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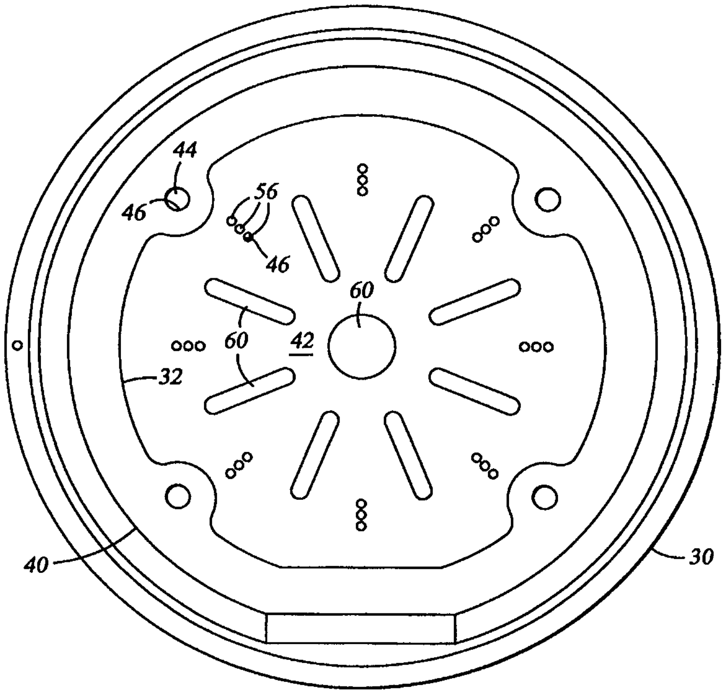
(54) Title: IMPROVED SUBSTRATE SUPPORT MEMBER

(57) Abstract

A support member for supporting a substrate in a process chamber, the support member having an upper surface (32), an outer raised portion (40) of the upper surface extends about its periphery and defines an inner, recessed portion (42) of the upper surface. A plurality of raised support areas are disposed within the inner recessed portion (42). Thus, a substrate (20) placed upon the upper surface (32) rests upon the outer, raised portion (40) and the support areas in spaced relation to the inner, recessed area creating a cavity between the substrate (20) and the inner, recessed portion (42). A vacuum supply (50) in fluid communication with the inner, recessed portion (40) supplies a vacuum thereto creating a pressure differential between the cavity and the process chamber housing the support member. Thereby, the substrate is chucked to the support member. The transitions from the raised portions to the recessed portions are tapered to eliminate the formation of ridges of material on the upper surface.



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IMPROVED SUBSTRATE SUPPORT MEMBER

Technical Field

The present invention relates to the field of semiconductor substrate processing equipment. More particularly, the present invention relates to an improved support member adapted for vacuum chucking of a substrate.

Background Art

In the fabrication of integrated circuits, equipment has been developed to automate substrate processing by performing several sequences of processing steps without removing the substrate from a vacuum environment, thereby reducing transfer times and contamination of substrates. Such a system has been disclosed for example by Maydan et al., U.S. Pat. No.4,951,601, in which a plurality of processing chambers are connected to a transfer chamber. A robot in a central transfer chamber passes substrates through slit valves in the various connected processing chambers and retrieves them after processing in the chambers is complete.

The processing steps carried out in the vacuum chambers typically require the deposition or etching of multiple metal, dielectric and semiconductor film layers on the surface of a substrate. Examples of such processes include chemical vapor deposition (CVD), physical vapor deposition (PVD), and etching processes. Although the present application primarily discusses CVD process chambers and systems, the present invention is equally applicable to other process chambers and systems.

CVD vacuum chambers are employed to deposit thin films on semiconductor substrates. Typically, a precursor gas is charged into a vacuum chamber through a gas manifold plate situated above the substrate, which substrate is heated to process temperatures, generally in the range of about 250 to about 650 °C. The precursor gas reacts on the heated substrate surface to deposit a thin layer thereon.

In a typical process chamber, a support member, commonly formed of aluminum, ceramic, or other material, on which a substrate is mounted during processing is vertically movable in the chamber. A plurality of support fingers are also vertically movable by an elevator and extend through the support member to facilitate transfer of the substrate from a robot blade to the support member. Typically, the support member also acts as a heater plate that is heated by a resistive heating element located therein which provides sufficient heat to maintain the upper surface at an elevated process temperature.

To increase the heat transfer from the support member to the substrate, the substrate is typically adhered to the upper surface of the support member by a "vacuum chuck." Pulling the substrate tightly against the upper surface of the support member enhances the surface to surface contact and, therefore, the heat transfer therebetween. Typically, the vacuum chucking is accomplished by applying a pressure differential between grooves formed in the upper surface of the support member and the process chamber. As shown in the prior art drawing of Figure 1, the upper surface of the support member of the prior systems includes a plurality of concentric grooves therein which intersect a plurality of radial grooves. A set of vacuum ports are disposed to communicate between the base of the grooves and a circular manifold disposed in the support member. A vacuum supply communicates with the manifold to supply a vacuum thereto. Thereby, the vacuum supply is able to create a low pressure environment under the substrate in the grooves to chuck, or adhere, the substrate to the support member upper surface. Such a vacuum chucking system is shown, for example, in U.S. Patent No. 5,516,367 that issued to Lei et al. on December 19, 1995. As shown therein, the grooves formed in the support member generally have a rectangular cross sectional shape which forms square corners at the intersection of the grooves with the upper surface.

