

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
19 January 2006 (19.01.2006)

PCT

(10) International Publication Number
WO 2006/007355 A1

(51) International Patent Classification⁷: **H01L 21/311**,
G03F 7/42, H01J 37/32

(21) International Application Number:
PCT/US2005/020359

(22) International Filing Date: 8 June 2005 (08.06.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/877,222 25 June 2004 (25.06.2004) US

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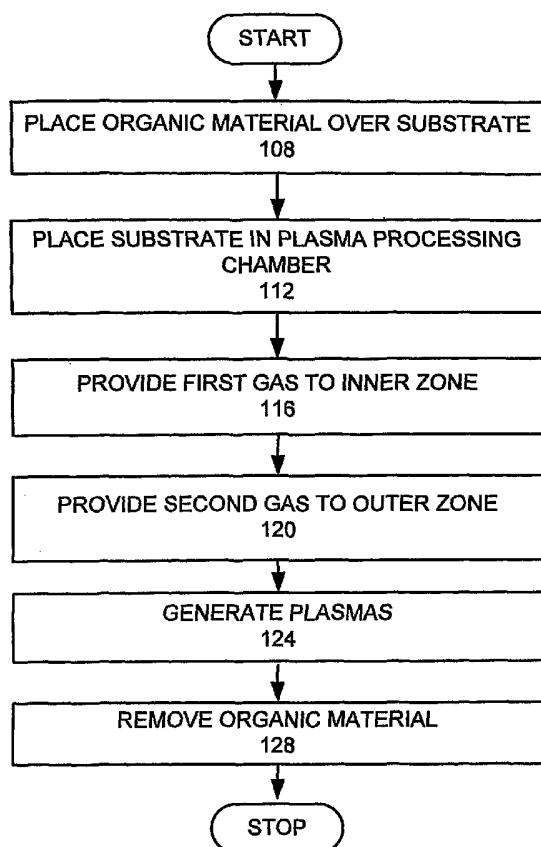
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

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(54) Title: METHOD FOR PROVIDING UNIFORM REMOVAL OF ORGANIC MATERIAL



(57) Abstract: A method for removing organic material over a substrate is provided. The substrate is placed in a plasma processing chamber. A first gas is provided to an inner zone within the plasma processing chamber. A second gas is provided to an outer zone of the plasma processing chamber, wherein the outer zone surrounds the inner zone and the second gas has a carbon containing component, wherein a concentration of the carbon containing component of the second gas is greater than a concentration of the carbon containing component in the first gas. Plasmas are simultaneously generated from the first gas and second gas. Some or all of the organic material is removed using the generated plasmas.

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European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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METHOD FOR PROVIDING UNIFORM REMOVAL OF ORGANIC MATERIAL

BACKGROUND OF THE INVENTION

5 Semiconductor processing includes deposition processes such as chemical vapor deposition (CVD) of metal, dielectric and semiconducting materials, etching of such layers, ashing of photoresist masking layers, etc. Such semiconductor processes are typically carried out in vacuum chambers wherein process gas is used to treat a substrate such as a semiconductor wafer, flat panel display substrate, etc. The process gas can be supplied to the interior of the vacuum chamber by a gas distribution system such as a showerhead, a gas distribution ring, gas injectors, etc. Reactors having plural gas distribution systems are disclosed in U.S. Pat. Nos. 5,134,965; 5,415,728; 5,522,934; 5,614,055; 5,772,771; 6,013,155; and 6,042,687.

15 In the case of etching, plasma etching is conventionally used to etch metal, dielectric and semiconducting materials. A plasma etch reactor typically includes a pedestal supporting the silicon wafer on a bottom electrode, an energy source which energizes process gas into a plasma state, and a process gas source supplying process gas to the chamber.

A common requirement in integrated circuit fabrication is the etching of openings such as contacts and vias in dielectric materials. The dielectric materials include doped silicon oxide such as fluorinated silicon oxide (FSG), undoped silicon oxide such as silicon dioxide, silicate glasses such as boron phosphate silicate glass (BPSG) and phosphate silicate glass (PSG), doped or undoped thermally grown silicon oxide, doped or undoped TEOS deposited silicon oxide, etc. The dielectric dopants include boron, phosphorus and/or arsenic. The dielectric can overlie a conductive or semiconductive layer such as polycrystalline silicon, metals such as aluminum, copper, titanium, tungsten, molybdenum or alloys thereof, nitrides such as titanium nitride, metal silicides such as titanium silicide, cobalt silicide, tungsten silicide, molybdenum silicide, etc. A plasma etching technique, wherein a parallel plate plasma reactor is used for etching openings in silicon oxide, is disclosed in U.S. Pat. No. 5,013,398.

30 U.S. Pat. No. 5,736,457 describes single and dual "damascene" metallization processes. In the "single damascene" approach, vias and conductors are formed in separate steps wherein a metallization pattern for either conductors or vias is etched into a dielectric layer, a metal layer is filled into the etched grooves or via holes in the dielectric layer, and the

excess metal is removed by chemical mechanical planarization (CMP) or by an etch back process. In the "dual damascene" approach, the metallization patterns for the vias and conductors are etched in a dielectric layer and the etched grooves and via openings are filled with metal in a single metal filling and excess metal removal process.

5 Various methods in semiconductor processing, such as damascene metallization processes, require methods for removing organic material over substrates, such as stripping a photoresist mask, etching an organic bottom antireflective coating (BARC), removing a via plug, or etching an organic dielectric layer.

SUMMARY OF THE INVENTION

10 To achieve the foregoing and in accordance with the purpose of the present invention a method for removing organic material over a substrate is provided. The substrate is placed in a plasma processing chamber. A first gas is provided to an inner zone within the plasma processing chamber. A second gas is provided to an outer zone of the plasma processing chamber, wherein the outer zone surrounds the inner zone and the second gas has a carbon containing component, wherein a concentration of the carbon containing component of the second gas is greater than a concentration of the carbon containing component in the first gas. Plasmas are simultaneously generated from the first gas and second gas. Some of the organic material is removed using the generated plasmas.

20 In another manifestation of the invention a method for stripping a photoresist mask over a substrate is provided. The substrate is placed in a plasma processing chamber. A first gas is provided to an inner zone within the plasma processing chamber. A second gas is provided to the outer zone of the plasma processing chamber, wherein the outer zone surrounds the inner zone and the first gas is different than the second gas. Plasmas are simultaneously generated from the first gas and second gas. The photoresist mask is stripped, wherein the photoresist mask is stripped by the plasmas from the first gas and second gas.

30 In another manifestation of the invention a method for removing plugs in a via of a dual damascene structure over a substrate is provided. The substrate with a dielectric layers with vias with via plugs is placed in a plasma processing chamber. A first gas is provided to an inner zone within the plasma processing chamber. A second gas is provided to the outer zone of the plasma processing chamber, wherein the outer zone surrounds the inner zone and the first gas is different than the second gas.

Plasmas are simultaneously generated from the first gas and second gas. The vias plugs are removed by the plasmas from the first gas and the second gas.

These and other features of the present invention will be described in more detail below in the detailed description of the invention and in conjunction with the following figures.

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 and in which:

FIG. 1 is a flow chart of an embodiment of the invention.

FIG. 2 is a flow chart of an embodiment of the invention for stripping.

FIG.'S 3A-C are cross-sectional views of a substrate in the processed according to the process shown in FIG. 2.

FIG.'S 4A-B are schematic illustrations of a computer system that may be used as a controller.

FIG. 5 is a schematic view of such a process chamber that may be used in practicing the invention.

FIG. 6 is a schematic bottom view of a gas distribution plate.

FIG 7 is a flow chart of an embodiment of the invention for removing via plugs.

FIG. 8 is a flow chart of an embodiment of the invention for opening a BARC layer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described in detail with reference to a few preferred embodiments thereof as illustrated in the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art, that the present invention may be practiced without some or all of these specific details. In other instances, well known process steps and/or structures have not been described in detail in order to not unnecessarily obscure the present invention.

