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(54) **SURFACE COATING FOR PLASMA PROCESSING CHAMBER COMPONENTS**

(71) Applicant: **Lam Research Corporation**, Fremont, CA (US)

(72) Inventors: **Slobodan MITROVIC**, Oakland, CA (US); **Jeremy George SMITH**, Oakland, CA (US); **Tony Shaleen KAUSHAL**, Campbell, CA (US); **Eric A. PAPE**, Santa Cruz, CA (US)

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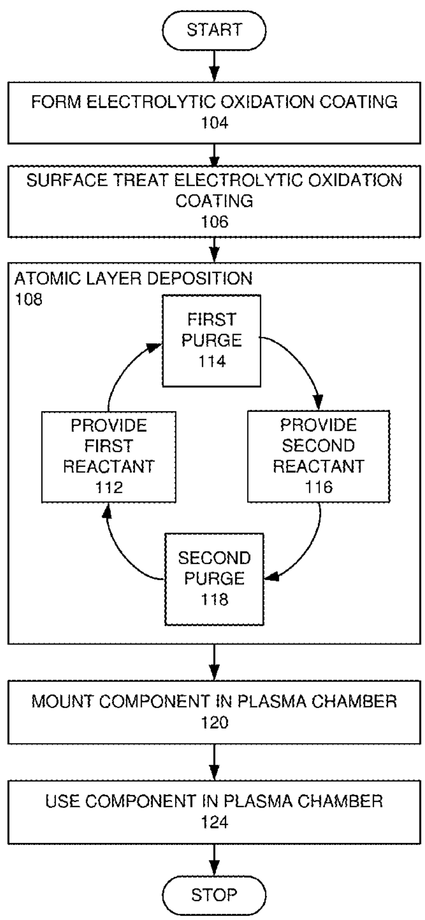
(57) **ABSTRACT**

A method for coating a component of a plasma processing chamber is provided. An electrolytic oxidation coating is formed over a surface of the component, wherein the electrolytic oxidation coating has a plurality of pores, wherein the electrolytic oxidation coating has a thickness and at least some of the plurality of pores extends through the thickness of the electrolytic oxidation coating. An atomic layer deposition is deposited on the electrolytic oxidation coating. The atomic layer deposition comprises a plurality of cycles, where each cycle comprises flowing a first reactant, wherein the first reactant forms a first reactant layer in the pores of the electrolytic oxidation coating, wherein the first reactant layer extends through the thickness of the electrolytic oxidation coating, stopping the flow of the first reactant, flowing a second reactant, wherein the second reactant reacts with the first reactant layer, and stopping the flow of the second reactant.



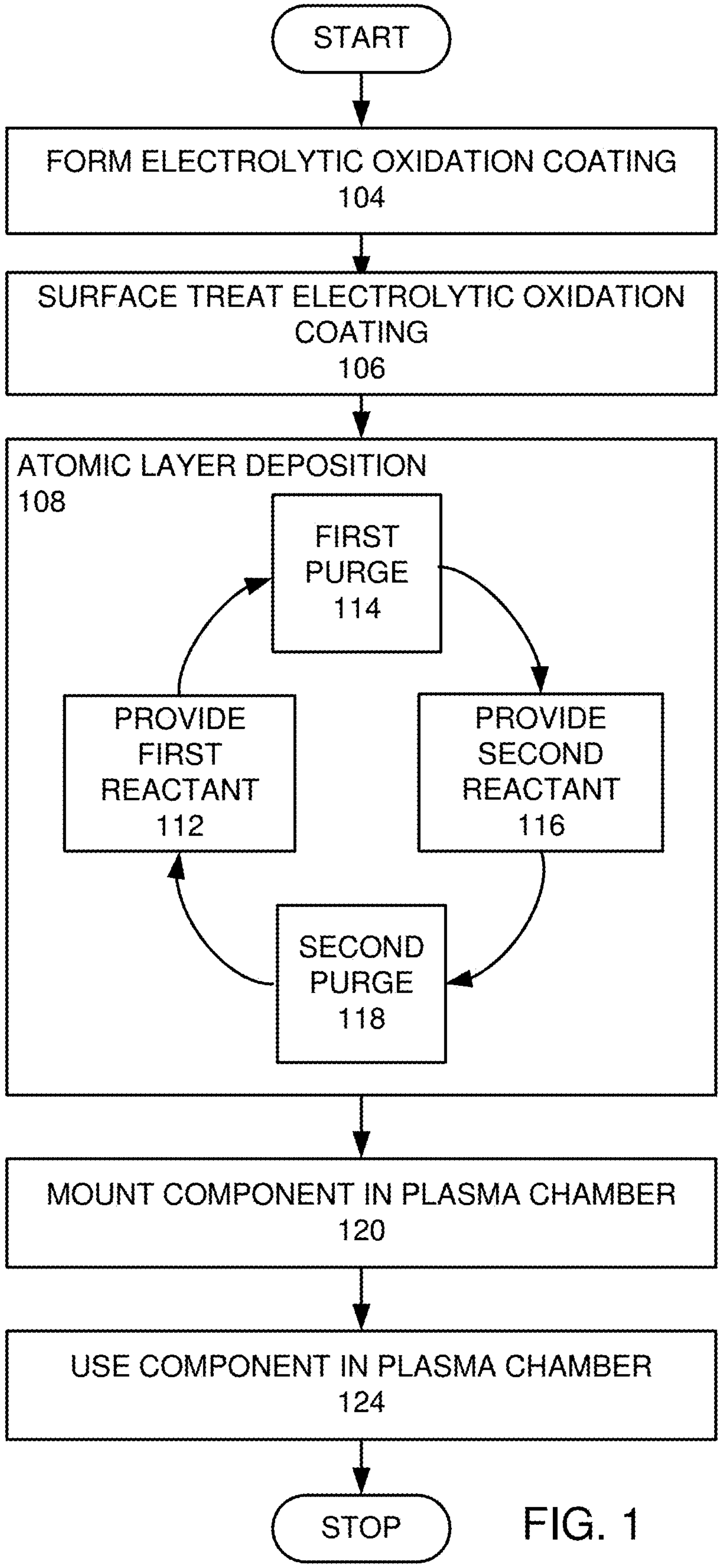

START
FORM ELECTROLYTIC OXIDATION COATING
104
SURFACE TREAT ELECTROLYTIC OXIDATION COATING
106
ATOMIC LAYER DEPOSITION
108
FIRST PURGE
114
PROVIDE FIRST REACTANT
112
PROVIDE SECOND REACTANT
116
SECOND PURGE
118
MOUNT COMPONENT IN PLASMA CHAMBER
120
USE COMPONENT IN PLASMA CHAMBER
124
STOP

