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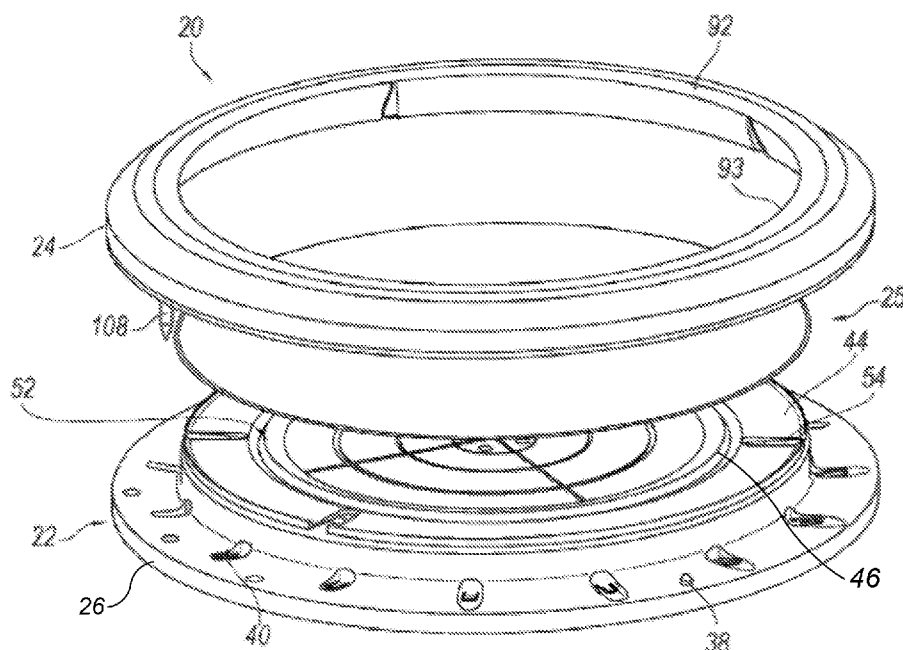


FIG. 3

(57) Abstract: Methods of cleaning an electroplating device may include processing a substrate coupled with the electroplating device. The substrate may be coupled with a substrate holder of the electroplating device. The substrate holder may include an annular component disposed about the substrate. A surface of the annular component may be exposed to an electroplating solution with the substrate. The processing may form a metal-containing material on the annular component. The methods may include removing the substrate from the substrate holder of the electroplating device. The methods may also include exposing the annular component of the substrate holder of the electroplating device to UV light. The UV light may be configured to modify the metal-containing material.



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METHODS OF INHIBITING METAL DEPOSITION

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] The application claims benefit of priority to U.S. Provisional Patent Application No. 62/524,187, filed June 23, 2017, the entire contents of which are hereby incorporated by reference in their entirety for all purposes.

TECHNICAL FIELD

[0002] The present technology relates to inhibiting metal deposition on semiconductor processing equipment. More specifically, the present technology relates to inhibiting deposition on substrate holders and removing metal-containing materials therefrom.

BACKGROUND

[0003] Semiconductor devices are generally formed by producing intricate structures on a substrate or workpiece. Fabrication often includes formation of conductive lines or metallization that deposits or forms metal-containing materials in trenches and vias through the device to provide conductive pathways between layers and structures.

[0004] The metal layers are often formed on the substrates with electrochemical plating in an electroplating processor. A typical electroplating processor includes a vessel or bowl for holding an electroplating solution, one or more anodes in the bowl in contact the electroplating solution, and a head having a contact ring with multiple electrical contacts that touch the wafer. A seal member may also be included about the head to maintain the bath solution away from the contacts. The front surface of the wafer may be immersed in the electroplating solution and an electrical field may cause metal ions in the electroplating solution to plate out onto the wafer, forming a metal-containing layer.

