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Nguyen

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(45) **Date of Patent: *Dec. 23, 2003**

(54) **SILICON WAFER POLISHER**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 234 days.

This patent is subject to a terminal disclaimer.

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(22) Filed: **Jul. 18, 2001**

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Related U.S. Application Data

(63) Continuation-in-part of application No. 09/840,506, filed on Apr. 23, 2001.

(51) **Int. Cl.**[7] **B24B 1/00**
(52) **U.S. Cl.** **156/345.12**; 156/345.22; 451/66; 134/113; 216/38
(58) **Field of Search** 156/345.22, 345.12; 451/66; 134/113

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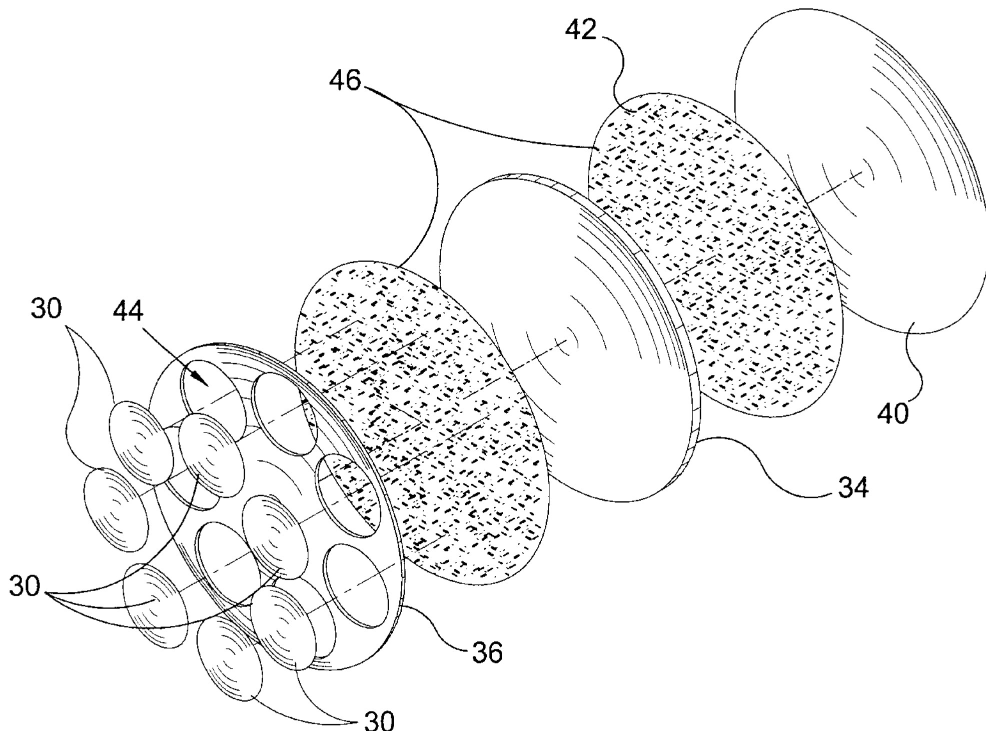
(57) **ABSTRACT**

An method and apparatus for forming wafers of varying thickness'. The apparatus includes a template. The template is formed of a main disk including a plurality of cavities extending into a first side thereof and a backing plate positioned on a side of the main disk opposite the first side. Holding disks are moistened and positioned within respective cavities for releasably securing a wafer in the cavity. When the template is releasably secured to and rotatable with a rotating head and positioned such that the first side faces a lapping and polishing surface, wafers received by the cavities are lapped and polished upon rotation of the rotating head. A plurality of shims are selectively received within respective cavities between a base of the cavity and the holding disk for adjusting a depth of the cavity thereby adjusting an amount of a wafer to be lapped and polished. The shims have varying thickness' and are color coated, each color being representative of a predetermined thickness for the shim. A mylar layer is bonded to a side of the backing plate opposite the main disk. A liquid is provided atop the lapping and polishing surface upon rotation of the templates.