FIG. 1

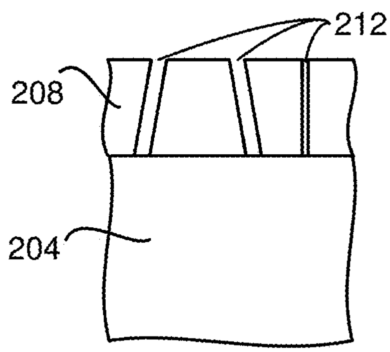


FIG. 2A

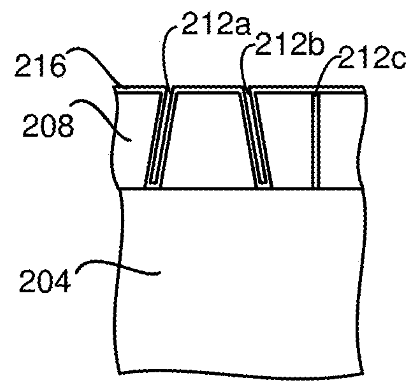


FIG. 2B

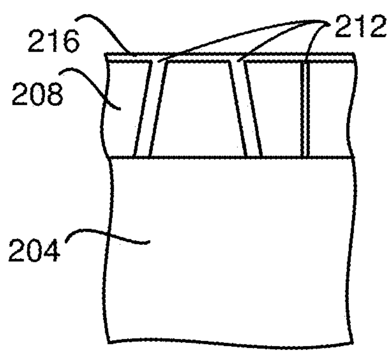


FIG. 2C

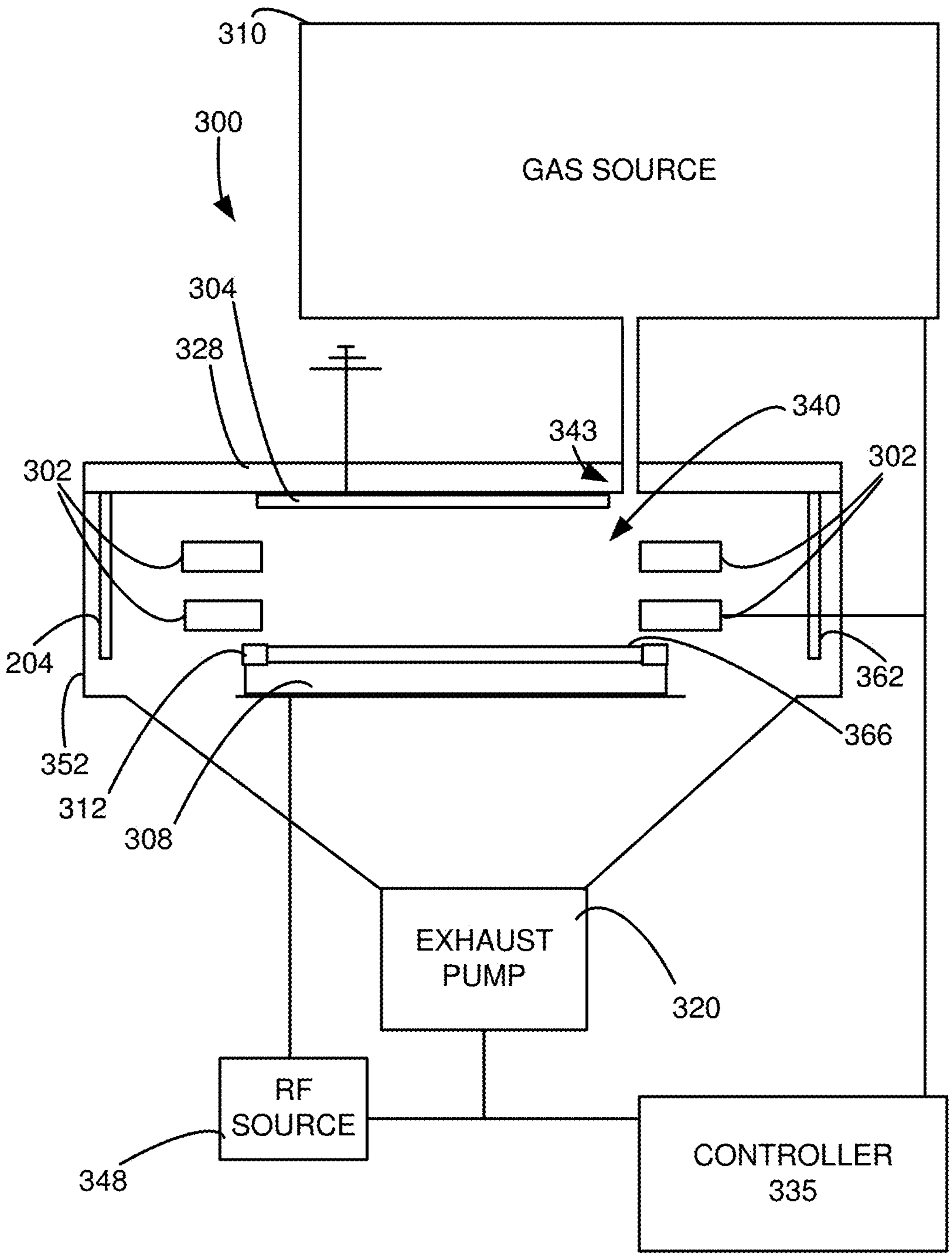

310
300
GAS SOURCE
304
328
343
340
302
302
204
362
352
312
308
366
EXHAUST
PUMP
320
RF
SOURCE
348
CONTROLLER
335

FIG. 3

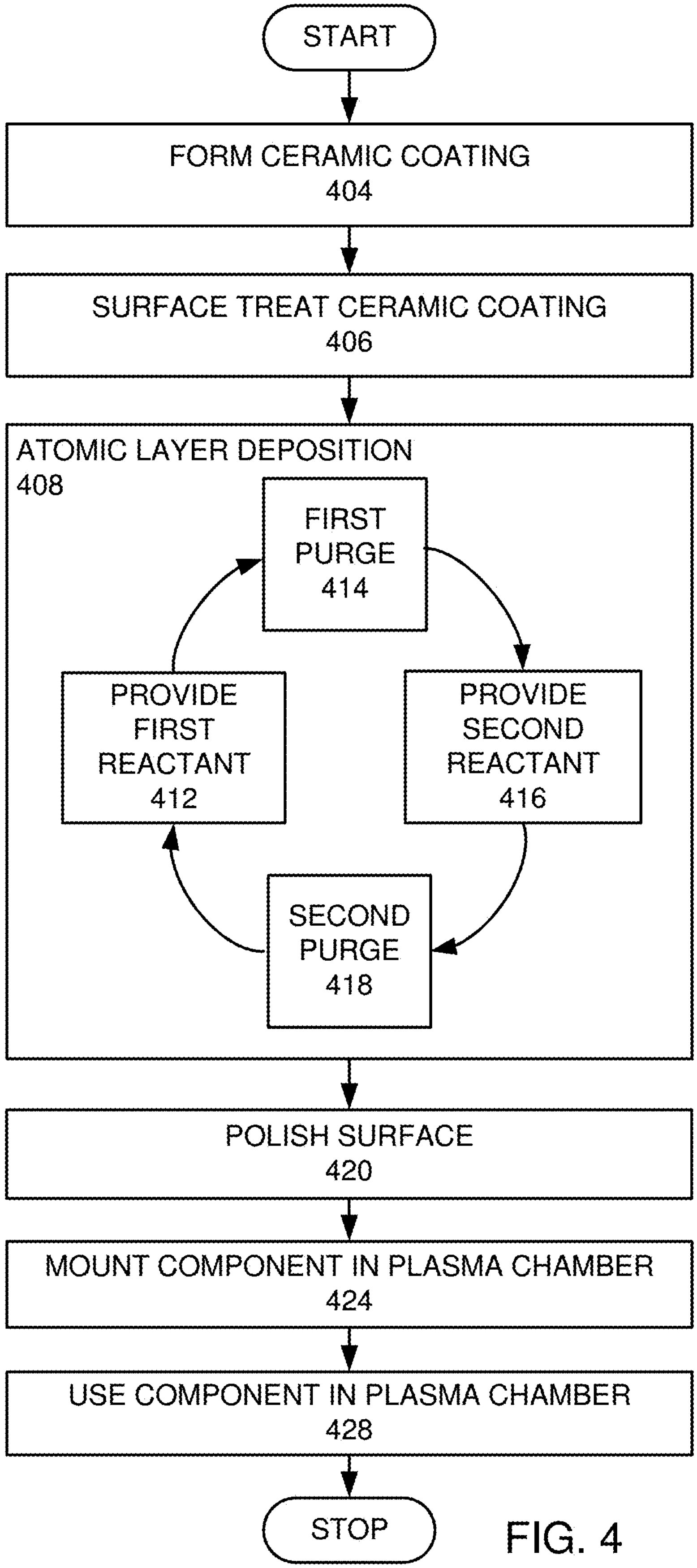

START
FORM CERAMIC COATING
404
SURFACE TREAT CERAMIC COATING
406
ATOMIC LAYER DEPOSITION
408
FIRST PURGE
414
PROVIDE SECOND REACTANT
416
SECOND PURGE