One problem encountered with the existing support members is that the upper surface and the substrate commonly have contact surface imperfections which create local heat transfer anomalies. The heat transfer anomalies cause nonuniform heating across the substrate resulting in nonuniform deposition on the substrate.

Another problem associated with the current systems occurs as a result of cleaning of the process chamber. During deposition of the material, for example tungsten, the material is deposited not only on the substrate, but also onto all of the hot chamber and support member components. Because the adhesion of the deposited material to the chamber and the support member is poor, the material tends to flake off creating particles within the system that can damage the chamber, the substrates, and the product. Therefore, the deposited material must be removed to avoid particle generation. Using tungsten as an example, the removal of the material is accomplished utilizing a NF_3 low power plasma. The fluorine radicals of the NF_3 low power plasma attack the deposited tungsten during cleaning. However, the fluorine radicals also react with the aluminum of the support member to create an aluminum fluoride layer on the heater surface. Typically, this layer of aluminum fluoride is only about 0.0004 to about 0.0006 inches in thickness and does not create any detrimental effects as long as the thickness of the material is uniform. However, empirical studies have shown that the aluminum fluoride has greater accumulation at the intersections of the grooves and holes with the upper surface of the support member. This added accumulation of aluminum fluoride creates "ridges," or raised areas, of aluminum fluoride. These ridges have been found to exceed 0.004 inches preventing the substrate from fully contacting the upper surface of the support member and interfering with chucking of the substrate by causing backside pressure faults. Accordingly, the ridges cause temperature anomalies which affect film uniformity.

Therefore, there is a need to provide a support member that eliminates these problems and provides for chucking of the substrate to the support member, uniform heating of the substrate, and eliminates the formation of ridges of aluminum fluoride.

Disclosure of the Invention

The present invention generally provides a support member adapted to provide vacuum chucking. More particularly, the present invention provides a support member having an upper surface having an outer, raised portion defining an inner, recessed portion. The inner recessed portion is in fluid communication with a vacuum supply. Preferably, the support member includes a plurality of raised support areas positioned within the inner, recessed portion having a height above the recessed portion equal to the height of the outer, raised portion. Thus, a substrate placed on the upper surface is supported on the raised portion and the support areas in spaced relation to the recessed portion. The transition between the raised portions and the recessed portion is gradual and the orifices formed by the holes extending through the upper surface are rounded to eliminate sharp edges and rapid changes in height at the upper surface.

Another aspect of the invention is a process chamber incorporating the above described support member.

Yet another aspect of the invention is a method of supporting a substrate on and adhering the substrate to a support member having an upper surface, the upper surface having an outer raised portion defining an inner recessed portion including the steps of positioning the substrate on the upper surface of the support member, supporting the substrate on the outer, raised portion in spaced relation to the inner, recessed portion, and applying a vacuum to the inner, recessed portion.

Brief Description of the Drawings

So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings.

It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

Figure 1 is a top elevational view of the upper surface of a prior art support member showing the grooves formed therein.

Figure 2 is a side cross sectional elevational view of the process chamber containing the support member.

Figure 3 is a top elevational view of the support member showing the improved upper surface design of the present invention.

Figure 4 is a top elevational view of the support member showing an alternate design for the improved upper surface design of the present invention.

Figure 5 is a side cross sectional elevational view taken along lines 5-5 in figure 4 showing the rounded hole orifice and the tapered area around the hole orifice.

Figure 6 is a side cross sectional elevational view taken along lines 6-6 in figure 4 showing the gradual transition between the raised and recessed portions.

Figure 7 is a side cross sectional elevational view taken along lines 7-7 in figure 4 showing the gradual transition between the raised and recessed portions.

Detailed Description of the Preferred Embodiment

In general and as will be described more particularly below, the present invention generally provides an improved support member 30 that has an outer, raised portion 40 extending about the periphery of the upper surface 32 that defines an inner, recessed portion 42. The recessed area is in flow communication with a vacuum supply 50 so that, when a substrate 20 is placed thereon, the recessed portion 42 and the vacuum supply 50 provide a vacuum chuck, adhering the substrate 20 to the support member 30. The transition from the raised portions to the recessed portions of the upper surface 32 is gradual to help reduce formation of ridges thereon.

For clarity and ease of description, the following description refers primarily to a CVD process chamber and system although the present invention is equally applicable to other types of processes that utilize vacuum chucking.

Figure 2 shows a typical process chamber 12 defined by an outer body 14. The chamber 12 may be part of a vacuum processing system having a plurality of process chambers 12 connected to a central transfer chamber. The process chamber 12 houses a support member 30 that may take the form of a pedestal or susceptor mounted on a generally vertically oriented shaft 38. The support member 30 serves to support a substrate 20 on its flat upper surface 32. The support member 30 also includes four finger apertures 44 which define hole orifices 46 at the intersection of the finger apertures 44 with the upper surface 32. Typically, the support member comprises a block of metal, *e.g.*, aluminum, that has a single coil resistance heater embedded therein to provide heat to a substrate 20 resting thereon. However, the support member 30 may be formed of other materials such as ceramic. In order to provide uniform heating of the support member 30 and to uniformly heat the substrate 20, the coil must be in contact with the bulk of the support member 30 on all sides. Typically, the heating element is adapted to provide sufficient heat to maintain the upper surface 32 of the support member 30 at elevated process temperatures between about 250 and about 650 °C.

