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(57) Abstract

A compact microwave dowstream plasma system includes, within a significantly small portable housing unit, a power supply, a microwave generator, a non–linear wave guide, a circulator, a dummy load, a plasma applicator, and an igniter. The microwave generator supplies microwaves to the guide to the applicator. The guide includes several curved regions that allow for a more compact design. The applicator is configured to generate a plasma and output reactants that can be used to remove photoresist layers from a wafer within a process reactor.

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COMPACT MICROWAVE DOWNSTREAM PLASMA SYSTEM

TECHNICAL FIELD

The present invention relates to systems and tools used in the fabrication of semiconductor devices on a work product, and more particularly to microwave downstream plasma systems, tools and methods for use in removing materials from the work product during the fabrication process.

BACKGROUND ART

There are several different means by which materials, such as photoresist, can be removed from a work product. The wet chemical stripping techniques that were used for many years have recently given way to dry stripping techniques or combinations of wet/dry stripping techniques. The dry stripping techniques typically include removing the resist materials by using reactants to burn off the organic materials in the resist at elevated temperatures. The reactants are often created by way of a plasma that is generated using one or more selected gases and a high energy source, such as a radio frequency (rf) or microwave energy source. For example, the plasma in a typical microwave downstream plasma system is arranged to produce a flux of radical species (i.e. reactants), such as, for example, atomic oxygen, which is then directed "downstream" to a process chamber and brought into contact with the work product. The work product is typically a semiconductor wafer on which a resist layer has previously been applied and patterned to form a mask.

A microwave downstream plasma system, such as that described above, is usually included in a fabrication facility along with other fabrication systems and tools, such as, for example, etching systems, ion implantation systems, and deposition systems. Within a typical fabrication facility there can be several stations, each having an assortment of systems or tools for use in the fabrication process. Moreover, the facility provides these stations/systems within a clean room environment to further reduce the chance of contaminants entering the work product.

The costs associated with providing and maintaining a fabrication facility having these types of systems are often very high. For example, it is not uncommon for new facilities to cost hundreds of millions, or even several billions of dollars to build. The operational costs for such a facility are often very high as well As a result, there is a continuing need to provide more cost effective systems and tools that reduce these expenses while also providing state of the art processing capabilities.

SUMMARY OF THE INVENTION

The present invention provides cost effective apparatus, systems and tools that are more compact and as such reduce facility related expenses while also providing state of the art processing capabilities. Additionally, a modular design has been implemented to provide for easier access and maintenance. The present invention further provides improved methods for using the apparatus, systems and tools to fabricate devices on work products, such as, for example, semiconductor wafers.

In accordance with one embodiment of the present invention, there is provided a plasma generating apparatus for use with a downstream process reactor. The apparatus includes a generator, a guide and an applicator. The generator is configured to output microwave energy into a first end of the guide. The guide is configured to direct at least a portion of the microwave energy output by the generator from the first end towards a second end, which is coupled to the applicator. The guide further includes at least one curved region between the first end and the second end. The applicator is configured to generate a plasma, within the applicator, using at least a portion of the microwave energy provided via the guide. In some embodiments, the applicator has an igniter, such as, for example, an ultraviolet energy source that assists in striking the plasma.

In certain embodiments, the guide has a tuner that is coupled between the first end and the second end. The tuner is configured to control at least one parameter, such as, for example, an amplitude, a frequency, or a phase, associated with the microwave energy within the guide. In other embodiments, the guide has an attenuating mechanism that is also coupled between the first end and the second end. This attenuating mechanism is configured to substantially attenuate microwave energy traveling towards the first end within the guide. Also, in some embodiments the guide includes a plurality of segments that are connected together, however, in these embodiments at least two of the plurality of segments are connected together without using a flange connector. For example, the two segments can be bonded together with a weld or a bonding material.

In another embodiment of the present invention, the apparatus further includes a power supply that is coupled to the generator and configured to supply electrical energy to the generator for use in outputting microwave energy. In certain embodiments, the power supply has been divided into separate subsystems. The subsystems can include, for example, a controller, a bus, and/or an inverter.

The apparatus in still other embodiments includes a housing that is configured to support at least the generator, the guide and the applicator. In certain embodiments, the housing has a mounting bracket that is suitable for pivotally mounting the apparatus to an external apparatus.

The above stated needs and others are further met by a downstream stripping tool for use in fabricating a semiconductor device on a work product. The tool includes a reactant generating arrangement that includes a generator, a guide and an applicator. In this embodiment, the generator supplies microwave energy to the guide, the guide directs the microwave energy through at least one curved region and provides at least a portion of the microwave energy to the applicator for use in generating a plasma within the applicator. The plasma causes at least one reactant to be supplied to a processing arrangement that is coupled to the reactant generating arrangement and configured to receive the reactant and direct the reactant to an exposed portion of the work product. In certain exemplary embodiments, the reactant generating arrangement further includes a housing that is configured to support at least the generator, the guide and the applicator. In other embodiments, the housing is also pivotally mounted to the processing arrangement.

A modular plasma source is also provided in yet another embodiment of the present invention. The modular plasma source can be used with a downstream process reactor. The modular plasma source has a footprint of less than approximately 576 square inches based the product of a maximum width measurement and a maximum depth measurement. In this embodiment, the maximum width and depth measurements are for an operatively configured modular plasma source. The modular plasma source includes, within the footprint, a power supply, an applicator and a microwave generator. The microwave generator is electrically coupled to the power supply and arranged to supply microwave energy to the applicator. In one embodiment, the modular plasma source has a maximum height measurement of less than approximately 36 inches. Also, in other embodiments, the modular plasma source further includes a tuner coupled between the microwave generator and the applicator, a circulator coupled between the microwave generator and the applicator and a dummy load coupled to the circulator, and/or an igniter that is configured to ignite a plasma within the applicator.