418
PROVIDE FIRST REACTANT
412
POLISH SURFACE
420
MOUNT COMPONENT IN PLASMA CHAMBER
424
USE COMPONENT IN PLASMA CHAMBER
428
STOP

FIG. 4

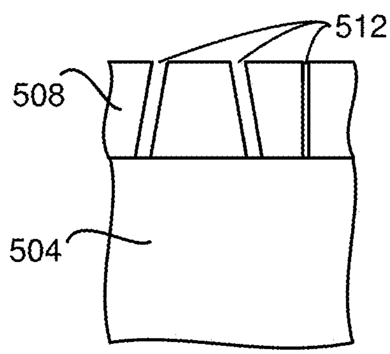


FIG. 5A

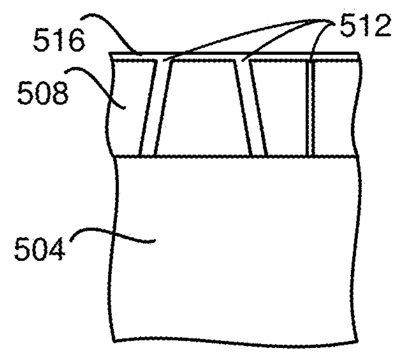


FIG. 5B

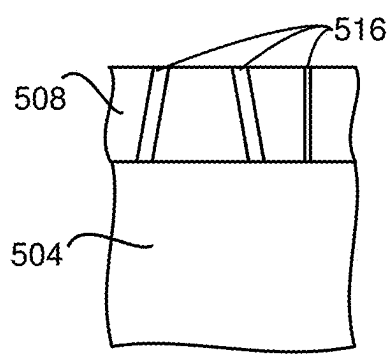


FIG. 5C

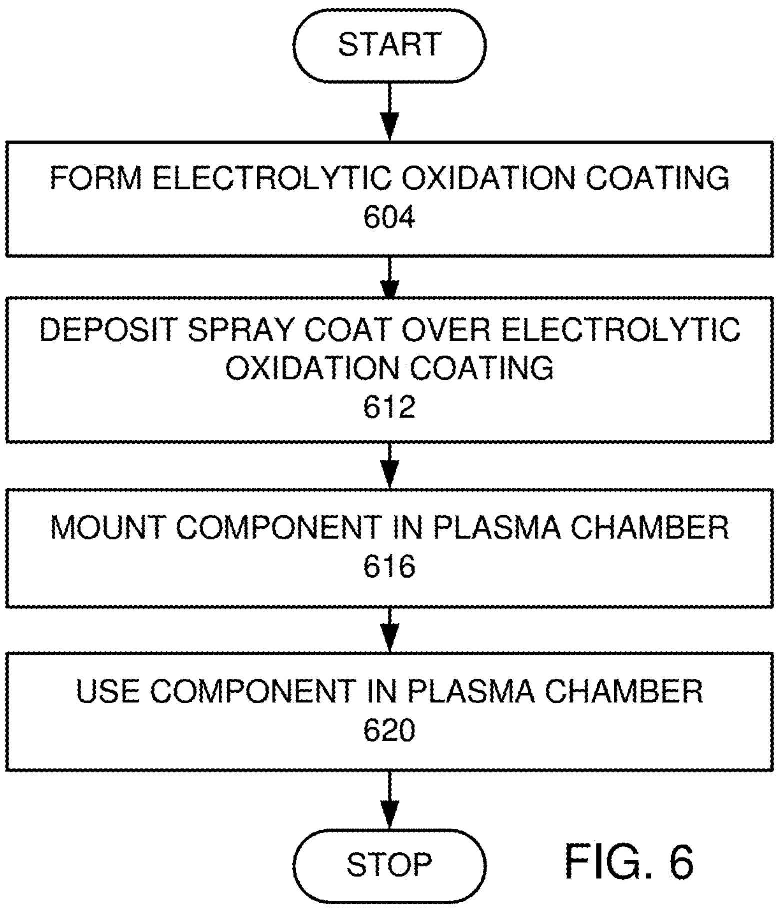

START
FORM ELECTROLYTIC OXIDATION COATING
604
DEPOSIT SPRAY COAT OVER ELECTROLYTIC OXIDATION COATING
612
MOUNT COMPONENT IN PLASMA CHAMBER
616
USE COMPONENT IN PLASMA CHAMBER
620
STOP