To facilitate understanding, FIG. 1 is a high level flow chart of an embodiment of the invention. Organic material is place over a substrate (step 108). The organic

material may be photoresist, BARC, a via plug, or an organic dielectric layer. In the case of photoresist, BARC, or a via plug, a dielectric layer is between the substrate and the organic material. The substrate is placed in a plasma processing chamber (step 112). A first gas is provided to an inner zone of the plasma processing chamber (step 116). A second gas is provided to an outer zone of the plasma processing chamber (step 120). The outer zone surrounds the inner zone. The second gas has a carbon containing component. The concentration of the carbon containing component of the second gas is greater than the concentration of the carbon containing component of the first gas. Plasmas are simultaneously generated from the first and second gas, by forming a plasma from the first gas and a plasma from the second gas (step 124). The plasmas remove some of the organic material (step 128). Although the providing the first gas (step 116) and the providing the second step (step 120) are shown sequentially, these steps may be done in opposite order or may be done simultaneously.

In the specification and claims, a first gas is defined as a gas with a single component or with a plurality of components to form a gas mixture. A first gas is different than a second gas, only if the first gas and second gas have different components or the same components in different ratios. Different flow rates of gases with the same components at the same ratios are not different gases.

In a preferred embodiment of the invention, the plasma processing chamber uses a confined plasma system, which confines the plasma to a region above the wafer. Such a confined plasma system may use confinement rings, as disclosed in U.S. Patent 6,019,060, by Eric Lenz, entitled "CAM-BASED ARRANGEMENT FOR POSITIONING CONFINEMENT RINGS IN A PLASMA PROCESSING CHAMBER", issued February 1, 2000, which is incorporated by reference for all purposes. Such a plasma confinement system is used in the 2300 Exelan chamber, made by Lam Research Corporation of Fremont, California.

Without being bound by theory, it is believed that in the removal of organic material from over a substrate, a loading effect at the edge of the substrate may be due to the lack of consumable organic material at the outer diameter of the substrate compared to the center of the substrate, which causes a non-uniform removal of organic material, where the organic material closer to the edge of the substrate is removed faster. As a result uneven etching or damage to a layer below the organic

material may result. Providing a higher concentration of carbon containing component at the edge of the substrate has been found to provide a more uniform removal of the organic material.

Some of the carbon containing components that may be used in the invention are
5 CH₄, C₂H₄, CO, CH₃F, CH₂F₂, and CF₄. For some applications, it is preferable to use a fluorine free carbon containing component.

Some of the gases that are useful in removing the organic components are O₂, O₂/N₂, O₂/CO, O₂, NH₃, N₂/H₂, N₂O, and H₂O.

Stripping

10 One example of the inventive process provides a uniform stripping of a photoresist mask. FIG. 2 is a flow chart of a process that is used in this example. In this example, a low-k dielectric layer, which is preferably organosilicate glass, is formed over a substrate. FIG.'s 3A-C are schematic side views of a low-k dielectric layer (k<3.0), according to the process of FIG. 2. A low-k dielectric layer 304 may be
15 deposited over a substrate 308 (step 204), as shown in FIG. 3A. The substrate 308 may be a silicon wafer or another type of material or may be part of a layer over a wafer. A cap layer 312 is formed over the low-k dielectric layer 304. The cap layer 312 may be silicon oxide. Generally, the cap layer is a protective layer of a dielectric material. The cap layer 312 protects the low-k dielectric layer 304 during chemical
20 mechanical polishing (CMP) and other processes. The cap layer 312 may be a low-k dielectric, since the cap layer is part of the end product. Preferably, the cap layer may be of a silicon oxide base material. An antireflective coating (ARC) 314 is deposited over the cap layer 312. The antireflective coating (ARC) 314 may be an organic bottom antireflective coating (BARC) or an inorganic dielectric antireflective coating (DARC).
25 A patterned photoresist mask 316 is provided over the ARC 314 (step 208). The patterned resist mask 316 has an aperture 320. The patterned resist mask may be formed by placing a layer of photoresist, which is exposed to a light pattern and then etched. Other methods of forming a patterned resist mask may be used. The substrate 308 may have a contact 309 and a barrier layer 310.

30 The substrate 308 is placed in a processing chamber where the low-k dielectric layer 304 is etched (step 212).

In this example of the implementation of the invention, an 2300 Exelan chamber, made by Lam Research Corporation of Fremont, California is used as the

etch process chamber for a 200 mm wafer, using a dual gas distribution system with a tuning gas as described above. FIG. 5 is a schematic view of such a system 500. In this example, the plasma processing chamber 500 comprises confinement rings 502, a gas distribution plate 504, a lower electrode 508, a gas source 510, and an exhaust pump 520. Within plasma processing chamber 500, the substrate wafer 308, on which the dielectric layer is deposited, is positioned upon the lower electrode 508. The lower electrode 508 incorporates a suitable substrate chucking mechanism (e.g., electrostatic, mechanical clamping, or the like) for holding the substrate wafer 308. The reactor top 528 incorporates the gas distribution plate 504 disposed immediately opposite the lower electrode 508. The gas distribution plate forms an upper electrode, which is grounded. The gas distribution plate 504, lower electrode 508, and confinement rings 502 define the confined plasma volume 540.

FIG. 6 is a schematic bottom view of the gas distribution plate 504. The gas distribution plate comprises an inner zone plate 512 and an outer zone plate 516. A plurality of ports 518 is formed in the inner zone plate 512 and the outer zone plate 516. The ports 518 may be placed in various configurations, where the shown configuration is provided to mainly to illustrate that each zone plate has a plurality of ports 518. Both the inner zone plate 512 and the outer zone plate 516 are spaced apart from and opposite from the wafer 580 on the lower electrode 508. The gas source 510 may be any gas source that provides different gases to the inner zone plate 516 and the outer zone plate 518.

Gas is supplied to the confined plasma volume by gas source 510 through the ports 518 of the inner zone plate 512 and the outer zone plate 516, and is exhausted from the confined plasma volume through the confinement rings 502 and an exhaust port by the exhaust pump 520. The exhaust pump 520 forms a gas outlet for the plasma processing chamber. A RF source 548 is electrically connected to the lower electrode 508. Chamber walls 552 define a plasma enclosure in which the confinement rings 502, the gas distribution plate 504, and the lower electrode 508 are disposed. The RF source 548 may comprise a high frequency power source operating at 27 MHz and a low frequency power source operating at 2 MHz. The gas distribution plate 504 may be grounded. Different combinations of connecting RF power to the electrodes are possible. A controller 535 is controllably connected to the RF source 548, the exhaust pump 520, and the gas source 510.

FIG.'S 4A and 4B illustrate a computer system 800, which is suitable for using as the controller 535. FIG. 4A shows one possible physical form of a computer system that may be used for the controller 340. Of course, the computer system may have many physical forms ranging from an integrated circuit, a printed circuit board, and a small handheld device up to a huge super computer. Computer system 800 includes a monitor 802, a display 804, a housing 806, a disk drive 808, a keyboard 810, and a mouse 812. Disk 814 is a computer-readable medium used to transfer data to and from computer system 800.

FIG. 4B is an example of a block diagram for computer system 800. Attached to system bus 820 is a wide variety of subsystems. Processor(s) 822 (also referred to as central processing units, or CPUs) are coupled to storage devices, including memory 824. Memory 824 includes random access memory (RAM) and read-only memory (ROM). As is well known in the art, ROM acts to transfer data and instructions uni-directionally to the CPU and RAM is used typically to transfer data and instructions in a bi-directional manner. Both of these types of memories may include any suitable type of the computer-readable media described below. A fixed disk 826 is also coupled bi-directionally to CPU 822; it provides additional data storage capacity and may also include any of the computer-readable media described below. Fixed disk 826 may be used to store programs, data, and the like and is typically a secondary storage medium (such as a hard disk) that is slower than primary storage. It will be appreciated that the information retained within fixed disk 826 may, in appropriate cases, be incorporated in standard fashion as virtual memory in memory 824. Removable disk 814 may take the form of any of the computer-readable media described below.