The foregoing and other features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements in which;

Figure 1 depicts a conventional microwave downstream plasma system having an external power supply, and a substantially linear wave guide between a microwave generator and an applicator;

Figure 2 depicts a compact microwave downstream plasma source having an on-board power supply, and a wave guide that includes curved regions between a microwave generator and an applicator, in accordance with an embodiment of the present invention;

Figure 3 isometrically depicts an exemplary housing unit having its side panels removed, within the housing unit there is a compact microwave downstream plasma source as in Figure 2, in accordance with one embodiment of the present invention;

Figure 4 isometrically depicts an exemplary housing unit, having attached side panels, that contains a compact microwave downstream plasma source, in accordance with one embodiment of the present invention;

Figure 5 depicts a back-side view of an exemplary housing unit, having its back-side panel removed, that contains a compact microwave downstream plasma source, in accordance with one embodiment of the present invention; and

Figure 6 isometrically depicts a microwave downstream plasma system that includes a process reactor within a base arrangement and a compact microwave down stream plasma source within a housing that is pivotally secured to the base arrangement, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

One important factor in reducing the costs associated with a fabrication facility is the physical requirements of the systems and tools that are to operate within the facility structure. By way of example, the physical requirements can include the size, weight, thermal characteristics, and noise/vibration of the system/tool. The size of the tool, for example, can increase the facility costs by requiring that more space be provided for the tool. Thus, reducing the footprint of a system or tool usually lowers the facility costs associated with the system/tool. Designers of fabrication facilities, systems and tools have had great success in reducing the footprints of many systems and tools, and as such have significantly reduced costs and increased throughput. For example, designers have continued to reduce the footprints of the transport and processing systems/modules to save space within the facility. Indeed, for many facilities, reduction of the space required for the transport and process modules has been a high priority goal in the pursuit of the optimal use of available space. Because the footprint of the aforementioned modules has been the determining factor, efforts to reduce footprints have been directed towards these modules in the prior art.

With this in mind, Figure 1 is a block diagram depicting the major components of a microwave downstream plasma system 10, as currently found in many fabrication facilities. System 10, which is typically included in a station or used as a stand-alone tool, includes a microwave generator 12, an external power supply 14, a wave guide 16, an applicator 18, and a processing reactor chamber 20. Within processing reactor chamber 20, there is shown a chuck 22 and a wafer 24 (i.e., the work product). Also shown is a gas inlet 26 leading into applicator 18 and an exhaust port 28 leading away from chamber 20. Microwave generator 12 is coupled to and powered by external power supply 14. Microwave generator 12 is arranged to output microwave energy through wave guide 16 and into applicator 18. Within applicator 18, the microwave energy is combined with one or more gases, as supplied within applicator 18 via inlet 26, to create a plasma that causes reactants to enter into chamber 20 and react with any resist materials on the exposed surfaces of wafer 24. Wafer 24 is positioned on chuck 22 during the stripping process. Chuck 22, which usually includes a mechanism (not shown) to hold wafer 24, is typically heated to raise the temperature of wafer 24 to further the resist stripping process.

As shown, wave guide 16 usually includes a tuner 30 that is used to adjust the phase, or some other parameter, associated with the microwave energy provided to applicator 18 to allow for, or enhance, the plasma generated within applicator 18. Tuner 30, which can be automatically or manually adjustable, typically includes a mechanism for arranging one or more rods within wave guide 16 that interact with the microwaves to provide the desired parameter adjustment.

System 10, while providing state of the art stripping capabilities, suffers from a rather large footprint due to several design features. First, power supply 14, which is often very large and bulky (e.g., 4-6 cubic feet), is typically located within a separate electrical rack either within the clean room, or external to the clean room (as shown), to reduce the footprint of system 10 about a station within the clean room. This, however, often leads to additional costs, for example, due to cabling and critical floor space. Secondly, in order to strike a plasma within applicator 18, wave guide 16 typically needs to be long enough to allow for tuner 30 to adjust the microwave energy to maximize the power provided to the gas(es) within applicator 18. Thus, in the past, wave guide 16 has been a significantly long and linear four-sided wave guide connected between microwave generator 12 and applicator 18. This long, linear arrangement tends to require additional space within the facility.

Additionally, the separation of components, such power supply 14, and the length and linear arrangement of wave guide 16 tend to increase operating expenses by requiring additional labor and time to troubleshoot, repair and/or maintain system 10. By way of example, assuming that system 14 fails to operate properly because of a malfunction in power supply 14. As depicted in Figure 1, to gain access to power supply 14 the systems operator would have to leave the clean room to check the status of the power supply, and/or a second operator would be required. As a further example, to gain access to chamber 20 to conduct routine cleaning/maintenance, the fixed or rigid structure of wave guide 16 combined with microwave generator 12 and applicator 18 typically needs to be disassembled. This can lead to additional downtime for the system and increased operation and maintenance costs.

Thus, in accordance with an embodiment of the present invention, the footprint of a microwave downstream plasma system has been significantly reduced by providing a compact microwave downstream plasma source that provides state of art stripping capabilities. In accordance with the present invention, the compact downstream plasma source is provided in a single unit or housing that can be easily lifted, removed and/or replaced within the clean room. Being self-contained and readily portable, the compact downstream plasma source tends to reduce maintenance costs and the related down time by providing a "plug-and-play" type of component. This plug-and-play feature is especially useful in minimizing the downtime required to exchange units as part of a preventive or corrective maintenance procedure, and/or as part of an upgrade cycle from one type of system or generation to another. Furthermore, being a substantially self-contained unit, there is no need for external space or additional electrical racks.

Figure 2 is a block diagram depicting a compact downstream plasma source 100 in accordance with an embodiment of the present invention. Compact downstream plasma source 100 includes a microwave generator 102, an on-board power supply 104, a non-linear wave guide 106, and an applicator 108. Wave guide 106 includes at least one substantial bend or curved region 110 that redirects the microwave energy generated by microwave generator 102 towards applicator 108. As shown, wave guide 106 further includes a automatic tuner 112 and an attenuating mechanism 18 that, in one embodiment of the present invention, includes a circulator 120 and a dummy load 122.