Figure 2 also illustrates a substrate lifting finger 200 received in the finger aperture 44 passing through the body of the support member 30. Typically, the support member 30 would include four such lifting fingers 200 to lift the substrate 20 clear of the upper surface 32 of the support member 30 after processing. This removal of the substrate 20 is achieved by means of a conventional process chamber robot arm (not shown) which enters the process chamber 12 through the slit valve opening 210 as would be known to those with ordinary skill in the art. The same robot arm is also used to insert the substrates 20 into the process chamber 12. The lifting fingers 200 are movable vertically under action of a secondary motion actuator 202.

A motion actuator 100 interconnected to the support member 30 is adapted to move the support member 30 vertically within the process chamber 12 alternately between a first, lowered position and a second, raised position where the process step is performed. In operation, the substrate 20 is placed onto the upper surface 32 of the support member 30 as follows. The robot arm inserts the substrate 20 into the process chamber 12 through the slit valve opening 210 supporting the substrate vertically above the support member 30. The secondary motion actuator 202 raises the lifting fingers 200, which extend through finger apertures in the support member 30, into contact with the substrate 20 and lifts the substrate 20 from the robot arm supporting the substrate 20 intermediate the first and second positions of the support member 30. The robot arm is retracted from the process chamber 12. Next, the motion actuator 100 lifts the support member 30 from the first position, past the top of the lifting fingers 200, to the second position. This motion of the support member 30 lifts the substrate 20 from the lifting fingers 200. Performing these steps in reverse order operates to complete a transfer of the substrate 20 from the support member 30 to the robot arm and from the process chamber 12.

To facilitate heat transfer between the support member 30 and the substrate 20, the substrate 20 is preferably chucked, or adhered, to the upper surface 32 of the support member 30. To provide the chucking, a pressure differential is created between the pressure in the process chamber 12 and the pressure between the substrate 20 and the support member 30. When the substrate 20 is chucked to the support member 30, the pressure between the substrate 20 and the support member 30 is less than the pressure in the process chamber 12. To create this pressure differential, the upper surface 32 includes a recessed portion 42 (shown in Figs. 3-3 and 6-7) in fluid communication with a vacuum supply 50. As shown in Figure 2, a vacuum pipe 52 extends through the shaft 38 of the support member 30 and provides fluid communication from the vacuum supply 50, positioned external the process chamber 12, to a manifold 58 formed in the center of the support member 30. A plurality of cross bores 54 extend radially from the manifold 58 and provide fluid communication to a plurality of vacuum ports 56 defined by the upper surface 32 of the support member 30. The interface of each vacuum port 56 with the upper surface 32 defines a hole orifice 46. The cross bores 54 are drilled into the support member 30 immediately below the upper surface 32. Thus, a vacuum is communicated from the vacuum supply 50 through the vacuum pipe 52 to the manifold 58 that distributes the vacuum to the cross bores 54 which communicate the vacuum to the upper surface 32 through the vacuum ports 56. Preferably, the support member 30 includes eight cross bores 54 extending radially from the center axis of the support member 30 and the cross bores 54 are equally spaced from one another so that the angle formed between adjacent cross bores 54 is about 45 degrees (See Figures 3 and 4). Also, the support member 30 preferably has three vacuum ports 56 per cross bore 54 communicating with the upper surface 32 for a total of twenty-four cross bores 54. Preferably, each set of three vacuum ports 56 is spaced from the center of the support member 30 and the sets are equally spaced from the center.

As shown in Figures 3 and 4, the upper surface 32 of the support member 30 is adapted to distribute and communicate the vacuum to a large portion of the lower surface of the substrate 20. Generally, to accomplish the distribution of the vacuum, the upper surface 32 includes raised areas adapted to support the substrate thereon and recessed areas adapted to provide fluid communication to the vacuum system. More specifically, the upper surface 32 has an outer, raised portion 40 about its periphery. Preferably, the upper surface 32 is circular forming is a continuous annular ring having an outer diameter approximately equal to the outer diameter of the substrate 20 and an inner diameter that is less than the outer diameter of the substrate 20. Note that the support member 30 may have a diameter that is greater than the diameter of the substrate 20 to allow, for example, attachment of guide pins 80 thereto as shown in Figure 2. However, as used herein, upper surface 32 refers to the area of the support member adapted to support the substrate 20 thereon. The outer, raised portion 40 defines an inner, recessed portion 42 that is recessed below the outer, raised portion 40. Thus, a substrate 20 placed upon the upper surface 32 rests upon the outer, raised portion 40 and is maintained in spaced relation above the inner, recessed portion 42. Because the outer, raised portion 40 is a continuous annular ring, it contacts the substrate 20 about its full periphery and defines an enclosed cavity between the inner, recessed portion 42 and the substrate 20 effectively sealing the cavity from the process chamber 12. Thus, when a vacuum is applied to the cavity, the support member 30 is capable of maintaining a pressure in the cavity that is lower than the pressure in the process chamber 12. The outer diameter of the inner, recessed portion 42, and thus the inner diameter of the outer, raised portion 40, is such that the majority of the surface area of the lower surface of the substrate 20 extends over the inner, recessed portion 42 whereas, by comparison, a lesser proportional share of the surface area of the substrate 20 is in contact and extends over the outer, raised portion 40. Therefore, the vacuum is applied to the majority of the lower surface of the substrate 20. In the preferred embodiment, the inner, recessed portion 42 is recessed below the outer, raised portion 40 by about 0.001 to about 0.0015 inches. Note that the amount of recess of the present invention is much less than the groove depth of about 0.015 to about 0.025 inches of prior art support members such as the one shown in Figure 1. Because of the close proximity of the substrate 20 to the upper surface, even over the recessed portion 42, the support member 30 is able to uniformly transmit the heat to the full lower surface area of the substrate 20. As the majority of the substrate 20 is spaced from the upper surface 32, over the recessed portion 42, surface imperfections in the substrate 20 or the upper surface 32 do not affect the heat transfer therebetween because the surfaces are not in contact facilitating more uniform distribution on the substrate 20.