FIG. 6

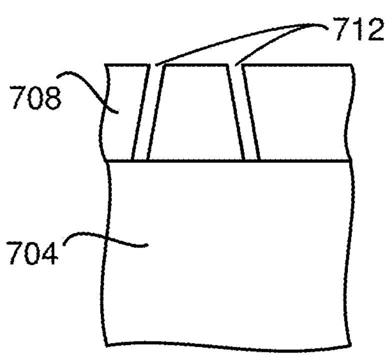


FIG. 7A

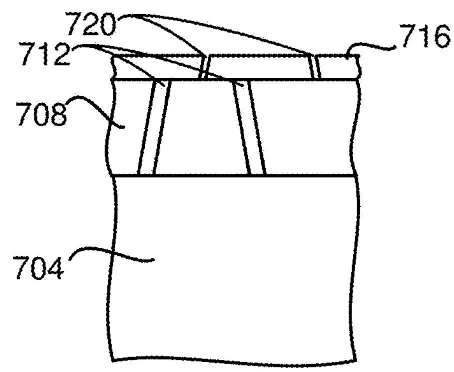


FIG. 7B

SURFACE COATING FOR PLASMA PROCESSING CHAMBER COMPONENTS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a Divisional of U.S. application Ser. No. 17/261,812, filed Jan. 20, 2021, which claims a 371 of international Application No. PCT/US2019/042569, filed Jul. 19, 2019, which claims priority of U.S. Application No. 62/703,698, filed Jul. 26, 2018, which is incorporated herein by reference for all purposes.

BACKGROUND

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

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

SUMMARY

[0004] To achieve the foregoing and in accordance with the purpose of the present disclosure, a method for coating a component of a plasma processing chamber is provided. An electrolytic oxidation coating is formed over a surface of the component, wherein the electrolytic oxidation coating has a plurality of pores, wherein the electrolytic oxidation coating has a thickness and at least some of the plurality of pores extend through the thickness of the electrolytic oxidation coating. An atomic layer deposition is deposited on the electrolytic oxidation coating, using an atomic layer deposition process. The atomic layer deposition process comprises a plurality of cycles, where each cycle comprises flowing a first reactant, wherein the first reactant forms a first reactant layer in the pores of the electrolytic oxidation coating, wherein the first reactant layer extends through the thickness of the electrolytic oxidation coating, stopping the flow of the first reactant, flowing a second reactant, wherein the second reactant reacts with the first reactant layer, and stopping the flow of the second reactant.

[0005] In another manifestation, a component adapted for use in a semiconductor processing chamber is provided. An electrolytic oxidation coating is on a surface of a component body, wherein the electrolytic oxidation coating has a plurality of pores, wherein the electrolytic oxidation coating has a thickness and at least some of the plurality of pores extend through the thickness of the electrolytic oxidation coating. An atomic layer deposition fills the plurality of pores of the electrolytic oxidation coating.

[0006] In another manifestation, a method for coating a component of a plasma processing chamber is provided. A ceramic coating is formed over a surface of the component, wherein the ceramic coating has a plurality of pores, wherein the ceramic coating has a thickness and at least some of the plurality of pores extend through the thickness of the ceramic coating. An atomic layer deposition is deposited on the ceramic coating using an atomic layer deposition process, wherein the atomic layer deposition process comprises a plurality of cycles, wherein each cycle comprises flowing a first reactant gas, wherein the first reactant gas forms a first reactant layer in the pores of the ceramic coating, wherein the first reactant layer extends through the thickness of the ceramic coating, stopping the flow of the first reactant gas, flowing a second reactant gas, wherein the second reactant gas reacts with the first reactant layer, and stopping the flow of the second reactant gas. Some of the atomic layer deposition is polished away.

[0007] In another manifestation, a component adapted for use in a semiconductor processing chamber is provided. A ceramic coating is over a surface of a component body, wherein the ceramic coating has a plurality of pores, wherein the ceramic coating has a thickness and at least some of the plurality of pores extend through the thickness of the ceramic coating. An atomic layer deposition fills the plurality of pores of the ceramic coating. A surface of the atomic layer deposition is polished.

[0008] In another manifestation, a method for coating a component of a plasma processing chamber is provided. An electrolytic oxidation coating is formed over a surface of the component. A spray coating is deposited over the electrolytic oxidation coating.

[0009] In another manifestation, a component adapted for use in a semiconductor processing chamber is provided. An electrolytic oxidation coating is over a surface of a component body. A spray coating is over the electrolytic oxidation coating.

[0010] These and other features of the present disclosure will be described in more detail below in the detailed description and in conjunction with the following figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] 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:

[0012] FIG. **1** is a high level flow chart of an embodiment.

[0013] FIGS. **2**A-C are schematic views of a component processed according to an embodiment.

[0014] FIG. **3** is a schematic view of an etch reactor that may be used in an embodiment.

[0015] FIG. **4** is a high level flow chart of another embodiment.

[0016] FIGS. **5**A-C are schematic views of a component processed according to an embodiment.

[0017] FIG. **6** is a high level flow chart of another embodiment.

[0018] FIGS. **7**A-B are schematic views of a component processed according to an embodiment.

DETAILED DESCRIPTION

[0019] The present disclosure will now be described in detail with reference to a few 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.

[0020] To facilitate understanding, FIG. **1** is a high level flow chart of a process used in an embodiment. In an example of an embodiment, an electrolytic oxidation coating is formed on a surface of a component (step **104**). Electrolytic oxidation is also known as plasma electrolytic oxidation (PEO) and electrolytic plasma oxidation (EPO) or microarc oxidation (MAO). Electrolytic oxidation is a method of generating oxide coatings on metals. Electrolytic oxidation uses AC voltage of higher potential than anodization to create a discharge and in the case of PEO/EPO plasma discharge that provides an electrolytic oxidation coating of a crystalline metal oxide layer with interconnected and surface-connected pores that extend through the thickness of the electrolytic oxidation coating.