Power supply 104 supplies power to microwave generator 102 to control the microwave energy supplied by microwave generator 102 to wave guide 106. In one embodiment of the present invention, power supply 104 monitors and compensates for changes in the output of microwave generator 102 during operation. As such, power supply 104 includes several functional subsystems or circuits that, in certain embodiments, have been advantageously separated (physically) to further enhance the compactness of source 100.

For example, in a preferred embodiment of the present invention, power supply 104 has been divided into three subsystems (see Figure 2), namely a bus 123, a controller 124 and an inverter 125. Bus 123 is configured to receive an outside alternating current (AC) signal, and convert and/or distribute the AC signal to controller 124 and inverter 125. For example, in accordance with a preferred embodiment of the present invention, the AC signal is a 208 V AC, 3-phase, signal that is provided to bus 123. Bus 123 provides one phase to controller 124 and further rectifies/conditions the 208 V AC signal to provide a 300 V direct current (DC) signal to inverter 125. Inverter 125 includes switched power transistors that are arranged to a produce 600 V AC (peak-to-peak) signal that is then supplied to a high voltage transformer to produce a 4000 V AC (peak-to-peak) signal which is then rectified/conditioned to a 4000 V DC signal. The resulting 4000 V DC signal is preferably capable of supplying up to approximately 600 mA to microwave generator 102. The switching of the transistors within inverter 125 is controlled via logic within controller 124 in response to selected control inputs and monitored performance parameters associated with microwave generator 102. Thus, controller 124 essentially controls the current supplied to microwave generator 102 by inverter 125.

Microwave generator 102 generates microwave energy and outputs the microwave energy to wave guide 106. In a preferred embodiment of the present invention, microwave generator 106 is capable of outputting approximately 125 to 1500 Watts at a frequency of approximately 2.45 GHz +/- 15 MHz with less than 1% ripple. By way of example, power supply 104 (as described above) and microwave generator 102 (e.g., a forward power magnetron head) are both available from Applied Science and Technology, Inc. (ASTeX™), of Woburn, Massachusetts.

Wave guide 106, which is arranged to direct the microwave energy from microwave generator 102 to applicator 108, is preferably a single integrated unit that includes a four-sided structure or other suitable medium to guide the microwave energy to applicator 108. In other embodiments, wave guide 106 includes two or more sections that are arranged to serve as the medium. Unlike the linear wave guides in previous systems, wave guide 106 includes at least one significantly curved region 110. For example, as depicted in Figure 2, a curved region 110 provides a 90 degree bend. It is recognized that other angles can be used and/or combined over a distance to direct the microwave energy from microwave generator 102 to applicator 108.

Contrary to the design of wave guide 16 in Figure 1, non-linear wave guide 106, which is essentially bent or folded, effectively reduces the footprint of the system/tool. Thus, wave guide 106 can be just as long, or longer than wave guide 16 without occupying as much space within the clean room. Additionally, wave guide 106, in a preferred embodiment of the present invention, is actually shorter than a conventional wave guide 16. However, additional efforts may be required to initiate and control the plasma within applicator 108 due to the shortened length of wave guide 106. One way to compensate for the shorted length is to provide a state of the art tuner 112 that effectively enables source 100 to stay within the process window specified for a given work product process.

Thus, in accordance with an embodiment of the present invention, tuner 112 is preferably an automatic load matching device that includes a closed-loop control circuit, with power sensors (not shown) and attenuators 114. Tuner 112 is preferably located along wave guide 106 between microwave generator 102 and applicator 108. The control circuit within tuner 112, in one embodiment, includes three sensors, separated by 60 degree increments associated with the microwaves within wave guide 106, that detect both the applied power from microwave generator 102 and the reflected power from the plasma within applicator 108. When the sensors detect reflected power, their output is fed to the control circuit in tuner 112 that provides corrective signals to three stepper motors which control the positioning of attenuators 114 within wave guide 106. Attenuators 114 are preferably stubs that are also positioned in 60 degree increments (similar to the sensors above) to selectively attenuate the top half (i.e., 180 degrees) of the microwaves within wave guide 106. This attenuation is then inherently reproduced in the bottom half of the microwaves also. When attenuators 114 are properly set, the reflected power is substantially eliminated and the supplied power significantly matches the load in applicator 108. Thus, during the initial ignition of the plasma within applicator 108, and/or in response to changes in the stripping recipe, the control circuit within tuner 112 matches the applied power of the microwave energy within wave guide 106 to the load. By way of example, in a preferred embodiment of the present invention, tuner 112 is a SmartMatch™ autotuning system available from ASTeX™.

Attenuating mechanism 118, which is optional, is provided to remove microwaves that travel within wave guide 106 back towards microwave generator 102. In a preferred embodiment, attenuating mechanism includes circulator 120 that uses magnetic fields to redirect these microwaves towards dummy load 122. Dummy load 122 is configured to absorb the redirected microwaves. Circulator 120 and dummy load 122 are available from ASTeX™.

Applicator 108 preferably has an elongated tube, for example a quartz or sapphire tube, that has been configured to receive one or more gases through inlet 126, maintain a specified pressure, and receive the tuned microwave energy from wave guide 106. Applicators, such as this, and their operation, are known to those skilled in the art. Applicator 108 is preferably a water cooled applicator that is also available from ASTeX™.

In accordance with an embodiment of the present invention, inlet 126 is heated using a resistive heating element (not shown) that is wrapped about inlet 126 and controlled to maintain inlet 126 and the gas(es) therein at a specified temperature to assist in the stripping process. For example, if inlet 126 is a metallic pipe and the gases supplied to applicator 108 include vaporized H_2O, then the temperature of inlet 126 and the gases therein are maintained sufficiently high enough to prevent possible condensation within inlet 126 which could have deleterious affects on the process, equipment, and/or work product.

In one embodiment, applicator 108 further includes an igniter 116 that is used to strike the plasma during initiation. For example, igniter 116, in an exemplary embodiment is an ultraviolet light source. Thus, igniter 116 allows for quick plasma generation, and in certain embodiments further overcomes any potential plasma ignition/control difficulties presented by a shortened length of wave guide 106.