39 Claims, 21 Drawing Sheets



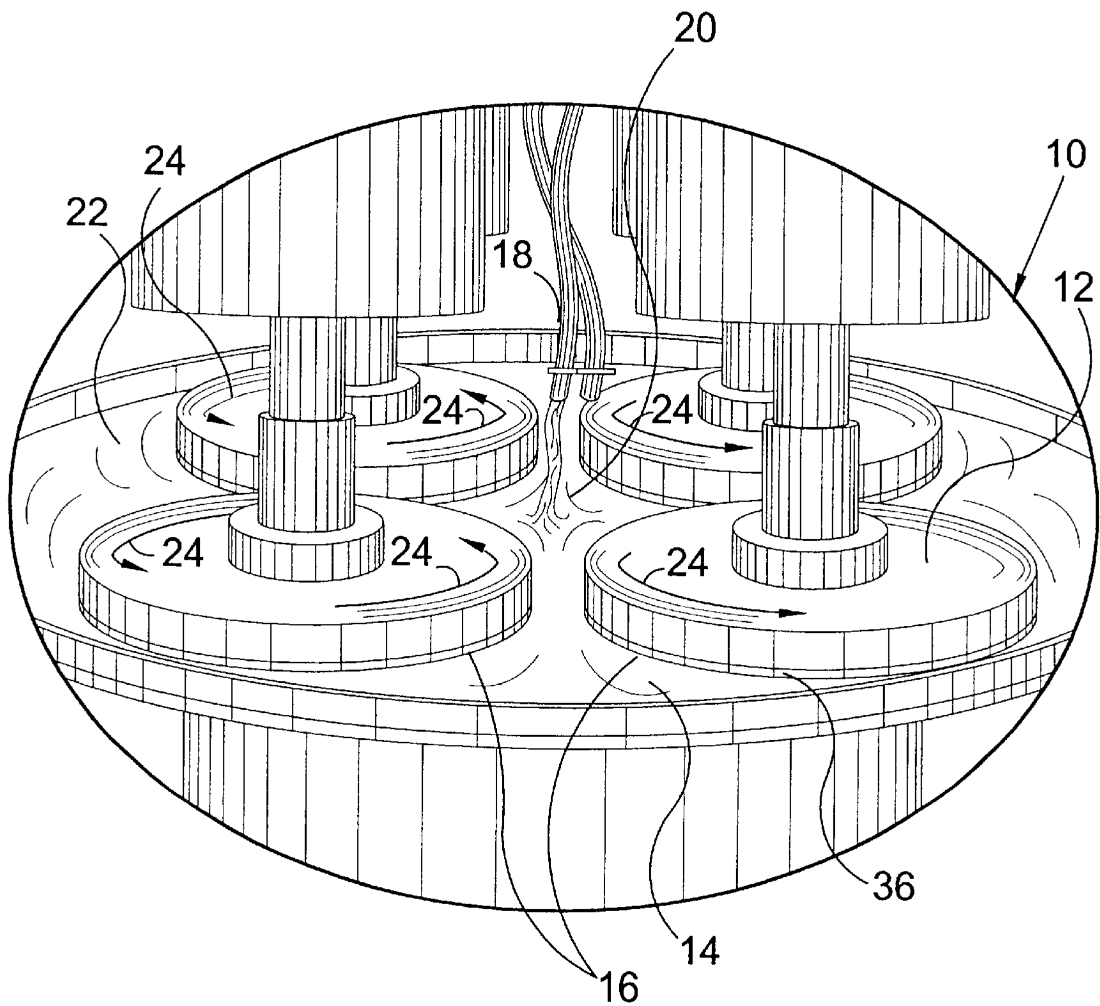


FIG. 1

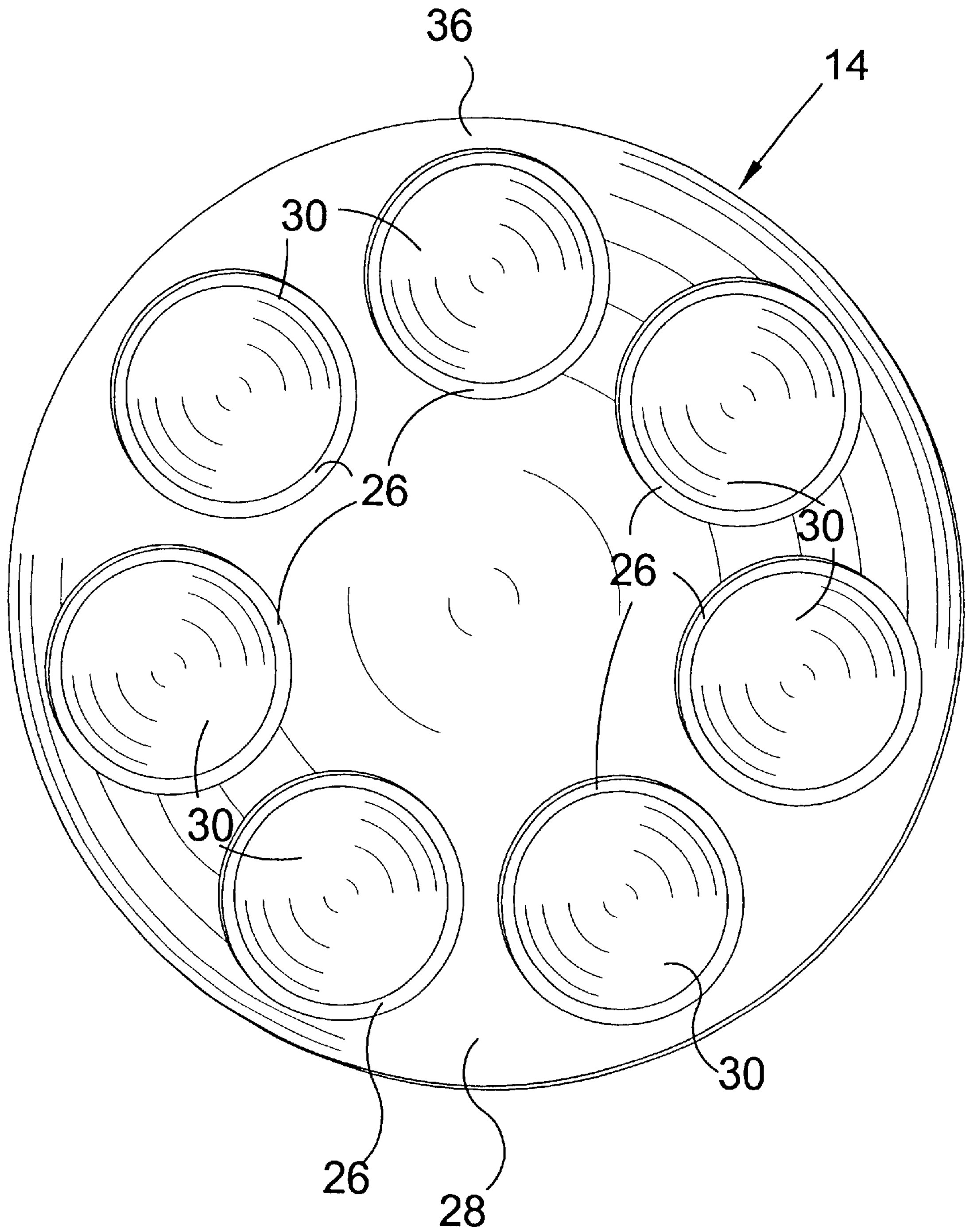


FIG. 2

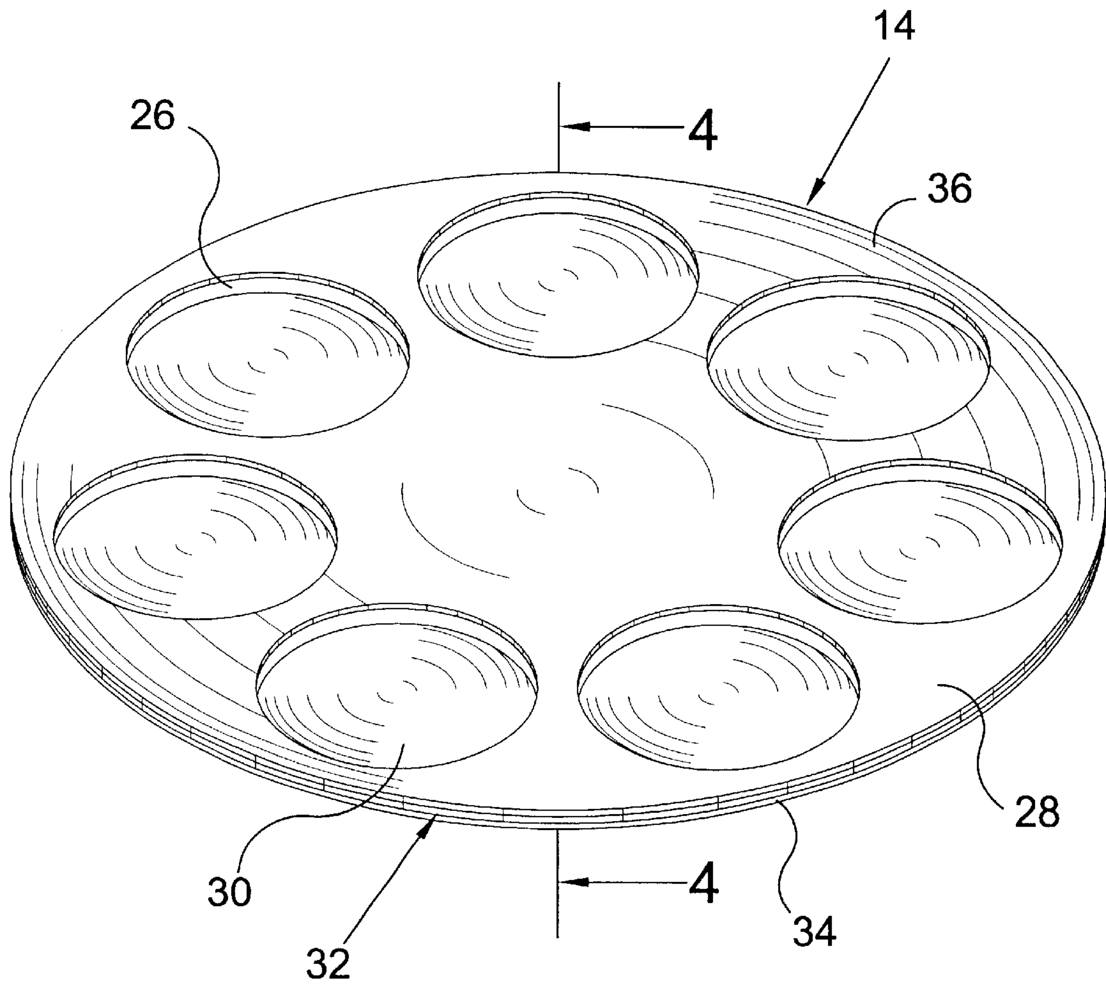


FIG. 3

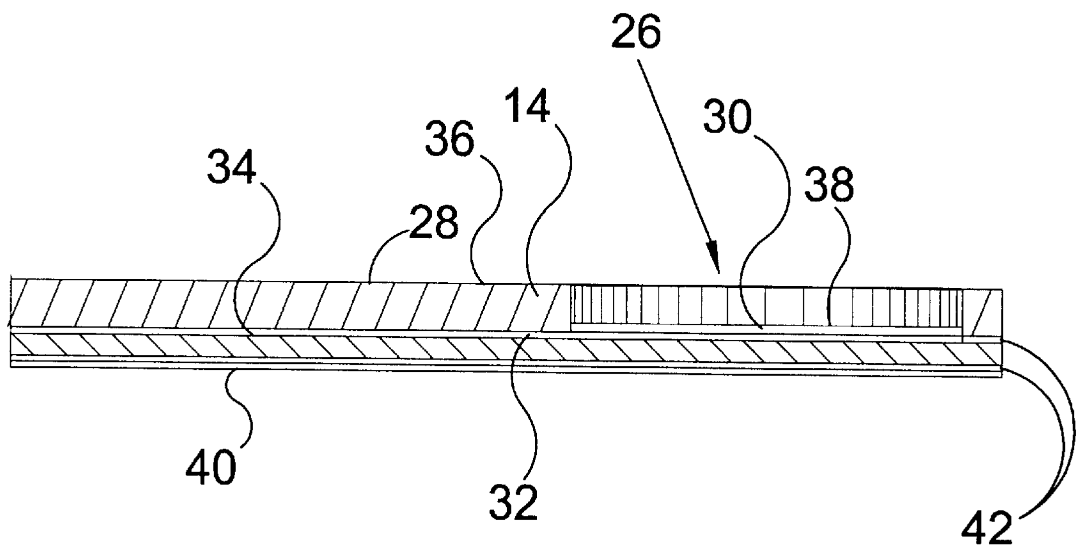


FIG. 4

FIG. 5

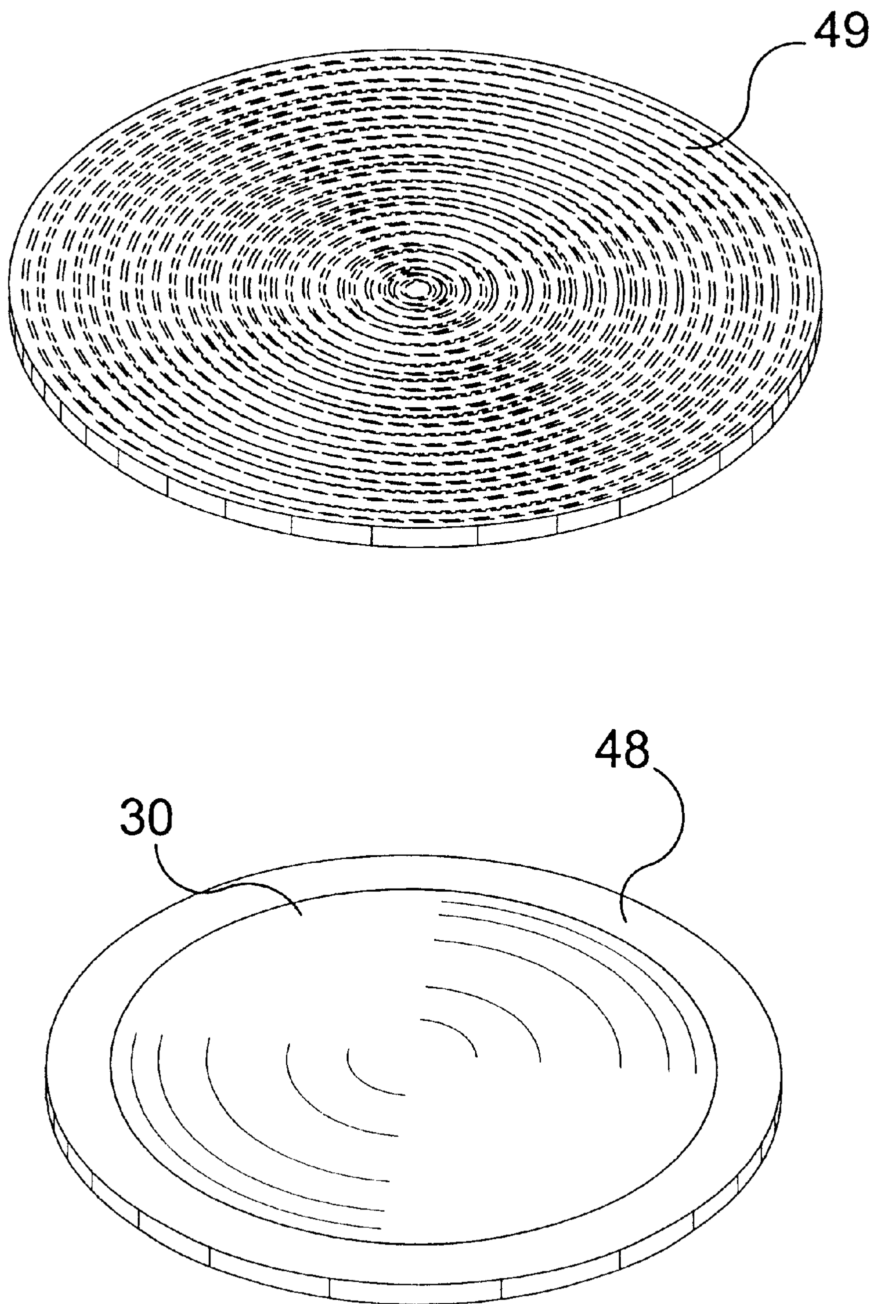


FIG. 6

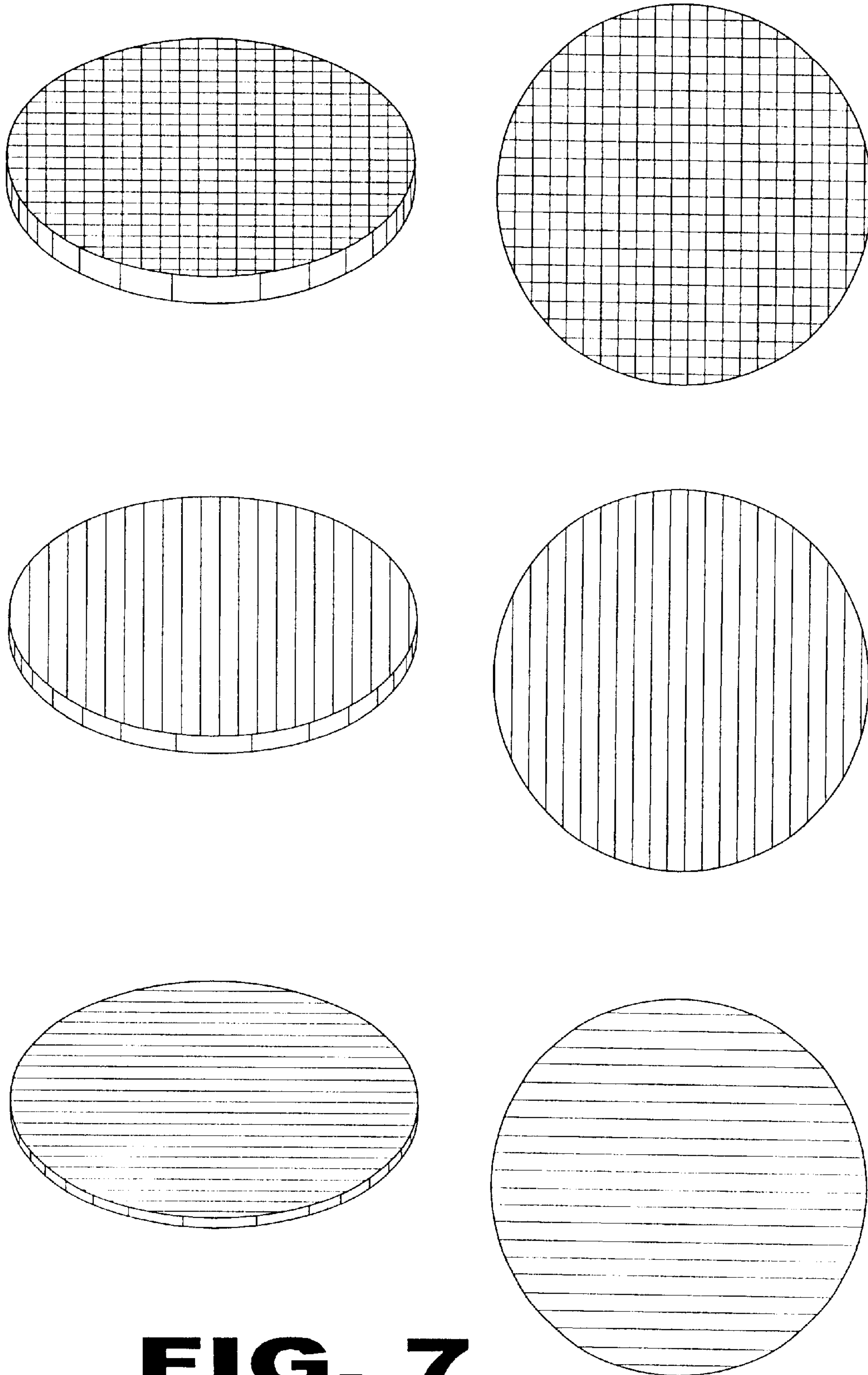


FIG. 7

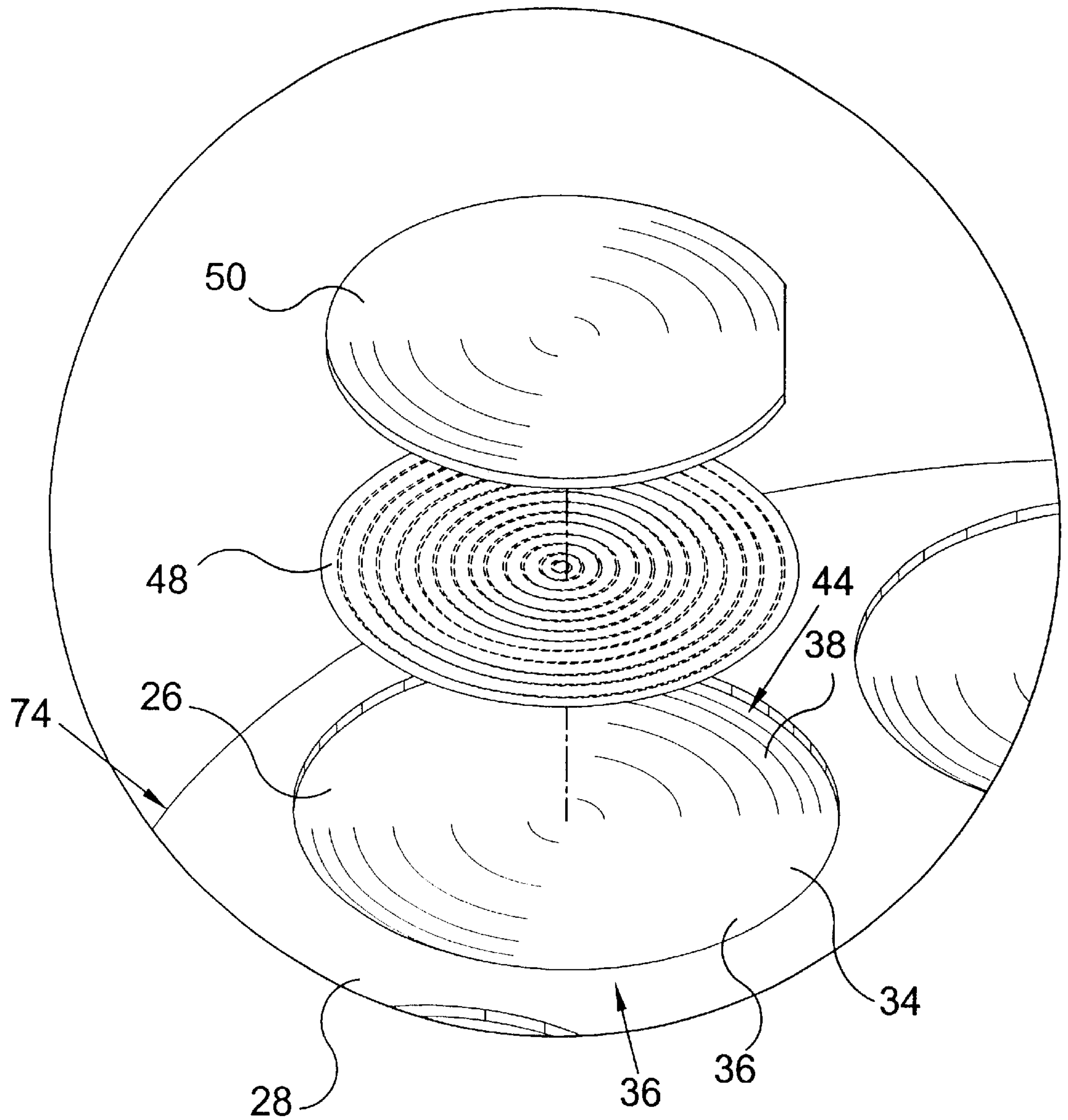


FIG. 8

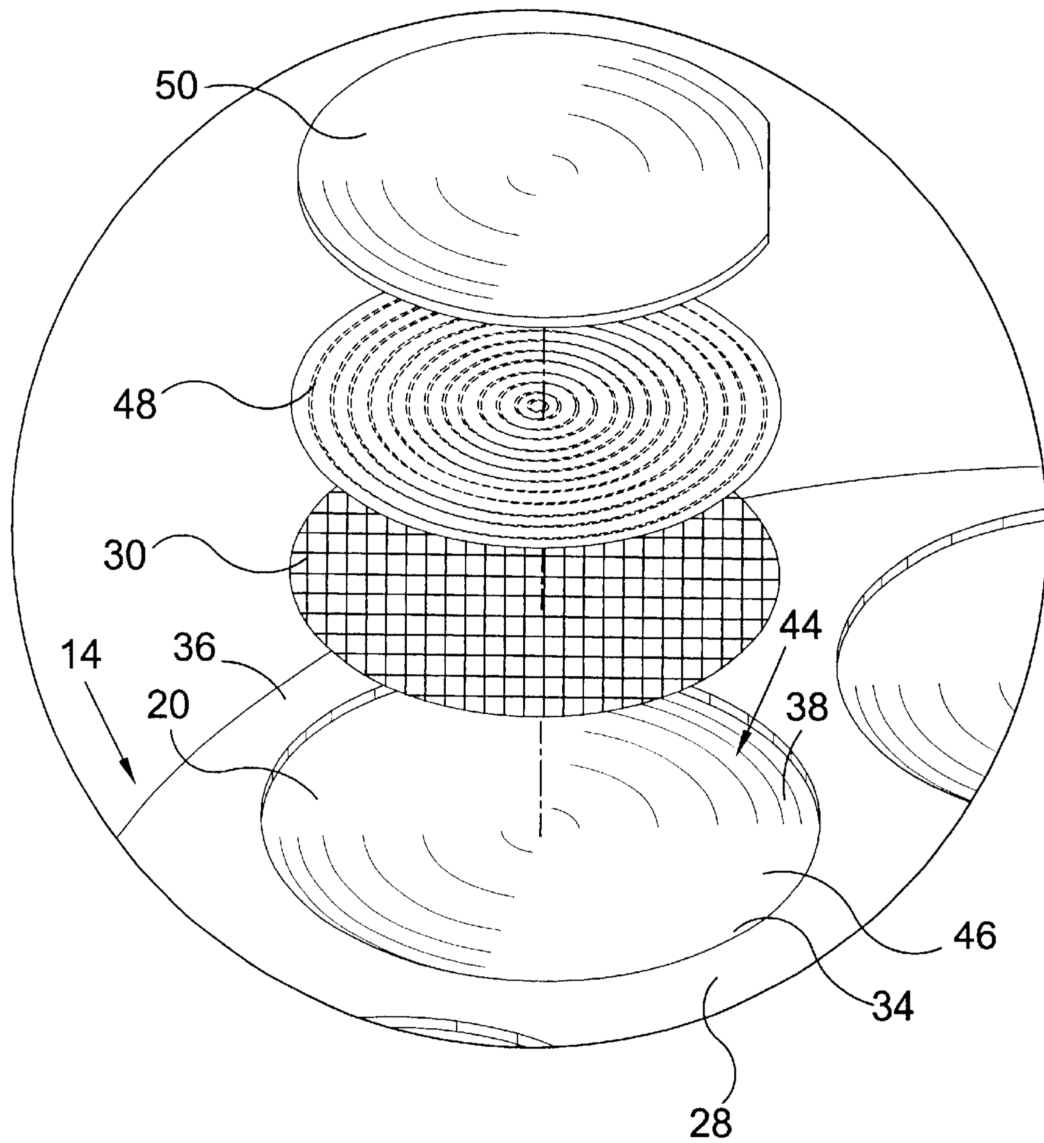


FIG. 9

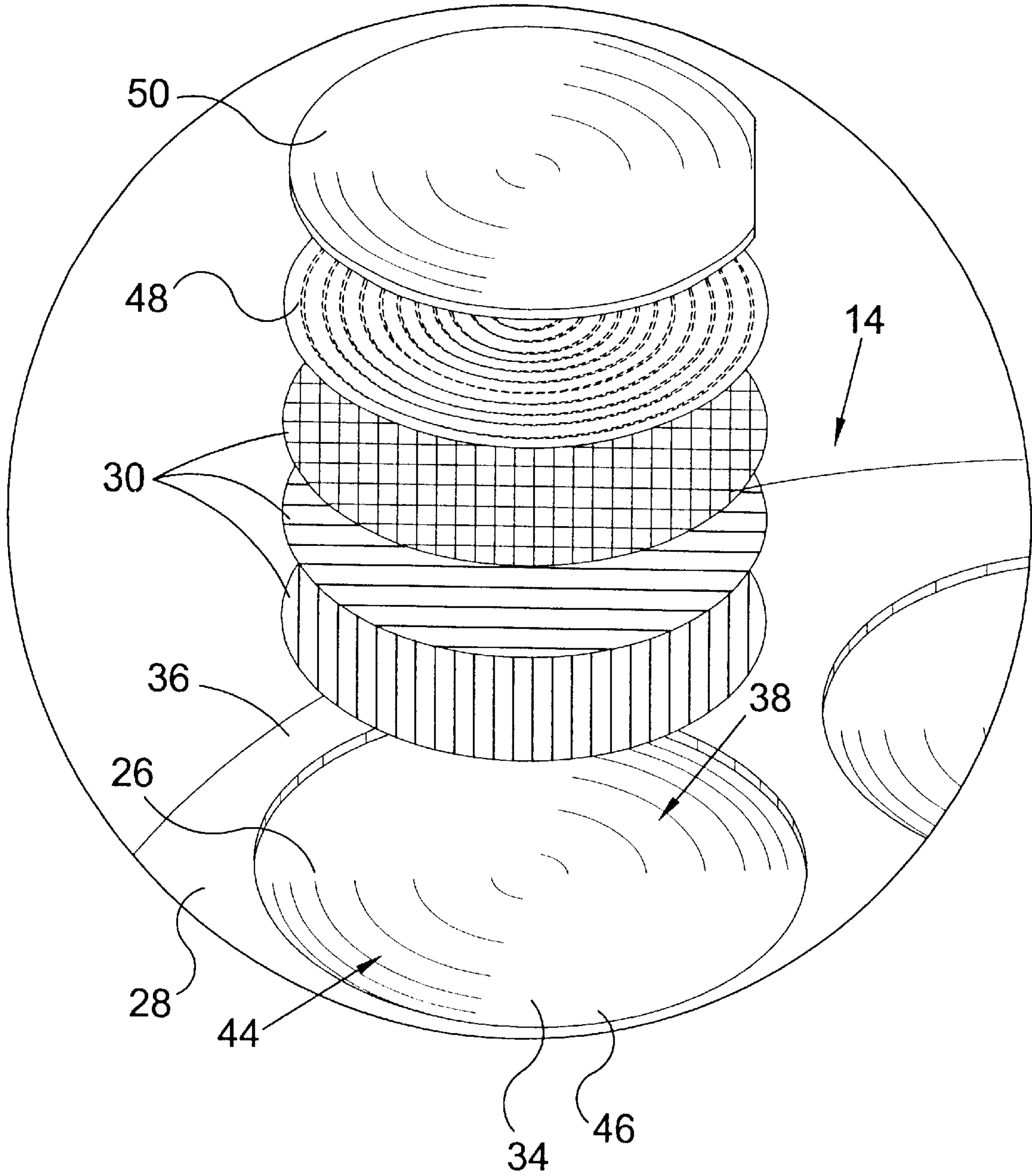


FIG. 10

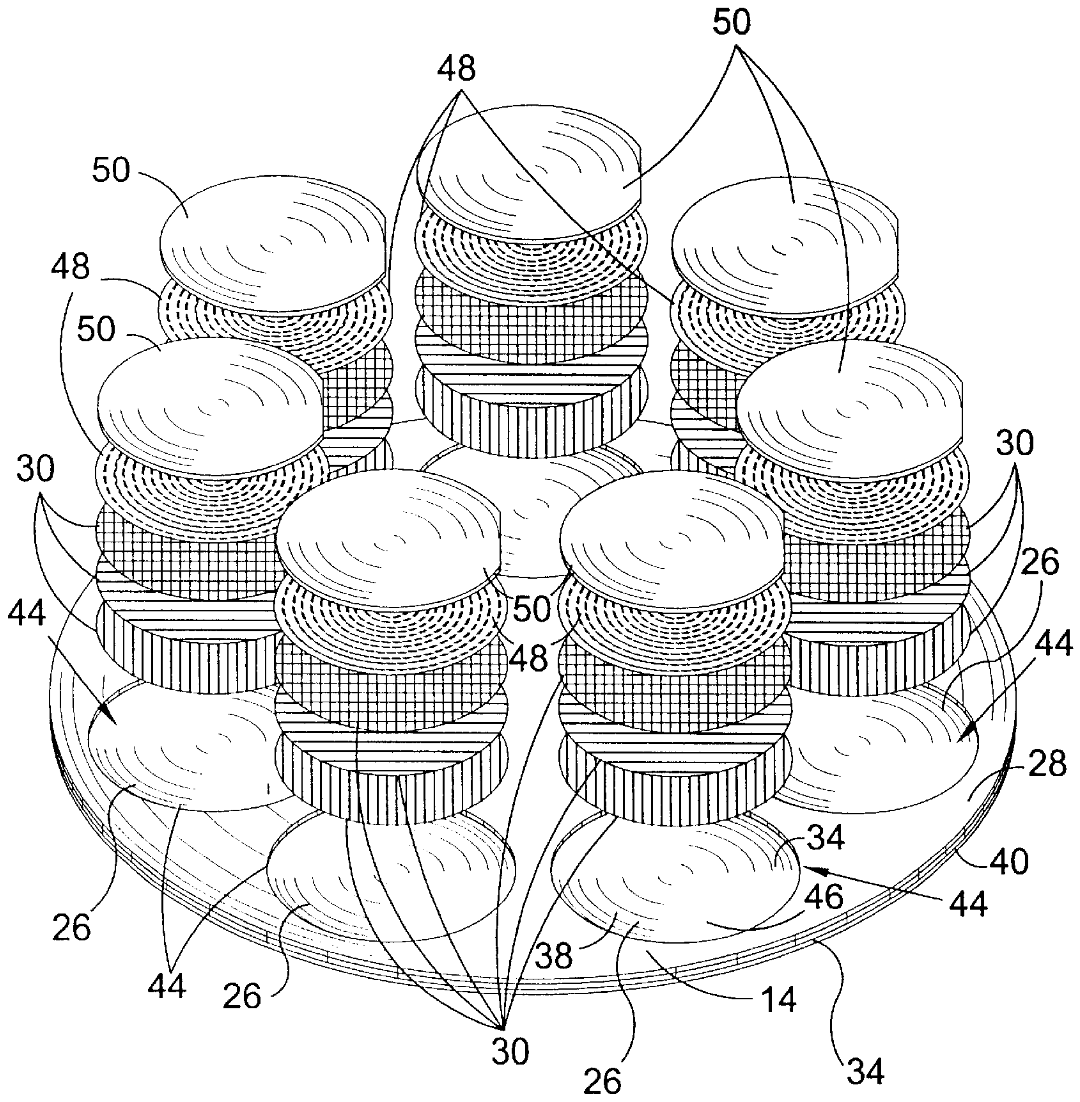


FIG. 11

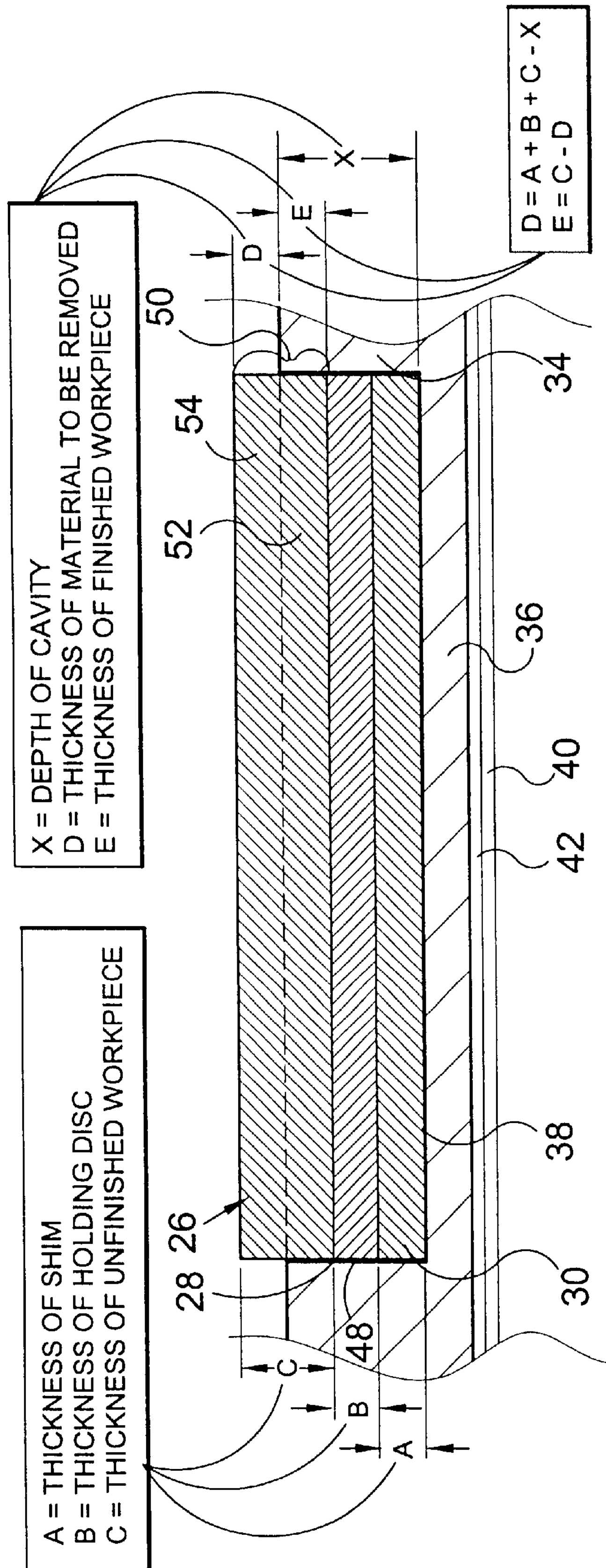


FIG. 12

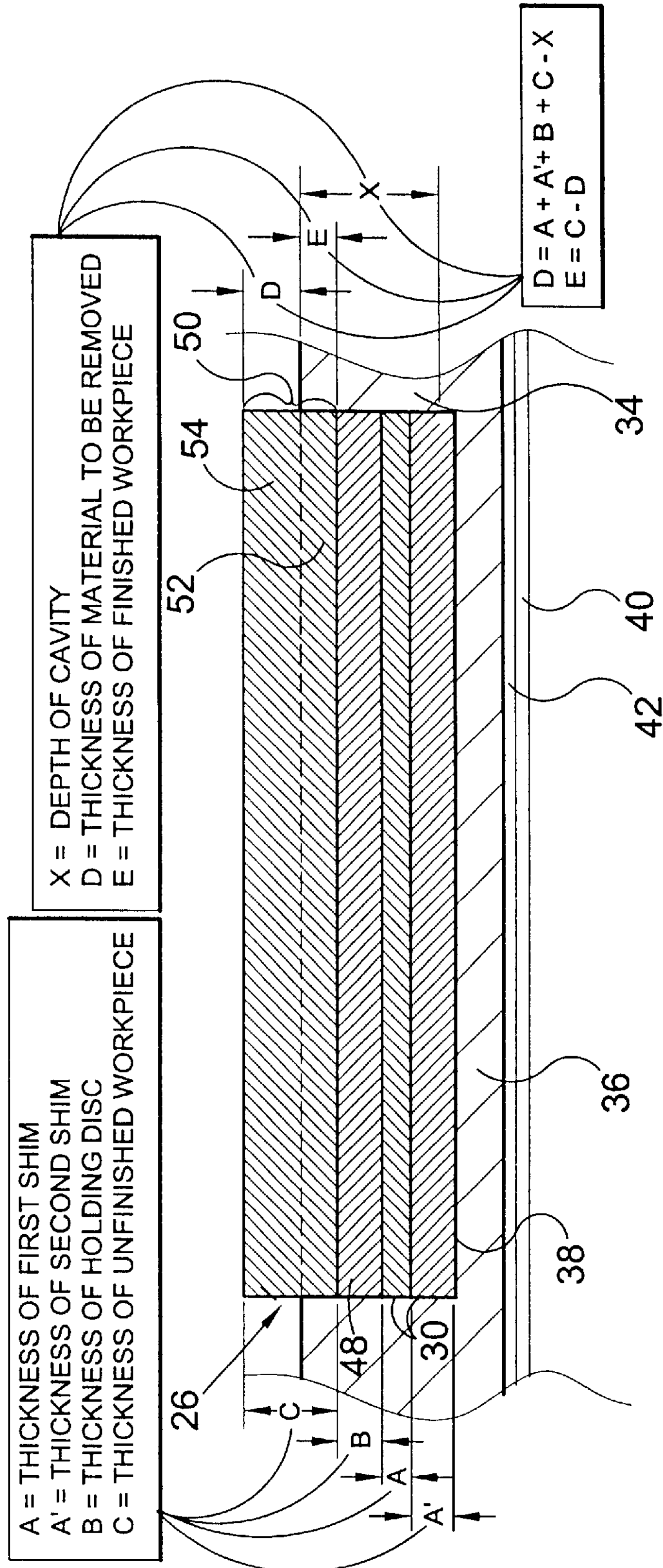


FIG. 13

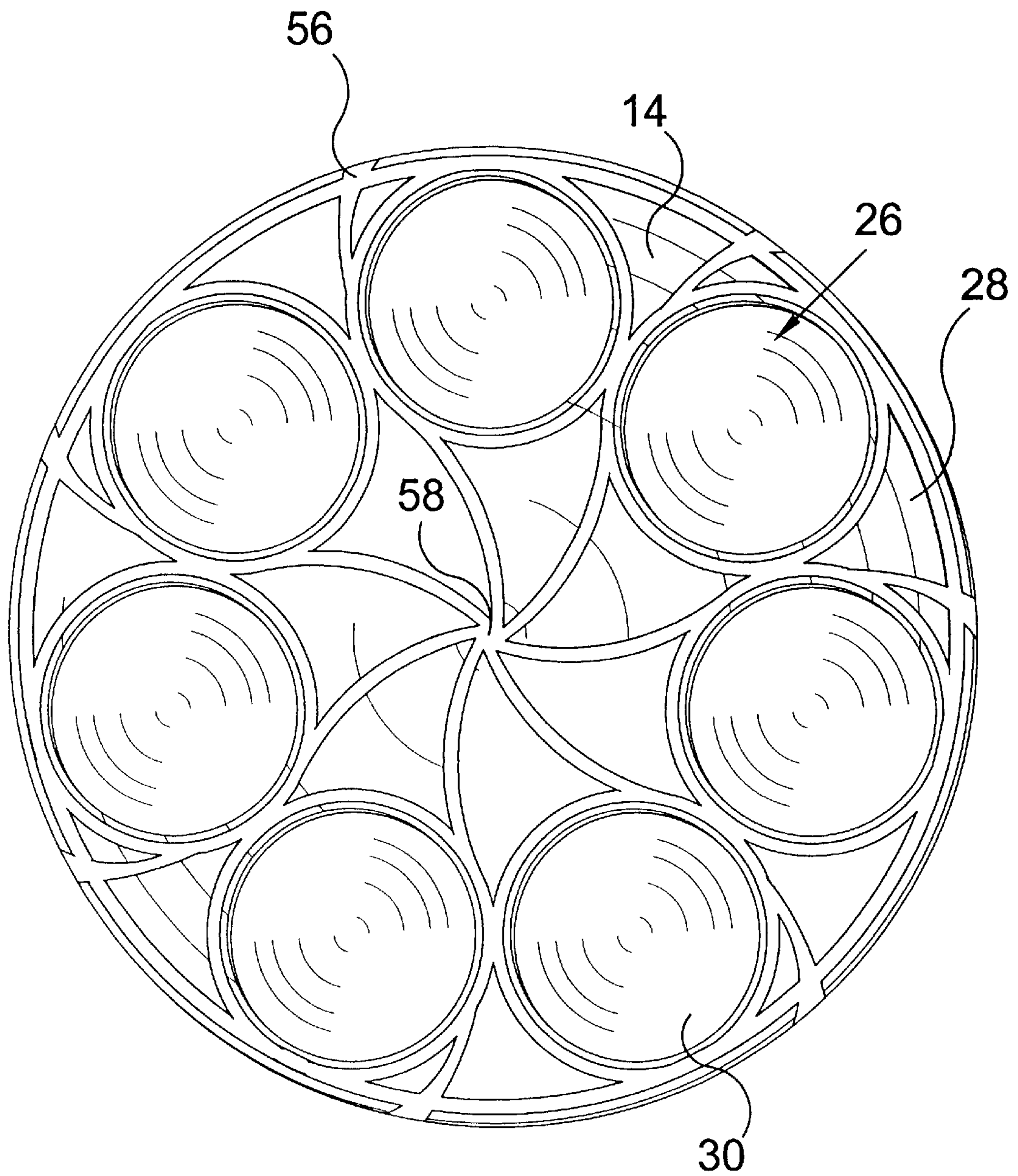


FIG. 14

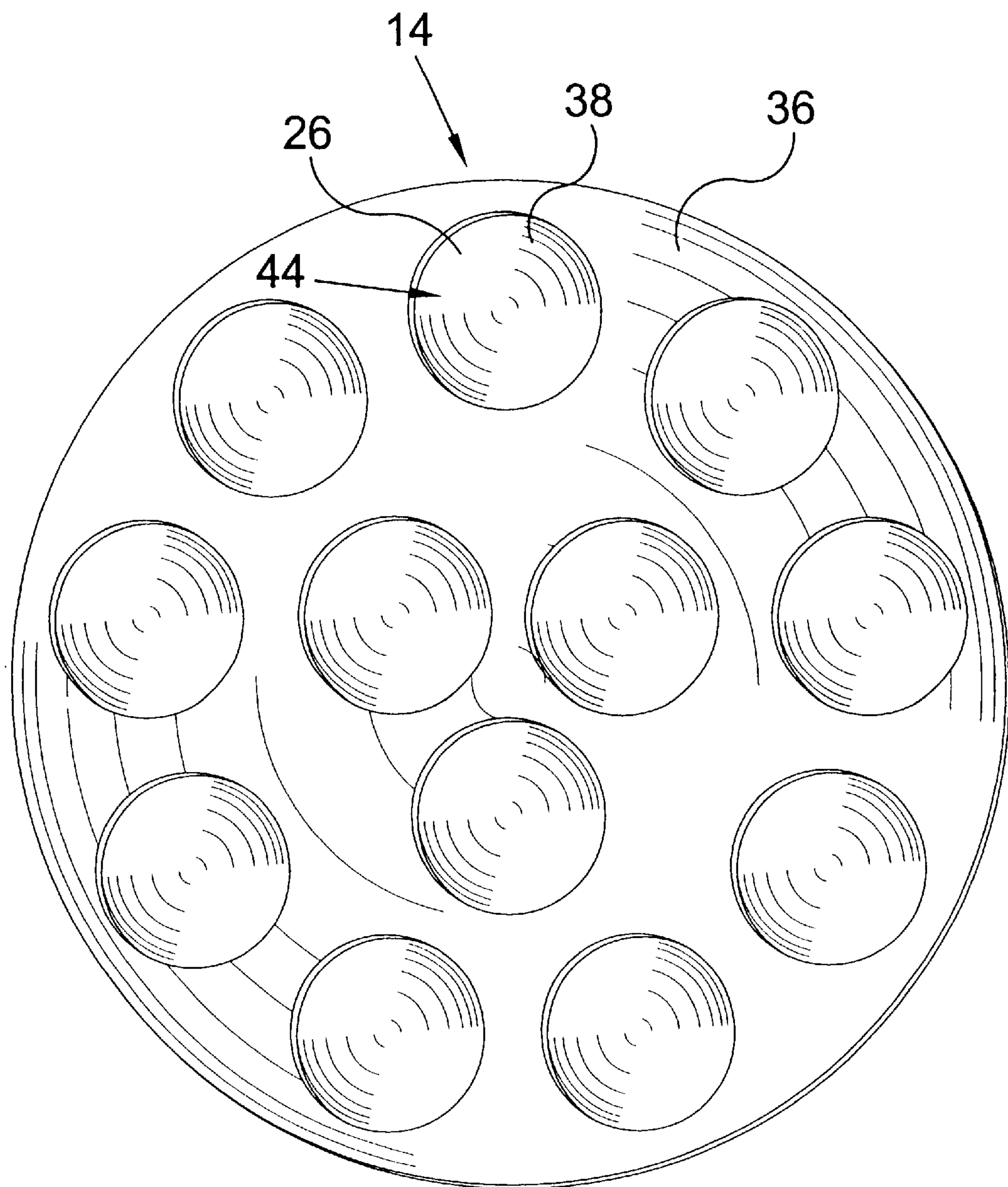


FIG. 15

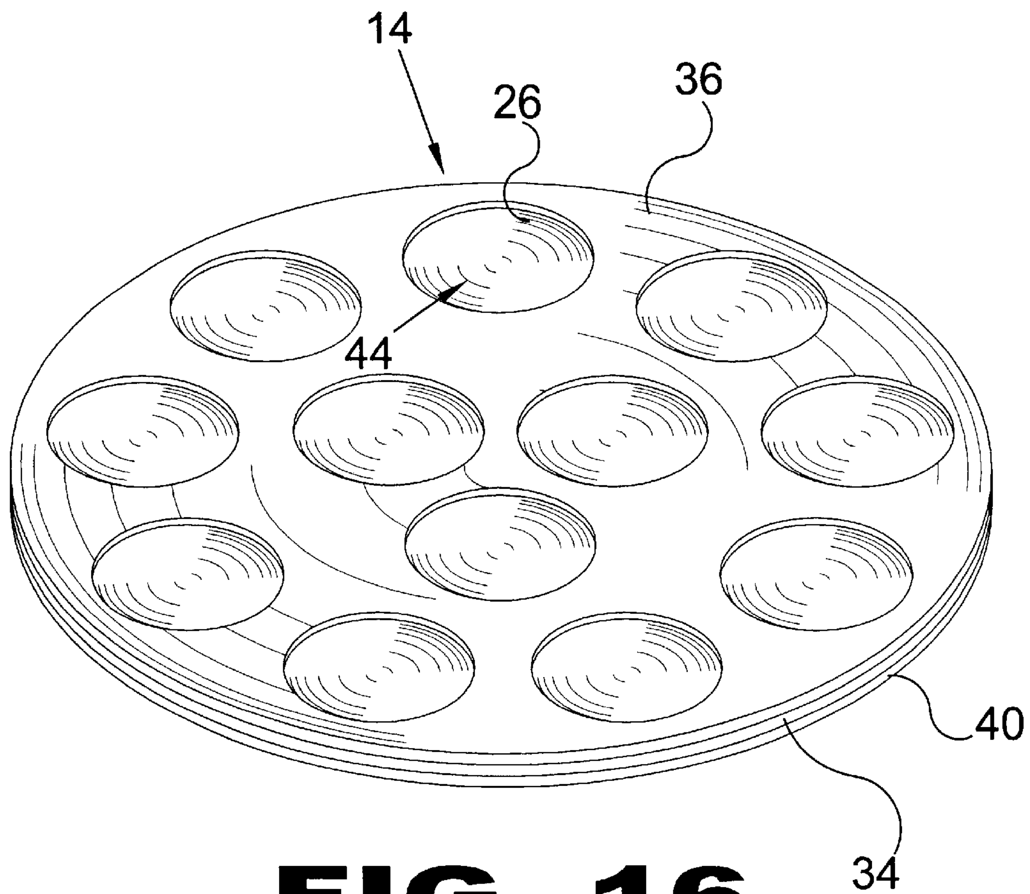


FIG. 16

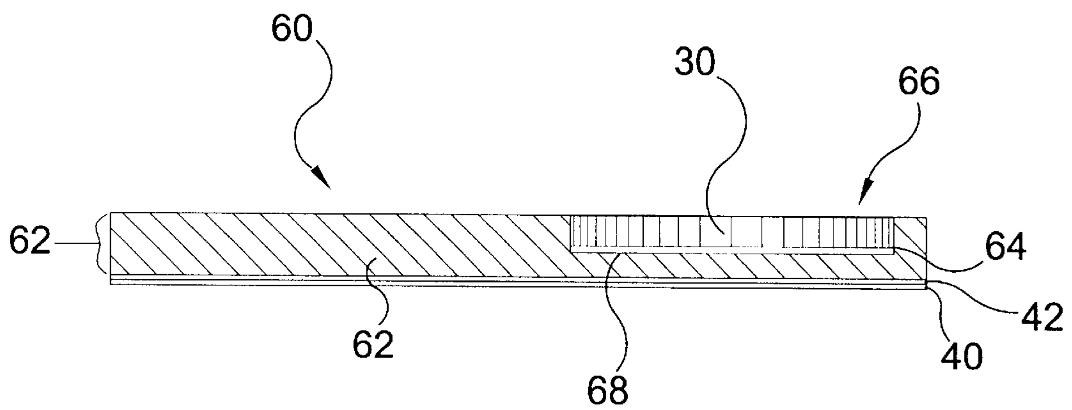


FIG. 17

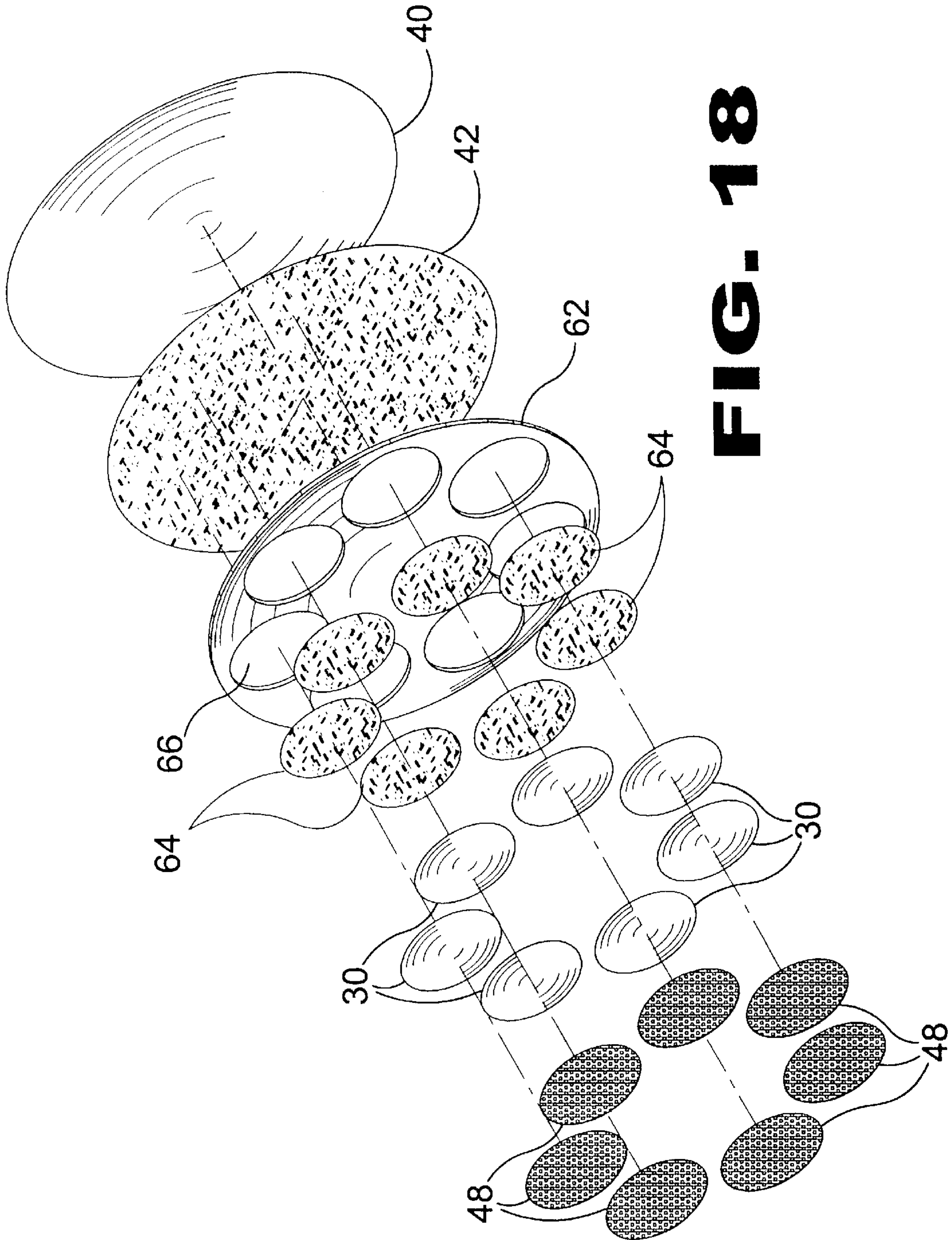


FIG. 18

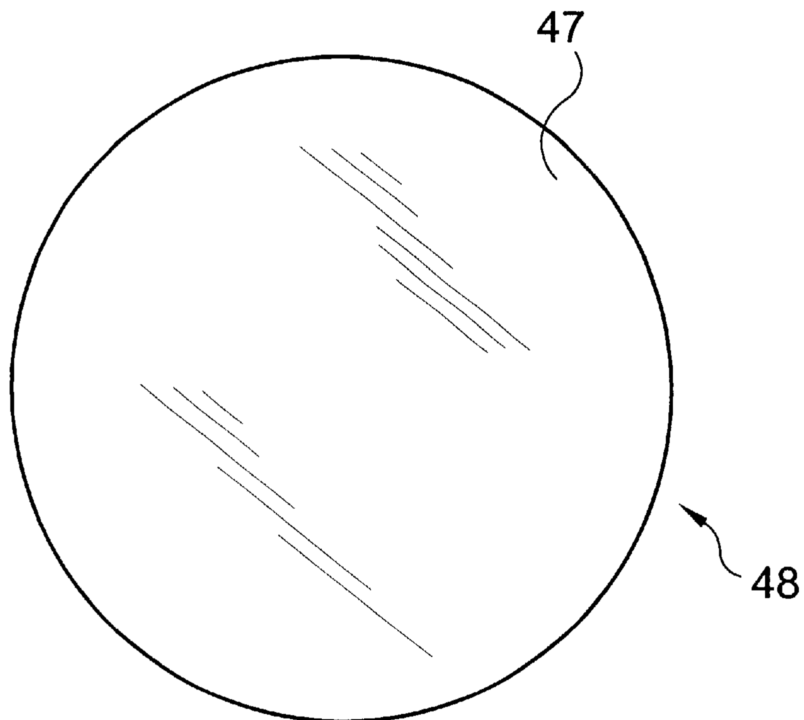


FIG. 19

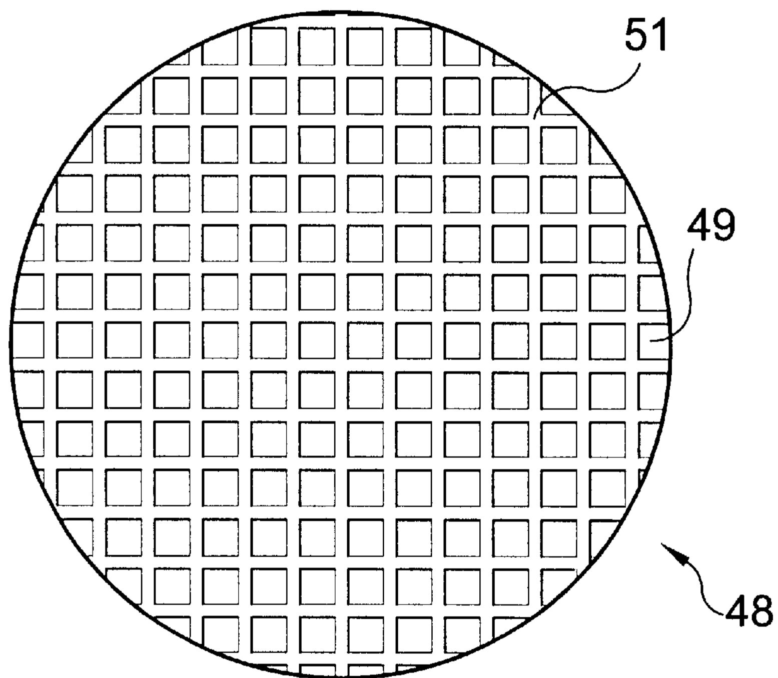


FIG. 20

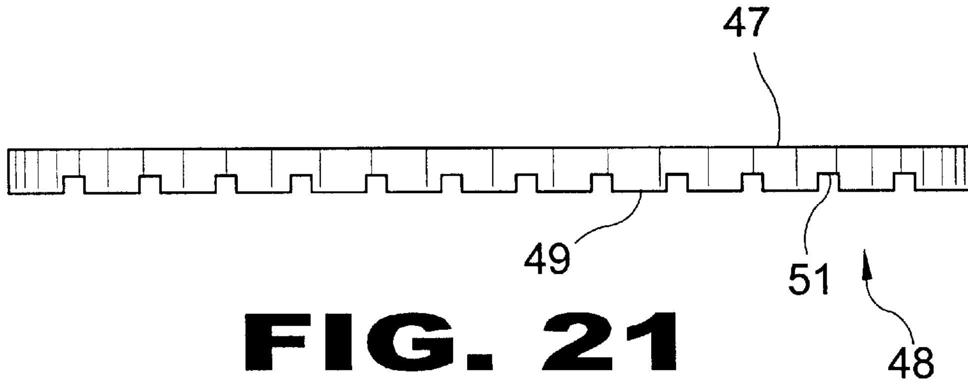


FIG. 21

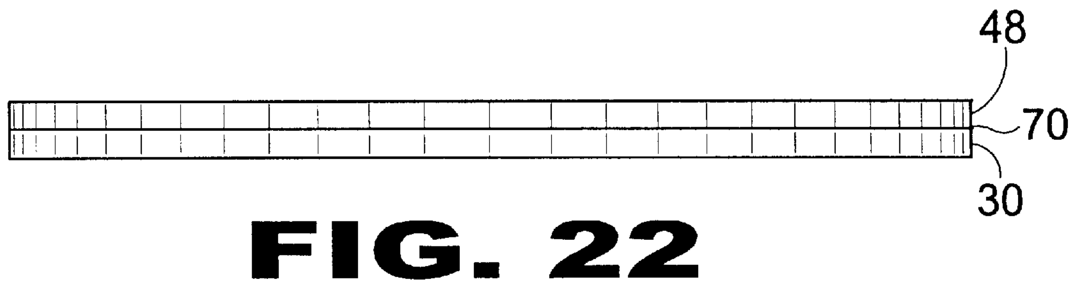


FIG. 22

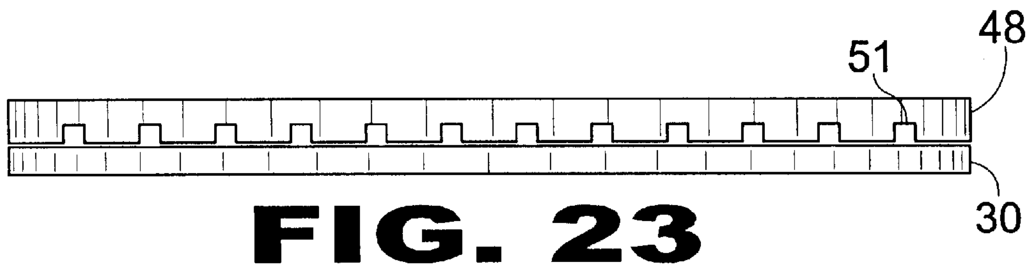


FIG. 23

FIG. 24

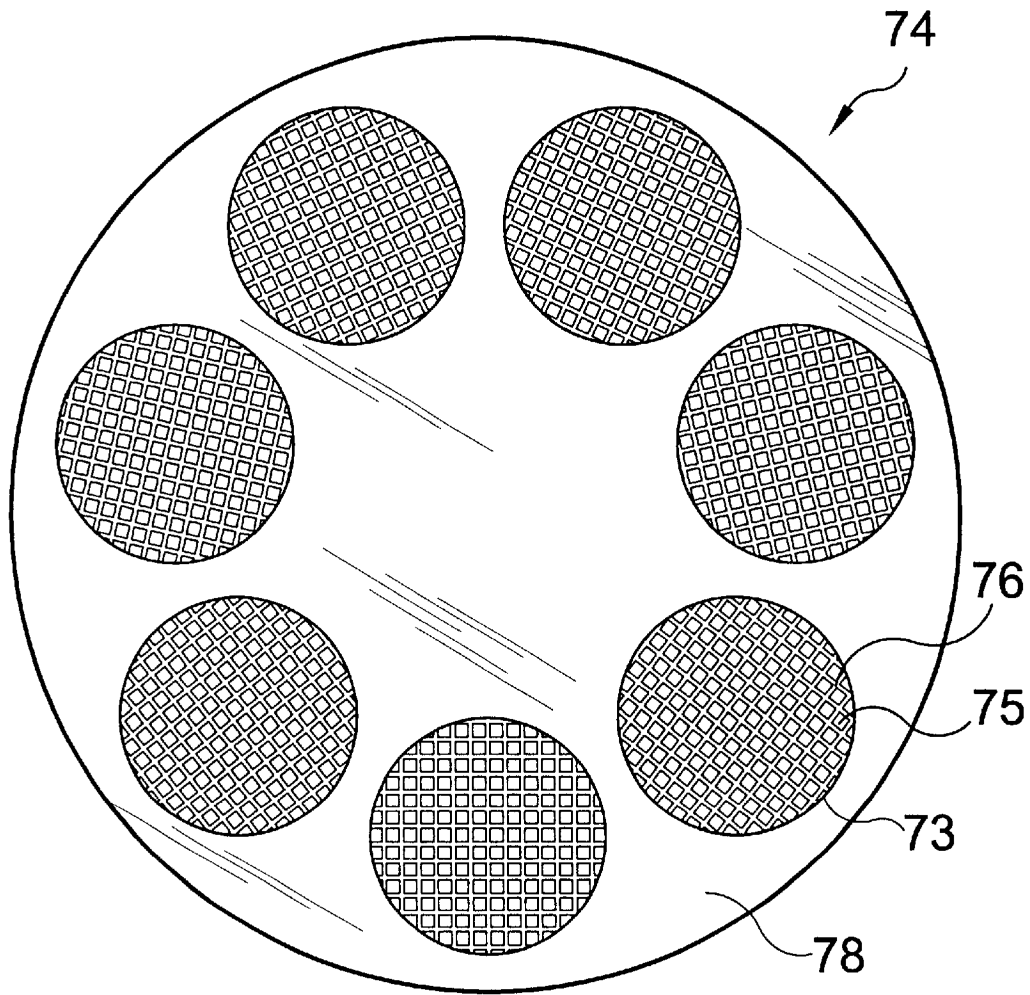


FIG. 25

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SILICON WAFER POLISHER

REFERENCE TO RELATED APPLICATIONS

This application is a continuation in part application of U.S. patent application Ser. No. 09/840,506 filed on Apr. 23, 2001.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to devices for polishing workpieces and, more specifically, to a device for polishing silicon wafers including a planar template having a plurality of cavities wherein a silicon wafer is placed within a respective cavity for polishing to a thickness equivalent to the depth of the template cavity.

2. Description of the Prior Art

The prior art discloses numerous templates for lapping and polishing wafers to a desirable thickness determined by the depth of the template cavity. However, the prior art devices and methods each contain one or more undesirable characteristics that render them unsuitable for repeated use.

A prior art process of lapping and polishing blank wafers includes placing the workpieces into a template and placing the template upside down between a rotating pneumatic head and a table. A controlled flow of abrasive slurry flows onto the table surface during rotation of the pneumatic head whereby the wafer blanks are honed and polished to the thickness of the template.

There are two undesirable side effects that can occur with this method. As the wafers approach the thickness of the template cavity, the amount of fluid between the template and table decreases causing spotted changes in the surface temperature of the template and thereby burnishing the template. In addition, the cross sectional thickness of the finished wafer is affected. The wafers rotate within the cavity causing the wafers to continuously butt up against the wall of the cavity and rise from the cavity base. This potentially causes the edge thickness of the wafer to vary from the center thickness, especially in applications where tolerances are measured in the +/− tens of picometers.

