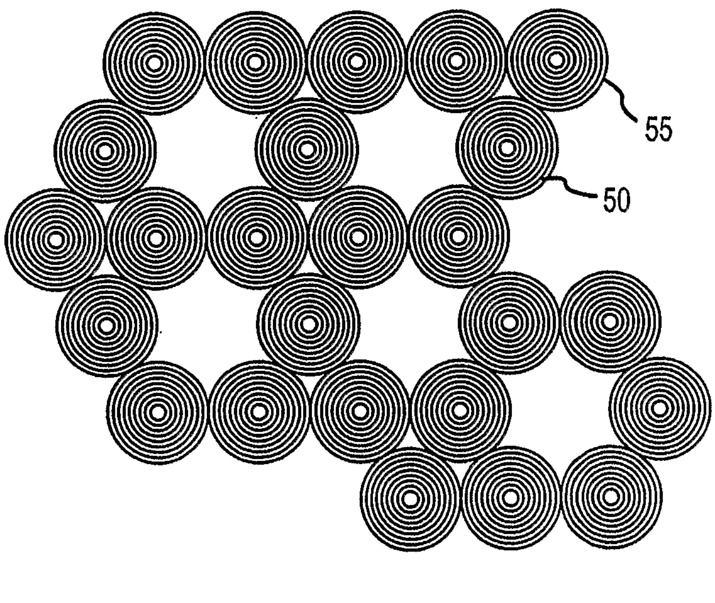

FIG.9

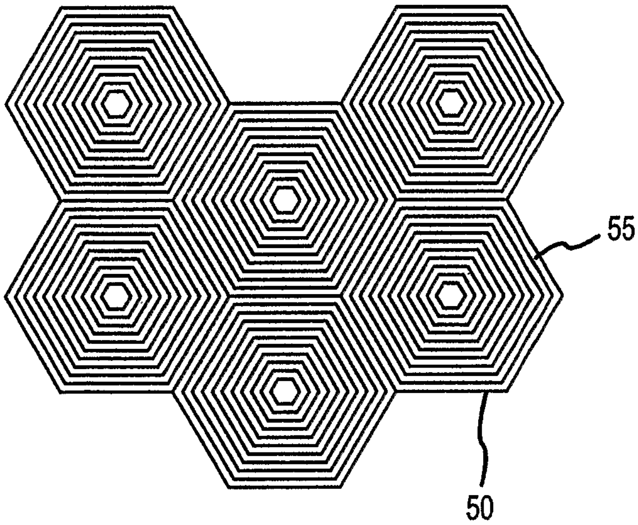

FIG.10

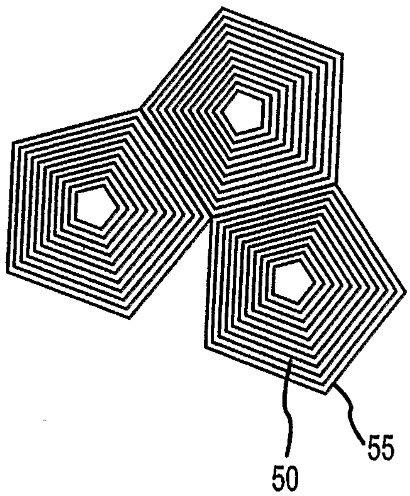

FIG.11