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ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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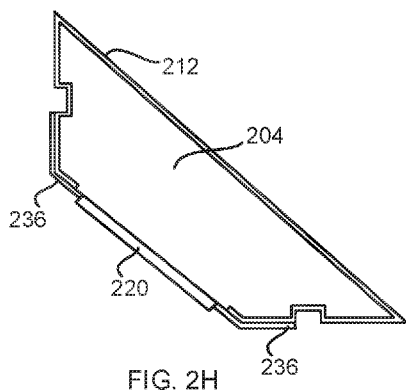


FIG. 2H

(57) Abstract: A component adapted for use in a plasma processing chamber is provided. An aluminum body with a surface is provided. An aluminum oxide coating is over a first region of the surface. An yttrium containing aerosol deposition coating is on a second region of the surface. An yttrium containing thermal spray coating is on the aluminum oxide coating and on the surface at a third region of the surface between the first region and the second region.



SURFACE COATING FOR ALUMINUM PLASMA PROCESSING CHAMBER COMPONENTS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority of U.S. Application No.
5 62/812,437, filed March 1, 2019, which is incorporated herein by reference for all purposes.

BACKGROUND

[0002] The present disclosure generally relates to the manufacturing of
semiconductor devices. More specifically, the disclosure relates to plasma chamber
10 components used in manufacturing semiconductor devices.

[0003] During semiconductor wafer processing, plasma processing chambers are
used to process semiconductor devices. Aluminum components of plasma processing
chambers are subjected to plasmas. The plasmas may degrade the component.

SUMMARY

15 **[0004]** To achieve the foregoing and in accordance with the purpose of the present
disclosure, a component adapted for use in a plasma processing chamber is provided.
An aluminum body with a surface is provided. An aluminum oxide coating is over a
first region of the surface. An yttrium containing aerosol deposition coating is on a
second region of the surface. An yttrium containing thermal spray coating is on the
20 aluminum oxide coating and on the surface at a third region of the surface between
the first region and the second region.

[0005] In another manifestation, a method for coating a component of a plasma
processing chamber is provided. A first region of a surface of the component is
anodized. An yttrium containing aerosol deposition coating is aerosol deposited on a
25 second region of the surface of the component. An yttrium containing thermal spray
coating is thermal sprayed over the first region of the surface of the component and on
the surface at a third region of the surface between the first region and the second
region of the component.

[0006] These and other features of the present disclosure will be described in more
30 detail below in the detailed description of the disclosure and in conjunction with the
following figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The present disclosure 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:

5 [0008] FIG. 1 is a high level flow chart of an embodiment.

[0009] FIGS. 2A-H are schematic cross-sectional views of a component processed according to an embodiment.

[0010] FIG. 3 is a schematic view of a plasma processing chamber that may be used in an embodiment.

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DETAILED DESCRIPTION

[0011] The present disclosure 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 disclosure. It will be apparent, however, to one skilled in the art, that the present disclosure 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 disclosure.

20 [0012] For plasma processing chamber components, bare aluminum (Al) is a common component material for providing coated components due to the relative ease of lowering surface roughness. Remaining uncoated surfaces of the component may be anodized due to anodization's better resistance to plasma attack. On aerosol deposition coated components, there are regions where transitions between aerosol deposited regions and an aluminum oxide coating have a bare aluminum exposed surface. It is important to precisely terminate exactly at the end of the bare aluminum component since aerosol deposition adheres poorly to an aluminum oxide coating and since the bare aluminum exposed surface should be minimized. The transition/termination region between bare Al and uncoated aluminum oxide coating presents some challenges with chamber use.

30 [0013] To facilitate understanding, FIG. 1 is a high level flow chart of a process used in an embodiment. A component is masked (step 104). FIG. 2A is a schematic cross-sectional view of a component body 204 with a bare surface mask 208. In this

example, the component body 204 is part of a pinnacle. The component body 204 is aluminum. Therefore, the component body is an aluminum body. In this example, the aluminum body is at least 90% pure aluminum by weight. For example, the aluminum body is made of Al 6061. Generally, an aluminum body is either pure
5 aluminum or an aluminum alloy. Generally, the aluminum alloy is at least 90% pure aluminum by weight. A flat surface of the component body 204 that will be exposed to a plasma in the plasma processing chamber is masked by the bare surface mask 208.