CPU 822 is also coupled to a variety of input/output devices, such as display 804, keyboard 810, mouse 812 and speakers 830. In general, an input/output device may be any of: video displays, track balls, mice, keyboards, microphones, touch-sensitive displays, transducer card readers, magnetic or paper tape readers, tablets, styluses, voice or handwriting recognizers, biometrics readers, or other computers. CPU 822 optionally may be coupled to another computer or telecommunications network using network interface 840. With such a network interface, it is contemplated that the CPU might receive information from the network, or might output information to the network in the course of performing the above-described

method steps. Furthermore, method embodiments of the present invention may execute solely upon CPU 822 or may execute over a network such as the Internet in conjunction with a remote CPU that shares a portion of the processing.

5 In addition, embodiments of the present invention further relate to computer storage products with a computer-readable medium that have computer code thereon for performing various computer-implemented operations. The media and computer code may be those specially designed and constructed for the purposes of the present invention, or they may be of the kind well known and available to those having skill in the computer software arts. Examples of computer-readable media include, but are not
10 limited to: magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROMs and holographic devices; magneto-optical media such as floptical disks; and hardware devices that are specially configured to store and execute program code, such as application-specific integrated circuits (ASICs), programmable logic devices (PLDs) and ROM and RAM devices. Examples of computer code
15 include machine code, such as produced by a compiler, and files containing higher level code that are executed by a computer using an interpreter. Computer readable media may also be computer code transmitted by a computer data signal embodied in a carrier wave and representing a sequence of instructions that are executable by a processor.

20 A plasma dry etch may be used to etch the low-k dielectric layer 304, which forms an opening 324 under the aperture 320 in the patterned resist mask 316, as shown in FIG. 3B. Some of the patterned resist mask 316 is removed during the low-k dielectric layer etch. Such low-k dielectric etches may use a chemical etch, such as using a fluorine based etchant.

25 A uniform stripping process is then provided to remove the photoresist mask 316 without damaging the low-k dielectric layer. To provide the uniform stripping process, a first gas is provided to the inner zone 512 (step 216). In this example, the first gas is pure O₂. A second gas is provided to the outer zone 516 (step 220). In this example, the second gas is a mixture of O₂ for stripping and C₂H₄ as the carbon containing gas. Plasmas are generated
30 from the first and second gases (step 224). The plasmas are used to provide a uniform photoresist strip (step 228).

Therefore, in this example none of the carbon containing gas is provided directly to the inner zone. In one implementation of this, a dual gas feed divides the flow of O₂ between

the inner zone and outer zone. A tuning gas of C_2H_4 is then added only to the outer zone. In an example of a recipe, the chamber pressure is set at 20 mTorr. The lower electrode provides 600 Watts at 27 MHz and 0 Watts at 2 MHz. 300 sccm of O_2 is provided to the chamber, with the addition of a C_2H_4 tuning gas to only the outer zone. This is maintained for 60 seconds.

A preferred stripping process would have a chamber pressure between 0 and 1,000 mTorr, with a lower frequency (ie. 2 MHz) power of between 0-1,000 Watts, a higher frequency (i.e. 27 MHz) power between 50-1,000 Watts, an O_2 flow between 20-2,000 sccm, and a C_2H_4 addition to the outer region only of between 10-2,000 sccm.

A more preferred stripping process would have a chamber pressure between 1 and 500 mTorr, with a lower frequency (ie. 2 MHz) power of between 0-500 Watts, a higher frequency (i.e. 27 MHz) power between 100-900 Watts, an O_2 flow between 100-1,000 sccm, and a C_2H_4 addition to the outer region only of between 20-1,000 sccm.

In another embodiment, the first gas is pure O_2 and the second gas is pure C_2H_4 . There is sufficient loading so that enough O_2 migrates from the inner zone to the outer zone to uniformly strip the photoresist.

In some etching processes etch residue may redeposited. It may be desirable to provide small amounts of fluorine to help remove the etch residue. In such a case, the carbon containing component may be CH_3F . In a preferred embodiment, the CH_3F is only provided to the outer zone. Although fluorine from CH_3F is only directly provided to the outer zone, sufficient fluorine will migrate from the outer zone to the inner zone to reduce masking.

Etch Back

Another example of the inventive process provides a uniform via plug removal process. FIG. 7 is a flow chart of a process that is used in this example. A dielectric layer is deposited over a substrate and vias are formed in the dielectric layer (step 704). The substrate may be a silicon wafer or another type of material or may be part of a layer over a wafer. Via plugs of an organic material are formed in the vias (step 708). A trench pattern photoresist mask is then placed over the dielectric layer.

The substrate may be placed in a processing chamber where the dielectric layer is etched (step 712). The plasma process chamber described above or other plasma process chambers may be used. A plasma dry etch is used to etch the dielectric layer to form trenches. The via plugs are used to reduce faceting during the trench etch.

Fence formations may be formed during the trench etch around the via top. Some of the patterned resist mask is removed during the trench etch.

An etch back process is used to reduce the via plug height. By having the correct via height fence formations, and faceting of the vias is reduced or eliminated during the trench etch. Therefore the reduction of the via plug height is done after via etch and organic BARC fill but before trench patterning. To provide etch back process, a first gas is provided to the inner zone (step 716). In this example, the first gas is pure O_2 . A second gas is provided to the outer zone (step 720). In this example, the second gas is pure C_2H_4 . Plasmas are generated from the first and second gases (step 724). The plasmas are used to remove the via plugs (step 728). This process may be used to also strip the remaining photoresist.

This process provides a uniform plug removal, which provides the advantage of consistently fence and facet free vias in the dual damascene structures.

Therefore, in this example none of the carbon containing gas is provided directly to the inner zone. In one implementation of this, a dual gas feed divides the flow of O_2 between the inner zone and outer zone. A tuning gas of C_2H_4 is then added only to the outer zone. In an example of a recipe, the chamber pressure is set at 400 mTorr. The lower electrode provides 0 Watts at 27 MHz and 600 Watts at 2 MHz. 300 sccm of O_2 is provided to the chamber, with the addition of a C_2H_4 tuning gas to only the outer zone. This is maintained for 60 seconds.

A preferred uniform plug removal process would have a chamber pressure between 0 and 1,000 mTorr, with a lower frequency (ie. 2 MHz) power of between 50-1,000 Watts, a higher frequency (i.e. 27 MHz) power between 0-1,000 Watts, an O_2 flow between 20-2,000 sccm, and a C_2H_4 addition to the outer region only of between 10-2,000 sccm.

A more preferred uniform plug removal process would have a chamber pressure between 1 and 500 mTorr, with a lower frequency (ie. 2 MHz) power of between 0-500 Watts, a higher frequency (i.e. 27 MHz) power between 100-900 Watts, an O_2 flow between 100-1,000 sccm, and a C_2H_4 addition to the outer region only of between 20-1,000 sccm.

BARC Open

Another example of the inventive process provides a uniform BARC open process. FIG. 8 is a flow chart of a process that is used in this example. In this example, a dielectric layer is formed over a substrate. A dielectric layer is deposited over a substrate (step 804). The substrate may be a silicon wafer or another type of material or may be part of a layer over a wafer. A BARC layer is formed over

the dielectric layer (step 808). A patterned mask is then placed over the BARC layer (step 810).

The substrate is placed in a processing chamber (step 812). The plasma process chamber described above or other plasma process chambers may be used. A uniform BARC open process is then provided to open the BARC layer.. To provide the uniform BARC open process, a first gas is provided to the inner zone (step 816). In this example, the first gas is N_2/H_2 . A second gas is provided to the outer zone (step 820). In this example, the second gas is pure C_2H_4 . Plasmas are generated from the first and second gases (step 824). The plasmas are used to uniformly open the BARC layer (step 828).