[0021] FIG. **2**A is a schematic cross-sectional view of a component body **204** with an electrolytic oxidation coating **208**. The electrolytic oxidation coating **208** has a plurality of pores **212**, where some of the pores **212** create openings. The openings extend through the thickness of the electrolytic oxidation coating **208** to the surface of the component body **204**. The pores **212** are not drawn to scale but are shown with an enlarged width in order to better illustrate the working of this embodiment. In addition, the pores **212** may be much more irregular and serpentine. The schematic illustration is to facilitate a better understanding of the working of the embodiment. In this embodiment, the component body **204** is made of aluminum. In other embodiments, the component body **204** is made of an anodized aluminum or ceramic body. In this embodiment, the electrolytic oxidation coating **208** comprises alumina. In other embodiments, the electrolytic oxidation coating **208** comprises oxides or fluorinated oxides of at least one of aluminum, titanium, or magnesium.

[0022] If the component body **204** is a ceramic and/or is not solely metal, a metal layer may be deposited on the surface of the component body **204**. The metal layer may be deposited by physical vapor deposition, electrochemical deposition from a solution containing metal ions, or by 3D printing of metal directly on the surface of the component body **204**. The electrolytic oxidation would be performed on the deposited metal layer.

[0023] In the plasma electrolytic process for an aluminum component body **204**, a high voltage of at least 200 volts is applied. The high voltage exceeds the dielectric breakdown potential of an aluminum oxide film creating a discharge and a localized plasma. The high bias, discharge, and plasma create a localized high temperature. These conditions may result in sintering, melting, and densification of the resulting metal oxide. In an embodiment, the thickness of the electrolytic oxidation coating **208** is greater than 25 μm.

[0024] A surface treatment is provided to the electrolytic oxidation coating **208** (step **106**). In this example, the surface treatment is provided by exposing the electrolytic oxidation coating **208** to a flow of ozone at a temperature in the range from 150° to 320° C. This surface treatment provides a certain level of cleaning and prepares the surface for the subsequent ALD process. It is important that the surface be free of hydrocarbons, water or other contaminants and has activated oxygen radicals to absorb reactants with a metal precursor. In an alternative embodiment, a surface treatment is provided at a high temperature with a plurality of purge cycles of an inert gas to burn off hydrocarbons and eliminate water from the surfaces.

[0025] An atomic layer deposition (ALD) process is then provided (step **108**). The atomic layer deposition process (step **108**) comprises a plurality of cycles. In this example, each cycle comprises providing a first reactant (step **112**), purging the first reactant (step **114**), providing a second reactant (step **116**), and purging the second reactant (step **118**). In this embodiment, the component body **204** is maintained at a temperature of between about 150° to 320° C. for deposition of an aluminum oxide (Al_2O_3) ALD film to cover the surface of the pores **212** in the electrolytic oxidation coating **208**.

[0026] In this embodiment, the providing the first reactant (step **112**) comprises providing a flow of 500 to 200 sccm of trimethylaluminum ($Al_2(CH_3)_6$). The amount of trimethylaluminum varies with reactor size and the number of components **204** placed simultaneously in the reactor. The first reactant forms a first reactant layer, an aluminum containing layer, on the surfaces of the electrolytic oxidation coating **208** including surfaces of the pores **212**. The flow of the first reactant is stopped after 10-30 seconds. 10-30 seconds is usually sufficient to form a monolayer of absorbed aluminum (Al) and methyl radicals (CH_3) on the surface of the component body **204**.

[0027] The purging the first reactant (step **114**) comprises flowing nitrogen. The flow of nitrogen displaces remaining first reactant in the reactor.

[0028] In this embodiment, the providing the second reactant (step **116**) comprises providing a flow of water vapor. The water vapor reacts with the first reactant layer by hydrolyzing the aluminum in the first reactant layer. The flow of the second reactant is stopped after 10-30 seconds.

[0029] The purging the second reactant (step **118**) comprises flowing nitrogen. The flow of the nitrogen displaces remaining second reactant in the reactor.

[0030] Each of the first and second reactants absorbs and reacts on the component body **204** surface in what is defined as a half-cycle. The absorption is limited to one atomic layer. These two reactants build up a thin layer of an ALD film e.g. Al_2O_3, about 1 Å thick. The process is repeated until the desired film thickness is achieved. FIG. **2**B is a schematic cross-sectional view of a component body **204** with the electrolytic oxidation coating **208** over a surface of the component body **204** after a plurality of cycles of the atomic layer deposition process (step **108**). An atomic layer deposition **216** has been deposited. In this example, after a plurality of cycles, the ALD **216** is only able to partially fill the two pores **212***a*, **212***b* due to their width. A third pore **212***c* is thinner and is completely filled by the ALD **216**. The ALD **216** extends through the thickness of the electrolytic oxidation coating **208** to the component body **204**. The ALD **216** covers exposed parts of the component body **204** so that the surface of the component body **204** is not exposed. The ALD process is continued and repeated until all of the pores **212** are completely filled (step **108**). FIG. **2**C is a schematic cross-sectional view of the component body **204** with the electrolytic oxidation coating **208** after the pores **212** have been completely filled by the ALD **216**.

[0031] The component body **204** is mounted in a plasma processing chamber (step **120**). The plasma processing chamber is used to process a substrate (step **124**). A plasma is created within the chamber to process the substrate. Such processing may be etching the substrate. The processing the substrate (step **124**) exposes the component body **204** to the plasma.

[0032] FIG. **3** is a schematic view of a plasma processing chamber **300** with the mounted component body **204**. The plasma processing chamber **300** comprises confinement rings **302**, an upper electrode **304**, a lower electrode **308**, a gas source **310**, a liner **362**, and an exhaust pump **320**. In this example, the component body **204** is the liner **362**. Within plasma processing chamber **300**, a wafer **366** is positioned upon the lower electrode **308**. An edge ring **312** surrounds the wafer **366**. The lower electrode **308** incorporates a suitable substrate chucking mechanism (e.g., electrostatic, mechanical clamping, or the like) for holding the wafer **366**. The reactor top **328** incorporates the upper electrode **304** disposed immediately opposite the lower electrode **308**. The upper electrode **304**, lower electrode **308**, and confinement rings **302** define the confined plasma volume **340**.

[0033] Gas is supplied to the confined plasma volume **340** through a gas inlet **343** by the gas source **310**. The gas is exhausted from the confined plasma volume **340** through the confinement rings **302** and an exhaust port by the exhaust pump **320**. A radio frequency (RF) power source **348** is electrically connected to the lower electrode **308**.