[0014] The exposed or unmasked parts of the component are anodized (step 108)
10 forming an aluminum oxide (Al_2O_3) coating. In various embodiments, a Type II or Type III anodization may be used. FIG. 2B is a schematic cross-sectional view of the component body 204 with a bare surface mask 208 and an aluminum oxide coating 212 of the exposed parts of the component body 204. The aluminum oxide coating 212 is over a first region of the surface of the component body 204. The aluminum
15 oxide coating 212 has a thickness that is not drawn to scale, to facilitate understanding.

[0015] The bare surface mask 208 is removed (step 112). FIG. 2C is a schematic cross-sectional view of the component body 204 after the bare surface mask 208 is removed. The part of the surface of the component body 204 that is not anodized may
20 be polished to make the surface smoother. The aluminum oxide coating 212 and parts of the bare surface is masked (step 116) with an anodized surface mask 216.

[0016] An aerosol deposition layer is deposited on the exposed surface of the component body 204 (step 120). Aerosol deposition is achieved by passing a carrier gas through a fluidized bed of solid ceramic particles. Driven by a pressure difference,
25 the solid ceramic particles are accelerated through a nozzle, forming an aerosol jet at its outlet. The aerosol jet is then directed at the bare surface of the component body 204, where the aerosol jet impacts the surface with high velocity. The solid ceramic particles break up into solid nanosized fragments, forming a coating. Optimization of carrier gas species, gas consumption, standoff distance, and scan speed provides high
30 quality coatings. In this embodiment, the aerosol deposition layer is an yttrium containing coating, such as a coating comprising yttria (Y_2O_3). In other embodiments, the yttrium containing aerosol deposition coating comprises at least one

of yttrium oxyfluoride (YOF), yttrium aluminum oxide, yttria stabilized zirconia (YSZ), or yttrium (III) fluoride (YF₃). Yttrium aluminum oxide generally describes many materials, such as a yttrium aluminum garnet (Y₃Al₅O₁₂ (YAG)), yttrium aluminum monoclinic (Y₄Al₂O₉ (YAM)), or yttrium aluminum perovskite (YAlO₃ (YAP)). FIG. 2D is a schematic cross-sectional view of the component body 204 after the yttrium containing aerosol deposition coating 220 has been deposited. The yttrium containing aerosol deposition coating 220 is over a second region of the surface of the component body 204.

[0017] The anodized surface mask 216 is removed (step 124). FIG. 2E is a schematic cross-sectional view of the component body 204 after the anodized surface mask 216 has been removed. A bare surface region 228 of the component body 204 remains. The anodized surface mask 216 covered the bare surface region 228 in order to prevent the yttrium containing aerosol deposition coating 220 from being deposited on the aluminum oxide coating 212. The yttrium containing aerosol deposition coating 220 would have poor adhesion to the aluminum oxide coating 212. The poor adhesion would cause defects and contaminants when used in a plasma processing chamber. Since some tolerance is needed during the masking process to prevent the yttrium containing aerosol deposition coating 220 from depositing on the aluminum oxide coating 212, the anodized surface mask 216 covered the bare surface region 228.

[0018] The yttrium containing aerosol deposition coating 220 is masked (step 128). FIG. 2F is a schematic cross-sectional view of the component body 204 after aerosol deposition layer mask 232 has been formed.

[0019] A thermal spray deposition is deposited on the bare surface region 228 and the aluminum oxide coating 212. In one example, the thermal spray deposition layer is deposited using a plasma spray. Plasma spraying is a type of thermal spraying in which a torch is formed by applying an electrical potential between two electrodes, leading to ionization of an accelerated gas (a plasma). Torches of this type can readily reach temperatures of thousands of degrees Celsius, liquifying high melting point materials such as ceramics. Melted particles of the desired material are injected into the jet, and then accelerated towards the component so that the molten or plasticized material coats the surface of the component and then are cooled, forming a solid,

conformal coating. A carrier gas is pushed through an arc cavity and out through a nozzle. In the cavity, a cathode and anode comprise parts of the arc cavity and are maintained at a large direct current (DC) bias voltage, until the carrier gas begins to ionize, forming the plasma. The hot, ionized gas is in then pushed out through the
5 nozzle, forming the torch. Fluidized ceramic particles, tens of micrometers in size, are injected into the chamber near the nozzle. These particles are heated by the hot, ionized gas in the plasma torch such that they exceed the melting temperature of the ceramic. The jet of plasma and melted ceramic are then aimed at component body 204. The particles impact the component body 204, flattening and cooling to form a
10 ceramic coating. In this example, the thermal spray deposition is an yttrium containing thermal spray coating, such as a coating comprising yttria. In other embodiments, the yttrium containing thermal spray coating comprises at least one of YOF, yttrium aluminum oxide, YSZ, or YF_3 . FIG. 2G is a schematic cross-sectional view of the component body 204 after the yttrium containing thermal spray coating
15 236 has been deposited.