Therefore, in this example none of the carbon containing gas is provided directly to the inner zone. In one implementation of this, a dual gas feed divides the flow of O_2 between the inner zone and outer zone. A tuning gas of C_2H_4 is then added only to the outer zone. In an example of a recipe, the chamber pressure is set at 60 mTorr. The lower electrode provides 600 Watts at 27 MHz and 0 Watts at 2 MHz. 300 sccm of O_2 is provided to the chamber, with the addition of a C_2H_4 tuning gas to only the outer zone. This is maintained for 60 seconds.

A preferred BARC open process would have a chamber pressure between 0 and 1,000 mTorr, with a lower frequency (ie. 2 MHz) power of between 0-1,000 Watts, a higher frequency (i.e. 27 MHz) power between 50-1,000 Watts, an O_2 flow between 20-2,000 sccm, and a C_2H_4 addition to the outer region only of between 10-2,000 sccm.

A more preferred BARC open process would have a chamber pressure between 1 and 500 mTorr, with a lower frequency (ie. 2 MHz) power of between 0-500 Watts, a higher frequency (i.e. 27 MHz) power between 100-900 Watts, an O_2 flow between 100-1,000 sccm, and a C_2H_4 addition to the outer region only of between 20-1,000 sccm.

Other examples may use the inventive process to uniformly etch a SiLK layer by providing a higher concentration of carbon containing component on the outer zone. This results in improved uniformity for trench and improved uniformity allows for less over etch in the case of vias.

Other components may be found in alternative to a carbon containing component that reduces loading to slow down the etching of the outer part of the wafer to provide a more uniform etch.

Other gas distribution embodiments may be used in other embodiments to provide a first gas to an inner zone and a second gas to an outer zone surrounding the inner zone where the first gas is different than the second gas. For example alternating ports in the outer zone area may provide different component gases, which together make up the second gas provided to the outer zone and/or alternating ports in the inner zone area may provide different component gases, which together make up the first gas, so that the first gas is different than the second gas. However, it is preferable that the component gases of the first gas be combined in the gas distribution system before the first gas is provided into the chamber and that the component gases of the second gas be combined in the gas distribution system before the second gas is provided into the chamber.

While this invention has been described in terms of several preferred embodiments, there are alterations, modifications, permutations, and substitute equivalents, which fall within the scope of this invention. It should also be noted that there are many alternative ways of implementing the methods and apparatuses of the present invention. It is therefore intended that the following appended claims be interpreted as including all such alterations, permutations, and substitute equivalents as fall within the true spirit and scope of the present invention.

CLAIMS

What is claimed is:

1. A method for removing organic material over a substrate, comprising:
placing the substrate in a plasma processing chamber;
5 providing a first gas to an inner zone within the plasma processing chamber;
providing a second gas to an outer zone of the plasma processing chamber,
wherein the outer zone surrounds the inner zone and the second gas has a carbon
containing component, wherein a concentration of the carbon containing component
of the second gas is greater than a concentration of the carbon containing component
10 in the first gas;
simultaneously generating plasmas from the first gas and second gas;
removing some of the organic material using the generated plasmas.
2. The method, as recited in claim 1, wherein the inner zone comprises an
organic material removing gas.
- 15 3. The method, as recited in any of claims 1-2, wherein a dielectric layer is
between the organic material and the substrate, wherein the removing some of the
organic material removes some of the organic material above the dielectric layer.
4. The method, as recited in any of claims 1-3, wherein the first gas has no
carbon containing component.
- 20 5. The method, as recited in any of claims 1-4, wherein the outer zone is
adjacent to an edge of the wafer and the inner zone is adjacent to an interior of the
wafer surrounded by the edge of the wafer adjacent to the outer zone.
6. The method, as recited in any of claims 3-5, wherein the dielectric layer is
of a low-k dielectric.
- 25 7. The method, as recited in any of claims 1-6, wherein the carbon containing
component is at least one of CH₄, C₂H₄, CO, CH₃F, CH₂F₂, and CF₄.
8. The method, as recited in any of claims 2-7, wherein the organic material
removing gas is at least one of O₂, O₂/N₂, O₂/CO, O₂, NH₃, N₂/H₂, N₂O, and H₂O.
9. The method, as recited in any of claims 1-8, wherein the organic material
30 forms a photoresist mask and the removing some of the organic material strips the
photoresist mask.
10. The method, as recited in any of claims 3-9, wherein the dielectric layer is
a organosilicate glass layer.

11. The method, as recited in any of claims 3-10, wherein the dielectric layer has a plurality of vias and the organic material forms via plugs, and further comprising etching a plurality of trenches in the dielectric layer after the placing the substrate in the processing chamber, wherein the removing some of the organic material reduces heights of organic plugs in the vias.
12. The method, as recited in claim 11, wherein the etching the plurality of trenches creates fence formations, wherein the removing some of the organic material further removes the fence formations.
13. The method, as recited in any of claims 1-12, wherein the organic material is a BARC layer, wherein a photoresist mask is over the BARC layer, wherein the removing some of the organic material opens the BARC layer.
14. The method, as recited in any of claims 1-13, wherein the organic material is a SiLK dielectric layer, wherein a photoresist mask is over the SiLK dielectric layer, and wherein the removing some of the SiLK etches features into the SiLK dielectric layer.
15. A method for stripping a photoresist mask over a substrate, comprising:
placing the substrate in a plasma processing chamber;
providing a first gas to an inner zone within the plasma processing chamber;
providing a second gas to the outer zone of the plasma processing chamber,
wherein the outer zone surrounds the inner zone and the first gas is different than the second gas;
simultaneously generating plasmas from the first gas and second gas;
stripping the photoresist mask, wherein the photoresist mask is stripped by the plasmas from the first gas and second gas.
16. A method for removing plugs in vias of a dual damascene structure over a substrate, comprising:
placing the substrate with a dielectric layer with vias with via plugs in a plasma processing chamber;
providing a first gas to an inner zone within the plasma processing chamber;
providing a second gas to the outer zone of the plasma processing chamber,
wherein the outer zone surrounds the inner zone and the first gas is different than the second gas;
simultaneously generating plasmas from the first gas and second gas;

reducing heights of the vias plugs by the plasmas from the first gas and the second gas.