Preferably, to help support the substrate 20 on the support member 30 and prevent the substrate from bending or deforming during vacuum chucking, the upper surface 32 includes at least one, but preferably a plurality of, raised support areas 60 positioned within the inner, recessed portion 42. The support areas 60 rise above the inner, recessed portion 42 to provide supports upon which the substrate 20 may rest. Accordingly, so that the upper surface provides a flat surface upon which the substrate 20 may rest, the height that the support areas 60 extend above the inner, recessed portion 42 is equal to the height of the outer, raised portion 40 relative to the inner, recessed portion 42 (*i.e.*, between about 0.001 and 0.0015 inches). As shown in Figures 3 and 4, the support areas 60 may extend into the inner, recessed portion 42 from the raised portion 40 or may be separated therefrom. Preferably, at least one support area 60 is positioned at the center axis of the upper surface 32 to provide support for the center of the substrate 20. Further, the support areas 60 are preferably equally spaced about the upper surface 32 and have sufficient surface area to support the substrate 20 and prevent it from bending.

For example, Figure 3 shows an upper surface 32 wherein the raised portion 40 is substantially annular having a wafer flat area provided along a small portion thereof. The finger apertures 44 extend through the support member 30 and define hole orifices 46 in the raised portion 46. The raised portion 40 extends inwardly around the hole orifices 46 to provide support around the hole orifices 46 and to limit fluid communication between the hole orifices and the inner, recessed portion 42. The inner, recessed portion 42 includes nine support areas 60 positioned therein. One circular support area 60 is positioned at the center of the upper surface 32. The other eight support areas 60 are positioned intermediate this central support area 60 and the raised portion 40. The eight support areas 60 are equally spaced from one another at approximately 45 degrees and each have an elongated shape that extends radially from the center of the upper surface 32.

Likewise, the example shown in Figure 4 includes an annular outer, raised portion 40 having hole orifices 46 therein and extending inwardly around the hole orifices 46. Further, the inner, recessed portion 42 includes a support area 60 positioned at the center of the upper surface 32 and a plurality of elongated support areas 60 extending radially from the center of the upper surface 32. Some of the support areas 60 are connected to the raised portion 40 while others are connected to the support area 60 positioned at the central axis of the upper surface 32 and others are intermediate the raised portion 40 and the central support area 60. However, none of the support areas 60 extend from the central support area 60 to the raised area 40 that would section the inner, recessed portion 42 so that the vacuum is readily communicated throughout the inner, recessed portion 42. Although Figures 3 and 4 show exemplary upper surface areas 32, the exact pattern created by the raised portion 40, the recessed portion 42, and the support areas 60 may vary without departing from the scope of the present invention.

As mentioned, one problem associated with the prior art support members 30 is that they tend to form ridges of material at the intersection of the grooves and the holes with the upper surface 32 where sharp edges and rapid changes in the height of the upper surface 32 are formed. The present invention overcomes this problem by eliminating the sharp edges and rapid changes in the height of the upper surface 32 by providing a gradual transition from raised to recessed portions. Figures 5 through 7 show the gradual transitions.

Figure 5 is a partial cross sectional view of the hole orifice 46 created at the intersection of the finger aperture 44 with the upper surface 32. As shown, the present invention eliminates the sharp edges at the interface by rounding the edges. In addition, the area around the hole orifice 46 is tapered slightly downward toward the hole orifice 46. Preferably, the angle of the taper is about five degrees. Note that this rounding and tapering also applies to the hole orifices 46 formed by the intersection of the vacuum ports 56 with the upper surface.

Similarly, Figure 6 shows a partial cross sectional view of the transition of the upper surface 32 from the outer, raised portion 40 to the inner, recessed portion 42. The present invention utilizes a gradual taper, or slope, having a ratio of the rise to the run (*i.e.*, amount of vertical distance compared to amount of lateral distance) of about 1 to 50. Thereby, the present invention eliminates the sharp transition between the raised portion 40 and the recessed portion 42.

Figure 7 shows a partial cross sectional view of a support area 60 showing the transition from the raised support area 60 to the recessed area 42. As in the transition from the raised portion 40 to the recessed portion 42, the transition of the support area 60 to the recessed area 42 uses a gradual slope, or taper, having a ratio of rise to run of about 1 to 50 to eliminate any sharp transition therebetween.

While the foregoing is directed to the preferred embodiment of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims which follow.

Claims:

1. An apparatus for supporting a substrate, comprising:

a support member having an upper surface;

an outer, raised portion of the upper surface extending about the periphery of the upper surface;

the outer, raised portion defining an inner, recessed portion; and

a vacuum supply in fluid communication with the inner, recessed portion.

2. The apparatus of claim 1, further comprising:

at least one raised support area of the upper surface; and

the at least one raised support area positioned in the inner, recessed portion.

3. The apparatus of claim 2, wherein the upper surface includes a plurality of raised support areas.

4. The apparatus of claim 2, wherein the raised support areas are equally spaced about the inner, recessed area.

5. The apparatus of claim 1, wherein the transition from the support area to the inner recessed area is gradual.

6. The apparatus of claim 5, wherein the transition taper from the support area to the inner, recessed area has a ratio of the rise to the run of about 1 to 50.