[0020] The aerosol deposition mask 232 is removed (step 136). FIG. 2H is a schematic cross-sectional view of the component body 204 after aerosol deposition layer mask 232 has been removed. The yttrium containing thermal spray coating 236 is over a third region of the surface of the component body 204 and over the first
20 region of the surface of the component body 204. In this embodiment, the first region, the second region, and the third region are mutually exclusive and non-overlapping.

[0021] The component is adapted for use in a plasma processing chamber. The component body 204 is mounted in a plasma processing chamber (step 140). The plasma processing chamber is used to process a substrate (step 144). A plasma is
25 created within the plasma processing chamber to process the substrate, such as etching the substrate, and the yttrium containing aerosol deposition coating 220 is exposed to the plasma. The yttrium containing aerosol deposition coating 220 protects the component body 204 from plasma damage.

[0022] In some embodiments, the yttrium containing aerosol deposition coating
30 220 is not masked during the thermal spraying of the yttrium containing thermal spray coating 236. As a result, in such embodiments, the yttrium containing thermal spray coating 236 is also deposited over the yttrium containing aerosol deposition coating

220, providing additional protection. In some embodiments, the yttrium containing thermal spray coating 236 has a thickness of between 150 to 200 microns.

[0023] In various embodiments, for aerosol deposition, it is preferable that a direction of spray of the aerosol deposition be perpendicular to the application surface. When the direction of spray is not perpendicular to the application surface, the adhesion of the particles is decreased. As a result, aerosol deposition on corners or curved surfaces is reduced. For this reason, the corners or curved surfaces of the component body 204 are protected by the yttrium containing thermal spray coating 236 and the aluminum oxide coating 212, instead of the yttrium containing aerosol deposition coating 220. The bare surface regions 228 between the aluminum oxide coating 212 and the yttrium containing aerosol deposition coating 220 are protected by the yttrium containing thermal spray coating 236. This embodiment prevents any overspray of the yttrium containing aerosol deposition coating 220 on the aluminum oxide coating 212. As a result, the component body 204 is provided with a surface protected from the plasma processing. This embodiment also minimizes defects and contaminants.

[0024] In various embodiments, to improve aerosol deposition, the surface covered by the aerosol deposition should be relatively flat. It is generally challenging to aerosol deposition coat surfaces where the direction the spray of the aerosol deposition is not normal to the surface. Therefore, it is preferable that the surface to be covered by aerosol deposition is relatively flat without curves or bends. In addition, the surface covered by the aerosol deposition should be smooth. For example, the surface covered by the aerosol deposition should have a roughness of less than 5 Ra (microinches). In other embodiments, the surface covered by aerosol deposition has a roughness of less than 15 Ra. In various embodiments, the surface that is anodized is curved or bent.

[0025] FIG. 3 schematically illustrates an example of a plasma processing chamber 300 used in an embodiment. The plasma processing chamber 300 includes a plasma reactor 302 having a plasma processing confinement chamber 304 therein. A plasma power supply 306, tuned by a match network 308, supplies power to a transformer coupled plasma (TCP) coil 310 located near a power window 312 to create a plasma 314 in the plasma processing confinement chamber 304 by providing an inductively

coupled power. A pinnacle 372 extends from a chamber wall 376 of the plasma processing confinement chamber 304 to the power window 312 forming a pinnacle ring. The pinnacle 372 is angled with respect to the chamber wall 376 and the power window 312, such that the interior angle between the pinnacle 372 and the chamber wall 376 and the interior angle between the pinnacle 372 and the power window 312 are each greater than 90° and less than 180°. The pinnacle 372 provides an angled ring near the top of the plasma processing confinement chamber 304, as shown. The TCP coil (upper power source) 310 may be configured to produce a uniform diffusion profile within the plasma processing confinement chamber 304. For example, the TCP coil 310 may be configured to generate a toroidal power distribution in the plasma 314. The power window 312 is provided to separate the TCP coil 310 from the plasma processing confinement chamber 304 while allowing energy to pass from the TCP coil 310 to the plasma processing confinement chamber 304. A wafer bias voltage power supply 316 tuned by a match network 318 provides power to an electrode 320 to set the bias voltage on the substrate 366. The substrate 366 is supported by the electrode 320. A controller 324 sets points for the plasma power supply 306 and the wafer bias voltage power supply 316.