To illustrate the reduced footprint/design features of compact microwave downstream plasma source 100 depicted in Figure 2, an isometric view is presented in Figure 3 that depicts an exemplary housing unit 128 having its side panels (not shown) removed. Within housing unit 128 are several structural and functional components of source 100, as in Figure 2, with like reference numbers referring to like components. The arrangement of the components within housing unit 128 is exemplary and additional arrangements exist within the scope of the present invention.

Thus, in accordance with an embodiment of the present invention, housing unit 128 essentially defines the preferred size for a modular plasma source for use with a downstream process reactor. As shown, in this embodiment, housing unit 128 has a maximum footprint of less than approximately 576 square inches based the product of a maximum width measurement (24 inches) and a maximum depth measurement (24 inches). The maximum width and depth measurements are for an operatively configured modular plasma source. Additionally, although not as important, a preferred housing unit 128 also has a maximum height measurement of less than approximately 36 inches.

The values listed above represent maximum preferred measurements based, in part, on particular installation characteristics/requirements. It is therefore recognized that these values can fluctuate depending upon the station and facility. In a preferred embodiment, for example, the maximum width and depth can vary, independently, down to approximately 14 inches, or less, depending on the positioning and/or subdivision of the various components within housing unit 128. By way of example, power supply 104 in certain embodiments has been physically divided into a plurality of subsystems (as described above) that are then strategically positioned within housing unit 128 to reduce the dimension(s) as required for a specific installation. Furthermore, it is recognized that, by folding or bending the wave guide and/or subdividing the power supply or other control/monitoring devices into a plurality of units, source 100 can be arranged in a advantageously compact form without requiring a housing unit.

Figure 4 isometrically depicts an exemplary housing unit 130, having attached side panels 132. A compact microwave downstream plasma source as in Figure 2, in accordance with one embodiment of the present invention, is included within housing unit 130. In this embodiment, the external connections include AC power connector, gas(es) connector(s), cooling water in/out, and control input/output port(s). Housing unit 130, in a preferred embodiment, has a maximum width of approximately 14 inches, a maximum depth of approximately 21 inches, a maximum height of approximately 30 inches, and a weighs approximately 166 pounds.

Figure 5 depicts a back-side view of an exemplary housing unit 134, in accordance with one embodiment of the present invention, having its back-side panel removed to reveal several of the visible components of the compact microwave downstream plasma source 100. In this embodiment, for example, power supply 104 has been subdivided into the three subsystems depicted in Figure 2, above. Each of these subsystems (i.e., bus 123, controller 124 and inverter 125) is then positioned within housing unit 134, along a side. For example, bus 123 is positioned along the left-hand side (as shown, from the back side), inverter 125 is positioned along the right-hand side, controller 124 (depicted as a dashed box) is similarly positioned along the front side, within housing unit 134. As shown, by simply removing a panel, access is provided to a plurality of internal devices and apparatus. Thus, in accordance with an embodiment of the present invention, serviceability is enhanced by adding side panels, doors, or the like to provide quick access to the internal structure of source 100.

In accordance with an embodiment of the present invention, a plurality of interlock mechanisms has also been provided to promote personnel and equipment/work product safety. Unlike system 10 in Figure 1, source 100, and in particular exemplary housing units 128, 130 and 134, have brought power supply 104 within close proximity to cooling water, inlet 126 (that may carrying H_2O vapors), and the operators. As such, interlocking devices and logic have been included to reduce the chance of an accident occurring. By way of example, a water detector has been provided within housing unit 134 to detect the presence of water therein. When water is detected, the power is shut off via controller 124 or another safety circuit. Additional interlocks detect when side panels have been removed, or are not properly secured, and shuts the power off. In one embodiment, an interlock shuts off the power when housing unit 134 is tilted or otherwise positioned in a non-operative position.

Figure 6 isometrically depicts a microwave downstream plasma system 150 that includes a process reactor 142 within a supporting base arrangement 144 and a compact microwave down stream plasma source 100 within a housing unit 130 that is pivotally secured at point 146 to base arrangement 144, in accordance with an embodiment of the present invention. As shown, plasma system 150 exhibits a significantly reduced footprint due to the size of microwave down stream plasma source 100 within housing unit 130. Moreover, as depicted access to the chamber in process reactor 142 does not require disassembly of any of the components within microwave down stream plasma source 100. Instead, housing unit 130 is simply disconnected, if required, from power, water, data, etc. connections, unsecured from base arrangement 144 and tilted or otherwise pivoted to expose reactor 142. Furthermore, by disconnecting the pivoting mechanism at point 146, the entire housing unit 130 and microwave down stream plasma source 100 can be removed. This allows for quick replacement of microwave down stream plasma source 100 with very little downtime.

Although the present invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

CLAIMS

What is claimed is:

1. A plasma generating apparatus for use with a downstream process reactor, the apparatus comprising:

a generator configured to output microwave energy;

a guide having a first end and a second end, wherein the first end is coupled to the generator, and the guide is configured to direct at least a portion of the microwave energy output by the generator from the first end towards the second end, and wherein the guide further includes at least one curved region between the first end and the second end; and

an applicator coupled to the second end of the guide and configured to generate a plasma, within the applicator, using at least a portion of the microwave energy as directed by the guide from the first end to the applicator.

2. The apparatus as recited in Claim 1, wherein the guide further includes a tuner coupled between the first end and the second end, and wherein the tuner is configured to control at least one parameter associated with the microwave energy within the guide.

3. The apparatus as recited in Claim 2, further comprising a power supply coupled to the generator and configured to supply electrical energy to the generator for use in outputting microwave energy.

4. The apparatus as recited in Claim 3, wherein the power supply further includes at least two separate subsystems selected from the set of a controller, a bus, and an inverter.

5. The apparatus as recited in Claim 2, wherein the guide further includes an attenuating mechanism coupled between the first end and the second end, and wherein the attenuating mechanism is configured to substantially attenuate microwave energy traveling towards the first end within the guide.