It is thus desirable to provide a method and apparatus for polishing a wafer which overcomes both of the above discussed shortcomings with the prior art. It is further desirable to provide a method and apparatus for polishing a wafer which is able to increase the efficiency of present methods by reducing the number of templates used. It is even further desirable to provide a method and apparatus for polishing a wafer which is able to account for the varied thickness' required within the end product.

Therefore because of the aforementioned problem it is felt that a need exists for the present invention and while the prior art may be suitable for the purposes for which they were designed, they would not be as suitable for the purposes of the present invention, as hereinafter described.

SUMMARY OF THE PRESENT INVENTION

The present invention relates generally to devices for polishing workpieces and, more specifically, to a device for polishing silicon wafers including a planar template having a plurality of cavities wherein a silicon wafer is placed for polishing to a thickness equivalent to the depth of the template cavity.

A primary object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers that will overcome the shortcomings of prior art devices.

Another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers that can be used repeatedly.

Yet another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers wherein the apparatus includes templates substantially comprised of fiberglass-epoxy laminates.

Still yet another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers wherein the templates have a backing material adhesively affixed thereto.

Another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers wherein the templates include a backing adhesively affixed thereto formed from mylar or other suitable frictionless material.

Still yet another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers having a plurality of shims preferably manufactured from a suitable material such as polyurethane.

Yet another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers wherein the shim is affixed to the base of the plurality of cavities within said template thereby adjusting the depth of the cavity.

Still yet another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers wherein the affixed shim is of smaller diameter than the diameter of the plurality of workpiece cavities within the template and the periphery of the wafer contained within the workpiece cavity extends beyond the circumference of the shim.

Yet another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers able to reduce tapering of the wafer.

Another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers wherein the plurality of shims are of various thickness' that can be removably inserted into each of the plurality of cavities within the template.

Yet another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers wherein the template can be used to produce wafers of various and/or calculated thickness'.

Additional objects of the present invention will appear as the description proceeds.