[0026] The plasma power supply 306 and the wafer bias voltage power supply 316 may be configured to operate at specific radio frequencies such as, for example, 13.56 megahertz (MHz), 27 MHz, 2 MHz, 60 MHz, 400 kilohertz (kHz), 2.54 gigahertz (GHz), or combinations thereof. Plasma power supply 306 and wafer bias voltage power supply 316 may be appropriately sized to supply a range of powers in order to achieve desired process performance. For example, in one embodiment, the plasma power supply 306 may supply the power in a range of 50 to 5000 Watts, and the wafer bias voltage power supply 316 may supply a bias voltage of in a range of 20 to 2000 volts (V). In addition, the TCP coil 310 and/or the electrode 320 may be comprised of two or more sub-coils or sub-electrodes. The TCP coil 310 and/or electrode 320 may be powered by a single power supply or powered by multiple power supplies.

[0027] As shown in FIG. 3, the plasma processing chamber 300 further includes a gas source/gas supply mechanism 330. The gas source 330 is in fluid connection with plasma processing confinement chamber 304 through a gas inlet, such as a gas injector 340. The gas injector 340 may be located in any advantageous location in the

plasma processing confinement chamber 304 and may take any form for injecting gas. Preferably, however, the gas inlet may be configured to produce a “tunable” gas injection profile. The tunable gas injection profile allows independent adjustment of the respective flow of the gases to multiple zones in the plasma process confinement chamber 304. More preferably, the gas injector is mounted to the power window 312. In such a case, the gas injector may be mounted on, mounted in, or form part of the power window. The process gases and by-products are removed from the plasma process confinement chamber 304 via a pressure control valve 342 and a pump 344. The pressure control valve 342 and pump 344 also serve to maintain a particular pressure within the plasma processing confinement chamber 304. The pressure control valve 342 can maintain a pressure of less than 1 torr during processing. An edge ring 360 is placed around the substrate 366. The gas source/gas supply mechanism 330 is controlled by the controller 324. A Kiyo by Lam Research Corp. of Fremont, CA, may be used to practice an embodiment.

15 **[0028]** In various embodiments, the component may be other parts of a plasma processing chamber, such as confinement rings, edge rings, the electrostatic chuck, ground rings, chamber liners, door liners, or other components. Other components of other types of plasma processing chambers may be used. For example, plasma exclusion rings on a bevel etch chamber may be coated in an embodiment. In another example, the plasma processing chamber may be a dielectric processing chamber or conductor processing chamber. In some embodiments one or more, but not all surfaces are coated.

20 **[0029]** While this disclosure has been described in terms of several preferred embodiments, there are alterations, permutations, modifications, and various substitute equivalents, which fall within the scope of this disclosure. It should also be noted that there are many alternative ways of implementing the methods and apparatuses of the present disclosure. It is therefore intended that the following appended claims be interpreted as including all such alterations, permutations, and various substitute equivalents as fall within the true spirit and scope of the present disclosure.

25
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CLAIMS

What is claimed is:

1. A component adapted for use in a plasma processing chamber, the component comprising:
 - 5 an aluminum body with a surface;
 - an aluminum oxide coating over a first region of the surface;
 - an yttrium containing aerosol deposition coating on a second region of the surface; and
 - an yttrium containing thermal spray coating on the aluminum oxide coating
 - 10 and on the surface at a third region of the surface between the first region and the second region.
2. The component, as recited in claim 1, wherein the yttrium containing thermal spray coating is on the yttrium containing aerosol deposition coating.
3. The component, as recited in claim 1, wherein the yttrium containing aerosol
 - 15 deposition coating and the yttrium containing thermal spray coating comprises one or more of yttria, yttrium oxyfluoride, yttrium aluminum oxide, yttria stabilized zirconia, and yttrium (III) fluoride.
4. The component, as recited in claim 1, wherein the second region of the surface has a roughness of less than 5 Ra (microinches).
- 20 5. The component, as recited in claim 1, wherein part of the first region of the surface is curved or bent.
6. The component, as recited in claim 1, wherein the second region of the surface is flat.
7. The component, as recited in claim 1, wherein the component is at least one of
 - 25 a confinement ring, an edge ring, an electrostatic chuck, a ground ring, a chamber liner, or a door liner.
8. The component, as recited in claim 1, wherein the yttrium containing aerosol deposition coating and the yttrium containing thermal spray coating comprise yttria.
9. The component, as recited in claim 1, wherein the aluminum body is at least
 - 30 90% pure aluminum by weight.
10. A method for coating a component of a plasma processing chamber, wherein the method comprises:

anodizing a first region of a surface of the component;
aerosol depositing an yttrium containing aerosol deposition coating on a
second region of the surface of the component; and
thermal spraying an yttrium containing thermal spray coating over the first
5 region of the surface of the component and on the surface at a third region of the
surface between the first region and the second region of the component.