[0005] Because of leakage current or particular coupling allowing current to pass through the substrate holder, the deposition process may form an amount of metal-containing material on portions of the substrate holder. When a seal member is utilized, the additional formation may be limited to this section of the substrate holder. The seal must be periodically cleaned to work effectively and avoid thieving deposition material from the substrate by causing

formation to occur on the substrate holder instead of the substrate. In some cases, this lipseal plating may cause failure of the seal between the seal and the substrate.

[0006] Thus, there is a need for improved systems and methods that can be used to produce high quality devices and structures. These and other needs are addressed by the present technology.

SUMMARY

[0007] Systems and methods of cleaning an electroplating device may include exposing at least a portion of a substrate holder of the electroplating device to UV light. The UV light may be configured to adjust metal-containing material on the substrate holder from a first oxidation state to a second oxidation state.

[0008] In some embodiments, the methods may also include processing a substrate coupled with the substrate holder prior to the exposure. The processing may cause the metal-containing material to form on at least a portion of the substrate holder. The methods may also include removing the substrate from the substrate holder prior to the exposure. The processing may include forming the metal-containing material on the substrate by an electrochemical deposition process. The metal-containing material may be or include tin. The first oxidation state may be +2, and the second oxidation state may be +4. Exposing at least a portion of the substrate holder may be performed in an oxygen-containing environment, and the oxygen-containing environment may be an ambient environment in which the plating was performed, or ambient conditions of the processing room or facility. The tin may be oxidized to tin(IV) oxide. The UV light may operate at a wavelength below or about 300 nm. The exposure to UV light may occur for at least about 10 seconds at each discrete segment of the at least a portion of the substrate holder.

[0009] The present technology may also include additional methods of cleaning an electroplating device, and may include processing a substrate coupled with the electroplating device. The substrate may be coupled with a substrate holder of the electroplating device. The substrate holder may include an annular component disposed about the substrate. A surface of the annular component may be exposed to an electroplating solution with the substrate. The processing may form a metal-containing material on the annular component. The methods may include removing the substrate from the substrate holder of the electroplating device. The methods may also include exposing the annular component of the

substrate holder of the electroplating device to UV light. The UV light may be configured to modify the metal-containing material.

[0010] In some embodiments, the metal-containing material may be or include tin. The tin may be modified by the UV light to form tin(IV) oxide. The tin may be modified in ambient conditions. The methods may further include rotating the annular component during the exposure to the UV light. Each segment of the annular component may be exposed to the UV light for at least about 5 seconds. The UV light may operate at a wavelength below or about 300 nm.

[0011] The present technology may also include methods of cleaning an electroplating device. The methods may include processing a substrate coupled with the electroplating device. The substrate may be coupled with a substrate holder of the electroplating device. The substrate holder may include an annular component disposed about the substrate. A surface of the annular component may be exposed to an electroplating solution with the substrate. The processing may form a metal-containing material on the annular component. The methods may also include removing the substrate from the substrate holder of the electroplating device. The methods may include rotating the annular component. While rotating the annular component, the methods may also include exposing the annular component of the substrate holder of the electroplating device to a fixed UV light source producing UV light. The UV light may be configured to modify the metal-containing material. In some embodiments exposing the annular component may be performed in an oxygen-containing environment. The metal-containing material may be or include tin, and the tin may be modified by the UV light to form tin(IV) oxide.

[0012] Such technology may provide numerous benefits over conventional technology. For example, the present devices may reduce deposition on a workpiece holder. Additionally, the improved methodology may reduce queue times by providing improved ways of removing contaminants on the workpiece holder. These and other embodiments, along with many of their advantages and features, are described in more detail in conjunction with the below description and attached figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A further understanding of the nature and advantages of the disclosed embodiments may be realized by reference to the remaining portions of the specification and the drawings.

[0014] FIG. 1 shows a schematic view of an exemplary processing system according to embodiments of the present technology.

[0015] FIG. 2 shows a schematic bottom perspective view of an exemplary substrate holder according to embodiments of the present technology.

5 [0016] FIG. 3 shows a schematic bottom exploded view of components of an exemplary substrate holder according to embodiments of the present technology.