A method and apparatus for forming wafers of varying thickness' is disclosed by the present invention. The apparatus includes a template. The template is formed of a main disk including a plurality of cavities extending into a first side thereof and a backing plate positioned on a side of the main disk opposite the first side. Holding disks are moistened and positioned within respective cavities for releasably securing a wafer in the cavity. When the template is releasably secured to and rotatable with a rotating head and positioned such that the first side faces a lapping and polishing surface, wafers received by the cavities are lapped and polished upon rotation of the rotating head. A plurality of shims are selectively received within respective cavities between a base of the cavity and the holding disk for adjusting a depth of the cavity thereby adjusting an amount of a wafer to be lapped and polished. The shims have varying thickness' and are color coated, each color being representative of a predetermined thickness for the shim. A mylar layer is bonded to a side of the backing plate opposite

the main disk. A liquid is provided atop the lapping and polishing surface upon rotation of the templates.

The present invention overcomes the shortcomings of the prior art by providing a method and device whereby employing the reusable workpiece template and selectively inserting shims of various thickness' produce semiconductor wafers of varying thickness'.

In addition, the workpiece template having a shim centrally affixed and positioned within the base of the workpiece cavities reduce tapering of the wafer. Furthermore, having a suitable frictionless material, such as mylar, induce rotation of the wafer thereby reducing tapering.

The foregoing and other objects and advantages will appear from the description to follow. In the description reference is made to the accompanying drawing, which forms a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments will be described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural changes may be made without departing from the scope of the invention. In the accompanying drawing, like reference characters designate the same or similar parts throughout the several views.

The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is best defined by the appended claims.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

In order that the invention may be more fully understood, it will now be described, by way of example, with reference to the accompanying drawing in which:

FIG. **1** is a perspective view of the silicon wafer polishing holder of the present invention;

FIG. **2** is a bottom side view of a workpiece template used with the silicon wafer polishing holder of the present invention;

FIG. **3** is a perspective view of the workpiece template of the silicon wafer polishing holder of the present invention;

FIG. **4** is a cross sectional view of the workpiece template of the silicon wafer polishing holder of the present invention;

FIG. **5** is an exploded view of the workpiece template of the silicon wafer polishing holder of the present invention;

FIG. **6** is a top exploded view of a holding disk of the silicon wafer polishing holder of the present invention;

FIG. **7** is a perspective view of a plurality of color-coded shims for use with the silicon wafer polishing holder of the present invention;