11. The method, as recited in claim 10, further comprising polishing the second
region of the surface of the component after anodizing the first region of the surface
of the component.

10 12. The method, as recited in claim 11, further comprising:
masking the second region of the surface of the component before anodizing
the first region of the surface of the component;
removing masking of the second region of the surface of the component after
anodizing the first region of the surface of the component;
15 masking the first region and the third region of the surface of the component
before aerosol depositing the yttrium containing aerosol deposition coating on the
second region of the surface of the component; and
removing masking of the first region and the third region of the surface of the
component after aerosol depositing the yttrium containing aerosol deposition coating
20 on the second region of the surface of the component.

13. The method, as recited in claim 12, further comprising polishing the second
region of the surface of the component after removing masking of the second region
of the surface of the component.

14. The method, as recited in claim 12, wherein the component is at least one of a
25 confinement ring, an edge ring, an electrostatic chuck, a ground ring, a chamber liner,
or a door liner.

15. The method, as recited in claim 10, wherein part of the yttrium containing
thermal spray coating is on the yttrium containing aerosol deposition coating.

16. The method, as recited in claim 10, wherein the yttrium containing aerosol
30 deposition coating and the yttrium containing thermal spray coating comprises one or
more of yttria, yttrium oxyfluoride, yttrium aluminum oxide, yttria stabilized zirconia,
and yttrium (III) fluoride.

17. The method, as recited in claim 10, further comprising polishing the second region of the surface of the component to have a roughness of less than 5 Ra (microinches) after anodizing the first region of the surface of the component.
18. The method, as recited in claim 10, wherein part of the first region of the surface is curved or bent.
19. The method, as recited in claim 10, wherein the second region of the surface is flat.
20. The method, as recited in claim 10, wherein the yttrium containing aerosol deposition coating and the yttrium containing thermal spray coating comprises yttria.

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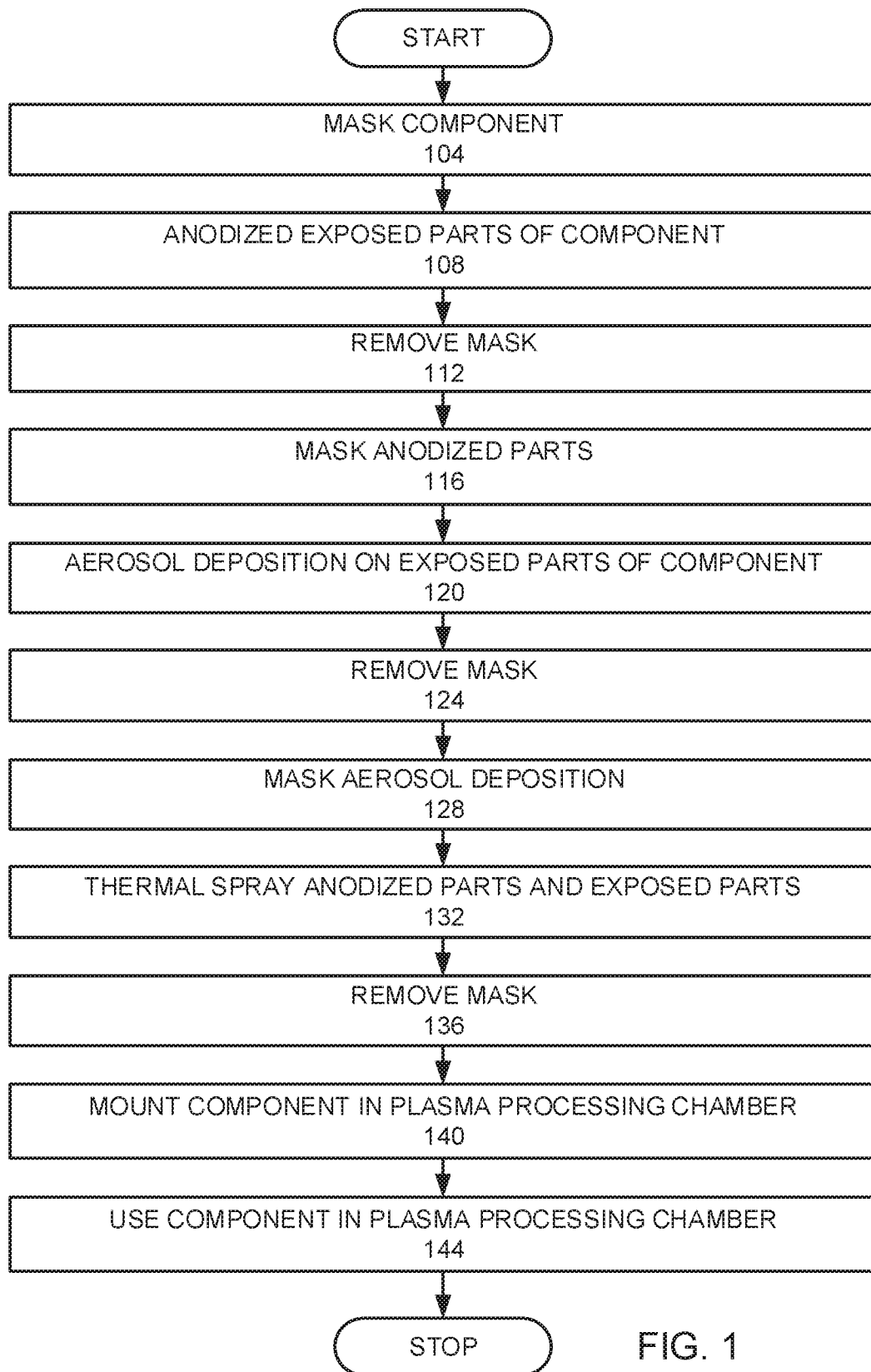