[0017] FIG. 4 shows exemplary operations of a method of cleaning an electroplating device according to embodiments of the present technology.

10 [0018] Several of the figures are included as schematics. It is to be understood that the figures are for illustrative purposes, and are not to be considered of scale unless specifically stated to be of scale. Additionally, as schematics, the figures are provided to aid comprehension and may not include all aspects or information compared to realistic representations, and may include exaggerated material for illustrative purposes.

15 [0019] In the figures, similar components and/or features may have the same numerical reference label. Further, various components of the same type may be distinguished by following the reference label by a letter that distinguishes among the similar components and/or features. If only the first numerical reference label is used in the specification, the description is applicable to any one of the similar components and/or features having the same first numerical reference label irrespective of the letter suffix.

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DETAILED DESCRIPTION

[0020] Electroplating processes may be used to form conductive materials along and through various features of a semiconductor substrate. One type of plating operation forms tin materials and alloys of tin, such as tin-silver alloys, on the substrate. The plating bath
25 may include a number of metal ions that are electrically activated by the electroplating device to form or deposit on the substrate. However, a common issue in this formation is that formation may also occur on the substrate holder of the electroplating device that is also exposed to the electroplating bath. This formation may cause a number of issues as metal that was intended to be formed on the substrate may form on the holder instead. This may
30 lead to voids or incomplete coating of the metal-containing material on the substrate regions adjacent the exposed portions of the substrate holder, such as along the outer edges. This

micro-loading effect may cause insufficient material on the substrate, which may limit attachment to a circuit board or other structures.

[0021] As processing continues from substrate to substrate, this plating on the substrate holder may increase. The increase may not be linear, and thus at a time when the material is visible on the holder, the issue may be extensive enough that die failure occurs from incomplete coverage. The issue may not be susceptible to re-working, and thus portions of the fabricated substrate, or entire devices may be unusable. Additionally, material formed on the substrate holder from a previous substrate may enable increased formation on the holder during subsequent substrate processing. In one potential mechanism of formation, metal ions or oxides may form on the substrate holder. This material may interact with stray electrons from the surface of a substrate, with underlying contacts, or stray current along the holder may access this material, which may cause it to reduce to a metallic state on the surface of the holder.

[0022] Conventional technologies may address this issue by performing cleaning operations on the substrate holder. For example, a cleaning solution may be applied to the substrate holder after a certain number of substrates have been processed, or after analysis determines cleaning may be necessary. However, this cleaning solution may be inadequate. The spray process may not completely remove the metal-containing materials, which may require more frequent cleaning. Additionally, the cleaning solution may remain on the substrate holder subsequent the cleaning, which may contaminate the electroplating solution with subsequent substrate processing. Another cleaning technique includes utilizing a reverse current to deplate the deposited material. This process may require additional time as current must be applied until all metal is removed. The process may also not fully remove the metal as residual material may remain in the surface roughness of the holder, which may not maintain electrical contact during the process. This may again increase queue times from longer and more frequent deplating.

[0023] The present technology overcomes these issues by utilizing UV light to modify the formed material on the substrate holder. The UV light may form a material less likely to remain on the substrate holder, and which may be filtered from the electroplating solution. The process may not utilize cleaning materials that may compromise the bath, and may reduce queue times over conventional techniques. After describing an exemplary processing

system in which the present technology may be used, the description will cover methods of performing cleaning processes according to the present technology.

[0024] FIG. 1 shows a schematic view of an exemplary processing system 100 according to embodiments of the present technology. Processing system 100 may include some of the components which may be used in the cleaning technology discussed throughout the present disclosure. As illustrated, processing system 100 may include a substrate holder 20 used for electroplating a semiconductor substrate or wafer 25. The substrate holder 20 may include an annular member 24 and a backing plate assembly 22. The substrate holder 20 may be moved from a load/unload module to a processor 202 via the robot 200. The substrate holder 20 may be attached to the rotor 206 of the processor 202 via the hub 30 engaging a fitting on the rotor. During processing, an electric current path may be provided from the processor 202, which may be a cathode in the processor, to the wafer 25 with a fitting to internal electrical contacts, a backing plate bus bar, chuck contacts, a ring bus bar, and to the electrical contact fingers that contact the wafer. As will be identified below, the chuck contacts may make an electrical connection between the backing plate assembly 22 and a ring bus bar.