6. The apparatus as recited in Claim 5, wherein the attenuating mechanism includes a circulator and a dummy load, wherein the circulator is configured to redirect microwave energy traveling towards the first end within the guide to the dummy load, and wherein the dummy load is configured to absorb the redirected microwave energy.

7. The apparatus as recited in Claim 1, wherein the applicator further includes an igniter that is configured to ignite the plasma within the applicator.

8. The apparatus as recited in Claim 7, wherein the igniter includes an ultraviolet energy source.

9. The apparatus as recited in Claim 2, further comprising a housing, configured to support the generator, the guide, and the applicator.

10. The apparatus as recited in Claim 9, wherein the housing is further configured to support a power supply having at least one subsystem selected from the set of a controller, a bus, and an inverter.

11. The apparatus as recited in Claim 9, wherein the housing further includes a mounting bracket suitable for pivotally mounting the apparatus to an external apparatus.

12. The apparatus as recited in Claim 2, wherein the parameter associated with the microwave energy in the guide is selected from a group of parameters including an amplitude, a frequency, and a phase.

13 The apparatus as recited in Claim 1, wherein the guide includes a plurality of segments that are connected together, and wherein at least two of the plurality of segments are connected together without a flange connector.

14. The apparatus as recited in Claim 1, wherein the guide includes a plurality of curved regions between the first end and the second end.

15. The apparatus as recited in Claim 1, wherein the generator, the guide and the applicator are arranged to be connected and disconnected from a second apparatus without requiring additional assembly and disassembly of the generator, the guide and the applicator.

16. A downstream stripping tool for use in fabricating a semiconductor device on a work product, the tool comprising:

a reactant generating arrangement that includes a generator, a guide, and an applicator, wherein the generator supplies microwave energy to the guide, the guide directs the microwave energy through at least one curved region and provides at least a portion of the microwave energy to the applicator for use in generating a plasma within the applicator and outputting at least one reactant; and

a processing arrangement, coupled to the reactant generating arrangement, and configured to receive the reactant and direct the reactant to an exposed portion of a work product.

17. The tool as recited in Claim 16, wherein the guide further includes a tuner coupled between the generator and the applicator, wherein the tuner is configured to control at least one parameter associated with the microwave energy within the guide.

18. The tool as recited in Claim 17, wherein the reactant generating arrangement further includes a power supply, coupled to the generator, and configured to supply electrical energy to the generator for use in outputting microwave energy.

19. The tool as recited in Claim 17, wherein the reactant generating arrangement further includes a controller coupled to the generator and configured to control the outputting of microwave energy from the generator.

20. The tool as recited in Claim 17, wherein the guide further includes an attenuating mechanism, coupled between the generator and the applicator, the attenuating mechanism being configured to substantially attenuate microwave energy traveling towards the generator within the guide.

21. The tool as recited in Claim 17, wherein the applicator further includes an igniter that is configured to ignite the plasma within the applicator.

22. The tool as recited in Claim 17, wherein the reactant generating arrangement further includes a housing, configured to support the generator, the guide, and the applicator.

23. The tool as recited in Claim 22, wherein the housing is pivotally mounted to the processing arrangement.

24. The tool as recited in Claim 16, wherein the guide includes a plurality of curved regions.

25. The tool as recited in Claim 16, wherein the reactant generating arrangement is arranged to be connected and disconnected from the processing arrangement without requiring additional assembly and disassembly of the generator, the guide and the applicator within the reactant generating arrangement.

26. A modular plasma source for use with a downstream process reactor, the modular plasma source comprising a footprint of less than approximately 576 square inches based the product of a maximum width measurement and a maximum depth measurement, wherein the maximum width and depth measurements are for an operatively configured modular plasma source, and wherein the modular plasma source includes, within the footprint, a power supply, an applicator, and a microwave generator electrically coupled to the power supply and arranged to supply microwave energy to the applicator.

27. The modular plasma source as recited in Claim 26, further having a maximum height measurement of less than approximately 36 inches.

28. The modular plasma source as recited in Claim 26, further including at least one additional component selected from a set of:

a tuner coupled between the microwave generator and the applicator;

a circulator coupled between the microwave generator and the applicator and a dummy load coupled to the circulator, wherein the circulator is configured to direct microwave energy traveling towards the microwave generator to the dummy load, and wherein the dummy load is configured to absorb microwave energy; and

an igniter that is configured to ignite a plasma within the applicator.

29. A method for processing a work product using a plasma generating apparatus and a downstream process reactor, the method comprising:

generating microwave energy within the plasma generating apparatus;

providing the microwave energy within a guide having a first end and a second end, wherein the first end is coupled to a microwave generator;

directing at least a portion of the microwave energy through the guide from the first end to the second end and through at least one curved region therebetween; and

generating a plasma, within an applicator, using at least a portion of the microwave energy as directed by the guide from the first end to the second end.

30. The method as recited in Claim 29, further comprising controlling at least one parameter associated with the microwave energy within the guide using a tuner arranged between the first and the second ends of the guide.

31. The method as recited in Claim 29, further comprising selectively attenuating reflected microwave energy traveling within the guide towards the first end.