FIG. **8** is an exploded perspective view of the workpiece cavity of the silicon wafer polishing holder of the present invention;

FIG. **9** is an exploded perspective view of a workpiece cavity of the silicon wafer polishing holder of the present invention including a shim positioned therein for adjusting the depth of the cavity;

FIG. **10** is an exploded view of the workpiece cavity of the silicon wafer polishing holder of the present invention including a plurality of shims positioned therein for adjusting the depth of the cavity;

FIG. **11** is a bottom side view of the workpiece template the silicon wafer polishing holder of the present invention showing workpiece cavities in exploded form;

FIG. **12** is a cross-sectional view of a workpiece cavity of the silicon wafer polishing holder of the present invention;

FIG. **13** is a cross-section side view of the silicon wafer polishing holder of the present invention including more than one shim within the cavity;

FIG. **14** is a bottom side view of the workpiece template of the silicon wafer polishing holder of the present invention;

FIG. **15** is a bottom side view of an alternate workpiece template embodiment for use with the silicon wafer polishing holder of the present invention; and

FIG. **16** is a perspective view of an alternate embodiment of the silicon wafer polishing holder of the present invention;

FIG. **17** is a cross sectional view of an alternate workpiece template for use in the silicon wafer polishing holder of the present invention;

FIG. **18** is an exploded view of the alternate workpiece template for use in the silicon wafer polishing holder of the present invention;

FIG. **19** is a top side view of the holding disk for use in the silicon wafer polishing holder of the present invention;

FIG. **20** is a back side view of the holding disk for use in the silicon wafer polishing holder of the present invention;

FIG. **21** is a cross sectional view of the holding disk for use in the silicon wafer polishing holder of the present invention;

FIG. **22** is cross sectional view of the holding disk and a shim with an adhesive layer positioned therebetween for use in the silicon wafer polishing holder of the present invention;

FIG. **23** is cross sectional view of the holding disk positioned atop a shim for use in the silicon wafer polishing holder of the present invention;

FIG. **24** is a cross sectional view of one shim positioned atop a second shim with an adhesive layer positioned therebetween for use in the silicon wafer polishing holder of the present invention; and

FIG. **25** is a top side view of an alternative main plate for use in the silicon wafer polishing holder of the present invention.

DESCRIPTION OF THE REFERENCED NUMERALS

Turning now descriptively to the drawings, in which similar reference characters denote similar elements throughout the several views, the Figures illustrate the silicon wafer polishing holder of the present invention. With regard to the reference numerals used, the following numbering is used throughout the various drawing figures.

10 silicon wafer polishing holder of the present invention
12 rotating pneumatic heads