[0025] A processor head 204 of the processor 202 may move the wafer 25 held in the substrate holder 20 into a bath of electrolyte in vessel 210 of the processor 202 and may pass electrical current through the electrolyte to electroplate a metal or conductive film onto the wafer 25. After electroplating has been completed, this sequence of operations may be reversed. Lift pins in the load/unload module may extend up through lift pin clearance holes in the backing plate to allow the robot to pick up the plated wafer, and the plated wafer 25 may be removed from the electroplating system 220 for further processing. The backing plate assembly 22 and the annular member 24 may then be cleaned together or separately, and the annular member 24 may be deplated in cleaning/deplating modules inside or outside of the electroplating system 220, while the processor 202 electroplates a subsequent wafer using another substrate holder 20. As will be explained below, the cleaning process may include exposing the annular member 24 to a UV light source.

[0026] FIG. 2 shows a schematic bottom perspective view of an exemplary substrate holder 20 according to embodiments of the present technology. Additionally, FIG. 3 shows a schematic bottom exploded view of FIG. 2, illustrating components of a substrate holder 20 according to embodiments of the present technology. As shown in the figures, substrate holder 20 may include annular member 24, and backing plate assembly 22, which may be

joined or coupled with one another. The annular member 24 may include a wafer seal 92, which may cover a number of components, which may include electrical contact fingers, a ring bus bar, a seal retainer, a chuck seal, wafer guides, as well as centering pins 108 spaced apart at the perimeter of the annular member 24 and extending below the annular member 24 to engage backing plate assembly 22.

[0027] The wafer seal 92 may provide a barrier to maintain the plating liquid away from the electrical contact fingers. The electrical contact fingers may provide a uniform physical contact onto the wafer 25 for the purpose of uniform electroplating material onto the wafer 25. For plating a 300 mm diameter wafer, the annular member 24 may have, for example, up to 720 electrical contact fingers included in multiple segments, such as 4-8 segments. The electrical contact fingers may be precisely positioned relative to an inner diameter 93 of the wafer seal 92, which may be the portion of the wafer seal 92 that physically contacts the wafer 25. This inner diameter may be sized specific to the substrate being processed, such as up to, about, or greater than 150 mm, 300 mm, 450 mm, 600 mm, or greater. To align the annular member 24 with the rotor 206 of the processor 202, and specifically to align the inner diameter 93 of the wafer seal 92 with the rotor 206, the centering pins 108 on the annular member 24 may pass through clearance holes in the backing plate assembly 22, and engage into alignment holes 208 in the rotor 206 illustrated in FIG. 1. The centering pins 108 may ensure the wafer seal 92 is concentric to a spin axis of the processor 202.

[0028] Backing plate assembly 22 may include a wafer plate 44 supported on a base plate 26. The wafer plate 44 may be supported on and sealed against the base plate 26. Ring location pins 38 on the base plate 26 may ensure correct orientation of the annular member 24 to the backing plate assembly 22. Backing plate assembly 22 may also include chuck contacts 40 for receiving current into the substrate holder 20. As shown in FIG. 3, the wafer plate 44 may have a flange 46 extending radially outward from a wafer extract seal 52. The wafer extract seal 52 may provide a seal to the backside surface of the wafer 25. A vacuum may be applied to a vacuum port and through vacuum channels in the wafer plate 44 from a vacuum source in or connected to the electroplating system 220. As illustrated in FIG. 1, vacuum sensor 205 may measure the pressure in the space between the back side of the wafer 25 and the wafer plate 44. The sensed pressure may be used to confirm the presence of a wafer 25 in the substrate holder 20. Vacuum may also be applied at different operations of the chuck assembly opening sequence to monitor wafer status in the substrate holder 20. Where an initial vacuum measurement P1 exceeds a subsequent measurement P2, which may

be taken after the system control computer 207 indicates the wafer has been lifted up off of the wafer extract seal 52 by a predetermined value, the system control computer 207 may be notified that the wafer 25 was not successfully extracted. If the differential is below a predetermined value, the system control computer 207 may be notified that the wafer 25 was successfully extracted.