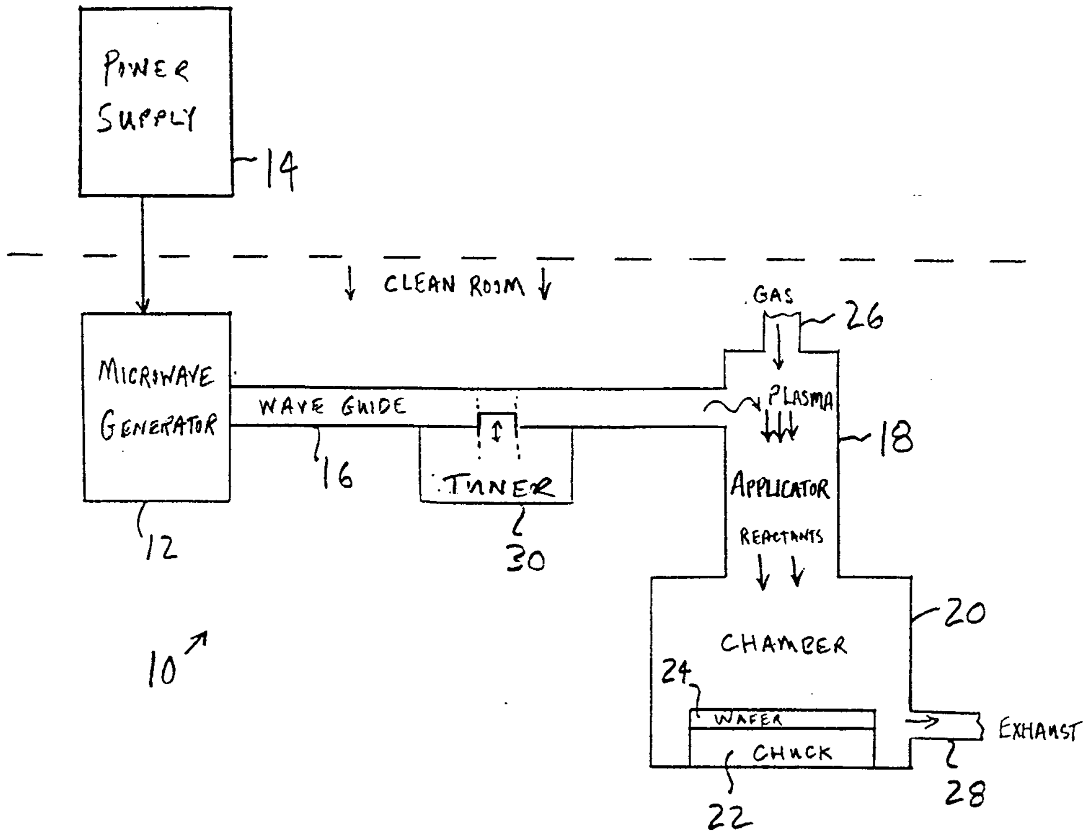

FIGURE 1
(PRIOR ART)

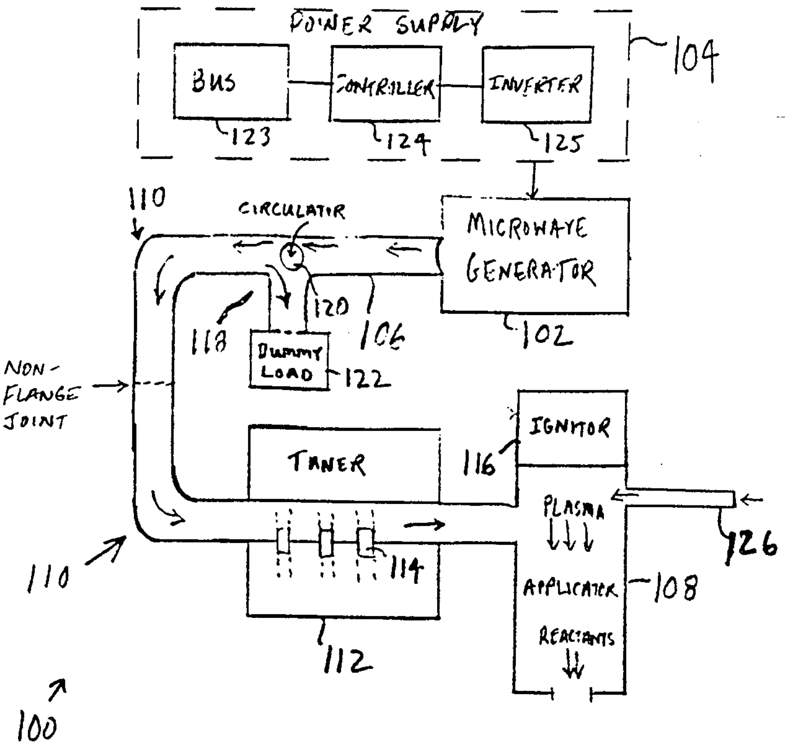
POWER SUPPLY
BUS
CONTROLLER
INVERTER
123
124
125
104
MICROWAVE GENERATOR
102
110
CIRCULATOR
120
106
118
DUMMY LOAD
122
NON-FLANGE JOINT
TUNER
116
IGNITOR
PLASMA
126
110
114
APPLICATOR
108
REACTANTS
112
100