14 lapping and polishing surface
16 workpiece template
18 tube
20 supply of moistening liquid
22 top side of lapping and polishing surface
24 arrows indicating rotation of the rotating pneumatic head
26 cavity within workpiece template
28 bottom surface of workpiece template
30 shim
32 top side of the workpiece template
34 backing plate
36 main plate

38 base of cavity
40 mylar layer
42 adhesive layer
44 aperture in main disk
46 adhesive layer
47 top side of holding disk
48 holding disk
49 bottom side of holding disk
50 wafer
51 grooves
52 portion of wafer remaining after lapping and polishing
54 portion of wafer removed by lapping and polishing
56 plurality of grooves extending along the top surface of main plate
58 center of workpiece template
60. Alternate workpiece template
62. Alternate main plate
63. Top Side of main plate
64. Adhesive layer
66. Recessed cavity
68. Base of the recessed cavity
70. Adhesive layer
72. Adhesive layer
73. Recessed cavity
74. Second alternate main plate
76. Grooves
78. Top side of second alternate main plate

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now descriptively to the drawings, in which similar reference characters denote similar elements throughout the several views, FIGS. **1** through **25** illustrate the silicon wafer polishing holder of the present invention indicated generally by the numeral **10**.

The silicon wafer polishing holder **10** of the present invention is shown polishing a wafer in FIG. **1**. As can be seen from this view, the silicon wafer polishing holder **10** includes a plurality of rotating pneumatic heads **12**. The plurality of rotating pneumatic heads **12** are positioned above a lapping and polishing surface **14**. A workpiece template **16** is positioned between the lapping and polishing surface **14** and a respective one of each of the plurality of rotating pneumatic heads **12**. The rotating heads rotate as indicated by the arrows labeled with the numeral **24**. Each workpiece template **16** includes a main plate **36** having a plurality of cavities extending therein. The cavities extend at least partially through the main plate and possible entirely through the main plate **36**. Each cavity is able to receive a silicon wafer, not shown in this figure. Each workpiece template **16** is positioned under and rotated by the respective rotating pneumatic head **12**. The workpiece templates **16** place the silicon wafers in communication with the lapping and polishing surface **14** and rotate the silicon wafers generating a frictional force between the silicon wafers and the lapping and polishing surface **14**. The frictional force acts to polish the silicon wafers. A tube **18** is positioned above the lapping and polishing surface **14** for providing a supply of moistening liquid **20** to a top side **22** of the lapping and polishing surface and between the lapping and polishing surface **14** and the workpiece template **16**. The supply of the moistening liquid **20** reduces the heat produced by the friction between the wafer and the lapping and polishing surface **14** while also aiding in producing a suction force to maintain the position of the wafer within the cavity.