FIG. 1

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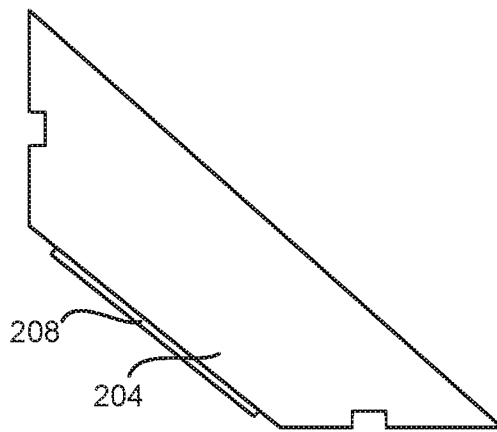


FIG. 2A

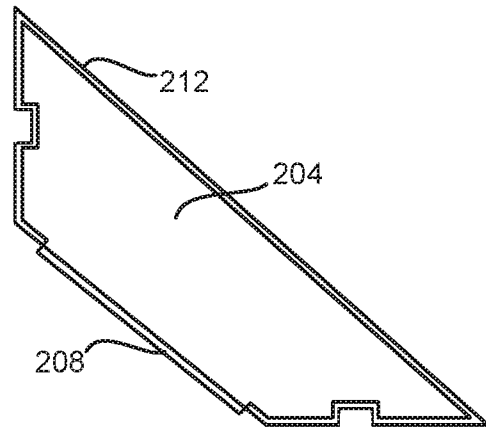


FIG. 2B

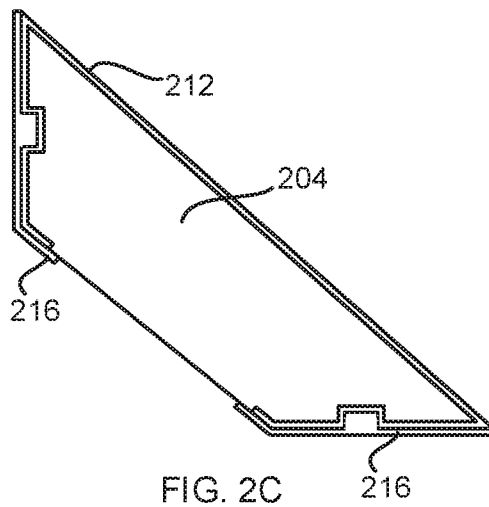