FIGURE 2

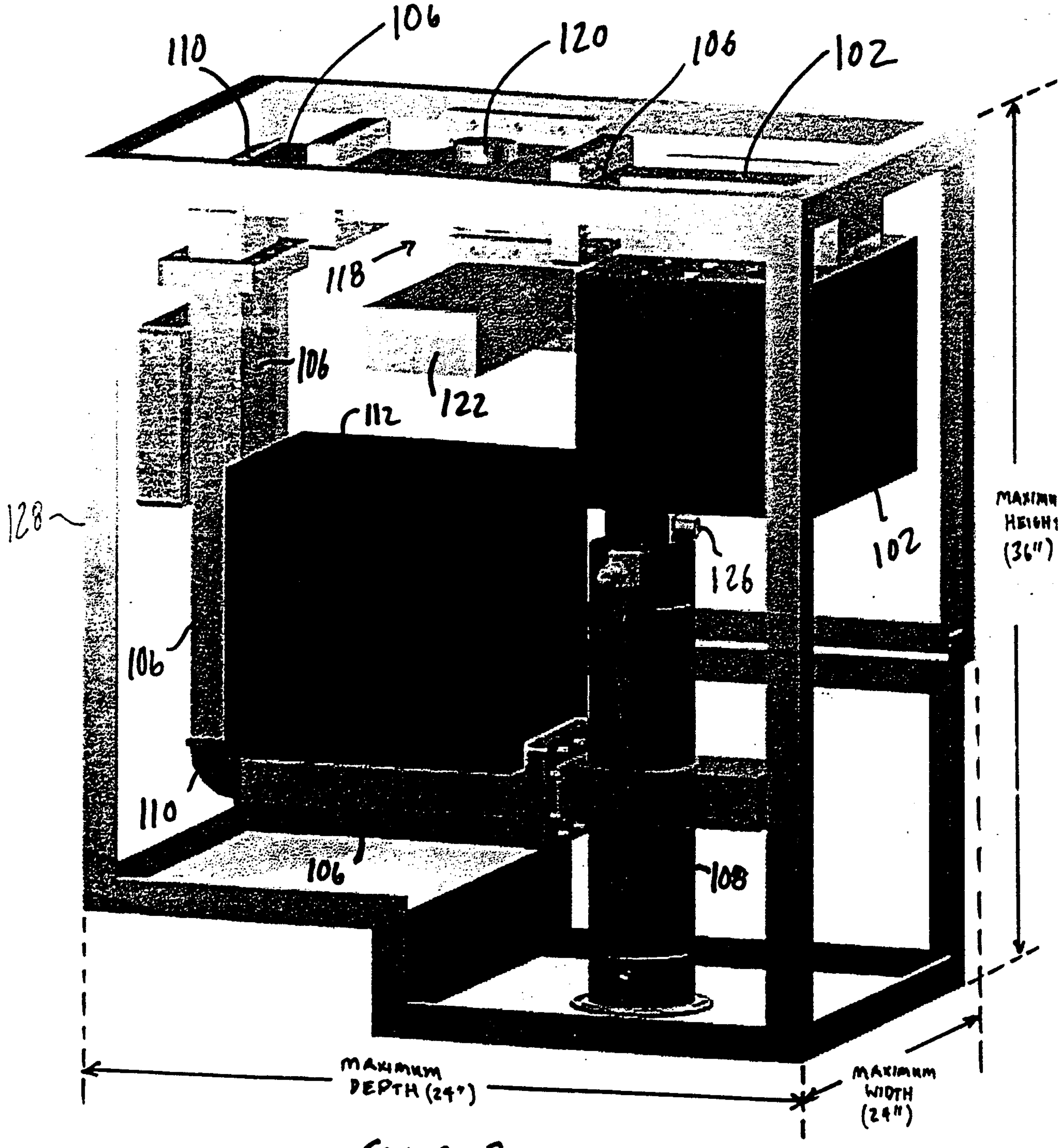
110
106
120
106
102
118
106
122
112
128
102
126
106
110
106
108
MAXIMUM HEIGHT (36")
MAXIMUM DEPTH (24")
MAXIMUM WIDTH (24")