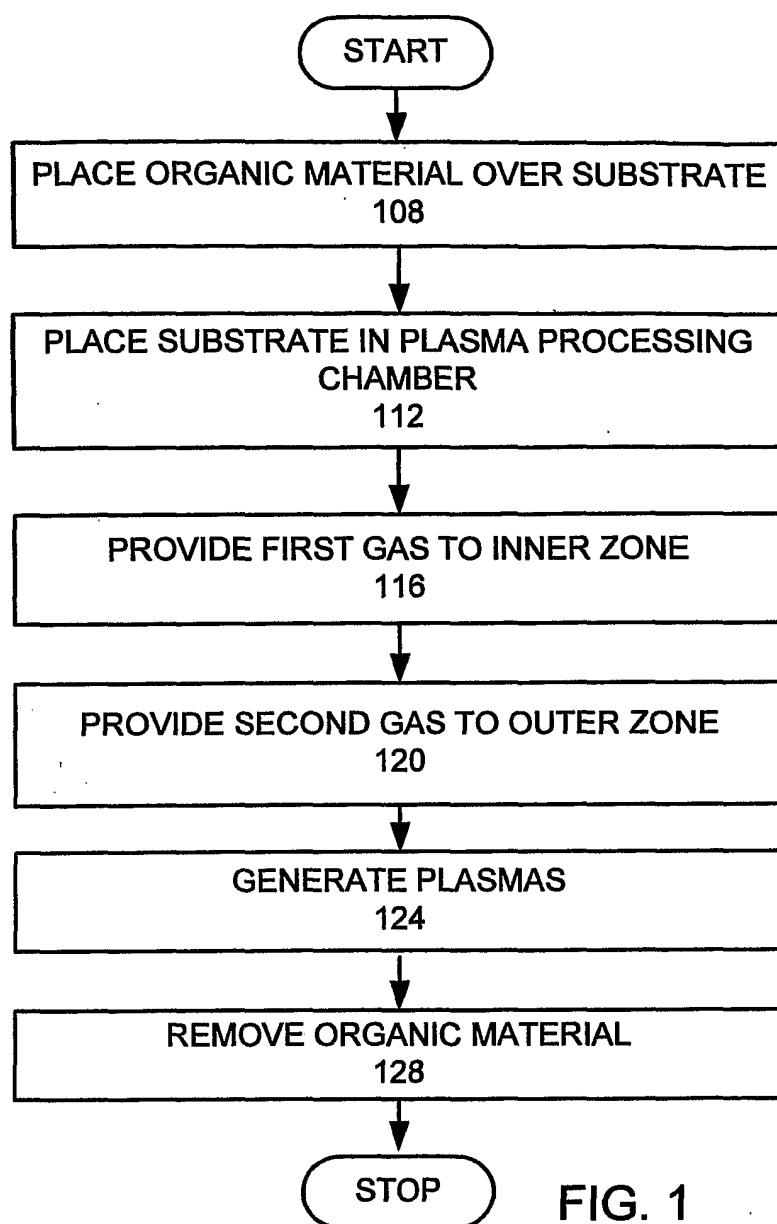


FIG. 1

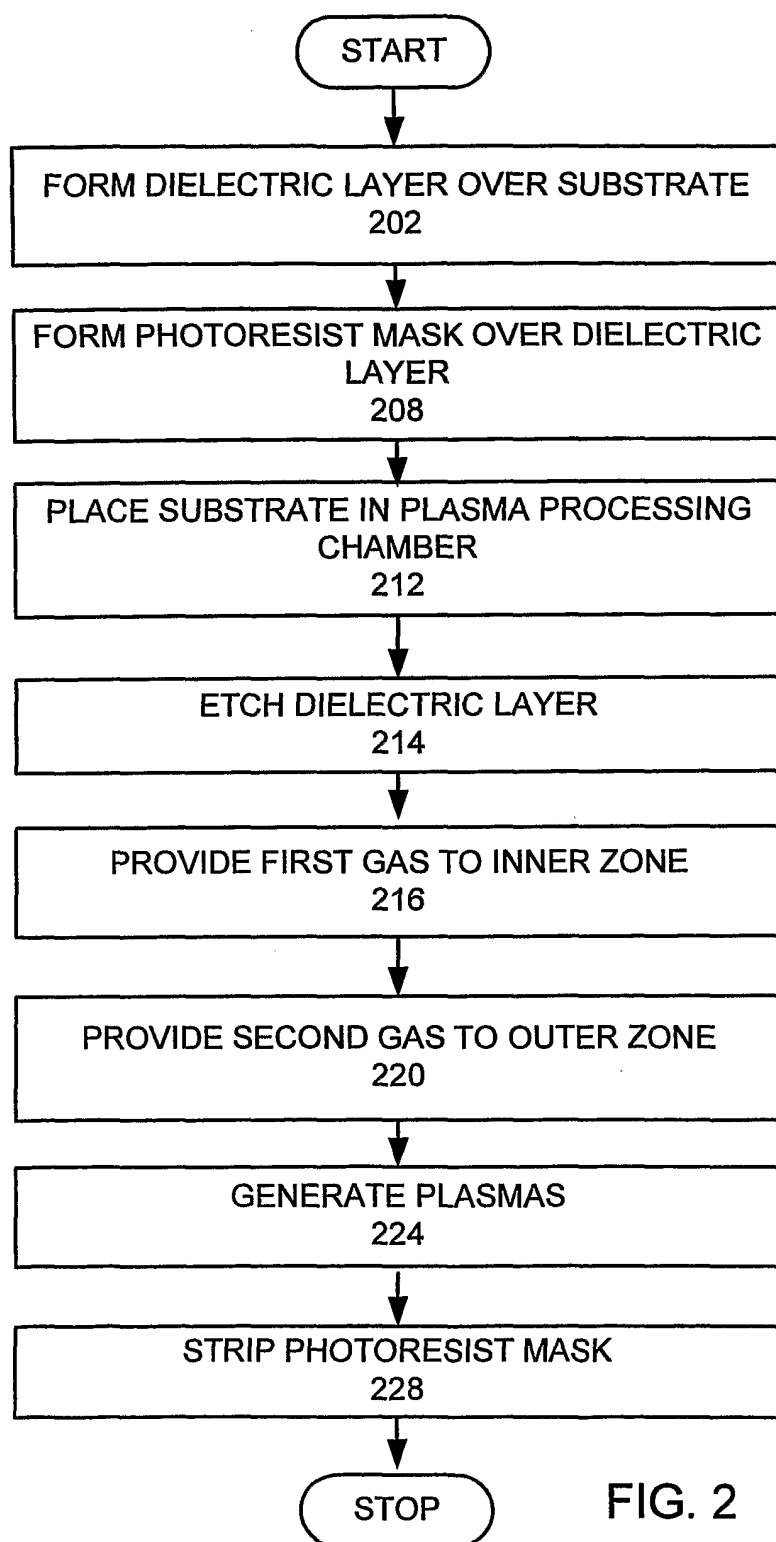


FIG. 2

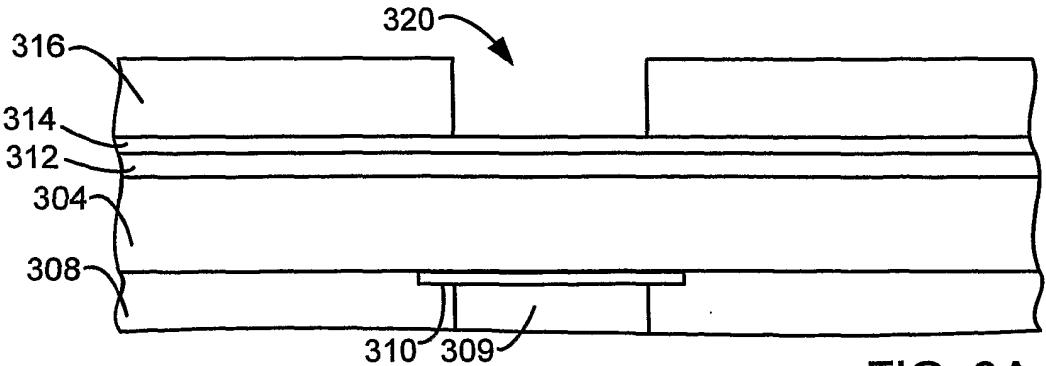


FIG. 3A