7. The apparatus of claim 1, wherein the outer, raised portion is substantially annular.

8. The apparatus of claim 7, wherein the outer, raised portion is continuous and extends about the full periphery of the upper surface.

9. The apparatus of claim 1, wherein the inner, recessed portion is recessed below the outer, raised portion by about 0.001 to 0.0015 inches.

10. The apparatus of claim 1, wherein the majority of the surface area of the lower surface of the substrate extends over the inner, recessed portion and is, thus, spaced from the upper surface.

11. The apparatus of claim 1, wherein the transition from the outer, raised portion to the inner, recessed portion is gradual.

12. The apparatus of claim 11, wherein the transition taper from the outer, raised portion to the inner, recessed area has a ratio of the rise to the run of about 1 to 50.

13. The apparatus of claim 1, wherein:
the support member defines holes therethrough;
the holes extend through the upper surface defining hole orifices in the upper surface; and
the hole orifices are rounded.

14. The apparatus of claim 13, wherein an area of upper surface surrounding each of the hole orifices tapers downward toward the hole orifice.

15. The apparatus of claim 14, wherein the taper of the area of upper surface surrounding each of the hole orifices is about five degrees.

16. A process chamber for processing a substrate, comprising:
a chamber body;
a support member positioned in the chamber body having an upper surface;
an outer, raised portion of the upper surface extending about the periphery of the upper surface;
the outer, raised portion defining an inner, recessed portion; and
a vacuum supply in fluid communication with the inner, recessed portion.

17. The apparatus of claim 16, further comprising:
at least one raised support area of the upper surface; and
the at least one raised support area positioned in the inner, recessed portion.

18. The apparatus of claim 17, wherein the upper surface includes a plurality of raised support areas.

19. The apparatus of claim 17, wherein the raised support areas are equally spaced about the inner, recessed area.

20. The apparatus of claim 16, wherein the transition from the support area to the inner recessed area is gradual.

21. The apparatus of claim 20, wherein the transition taper from the support area to the inner, recessed area has a ratio of the rise to the run of about 1 to 50.

22. The apparatus of claim 16, wherein the outer, raised portion is substantially annular.

23. The apparatus of claim 22, wherein the outer, raised portion is continuous and extends about the full periphery of the upper surface.

24. The apparatus of claim 16, wherein the inner, recessed portion is recessed below the outer, raised portion by about 0.001 to 0.0015 inches.

25. The apparatus of claim 16, wherein the majority of the surface area of the lower surface of the substrate extends over the inner, recessed portion and is, thus, spaced from the upper surface.

26. The apparatus of claim 16, wherein the transition from the outer, raised portion to the inner, recessed portion is gradual.

27. The apparatus of claim 26, wherein the transition taper from the outer, raised portion to the inner, recessed area has a ratio of the rise to the run of about 1 to 50.

28. The apparatus of claim 16, wherein:

the support member defines holes therethrough;

the holes extend through the upper surface defining hole orifices in the upper surface; and

the hole orifices are rounded.

29. The apparatus of claim 28, wherein an area of upper surface surrounding each of the hole orifices tapers downward toward the hole orifice.

30. The apparatus of claim 29, wherein the taper of the area of upper surface surrounding each of the hole orifices is about five degrees.

31. A method of supporting a substrate on and adhering the substrate to a support member having an upper surface, the upper surface having an outer raised portion defining an inner recessed portion, comprising the steps of:

positioning the substrate on the upper surface of the support member;

supporting the substrate on the outer, raised portion in spaced relation to the inner, recessed portion; and

applying a vacuum to the inner, recessed portion.

32. The method of claim 31, further comprising the step of providing at least one support area in the inner recessed portion adapted to support the substrate.

33. The method of claim 31, further comprising the step of providing a gradual taper between the inner, recessed portion and the outer, raised portion.