A bottom side view of the workpiece template **14** of the silicon wafer polishing holder **10** of the present invention is shown in FIG. **2**. From this view, the workpiece template **14** is shown having a main plate **36** including the plurality of cavities **26** extending into a bottom surface **28** thereof. Positioned within each cavity **26** is a shim **30** having a diameter smaller than the diameter of the workpiece cavity **26**. Each shim **30** has a predetermined thickness and insertion of a shim **30** within a cavity **26** adjusts the depth of the cavity **26** in which it is positioned. The adjustment of the depth of the cavity **26** allows a user to determine the amount of lapping and polishing to be performed on a wafer positioned within the cavity **26**.

A perspective bottom side view of the workpiece template **14** is illustrated in FIG. **3**. This figure shows the bottom side **28** of the planar main plate **36** including the plurality of cavities **26** extending therein. Positioned on a top side **32** of the main plate **36** opposite the bottom side **28** is a backing plate **34**. The main plate **36** is preferably formed of fiberglass-epoxy laminates.

A cross sectional view of the workpiece template **14** is shown in FIG. **4**. This figure shows the main plate **36** formed from heat and moisture resistant material such as fiberglass-epoxy laminates. Extending into the bottom side **28** of the main plate **36** and possibly extending through the main plate **36** are the plurality of cavities **26**. The cavities **26** extend at least partially and possibly fully through the main plate **36**. The backing plate **34** is adhesively bonded to the top side **32** of the main plate **36**. The backing plate acts as a base **38** for the cavities **26** should the cavity **26** extend entirely through the main plate **36**. On a side of the backing plate **34** opposite the main plate **36** is a mylar layer **40**. The mylar layer **40** is adhesively bonded to the backing plate by an adhesive layer **42**.

An exploded view of the workpiece template **14** is illustrated in FIG. **5**. As can be seen from this view, the workpiece template **14** includes the main plate **36** having a plurality of apertures **44** extending therethrough. When the backing plate **34** is secured to the top side **32** of the main plate **36**, the apertures **44** each form a respective one of the cavities **26** having a depth defined by the base **38**. The backing plate **36** is bonded to the main plate **36** by an adhesive layer **46**. Bonded to the backing plate **34** on a side opposite the main plate **36** is a mylar layer **40**. A second adhesive layer **40** secures the mylar layer **40** to the backing plate **34**. A shim **30** having a desired thickness may be adhesively bonded within the apertures **44** of the main plate **36** to adjust the depth of the cavity **26**. The shim **30** may be of any desired thickness to adjust the depth of the cavity **26** in which it is positioned. The shims **30** can be of varying thickness' therefore, a shim **30** in one cavity **26** need not be of the same thickness as a shim **30** in any other cavity **26**.

Within each cavity **26** a holding disk **48** is positioned atop the shim **30**. A top side view of a holding disk **48** is shown in FIG. **6**. The holding disk **48** is formed from a felt material and acts to hold a wafer within the workpiece template cavity **26**. Positioned within the cavity between the holding disk **48** and the base of the cavity **38** is a shim **30** for adjusting the depth of the cavity **26**. The shim **30** may be adhesively fixed to the backside of the holding disk **48**. Prior to insertion of the wafer the felt material of the holding disk **48** is moistened with a liquid. The liquid is partially forced out when the wafer is placed in the cavity **26** forming a suction bond between the wafer and workpiece template **14**.

A plurality of shim disks **30** are illustrated in FIG. **7**. The shim disks **30** are color-coded. Each color is associated with a particular thickness for the shim **30**. For each color shim disk **30** a face side view and perspective view is shown in

this figure. The perspective view illustrates an exemplary thickness for each color shim disk **30**. The differing colors are used to identify a specific thickness for each shim disk **30** and thus be able to accurately adjust the depth of each cavity **26**.

FIGS. **8**, **9** and **10** each illustrate an exploded perspective view of the elements within a workpiece cavity **26**. FIG. **8** illustrates a cavity **26** without a shim disk **30** therein. FIG. **9** illustrates a cavity **26** with a single shim disk **30** therein. FIG. **10** illustrates a cavity **26** with three shim disks **30** therein. As can be seen from these figures, the main disk **36** is positioned atop the backing plate **34** with the adhesive layer **46** positioned therebetween. Positioned within the cavity **26** and atop the base **38** is positioned the holding disk **48**. If use of shim disks **30**, as is shown in FIGS. **9** and **10**, is desired to adjust the depth of the cavity **26**, the shim disks **30** are positioned between the base **38** and the holding disk **48**. A wafer **50** to be lapped and polished is positioned atop the holding disk **48**. The holding disk **48** is moistened and the wafer **50** is placed atop the holding disk **48**. Moistening of the holding disk **48** creates a suctional force within the cavity **26**. Placement of the wafer **50** atop the moistened holding disk **48** utilizes the suction to maintain the wafer **50** in a stationary position within the cavity **26**. The placement of a shim disk **30** within the cavity as shown in FIG. **9** decreases the depth of the cavity **26** thereby raising the height of the wafer within the workpiece cavity **26**. This creates a cavity having a smaller depth and thus, upon lapping and polishing produces a thinner wafer **50**. The placement of additional shim disks **30** within the cavity **26** as shown in FIG. **10** decreases the depth of the cavity **26** more so than as shown in FIG. **9**. This raises the height of the wafer within the workpiece cavity **26** to a greater extent thereby creating a cavity **26** having an even smaller depth. Upon lapping and polishing a wafer **50** within a cavity **26** having a depth as shown in FIG. **10**, an even thinner wafer **50** is produced. Using variable amounts of shim disks **30** of differing thickness' allows the creation of a cavity having a desired depth.

FIG. **11** illustrates an exploded view of the cavities **26** of an entire template **14**. Each of the cavities **26** has a plurality of shim disks **30** positioned therein to adjust the thickness of the cavity **26**. It is thus shown that by positioning differing amounts of shim disks **30** having varying thickness' within each cavity **26**, a number of wafers **50** are able to be produced at a single time using a single template **14** whereby each wafers **50** produced can be varied to be a desired thickness. This allows for numerous wafers **50** of varying thickness' to be produced at a single time.

A cross-sectional view of a workpiece cavity **26** is shown in FIGS. **12** and **13**. These figures illustrate the template **14** and elements positioned therein prior to lapping and polishing. Positioned within the cavity **26** and above the base **38** are shims **30**. Positioned above the shims **30** is the holding disk **48**. The wafer **50** is then positioned and held above the holding disk **48** by the suctional force created when the holding disk **48** is moistened. As can be seen from these figures, prior to lapping and polishing, the wafer **50** extends above the top of the cavity **26**. The wafer **50** is thus divided into two portions, a portion remaining after lapping and polishing **52** and a portion removed by lapping and polishing **54**. Thus, when the template **14** is secured to the rotating pneumatic head **12** and against the lapping and polishing surface **16**, the portion **54** extending above the top of the cavity **26** will be removed. The thickness of the portion being removed **54** is dependent upon the number of shims **30** positioned within the cavity **26** and the thickness of the shims **30**. In order to calculate the thickness of the wafer **50** to be remaining after lapping and polishing, "X" represents the workpiece cavity depth. While "A", "B" and "C" represent the components placed within the cavity. "A" being the shims, "B" being the holding disk and "C" being the wafer **50**. "D" or **54** represents the material that will be removed from the wafer **50** by lapping and polishing. This results in a finished lapped and polished wafer **52** having a thickness of "E".

The main plate **36** is illustrated in FIG. **14**. As can be seen from this figure, the main plate **36** includes a plurality of grooves **56** extending along the top surface **28** thereof. The plurality of grooves **56** draw liquid toward a center **58** of the workpiece template **14** while in operation. The drawing of the liquid towards the center of the workpiece template **14** aids in retaining the wafers within their respective cavities **26** during lapping and polishing.

A workpiece template including an increased number of workpiece cavities **26** is illustrated in FIG. **15**. The template **14** illustrated herein also includes an increased surface area. Increasing the number of cavities **26** enables the lapping and polishing of a greater number of wafers **50** at a single time thereby increasing production limits.

A perspective view of the workpiece template **14** shown in FIG. **15** is illustrated in FIG. **16**. This workpiece template **14** includes an increased number of workpiece cavities **26** and increased surface area. This backing plate secured to the main disk **36** is of an increased size to match the dimensions of the workpiece template **14** for use with larger polishing machines.

A cross sectional view of an alternate embodiment for the workpiece template **60** is shown in FIG. **17**. The alternate workpiece template **60** includes an alternate main plate **62**. The alternate main plate **62** is preferably formed from heat and moisture resistant material such as fiberglass-epoxy laminates. However, any material able to perform the functions necessitated by the alternate main plate **62** may be used. The alternate main plate **62** includes a top side **63** having at least one recessed cavity **66** extending at least partially therethrough. An adhesive layer **64** having a circumference substantially equal to the circumference of the recessed cavity **66** is positioned within each recessed cavity **66**. In order to adjust the depth of the recessed cavity **66**, a shim **30** can be added thereto. The shim **30** is placed on top of the adhesive layer **64** and secured within the recessed cavity **66**. The adhesive layer is described for purposes of example. However, any method of releasably securing the shim **30** to the base of the recessed cavity **68** may also be used. The alternate main plate **62** is bonded to a mylar layer **40** by the adhesive layer **42**. The mylar layer **40** is bonded to a side of the main plate **62** opposite the top side.

An exploded view of the alternate workpiece template **60** is illustrated in FIG. **18**. The alternate workpiece template **60** consists of the alternate main plate **62** having at least one and preferably a plurality of recessed cavities **66**. The depth of each recessed cavity **66** is determined during construction of the alternate main plate **62**. The cavities **66** are provided to extend at least partially through the main plate **62**. The mylar layer **40** is bonded to a side of the alternate main plate **62** opposite the top side **63**. The aforementioned mylar layer **40** is preferably bonded to the main plate **62** by adhesive layer **42**. An adhesive layer **64** is placed within the recessed cavity **66**. The adhesive layer **64** preferably has a circumference substantially equivalent to the circumference of the recessed cavity **66**. A shim **30** having a desired thickness is selectively secured within the recessed cavity **66** by the adhesive layer

64. Placement of the shim **30** within the cavity **66** allows for adjustment of the depth of the recessed cavity **66** to a desired level. Alternatively the shim **30** may be releasably held in place by any material able to be placed within the cavity **66** that functions to hold the shim **30** in place. To further alter the depth of recessed cavity **66**, a second shim **30** can be placed directly on top of the shim **30** adhesively bonded to the base of the recessed cavity **68**. If multiple shims **30** are used to alter the depth of the recessed cavity, the shims **30** may be held together by additional adhesive layers **64** positioned therebetween. However, the shims **30** can also be stacked on top of the shim **30** bonded to the base of the recessed cavity **68**. The shim **30** or combination of shims **30** can be of varying thickness. As previously discussed the shims **30** may be color coated, each color identifying a respective shim thickness. Therefore, a shim **30** or combination thereof may produce recessed cavities **66** having differing depths within a single main plate **62**.

Positioned within the recessed cavity **66** atop the base of the cavity **68** is the holding disk **48**. The holding disk **48** is moistened and a wafer **50** is placed atop the moistened holding disk **48**. Placement of the wafer **50** atop the moistened holding disk **48** utilizes a suctional force to maintain the wafer **50** in a stationary position within the recessed cavity **66**. If use of shim disks **30**, as shown in FIGS. **16** and **17**, is desired to adjust the depth of the cavity **66**, the shim disks are positioned between the base of the cavity **68** and the holding disk **48**. The placement of a shim disk as shown in FIGS. **16** and **17** decreases the depth and thus, upon lapping and polishing produces a thinner wafer **50**. Using variable amounts of shim disks **30** of differing thickness allows the creation of a cavity **66** having a desired depth.

The holding disk **48** is illustrated in FIGS. **19** and **20** with FIG. **19** showing a view of the top side thereof and FIG. **20** showing a view of the bottom side thereof. The bottom side **49** of the holding disk **48** includes grooves **51**. The grooves **51** are preferably cut into the bottom side **49** of the holding disk **48** in a graph-like pattern. The grooves **51** are provided for increasing the suctional force created between the holding disk **48** and shims **30** positioned therebelow after the holding disk **48** is moistened and inserted into the cavity. Although the grooves are shown in the form of a graph like pattern, grooves having any desired pattern may be cut into the bottom side as long as the grooves are able to increase the suctional force created with the shims **30** positioned therebelow. The grooves **51** cut in the bottom side **49** of the holding disk **48** are better illustrated by the cross sectional view of the holding disk **48** in FIG. **21**. FIG. **21** shows alternating indentations in the bottom side **49** of the holding disk **48** representative of the grooves **51**.

FIGS. **22** and **23** show the different methods by which the holding disk **48** can be releasably secured to a shim **30**. FIG. **22** shows the holding disk **48** positioned atop the shim **30**. Positioned between the bottom side **49** of the holding disk **48** and the top side of the shim **30** is an adhesive layer **70**. When applied, the adhesive layer **70** fills the spaces created by any grooves **51** cut into the bottom side **49** of the holding disk **48** to thereby increase the force holding the holding disk **48** and the shim positioned therebelow together. Should the holding disk **48** not have grooves cut therein, the adhesive layer **70** provides the sole force securing the holding disk **48** and shim **30** positioned therebelow together. FIG. **23** shows an alternative method by which the holding disk **48** can be releasably secured to the shim **30**. FIG. **23** shows the holding disk **48** positioned atop the shim **30**. In this embodiment, there is no adhesive layer, rather, upon being moistened the holding disk **48** uses the grooves **51** cut in the bottom side **49** to create an increased suctional force. The increased suction force acts to releasably secure the holding disk **48** to the shim **30**.

FIG. **24** illustrates a cross sectional view of two shims **30**. The shims **30** function to alter the depth of the recessed cavity **68** thereby altering the thickness of the wafer **50** being polished. Using multiple shims **30** allows for greater variance in the depths of the recessed cavity **68**. FIG. **24** shows a first shim **30** positioned atop a second shim **30**. These shims **30** are releasably secured together via an adhesive layer **72** positioned therebetween. Upon being secured together the newly created thicker shim **30** is ready to be received by the cavity **68**.