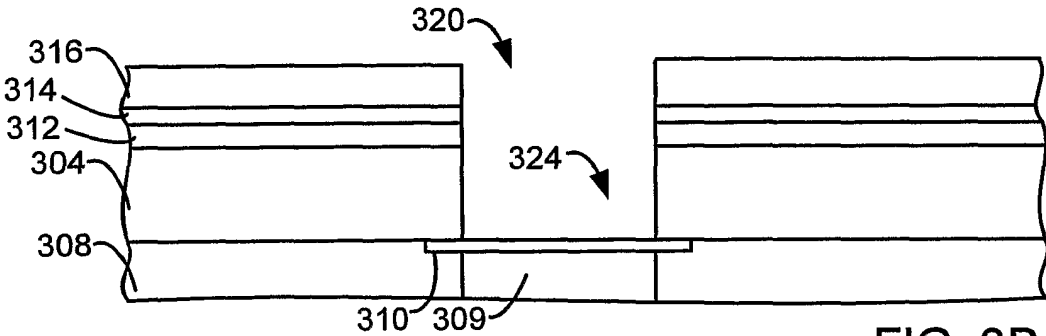


FIG. 3B

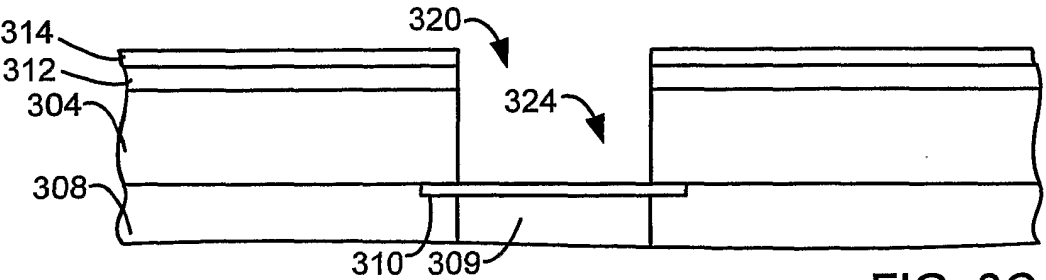
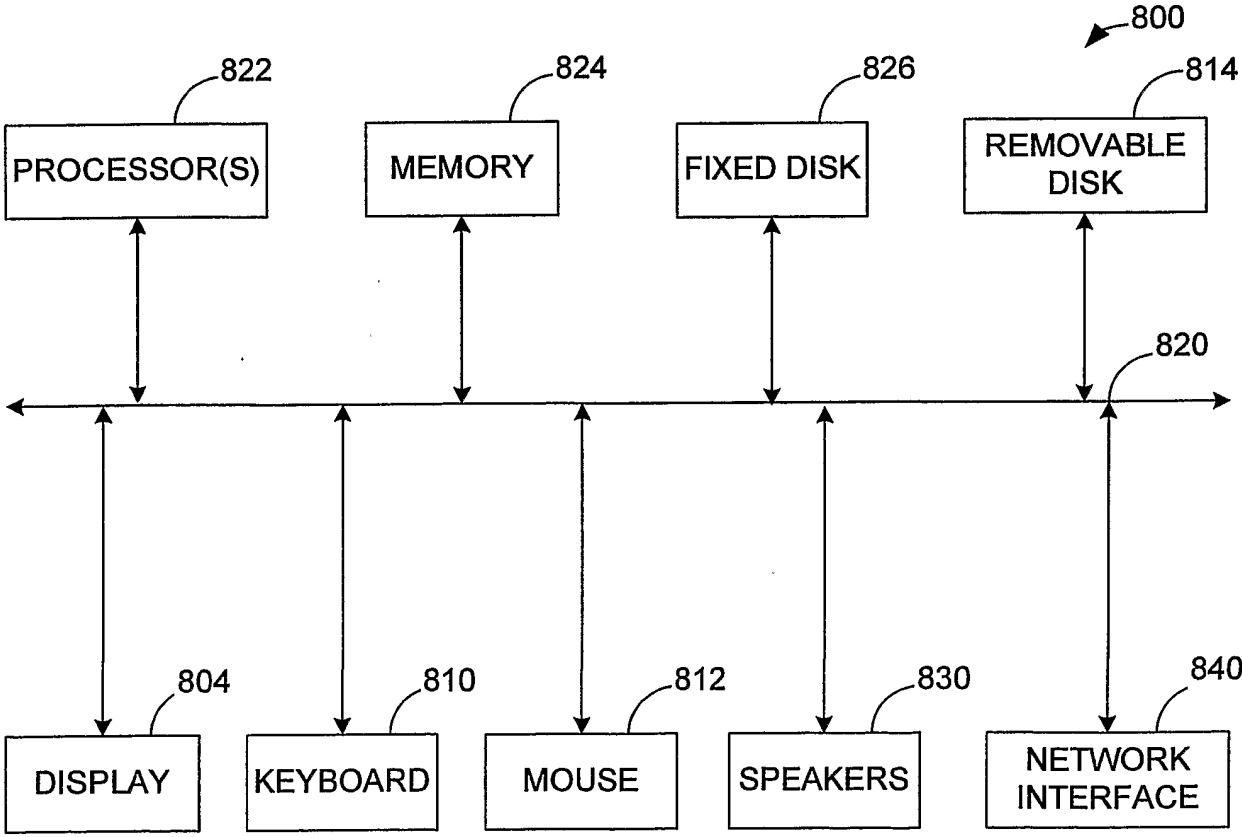
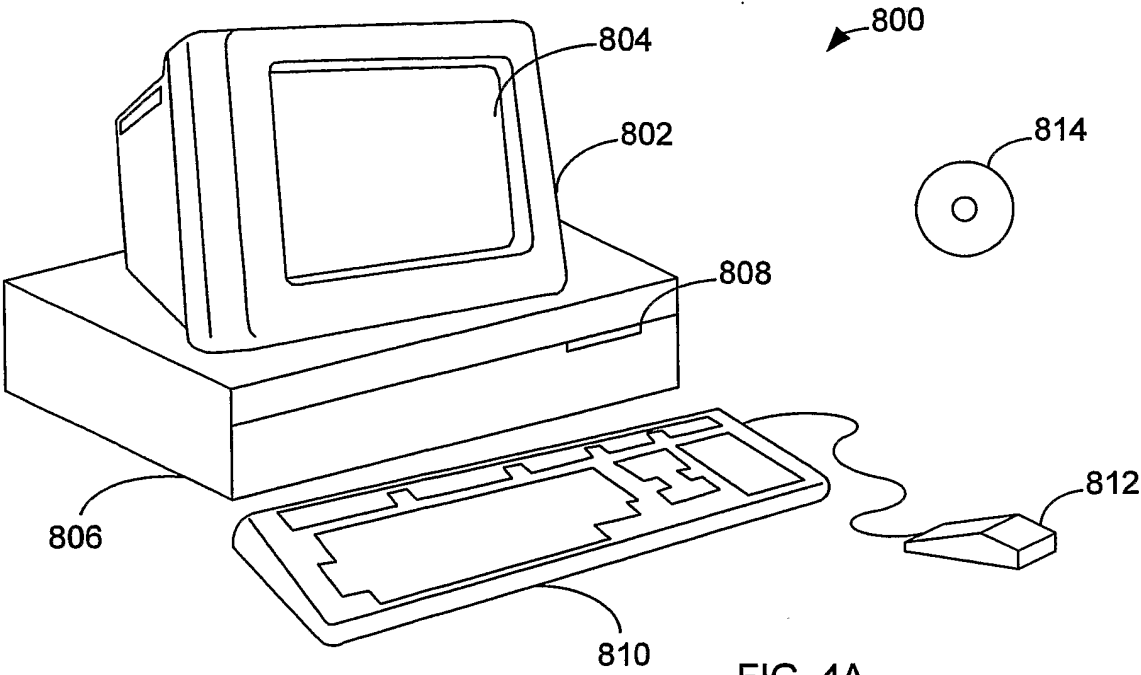