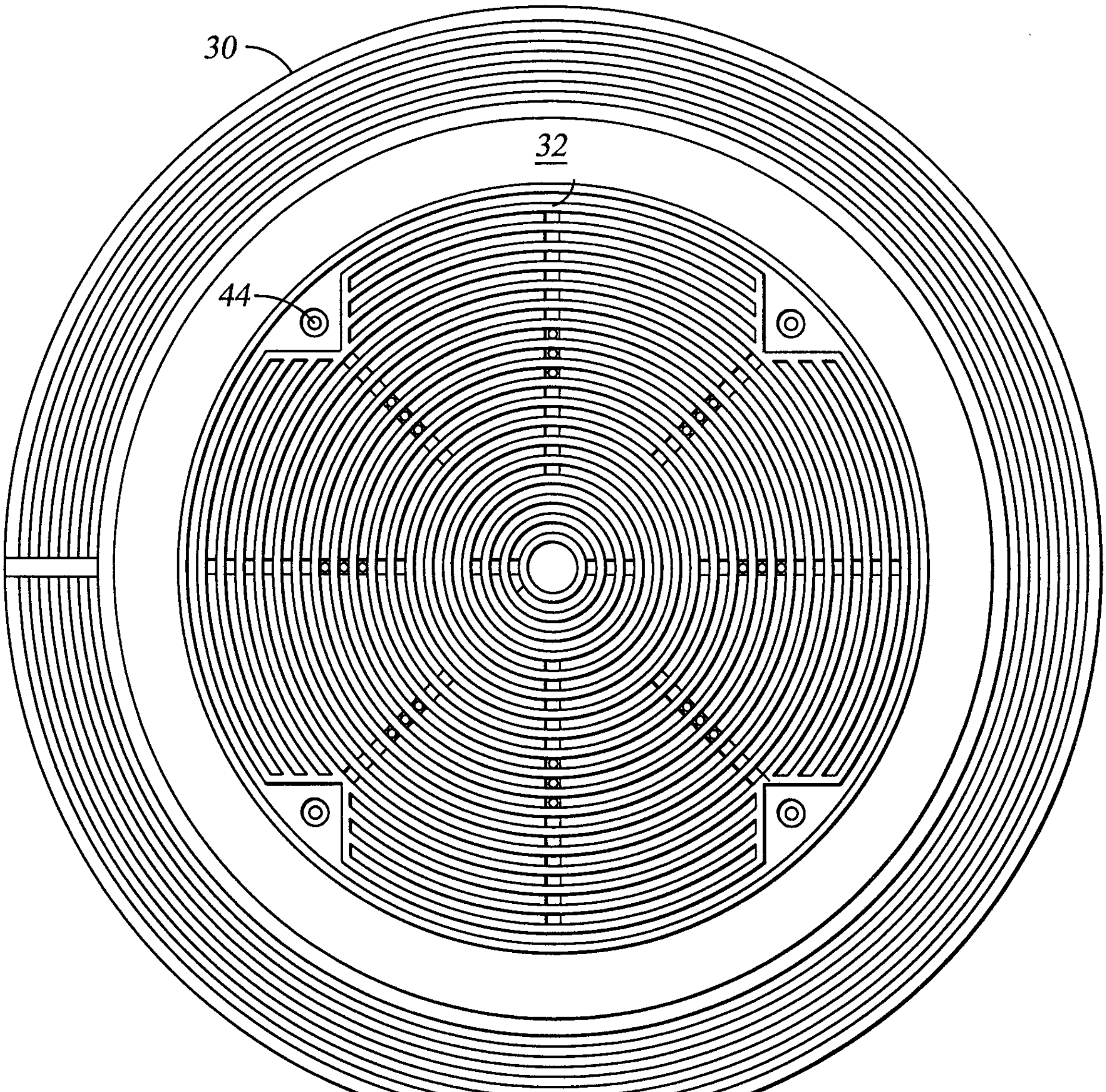
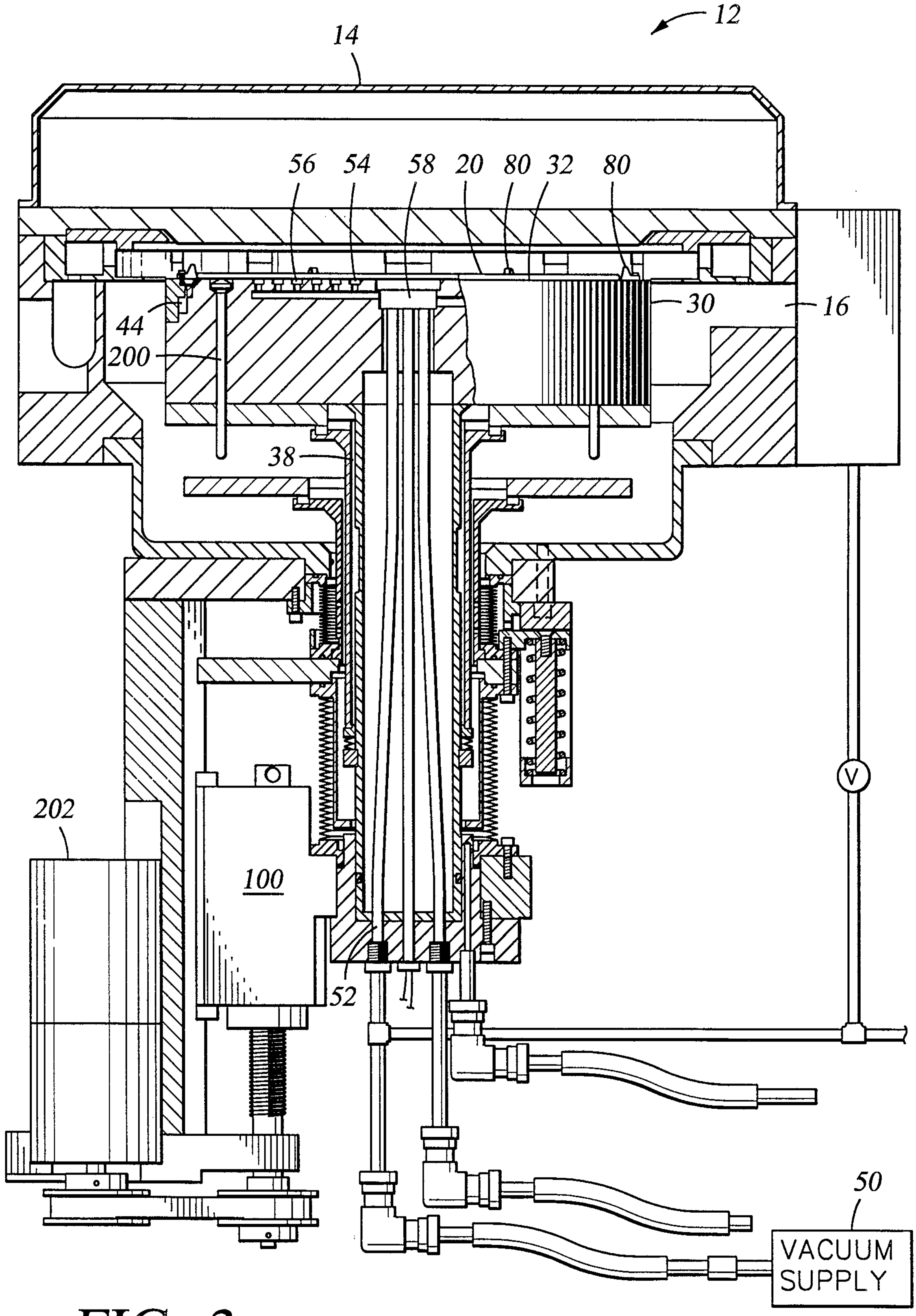