[0034] Chamber walls **352** surround the component body **204**, confinement rings **302**, the upper electrode **304**, and the lower electrode **308**. The component body **204** helps prevent gas or plasma that passes through the confinement rings **302** from contacting the chamber walls **352**. A controller **335** is controllably connected to the RF power source **348**, exhaust pump **320**, and the gas source **310**. The plasma processing chamber **300** may be a CCP (capacitively coupled plasma) reactor or an ICP (inductively coupled plasma) reactor. Other sources like a surface wave, microwave, or electron cyclotron resonance (ECR) may be used.

[0035] Next generations of dielectric memory tools operate at higher RF powers than prior tools. Such next-generation dielectric memory tools have shown arcing failures between the electrostatic chuck (ESC) base plate used for the lower electrode **308** and various edge hardware on the chamber, such as edge rings **312**, ground rings and coupling rings. The arcing failures account for >50% of all failures on next-generation tools. To prevent such failures the stand-off voltage of the base plate or other parts must be increased.

[0036] Without being bound by theory, it is believed that during plasma processing, chemical adsorbates within the pores **212** of the electrolytic oxidation coating **208** provide a conductive pathway. The conductive pathway can facilitate arcing. Filling the pores **212** with an atomic layer deposition **216** prevents such arcing, leading to improvement in breakdown performance. The ALD material should be non-conducting with a high-resistivity. In addition, the filling to pores **212** with an atomic layer deposition **216** closes the pores **212** to prevent permeation, thus preventing radicals of the plasma from reaching the component body **204**.

[0037] The resulting electrolytic oxidation coating **208** is resistant to chemical degradation and arcing. In some embodiments, the ALD process (step **108**) increases the ability of the electrolytic oxidation coating **208** to withstand arcing by up to 200% on a per unit thickness basis. Experimental data has found that an electrolytic oxidation coating **208** deposited using PEO to a thickness of 50 μm has a standoff voltage of about 1.7 kV (kilovolts) without an ALD **216**. The same electrolytic oxidation coating **208** has a standoff voltage of about 3.0-4.0 kV after an ALD **216** has been added. Therefore, the addition of the ALD **216** increases dielectric strength by about two times. As a result, the plasma processing chamber **300** with such components **204** will have fewer defects. In addition, the failure rates of such systems decrease, increasing the time between the replacements of components **204**.

[0038] In various embodiments, the ALD process (step **108**) may be used to form a dielectric atomic layer deposition **216** of a metal containing material such as ceria, zirconia, lanthanum oxide, yttria (Y_2O_3), alumina (Al_2O_3), aluminum nitride (AlN), aluminum carbide (Al_2C_3), or yttrium iodide (Y_2I_3). In some embodiments, a mixture of these film compositions can be utilized e.g. Y_2O_3 can be interlaid with Al_2O_3 to enhance the fluorine corrosion resistance of the electrolytic oxidation coating **208** in a plasma processing chamber **300**. Y_2O_3 is created by using an yttrium precursor e.g. yttrium cyclomethapentadiane3 with water vapor. In various embodiments, the dielectric layers of a metal containing material are a metal oxide, metal nitride, metal carbide, or metal iodide. In other embodiments, fluorinated versions of the above materials, such as AlF_3, AlOF, yttrium fluoride (YF_3), or yttrium oxyfluoride (YOF) can be created. In some embodiments, a first reactant may be trimethylaluminum and the second reactant is water vapor. In various embodiments, the ALD process (step **108**) may provide alternating layers of different materials. For example, alternating layers of alumina and yttria may be provided in an embodiment. In various embodiments, the first purge (step **114**) and/or the second purge (step **118**) may not be used.

[0039] The electrolytic oxidation coating **208** may have a density of less than **98**%, so that the pores **212** make up more than 2% of the electrolytic oxidation coating **208**, by volume, providing a porosity of greater than 2%. Preferably, the electrolytic oxidation coating **208** has a thickness of at least 25 μm and less than 500 μm. In another exemplary embodiment, the thickness is between 50 μm and 400 μm. In another exemplary embodiment, the electrolytic oxidation coating **208** has a thickness of at least 200 μm. In another exemplary embodiment, the electrolytic oxidation coating **208** has a thickness of at least 300 μm. For an electrolytic oxidation coating **208** formed by PEO, the porosity may be greater than 20%.

[0040] In various embodiments, the component body **204** may be other parts of a plasma processing chamber, such as confinement rings, edge rings **312**, the electrostatic chuck, ground rings, chamber liners, door liners, or other components **204**. The plasma processing chamber **300** may be a dielectric processing chamber or conductor processing chamber. In some embodiments, one or more, but not all surfaces are coated. Various embodiments provide electrolytic oxidation coatings **208** that allow flat surfaces, cornered radii, high aspect ratio holes, and helium channels. In some embodiments, the component body **204** may be a part made of aluminum. In other embodiments, the component body **204** may be an aluminum part with a surface coating. The surface coating may reduce the thermal mismatch between the aluminum and the electrolytic oxidation coating **208**.

[0041] Additional processing may be performed on the component body **204** before the component body **204** is mounted in a plasma processing chamber **300** (step **120**) or used in a plasma processing chamber **300** (step **124**). For example, a second coating may be sprayed over the electrolytic oxidation coating **208**. The second coating may have pores. However, since the electrolytic oxidation coating **208**

between the second coating and the component body **204** has pores **212** filled with the ALD **216**, arcing and chemical degradation is prevented.

[0042] In an embodiment, the component body **204** is aluminum and the electrolytic oxidation coating **208** is formed by providing an electrolytic oxidation coating **208** between 0.0005 (0.00127 mm) inches to 0.005 (0.0127 mm) inches thick. In another embodiment, an electrolytic oxidation coating **208** has a thickness of between 0.001 (0.0254 mm) inches to 0.040 inches (1.016 mm). In various embodiments, the pores **212** have a width of less than 1 micron. In some embodiments, using an aluminum containing reactant for atomic layer deposition, a gas transport of greater than 1000:1 is provided at a temperature greater than 300° C. This means that a ratio of the distance that the gas is able to travel through a pore **212** to the width of the pore **212** is greater than 1000:1.

[0043] In various embodiments, the first reactant may be an organic molecule attached to a metal-ligand at an end of the organic molecule and second reactants may be an oxidizing agent, such as water vapor or ozone. The organic molecule is reactive at a temperature below the melting point of the material that forms the component body **204**. For example, the organic molecule decomposes or is absorbed at a temperature below 50° C.