FIG. 3C



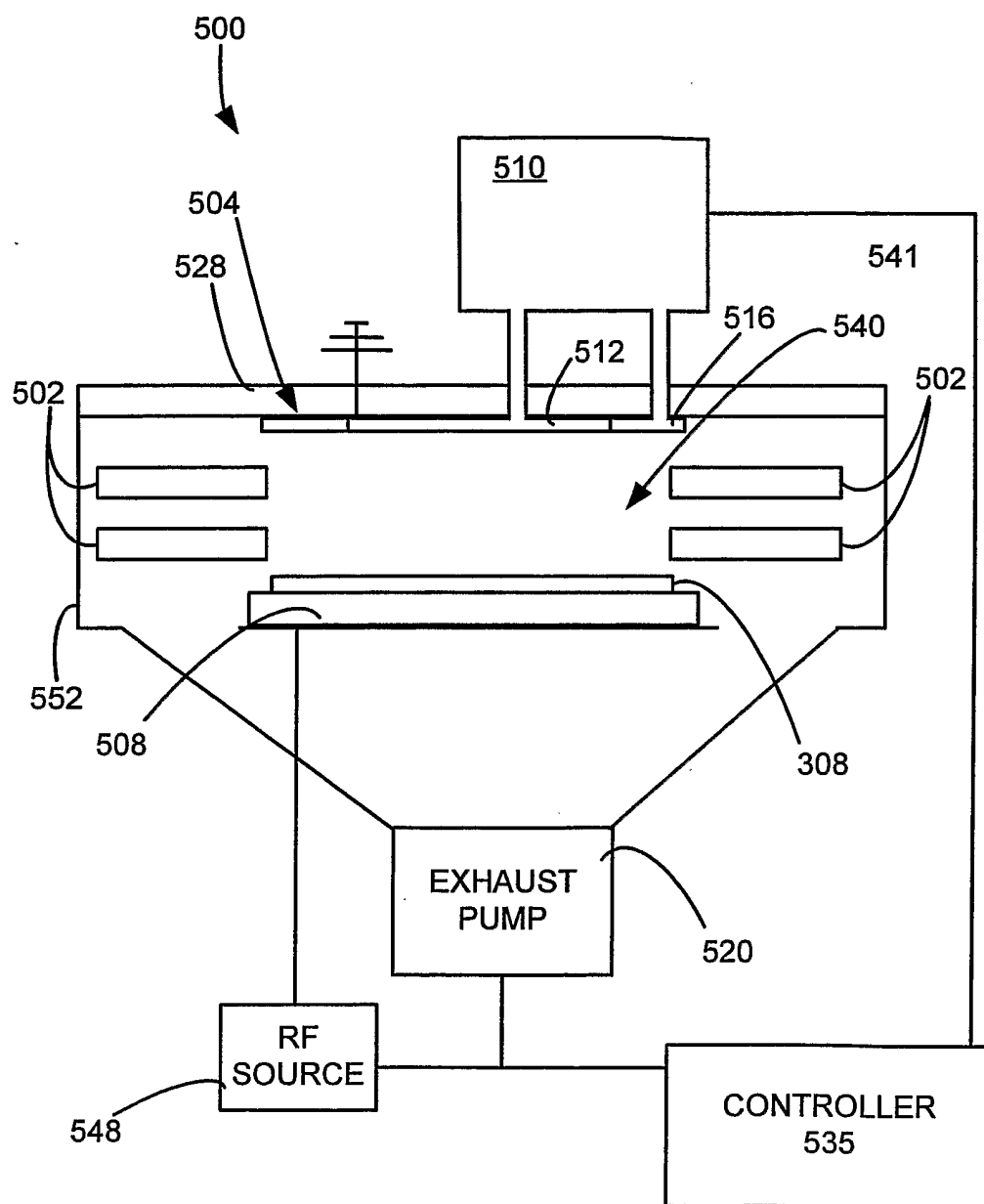


FIG. 5

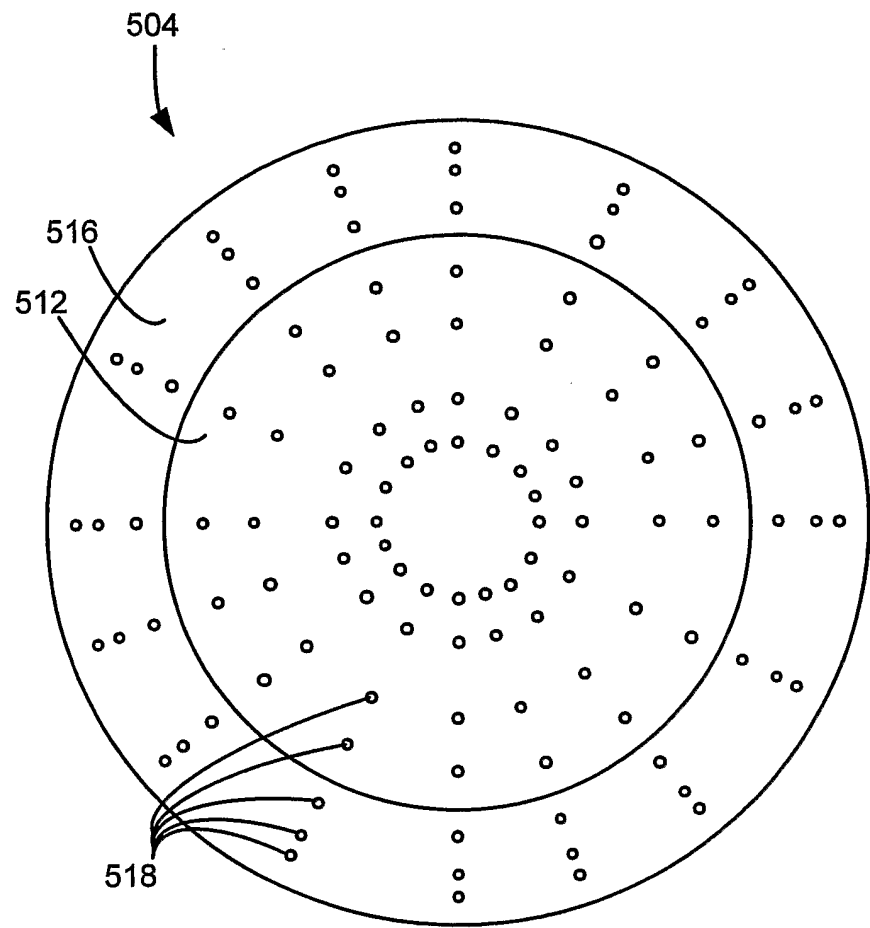


FIG. 6

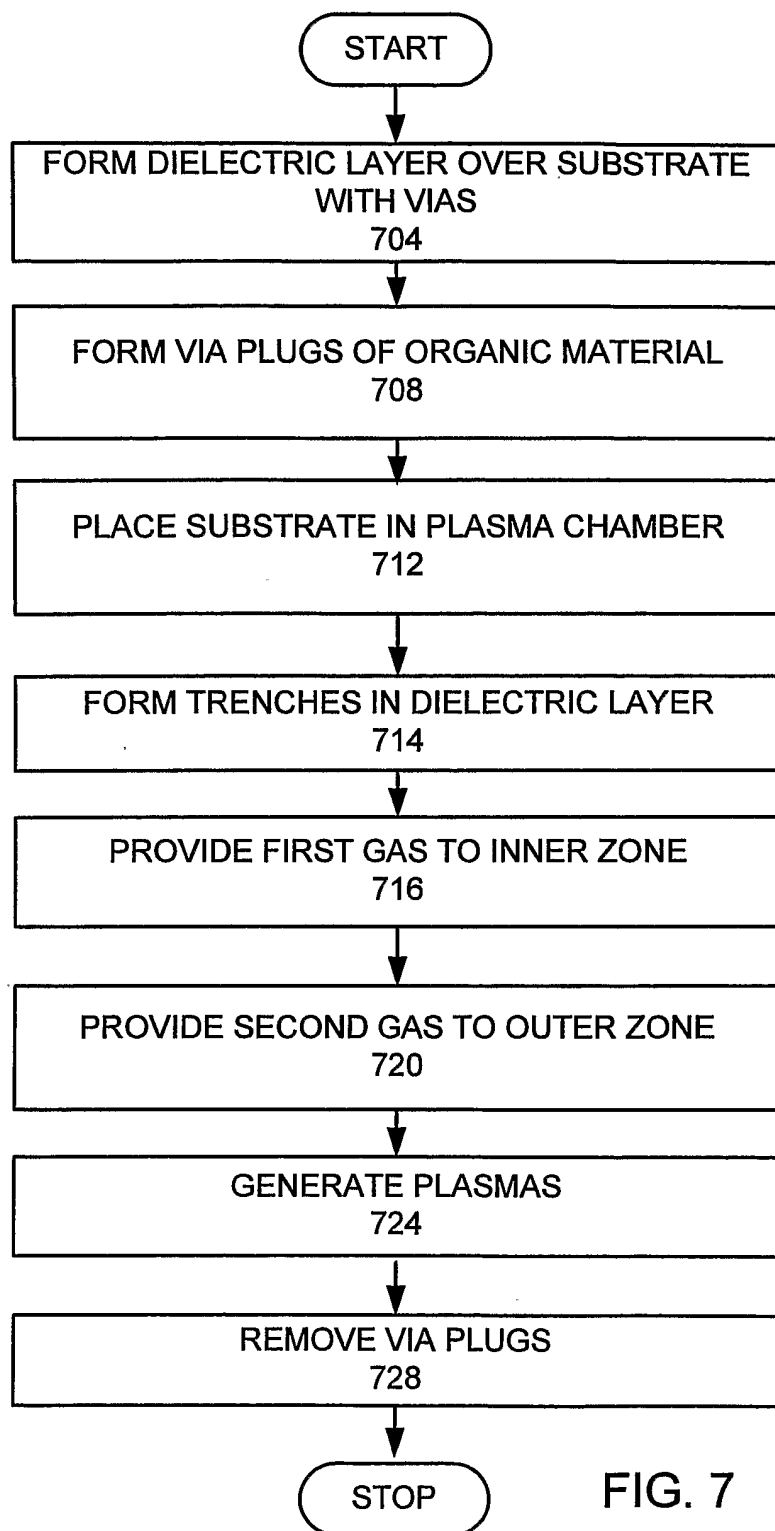


FIG. 7

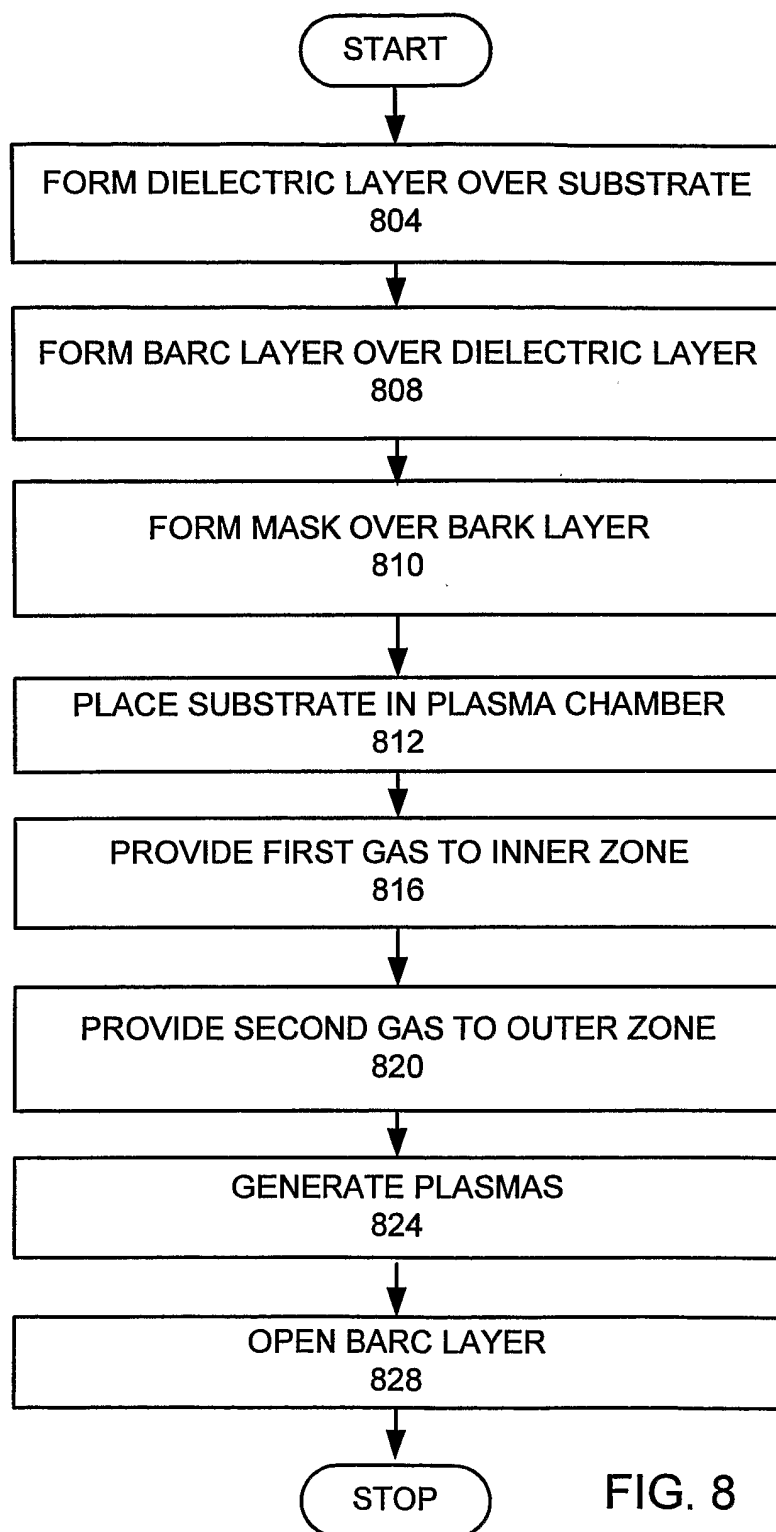


FIG. 8

INTERNATIONAL SEARCH REPORT

Application No
PCT/US2005/020359

A. CLASSIFICATION OF SUBJECT MATTER H01L21/311 G03F7/42 H01J37/32		
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) 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) EPO-Internal, WPI Data, INSPEC		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/112540 A1 (LARSON DEAN J ET AL) 17 June 2004 (2004-06-17) paragraphs '0051!, '0054! - '0056!, '0064!, '0070!, '0071! -----	1-16
X	US 6 333 272 B1 (MCMILLIN BRIAN K ET AL) 25 December 2001 (2001-12-25) column 3, line 32 - column 4, line 11 column 9, lines 1-23 -----	1-16
X	US 4 812 201 A (SAKAI ET AL) 14 March 1989 (1989-03-14) column 10, lines 1-33; figures 17,21,22 -----	15
X	EP 1 077 476 A (AXCELIS TECHNOLOGIES, INC) 21 February 2001 (2001-02-21) figure 5; example 3 ----- -/--	1-10,15
☒ Further documents are listed in the continuation of box C. ☐ Patent family members are listed in annex.		
* Special categories of cited documents : *A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed *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 *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *G* document member of the same patent family		