FIG. 1
(PRIOR ART)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VACUUM SUPPLY

FIG. 2

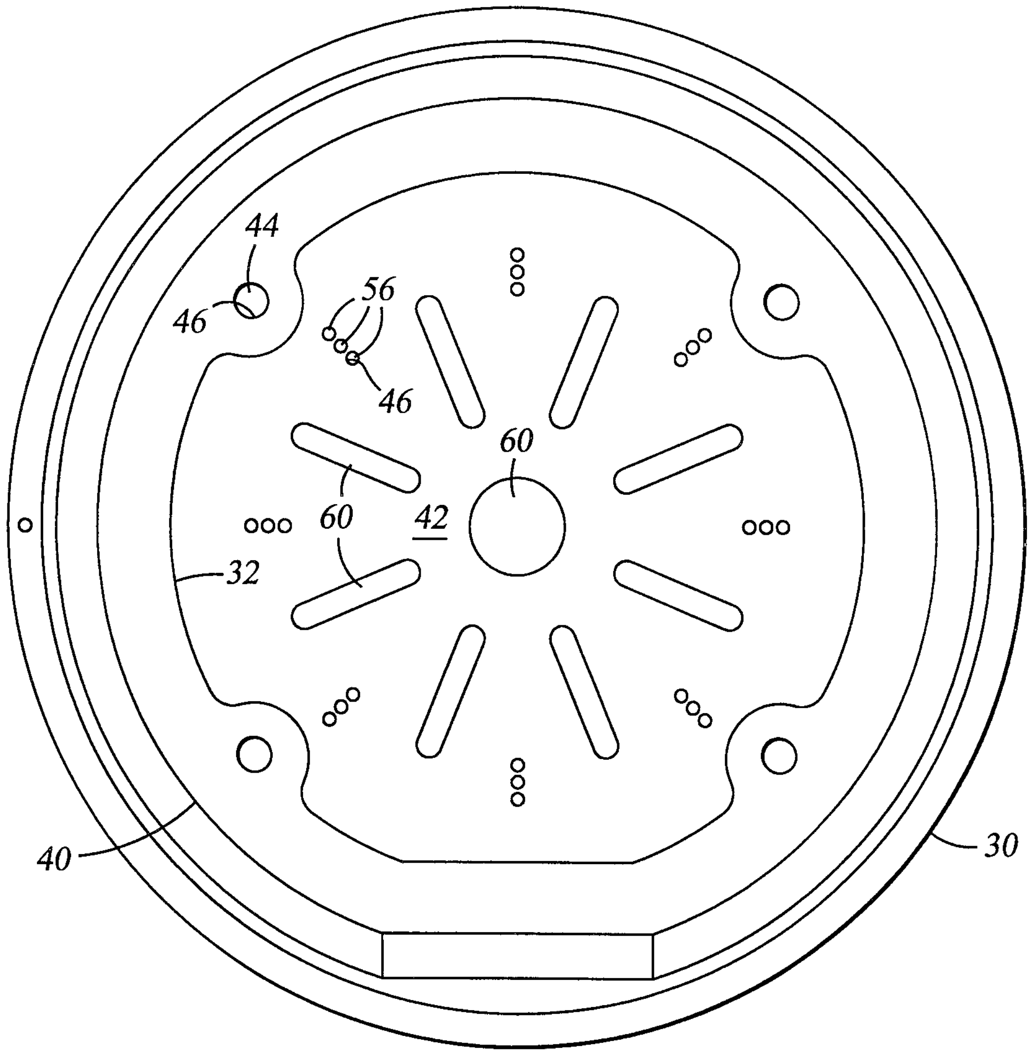


FIG. 3

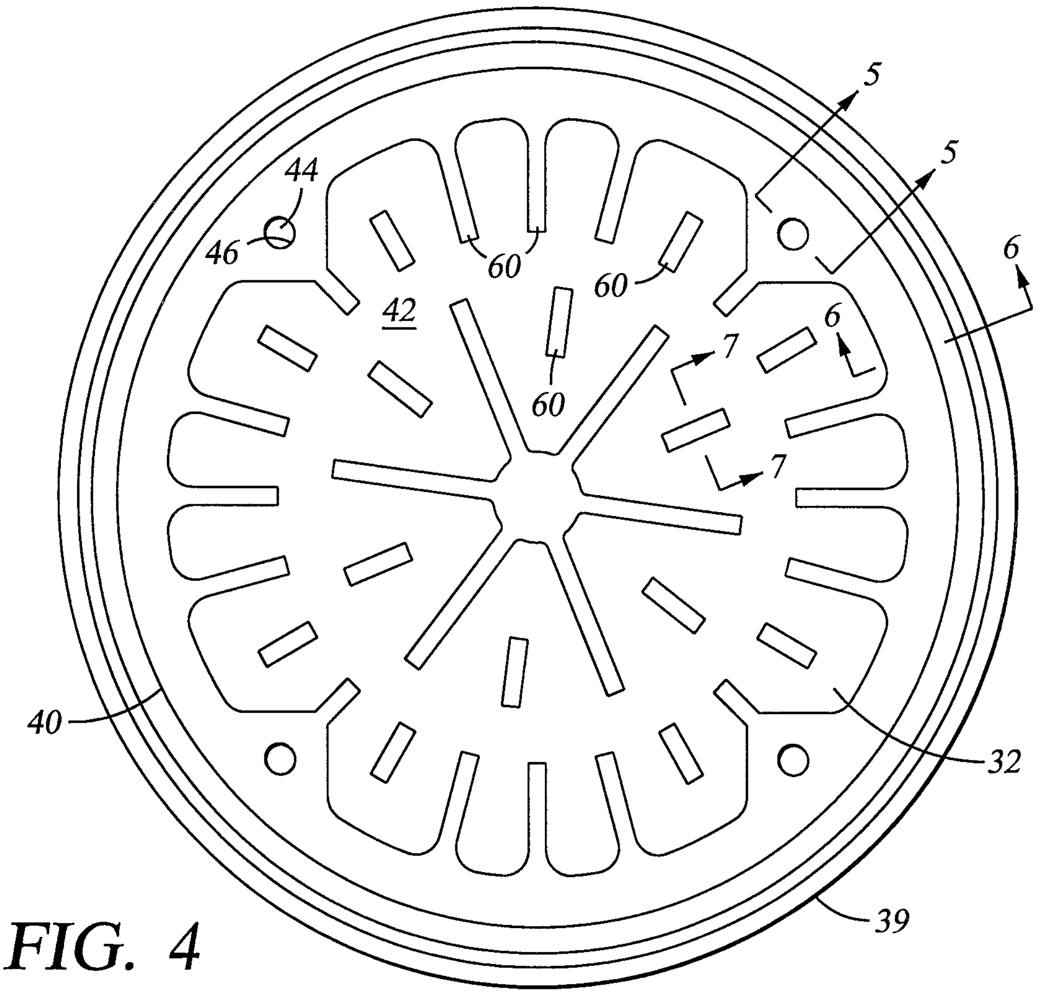


FIG. 4

FIG. 5

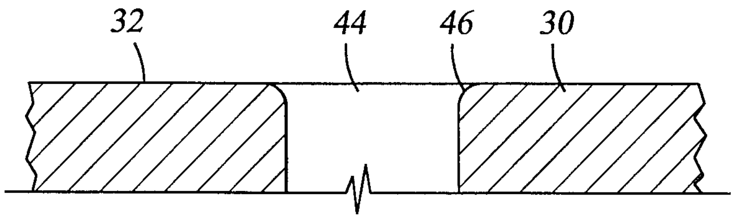


FIG. 6

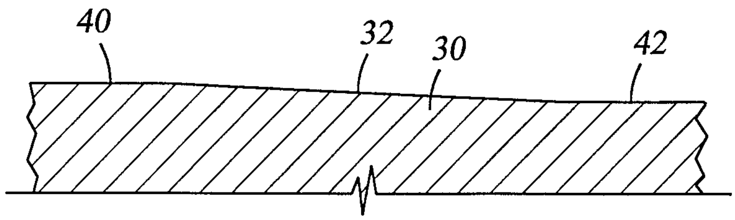
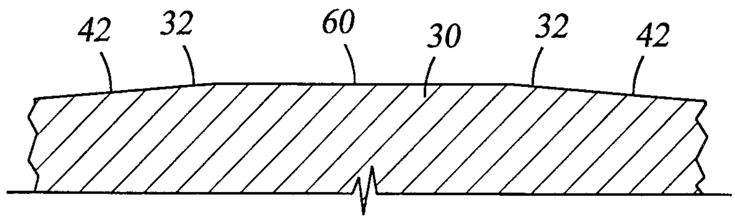


FIG. 7



INTERNATIONAL SEARCH REPORT

Inter ıal Application No
PCT/US 98/15532

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01L21/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 456 426 A (CANON KABUSHIKI KAISHA) 13 November 1991 see abstract; figures 1,2,5 see column 6, line 7-18 ---	1-4,7,8, 10,13, 16-19, 22,23, 25,28, 31,32
X	US 5 703 493 A (WEEKS ET AL.) 30 December 1997 see abstract; figure 1 ---	1,7,8, 13,16, 22,23, 25,28,31
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search	Date of mailing of the international search report
6 April 1999	14/04/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Oberle, T

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 738 165 A (IMAI) 14 April 1998 see abstract; figures 2,3 see column 3, line 60 - column 4, line 35 ---	1-4,7,8, 10,13, 16-19, 22,23, 25,28, 31,32
E	PATENT ABSTRACTS OF JAPAN vol. 098, no. 014, 31 December 1998 & JP 10 242255 A (KYOCERA CORP), 11 September 1998 see abstract -----	1-4,7,8, 10, 16-19, 22,23, 25,31,32

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/US 98/15532

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0456426 A	13-11-1991	JP 4324658 A	13-11-1992
		JP 4014239 A	20-01-1992
		US 5374829 A	20-12-1994
US 5703493 A	30-12-1997	NONE	
US 5738165 A	14-04-1998	JP 6037172 A	10-02-1994