[0044] Various embodiments provide a smooth surface. The resulting surface may be machined. An ALD process is a very slow process but provides a high-quality layer. Various embodiments are able to provide a layer faster than using only a pure ALD process, by using a faster method of forming an electrolytic oxidation coating **208** that is more porous or lower quality than a coating formed by only a pure ALD process. The pores **212** are filled and quality is improved using the ALD process (step **108**). As a result, a layer is deposited faster than using only a pure ALD process, with a porosity close to a layer formed by using only a pure ALD process. Since the pores **212** are filled with materials with similar or the same properties as the electrolytic oxidation coating **208**, there is no thermal expansion mismatch between the electrolytic oxidation coating **208** and the material filling the pores **212** deposited by the ALD process (step **108**). The electrolytic oxidation coating **208** and ALD **216** form a protective layer that does not have polymers. Polymers more easily degrade in plasma. The resulting layer is more corrosion resistant. In various embodiments, when the pores **212** are filled with the ALD **216**, the ALD **216** extends through the thickness of the electrolytic oxidation coating **208**, so that the component body **204** is not exposed. In various embodiments, the ALD **216** caps the pores **212** so that the component body **204** is not exposed.

[0045] In an exemplary embodiment, the ALD **216** fills the pores **212** with minimal pockets. In such an embodiment, the component body **204** is not exposed. In other embodiments, the ALD **216** may have pockets. In such embodiments, the ALD **216** extends to and covers the component body **204**, so that the component body **204** is not exposed.

[0046] In the above example and other embodiments, the ALD process (step **108**) is a plasmaless process. In other embodiments, the ALD process (step **108**) uses ozone instead of water vapor. Various embodiments may be performed without a surface treatment step (step **106**).

[0047] To facilitate understanding, FIG. **4** is a high level flow chart of a process used in another embodiment. In an example of an embodiment, a ceramic coating is formed on a surface of a component (step **404**). In this example, the ceramic coating is deposited (step **404**) using plasma spraying. FIG. **5**A is a schematic cross-sectional view of a component body **504** with a ceramic coating **508**. The ceramic coating **508** has been plasma sprayed on a surface of the component body **504**. The ceramic coating **508** has a plurality of pores **512**, where some of the pores **512** create openings. The openings extend through the thickness of the ceramic coating **508** to the surface of the component body **504**. The pores **512** are not drawn to scale but are shown with an enlarged width in order to better illustrate the working of this embodiment. In addition, the pores **512** may be much more irregular and serpentine. The schematic illustration is to facilitate a better understanding of the working of the embodiment. In this embodiment, the component body **504** is made of anodized aluminum. In other embodiments, the component body **504** is made of an aluminum or ceramic body. In this embodiment, the ceramic coating **508** comprises alumina. In other embodiments, the ceramic coating **508** comprises at least one of alumina, yttrium oxide (yttria), aluminum carbide, yttrium iodide ceria, zirconia, fluorinated yttria, aluminum nitride, or lanthanum oxide. In various embodiments, the ceramic coating **508** is applied by one or more of plasma electrolytic oxidation (PEO), anodization, or ceramic spraying.

[0048] Plasma spraying is a type of thermal spraying. For plasma spraying, 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, liquefying high melting point materials such as ceramics. Particles of the desired material are injected into the jet. The particles are melted and accelerated towards the substrate so that the molten or plasticized material coats the surface of the component body **504**. The material cools, forming a solid, conformal ceramic coating **508**. Plasma spraying processes are distinct from vapor deposition processes. Vapor deposition processes use vaporized material instead of spraying molten material used by plasma spraying processes.

[0049] In this embodiment, the thickness of the ceramic coating **508** is greater than 25 μm. In an example of a recipe for plasma spraying the ceramic coating **508**, 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. The cathode and anode 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 then pushed out through the nozzle forming the torch. Into the chamber, near the nozzle, are injected fluidized ceramic particles, tens of micrometers in size. These particles are heated by the hot, ionized gas in the plasma torch to a temperature that exceeds the melting temperature of the ceramic. The jet of plasma and melted ceramic is then aimed at the component body **504**. The particles impact the component body **504**, flattening and cooling to form the ceramic coating **508**.

[0050] A surface treatment is provided to the ceramic coating **508** (step **406**). In this example, the surface treatment is provided by exposing the ceramic coating **508** to a flow of ozone at a temperature in the range from 150° to 320° C. This surface treatment provides a certain level of cleaning and prepares the surface for the subsequent ALD process. It is important that the surface be free of hydrocarbons or other contaminants and has activated oxygen radicals to absorb the first reactant with a metal precursor.

[0051] An atomic layer deposition (ALD) process is then provided (step **408**). The atomic layer deposition process (step **408**) comprises a plurality of cycles. In this example, each cycle comprises providing a first reactant (step **412**), purging the first reactant (step **414**), providing a second reactant (step **416**), and purging the second reactant (step **418**). In this embodiment, the component body **504** is maintained at a temperature of between about 150° to 320° C. for deposition of an aluminum oxide (Al_2O_3) ALD film to cover the surface of the pores **512** in the ceramic coating **508**. In this embodiment, the providing the first reactant (step **412**) comprises providing a flow of 500 to 200 sccm of trimethylaluminum ($Al_2(CH_3)_6$). The amount of trimethylaluminum varies with reactor size and number of component bodies **504** placed simultaneously in the reactor. The first reactant forms a first reactant layer, an aluminum containing layer, on the surfaces of the ceramic coating **508** including surfaces of the pores **512**. The flow of the first reactant is stopped after 10-30seconds. 10-30 seconds is usually sufficient to form a monolayer of absorbed aluminum (Al) and methyl radicals (CH_3) on the component body **504** surface.

[0052] The purging the first reactant (step **414**) comprises flowing nitrogen. In this embodiment, the providing the second reactant (step **416**) comprises providing a flow of water vapor. The water vapor reacts with the first reactant layer by hydrolyzing the aluminum in the first reactant layer. The flow of the second reactant is stopped after 10-30 seconds. The purging the second reactant (step **418**) comprises flowing nitrogen. Each of these reactants absorbs and reacts on the component body **504** surface in what is defined as a half-cycle. The absorption is limited to one atomic layer. These two reactants build up a thin layer of an ALD film e.g. for Al_2O_3 about 1 Å thick. The ALD process is continued until all of the pores **512** are completely filled (step **408**). FIG. **5**B is a schematic cross-sectional view of the component body **504** with the ceramic coating **508** after the pores **512** have been completely filled by the ALD **516**.

[0053] The surface is then polished (step **420**). In this example, the polishing process removes parts of the ALD **516** that do not fill the pores **512** and may also polish a surface of the component body **504**, to provide a smooth polished ALD surface.