FIG. 2C

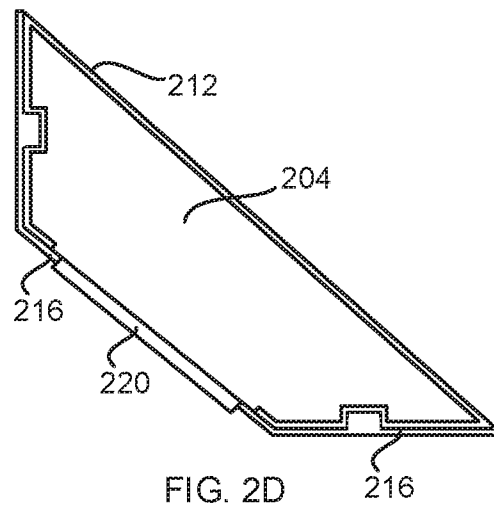


FIG. 2D

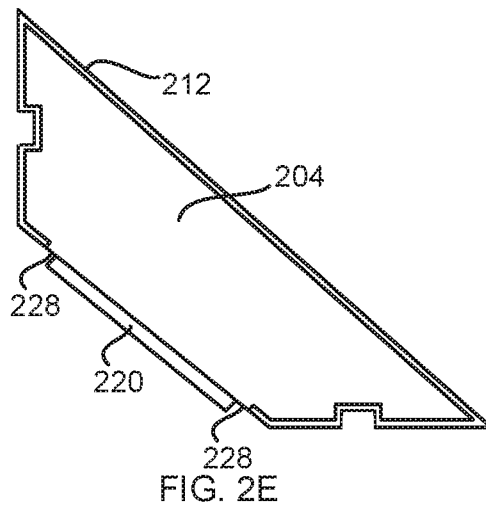


FIG. 2E

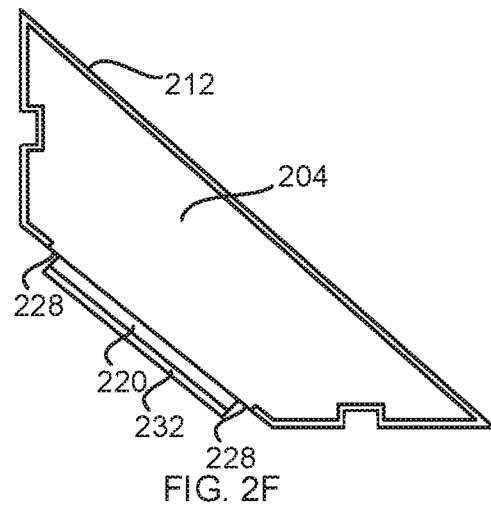
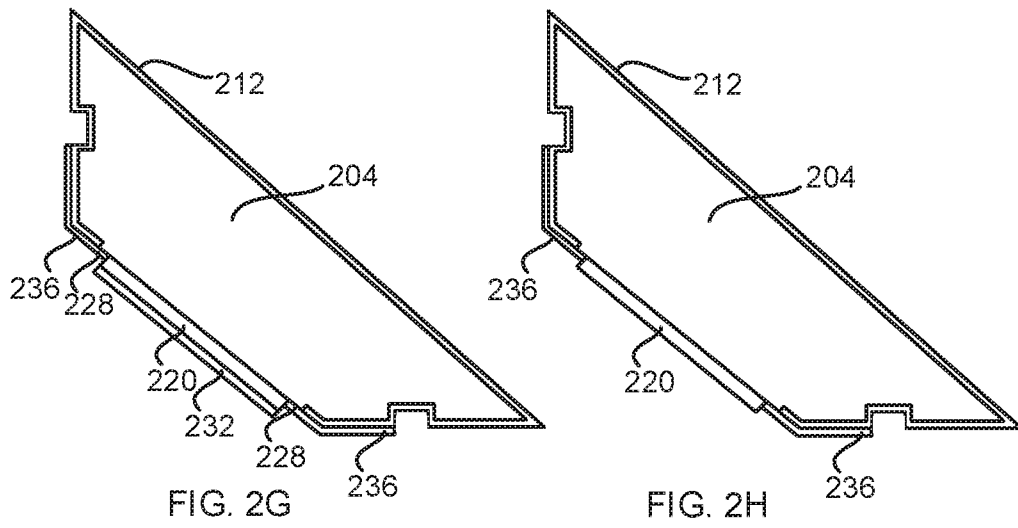