Date of the actual completion of the international search 23 November 2005		Date of mailing of the international search report 01/12/2005
Name and mailing address of the ISA 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		Authorized officer Szarowski, A

INTERNATIONAL SEARCH REPORT

Application No
PCT/US2005/020359

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/29879 A (MATTSON TECHNOLOGY, INC; SAVAS, STEPHEN, E; ZAJAC, JOHN; GUERRA, ROBER) 26 April 2001 (2001-04-26) pages 24-34; figures 11a,11b -----	1-10,15
X	US 2002/018965 A1 (VAHEDI VAHID ET AL) 14 February 2002 (2002-02-14) paragraphs '0039!, '0051! -----	1-10,15
X	US 2002/173160 A1 (KEIL DOUGLAS ET AL) 21 November 2002 (2002-11-21) paragraphs '0017! - '0022! paragraph '0031!; figure 5 -----	1-5,7,8, 11-13,16
X	JANOWIAK C ET AL: "Etching of organic low dielectric constant material SiLK(TM) on the Lam Research Corporation 4520XLE(TM)" JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY A. VACUUM, SURFACES AND FILMS, AMERICAN INSTITUTE OF PHYSICS, NEW YORK, NY, US, vol. 18, no. 4, July 2000 (2000-07), pages 1859-1863, XP012005235 ISSN: 0734-2101 the whole document -----	1,2,4,5, 7,8,14