[0054] The component body **504** is mounted in a plasma processing chamber (step **424**). The plasma processing chamber is used to process a substrate (step **428**). A plasma is created within the chamber to process the wafer **366**. Such processing may be etching a stack on the wafer **366**. The processing the wafer **366** (step **428**) exposes the component body **504** to the plasma.

[0055] In this embodiment, the polishing of the ALD **516** and the component body **504** provides a smoother finished surface. Experiments have found that for plasma spray coatings without an ALD **516** have a dielectric strength of about 20volts/micron. The same coatings have a dielectric strength of about 40 volts/micron and higher after an ALD **516** is added. Therefore, the addition of the ALD **516** increases dielectric strength by about four times.

[0056] FIG. **6** is a high level flow chart of a process used in another embodiment. In an example of an embodiment, an electrolytic oxidation coating is formed on a surface of a component (step **604**). FIG. **7**A is a schematic cross-sectional view of a component body **704** with an electrolytic oxidation coating **708**. The electrolytic oxidation coating **708** has a plurality of pores **712**, where some of the pores **712** create openings. The openings extend through the thickness of the electrolytic oxidation coating **708** to the surface of the component body **704**. The pores **712** are not drawn to scale but are shown with an enlarged width in order to better illustrate the working of this embodiment. In addition, the pores **712** may be much more irregular and serpentine. The schematic illustration is to facilitate a better understanding of the working of the embodiment. In this embodiment, the component body **704** is made of aluminum. In this embodiment, the electrolytic oxidation coating **708** comprises oxides or fluorinated oxides of at least one of aluminum, titanium, or magnesium.

[0057] A spray coat is deposited over the electrolytic oxidation coating **708** (step **612**). FIG. **7**B is a schematic cross-sectional view of a component body **704** with an electrolytic oxidation coating **708** after a spray coating **716** has been deposited on the electrolytic oxidation coating **708**. The spray coating **716** may partially fill the pores **712** in the electrolytic oxidation coating **708**. The spray coating **716** covers the pores **712** in the electrolytic oxidation coating **708**. The spray coating **716** has pores **720**. Generally, the pores **720** in the spray coating **716** do not align with the pores **712** in the electrolytic oxidation coating **708**. However, some of the pores **720** in the spray coating **716** may align with some of the pores **712** in the electrolytic oxidation coating **708**. Plasma spray coatings must be dense, to protect the substrate, and thick in order to get high dielectric breakdown voltage. Such a combination is prone to cracking during thermal cycling. If, instead, plasma spray coating is applied over PEO, where the PEO is much more stable during thermal cycling, a less dense spray coat can be applied over it to achieve higher cumulative breakdown voltage. The resulting coating would be less prone to cracking.

[0058] While this disclosure has been described in terms of several 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.

What is claimed is:

1. A method for coating a component of a plasma processing chamber, comprising:

forming an electrolytic oxidation coating over a surface of the component, wherein the electrolytic oxidation coating has a plurality of pores, wherein the electrolytic oxidation coating has a thickness and at least some of the plurality of pores extend through the thickness of the electrolytic oxidation coating; and

depositing an atomic layer deposition on the electrolytic oxidation coating using an atomic layer deposition process, wherein the atomic layer deposition process comprises a plurality of cycles, wherein each cycle comprises:

flowing a first reactant, wherein the first reactant forms a first reactant layer in the pores of the electrolytic oxidation coating, wherein the first reactant layer extends through the thickness of the electrolytic oxidation coating;

stopping the flow of the first reactant;

flowing a second reactant, wherein the second reactant reacts with the first reactant layer; and

stopping the flow of the second reactant.

2. The method, as recited in claim **1**, wherein the electrolytic oxidation coating comprises oxides or fluorinated oxides of at least one of aluminum, titanium, or magnesium.

3. The method, as recited in claim **1**, wherein the component comprises at least one of aluminum, anodized aluminum, or ceramic.

4. The method, as recited in claim **1**, wherein the electrolytic oxidation coating is thicker than 25 μm.

5. The method, as recited in claim **1**, wherein a porosity of the electrolytic oxidation coating is greater than 2%.

6. The method, as recited in claim **1**, wherein the atomic layer deposition includes at least one of ceria, zirconia, lanthanum oxide, yttria, alumina, aluminum nitride, aluminum carbide, or yttrium iodide.

7. The method, as recited in claim **1**, wherein the atomic layer deposition includes alumina.

8. The method, as recited in claim **7**, wherein the first reactant comprises trimethylaluminum and the second reactant comprises water vapor or ozone.

9. The method, as recited in claim **1**, wherein the depositing an atomic layer deposition on the electrolytic oxidation coating is a plasmaless process.

10. The method, as recited in claim **1**, further comprising providing a surface treatment after forming the electrolytic oxidation coating and before depositing the atomic layer deposition.

11. The method, as recited in claim **10**, wherein the providing a surface treatment comprises exposing the electrolytic oxidation coating to a flow of ozone or purging with heat and an inert gas.

12. The method, as recited in claim **1**, wherein the atomic layer deposition includes alternating layers of at least two of alumina, yttria, ceria, zirconia, or lanthanum oxide.

13. The method, as recited in claim **1**, wherein each cycle of the atomic layer deposition process deposits a monolayer.

14. The method, as recited in claim **1**, wherein the first reactant comprises an organic molecule with a metal ligand.

15. The method, as recited in claim **14**, wherein the second reactant comprises water vapor or ozone.

16. The method, as recited in claim **1**, wherein the component includes an electrostatic chuck.

17. The method, as recited in claim **1**, further comprising polishing the atomic layer deposition.

18. A method for coating a component of a plasma processing chamber, comprising:

forming a ceramic coating over a surface of the component, wherein the ceramic coating has a plurality of pores, wherein the ceramic coating has a thickness and at least some of the plurality of pores extend through the thickness of the ceramic coating;

depositing an atomic layer deposition on the ceramic coating using an atomic layer deposition process, wherein the atomic layer deposition process comprises a plurality of cycles, wherein each cycle comprises:

flowing a first reactant gas, wherein the first reactant gas forms a first reactant layer in the pores of the ceramic coating, wherein the first reactant layer extends through the thickness of the ceramic coating;

stopping the flow of the first reactant gas;

flowing a second reactant gas, wherein the second reactant gas reacts with the first reactant layer; and

stopping the flow of the second reactant gas; and

polishing away some of the atomic layer deposition.

19. The method, as recited in claim **18**, wherein the ceramic comprises at least one of yttria, ceria, zirconia, fluorinated yttria, aluminum nitride, alumina, or lanthanum oxide.

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