FIG. 2F

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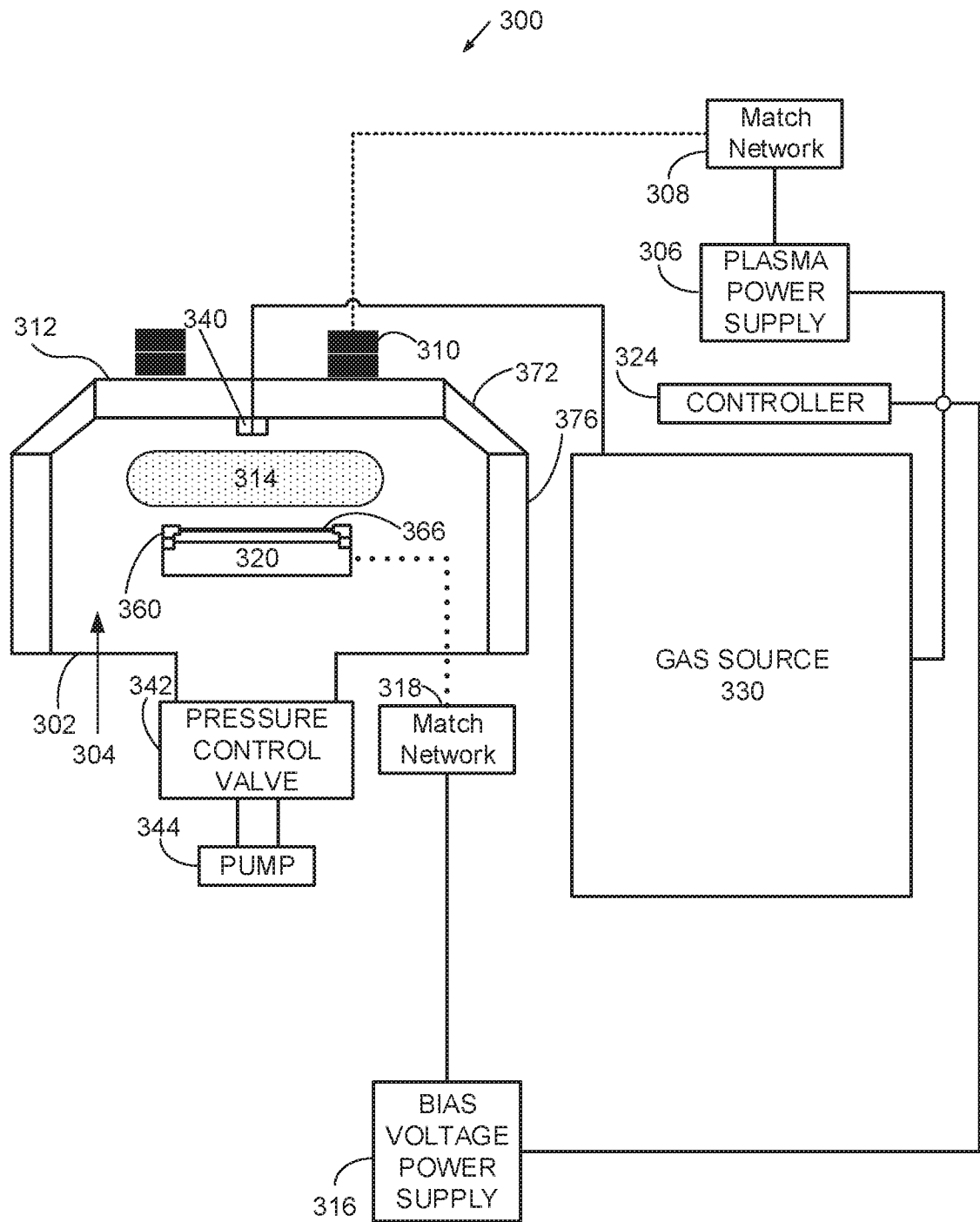


FIG. 3

A. CLASSIFICATION OF SUBJECT MATTER**H01J 37/32(2006.01)i**

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)

H01J 37/32; C23C 4/06; C23C 4/08; C23C 4/123; C23C 4/134; H01J 37/00; H01L 21/683; H05K 3/10

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: surface coating, aluminum, plasma, chamber, yttrium, aerosol deposition, thermal spray, anodizing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2018-0135157 A1 (KOMICO LTD.) 17 May 2018 See paragraphs 37-52, claims 1-17 and figures 1(a)-2.	1-20
Y	WO 2004-003962 A2 (LAM RESEARCH CORPORATION) 08 January 2004 See paragraphs 37-59, claims 1-9 and figures 2-4.	1-20
A	US 2015-0022936 A1 (APPLIED MATERIALS, INC.) 22 January 2015 See the entire document.	1-20
A	US 2016-0312351 A1 (LAM RESEARCH CORPORATION) 27 October 2016 See the entire document.	1-20
A	EP 1847628 A1 (SHIN-ETSU CHEMICAL CO., LTD.) 24 October 2007 See the entire document.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

12 June 2020 (12.06.2020)

Date of mailing of the international search report

12 June 2020 (12.06.2020)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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