FIG. **25** is a top side view of a second alternate main plate **74**. The main plate **74** is preferably formed from heat and moisture resistant material such as fiberglass-epoxy laminates. However, any material able to perform the functions necessitated by the main plate **74** may be used. The main plate **74** includes a top side **78** having at least one recessed cavity **73** extending at least partially therethrough. The base **75** of each at least one recessed cavity **73** having grooves **76** carved therein. The grooves **76** function to increase the suctional force created between the base of the recessed cavity **75** and a shim **30** or the holding disk **48** positioned within the cavity **75**. The grooves **76** present an alternative means for releasably securing the shim **30** or the holding disk **48** to the base of the cavity **75**.

The operation of the workpiece template and apparatus for lapping and polishing silicon wafers **10** will now be described with reference to the figures. In operation, the workpiece template and apparatus for lapping and polishing silicon wafers **10** is prepared for use. In preparing the workpiece template and apparatus for lapping and polishing silicon wafers **10**, a backing piece **34** is secured to the bottom side **28** of the main disk **36** by an adhesive layer **46**. The backing piece **34** forms a base **38** for the cavities **26**. On a side of the backing piece **34** opposite the main disk **36**, a mylar layer **40** is secured by a second adhesive layer **42**. Alternatively a first main plate **62** that contains recessed cavities **66** can be utilized to lap and polish wafers **50**, as well as a second main plate **74** that contains recessed cavities **75**. A mylar layer **40** is bonded to a side opposite the top side of the main plate **62** preferably by means of an adhesive layer **42**. Each cavity **26,66,73** is now prepared by placing a desired number of shims **30** of varying thickness therein. The number and thickness of the shims **30** placed within each cavity **26,66,73** determines the depth of the cavity **26** and the height to which the wafer **50**, when placed within the cavity **26,66,73** will extend thereabove. After placing the shims **30** in each cavity **26,66,73** a holding disk **48** is moistened and positioned within each cavity **26,66,73** above the shims **30**. The template **14** is now prepared to receive wafers **50** within respective cavities **26,66,73**. The wafers **50** are positioned within a predetermined cavity **26,66,73** having a predetermined depth determined by the number and thickness of shims **30** positioned therein. A portion of the wafer **52** is seated within the cavity below the bottom side **28** thereof. A portion of the wafer **54** is positioned extending through the rim of the cavity **26,66,73** and above the bottom side **28**.

The wafers are now prepared to be lapped and polished. The template is now received by the rotating pneumatic head **12** of the apparatus for lapping and polishing silicon wafers **10**. When connected to the rotating pneumatic head **12**, the template **14** is positioned such that the bottom side **28** and the wafers **50** are directly above the lapping and polishing surface **16**. The portion of the wafer **54** is positioned

extending through the rim of the cavity **26,66,73** and above the bottom side **28** is placed in contact with the lapping and polishing surface **16**. Upon turning on the portion of the wafer **54** is positioned extending through the rim of the cavity **26,66,73** and above the bottom side **28**, the rotating pneumatic heads **12** begin to rotate thereby rotating the template and the wafers **50** positioned within the cavities **26,66,73**. Rotation of the wafers **50** causes a frictional force to develop between the portion of the wafer **54** is positioned extending through the rim of the cavity **26,66,73** and above the bottom side **28** and the lapping and polishing surface **16**. The frictional force causes lapping and polishing of the wafer **50** to occur. The lapping and polishing of the wafer **50** continues until the portion of the wafer **54** is positioned extending through the rim of the cavity **26,66,73** and above the bottom side **28** is removed and the thickness of the wafer **50** equals the thickness of the portion of the wafer **54** is positioned within the cavity **26,66,73**. Throughout the rotation of the rotating pneumatic heads **12**, a liquid is deposited on top of the lapping and polishing surface thereby cooling the surface. As each wafer **50** within respective cavities **26,66,73** are polished to the same level, i.e. the level of the bottom surface of the main disk **36**, the production of all wafers is complete simultaneously. Furthermore, the thickness of each wafer **50** is dependent on the portion of the wafer which extends into the cavity **26,66,73**. Thus, wafers **50** of various sizes are able to be produced simultaneously.

From the above description it can be seen that the method and apparatus for lapping and polishing silicon wafers of the present invention is able to overcome the shortcomings of prior art devices by providing a method and apparatus for lapping and polishing silicon wafers which is able to be used repeatedly to produce a plurality of silicon wafers. The apparatus for lapping and polishing silicon wafers includes templates having a main disk substantially comprised of fiberglass-epoxy laminates and including cavities extending therein. A backing material adhesively affixed to the main disk and a layer formed of mylar or other suitable frictionless material is affixed to the backing material. A plurality of shims manufactured from a suitable material such as polyurethane may be affixed to the base of the cavities for adjusting the depth of the cavity. The shims are removably inserted into each of the plurality of cavities within the template. Another object of the present invention is to provide a method and apparatus for lapping and polishing silicon wafers having a plurality of shims of various thickness' that can be removably inserted into each of the plurality of cavities within the template whereby the template can be used to produce wafers of various and/or calculated thickness'. The method and apparatus for lapping and polishing silicon wafers is also able to reduce tapering of the wafer. Furthermore, the method and apparatus for lapping and polishing silicon wafers of the present invention is simple and easy to use and economical in cost to manufacture.

It will be understood the each of the elements described above, or two or more together may also find a useful application in other types of methods differing from the type described above.

While certain novel features of the invention have been shown and described and are pointed out in the annexed claims, it is not intended to be limited to the details above, since it will be understood that various omissions, modifications, substitutions and changes in the forms and details of the device illustrated and in its operation can be made by those skilled in the art without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed is new and desired to be protected by Letters Patent is set forth in the appended claims:

1. A template for forming wafers of varying thickness', said template comprising:

a) a main plate including at least one cavity extending into a first side thereof;

b) at least one adhesive layer positioned within said at least one cavity, said at least one adhesive layer having a circumference substantially equivalent to a circumference of said at least one cavity;

c) at least one holding disk, said at least one holding disk positioned within said at least one cavity and releaseably secured within said at least one cavity by said at least one adhesive layer, whereby when said template is releasably secured to and rotatable with a rotating head and positioned such that said first side faces a lapping and polishing surface, a wafer received within said at least one cavity is lapped and polished upon rotation of the rotating head.

2. The template as recited in claim **1** wherein said at least one holding disk having a top side and a bottom side, said bottom side having grooves carved therein, said grooves thereby increasing the suctional force created between the base of said at least one recessed cavity and said at least one holding disk.

3. The template as recited in claim **1**, further comprising a shim, said shim being selectively received within said at least one cavity between said at least one adhesive layer and said at least one holding disk for adjusting a depth of said at least one cavity and thereby adjusting an amount of a wafer to be lapped and polished.

4. The template as recited in claim **1**, the main plate further comprising a plurality of cavities and said template further comprises a plurality of adhesive layers, each of said plurality of adhesive layers having a circumference substantially equivalent to a circumference of said respective one of said plurality of cavities.

5. The template as recited in claim **4**, further comprising a plurality of holding disks positioned atop said plurality of adhesive layers positioned within said respective cavity.

6. The template as recited in claim **5**, wherein said plurality of holding disks each having a top side and a bottom side, said bottom side having grooves carved therein for increasing the suctional force created between the base of said respective cavity and said holding disk.

7. The template as recited in claim **6**, further comprising a plurality of shims, said plurality of shims being selectively received within respective ones of said plurality of cavities for adjusting a depth of said respective cavities.

8. The template as recited in claim **7**, wherein said plurality of shims have varying thickness'.

9. The template as recited in claim **7**, wherein said plurality of shims are color coated, each color being representative of a predetermined thickness for the shim.

10. The template as recited in claim **6**, wherein said shims are adhesively fixed within respective ones of said plurality of cavities by respective ones of said plurality of adhesive layers.

11. The template as recited in claim **7**, wherein said plurality of shims include a first shim and a second shim and said template further includes a shim adhesive layer positioned between said first shim and said second shim.

12. The template as recited in claim **11**, wherein said heat and moisture resistant material is a fiberglass-epoxy laminate.

13. The template as recited in claim **1**, wherein each of said plurality of holding disks is moistened prior to receiving a wafer in its respective cavity.

14. The template as recited in claim **1**, wherein said main disk is formed of a heat and moisture resistant material.

15. The template as recited in claim **1**, wherein each of said plurality of cavities extends at least partially into said main plate thereby forming said recessed cavities.

16. The template as recited in claim **1**, wherein a liquid is provided atop the lapping and polishing surface upon rotation of said template.

17. The template as recited in claim **1**, further comprising a layer of frictionless material is positioned on a side of the main plate opposite said first side.

18. The template as recited in claim **17**, wherein said layer of frictionless material is comprised of mylar.

19. The template as recited in claim **18**, further comprising an adhesive layer for securing said mylar layer to the main plate on the side opposite said first side.

20. A template for forming wafers of varying thickness', said template comprising:

a) a main plate including at least one cavity extending into a first side thereof;

b) said at least one cavity having grooves carved into the base thereof,

c) at least one moistened holding disk positioned within said at least one cavity and releaseably secured therein by a suctional force, whereby when said template is releasably secured to and rotatable with a rotating head and positioned such that said first side faces a lapping and polishing surface, a wafer received within said at least one cavity is lapped and polished upon rotation of the rotating head.

21. An apparatus for lapping and polishing silicon wafters, said apparatus comprising:

a) a rotational head

b) a lapping and polishing surface positioned adjacent said rotational head; and

c) a template; said template comprising:

i) a main plate including at least one cavity extending into a first side thereof;

ii) at least one adhesive layer positioned within said at least one cavity, said at least one adhesive layer having a circumference substantially equivalent to a circumference of said at least one cavity;

iii) at least one holding disk, said at least one holding disk positioned within said at least one cavity and releaseably secured within said at least one cavity by said at least one adhesive layer, whereby when said template is releasably secured to and rotatable with a rotating head and positioned such that said first side faces a lapping and polishing surface, a wafer received within said at least one of cavities are lapped and polished upon rotation of the rotating head.

22. The apparatus as recited in claim **21**, further comprising a shim, said shim being selectively received within said at least one cavity between said at least one adhesive layer and said at least one holding disk for adjusting a depth of said at least one cavity and thereby adjusting an amount of a wafer to be lapped and polished.

23. The apparatus as recited in claim **22**, wherein each of said plurality of holding disks is moistened prior to receiving a wafer in its respective cavity.

24. The apparatus as recited in claim **21**, the main plate further comprising a plurality of cavities and said template further comprises a plurality of adhesive layers, each of said plurality of adhesive layers having a circumference substantially equivalent to a circumference of said respective one of said plurality of cavities.

25. The template as recited in claim **24**, further comprising a plurality of holding disks positioned atop said plurality of adhesive layers positioned within said respective cavity.

26. The apparatus as recited in claim **25**, further comprising a plurality of shims, said plurality of shims being selectively received within respective ones of said plurality of cavities for adjusting a depth of said respective cavities.

27. The apparatus as recited in claim **21**, wherein said plurality of shims have varying thickness'.

28. The apparatus as recited in claim **27**, wherein said plurality of shims are color coated, each color representative of a predetermined thickness for the shim.

29. The apparatus as recited in claim **21**, wherein said shims are adhesively fixed within respective ones of said plurality of cavities by respective ones of said plurality of adhesive layers.

30. The apparatus as recited in claim **21**, wherein said main plate is formed of a heat and moisture resistant material.

31. The apparatus as recited in claim **30**, wherein said heat and moisture resistant material is fiberglass-epoxy laminate.

32. The apparatus as recited in claim **21**, wherein each of said plurality of cavities extends at least partially into said main plate thereby forming said recessed cavity.

33. The apparatus as recited in claim **21**, further comprising a layer of frictionless material is positioned on a side of the main plate opposite said first side.

34. The apparatus as recited in claim **33**, wherein said layer of frictionless material is comprised of mylar.

35. The apparatus as recited in claim **33**, further comprising said adhesive layer securing the mylar layer to said main plate on the side opposite said first side.

36. A method for lapping and polishing a wafer, said method comprising the steps of:

a) forming a cavity;

b) placing an adhesive layer within the cavity;

c) moistening a holding disk;

d) positioning a moistened holding disk within a cavity of said template;

e) positioning a wafer to be lapped and polished within the cavity above the holding disk whereby the moisture within said holding disk creates a suctional force to retain the wafer within the cavity;

f) releasably securing the template to a rotating head whereby a top surface of the cavity is facing a lapping and polishing surface and the wafer is in contact with lapping and polishing surface;

g) rotating the rotating head and template to create a frictional force between the wafer and the lapping and polishing surface causing the wafer to be lapped and polished;

h) continuing rotation of said rotating head and said template until the thickness of the wafer is decreased to a desired amount substantially equal to the amount of the extending outside said cavity.

37. The method as recited in claim **36**, further comprising the steps of:

a) forming a plurality of cavities;

b) placing a plurality of adhesive layers within a respective one of the plurality of cavities;

c) moistening a plurality of holding disks;

d) positioning each respective one of the plurality of holding disks within a respective one of the plurality of cavities; and

e) positioning a wafer to be lapped and polished within a respective one of each of the plurality of cavities above the respective holding disk whereby the moisture within the respective holding disk creates a suctional force to retain the wafer within the cavity.

38. The method as recited in claim **37**, further comprising the step of placing a plurality of shims within a respective one of the respective plurality of cavities prior to said step of positioning a respective one of the holding disks within the cavity and thereby adjusting the depth of the respective cavity.

39. The method as recited in claim **36**, further comprising the step of placing at least one of the shims within a respective one of the respective plurality of cavities prior to said step of positioning a respective one of the holding disks within the cavity and thereby adjusting the depth of the respective cavity.

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