FIGURE 3

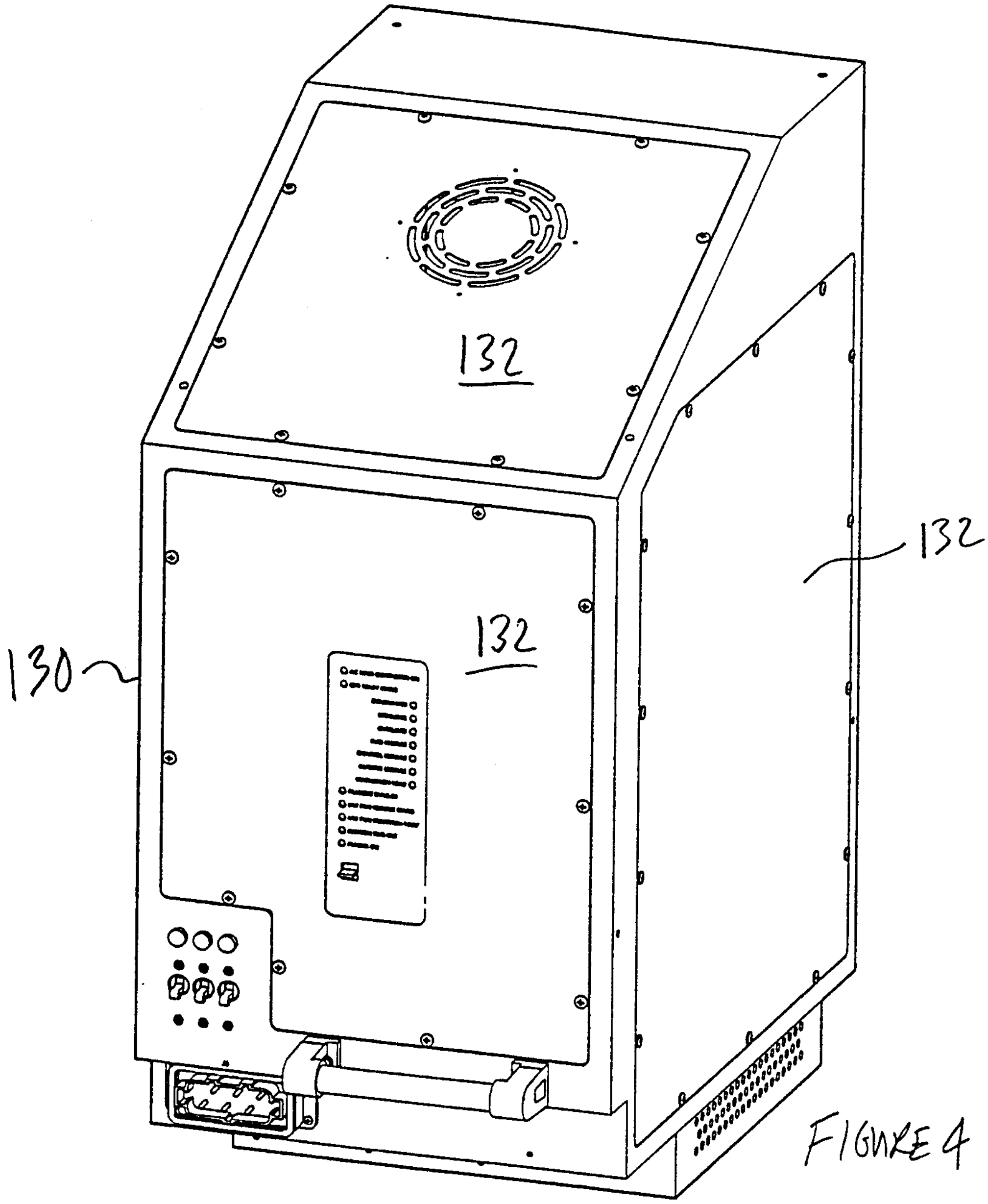

FIGURE 4

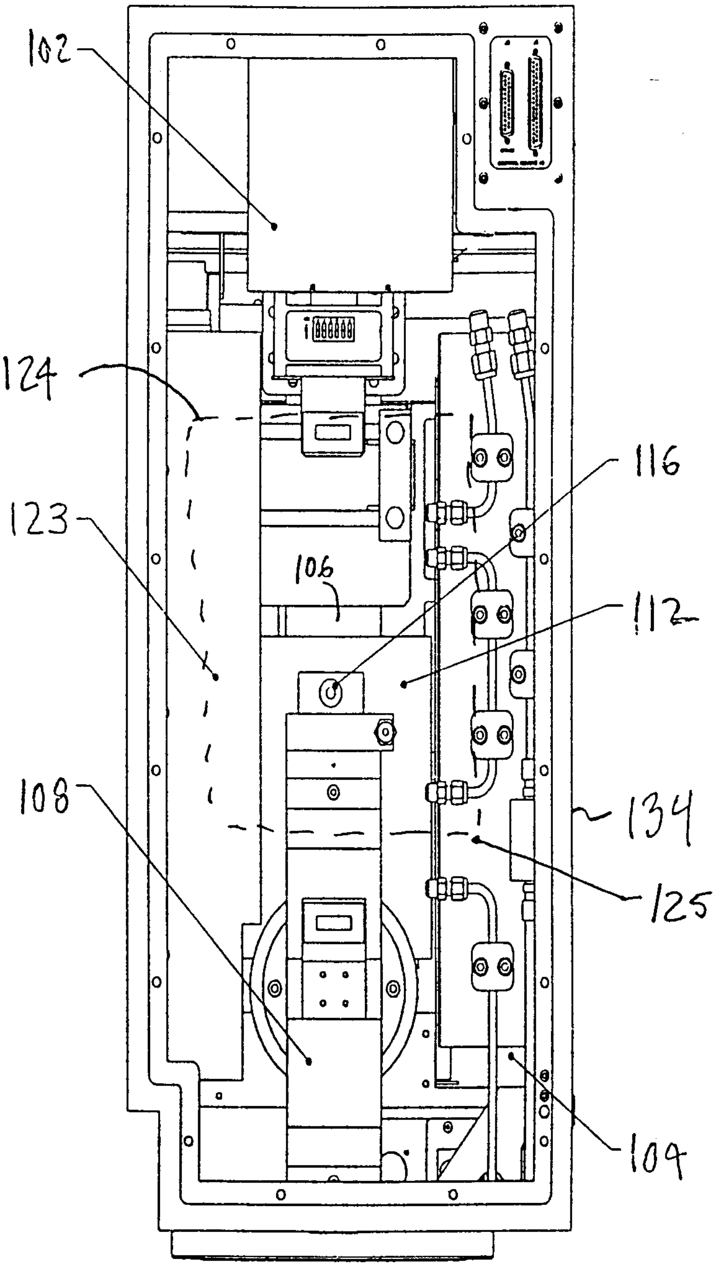

FIGURE 5

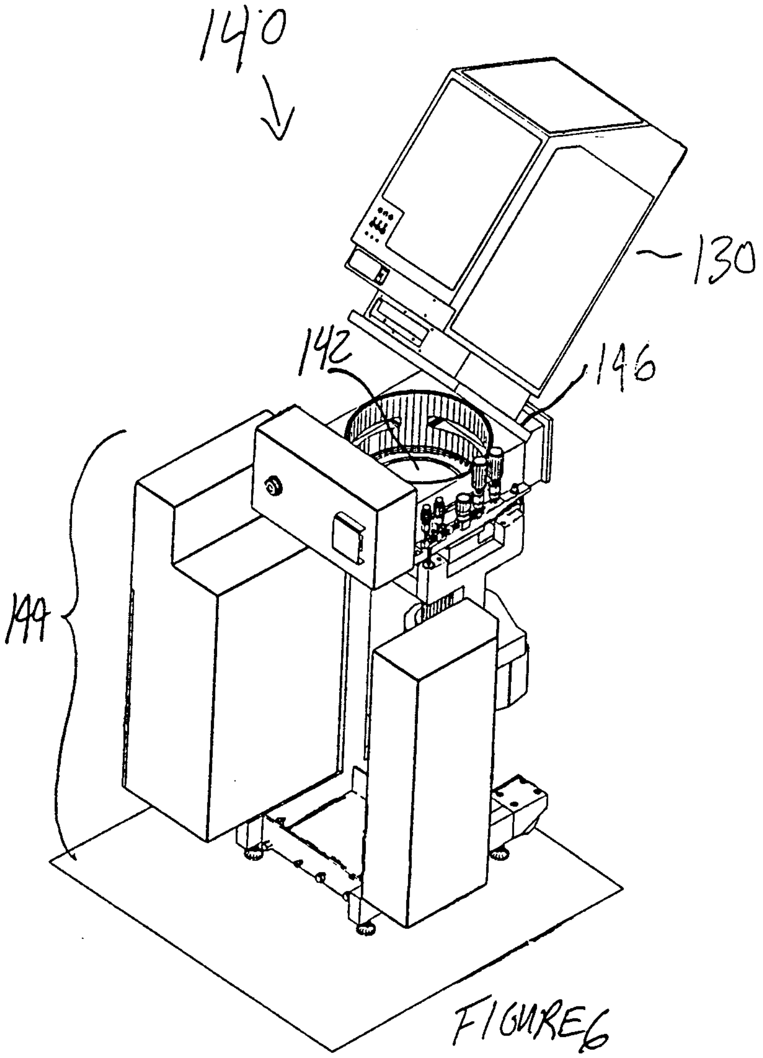

FIGURE 6