[0029] As the substrate holder 20 is closed, the wafer plate 44 may provide engagement force to the backside of the wafer 25 sufficient for the electrical contact fingers and the wafer seal 92 to engage the wafer 25. Backing plate 26 may also include springs 54 which may provide a preloaded force to the backside of wafer 25, to engage the wafer seal 92 and the electrical contact fingers 98. The substrate holder 20 may operate in a processing system as shown, or in any number of other systems. In use, a wafer 25 may be placed onto the wafer plate 44 of the backing plate assembly 22 via a load/unload robot in a wafer load/unload module of the processing system. During loading/unloading, the annular member 24 may be either removed and separated from the backing plate assembly 22, or the annular member 24 may be spaced apart from the backing plate via ring separation pins in the load/unload module extending up through ring separation clearance holes in the perimeter of the backing plate assembly 22.

[0030] After loading, the ring separation pins may be retracted and the annular member 24 may move into engagement with the backing plate via magnetic attraction to provide a closed substrate holder 20 now loaded with a wafer 25 to be electroplated. The electroplating processing system may then orient the wafer, and may be operated to adjust along multiple planes and directions. For example, the processing system may raise and lower the wafer or substrate, and may also tilt and rotate the wafer prior to, during, or subsequent the electroplating operations.

[0031] Turning to **FIG. 4** is shown exemplary operations of a method 400 of cleaning an electroplating device according to embodiments of the present technology. The electroplating process described previously may be performed to provide conductive or metallic materials onto the substrate. The metallic materials may include any metal or metal-containing materials as would be understood to the skilled artisan, and in some embodiments may include a transition metal or a Group 13, Group 14, or Group 15 metal from the periodic table of elements. Exemplary materials, which are not intended to limit the present technology, may include tin or tin-containing materials. For example, tin-silver alloys may

be used in some processes according to the present technology. The tin and silver may be included as ions within the electroplating solution, and may be formed or deposited onto a substrate during an electroplating operation.

[0032] As discussed previously, an issue with certain electroplating processes may include additional plating on annular member 24 previously described. The plating may occur on the substrate holder instead of the substrate being processed, which may reduce the uniformity of deposition on the substrate and adversely affect substrate yield. The present technology may utilize a UV light to modify this deposited material in order to overcome the issues with conventional cleaning as previously described.

[0033] As illustrated in FIG. 4, method 400 may include one or more operations, and may include optional operations as indicated by dashed lines. A processing operation, such as an electroplating operation including tin or some other metal may be performed at optional operation 410. The operation may be performed on a substrate coupled with an electroplating device such as previously described, where the substrate may be coupled with a substrate holder, such as substrate holder 20. The processing may form or deposit tin, tin-containing material, or other metal-containing material on the substrate, and may form additional metal-containing material on at least a portion of the substrate holder, such as on annular member 24 previously described. Because a surface of annular member 24 may also be exposed to the electroplating solution under potential along with the substrate, the deposition or metal formation may occur on this component as well. The formation on annular member 24 may be minor compared to the formation on a substrate, and in embodiments, the formation may occur that is not visible without subsequent analysis. The formation on annular member 24 may also be substantial, such as to be immediately viewed, or some level of formation in between.

[0034] Subsequent processing of the substrate, the substrate may be removed from the substrate holder of the electroplating device in optional operation 420. In some embodiments, the substrate holder may be cleaned in optional operation 430. The cleaning may involve a rinse step, and may include wiping down the holder as well. Rinsing and/or wiping the substrate holder may allow excess deposition material to be removed from the holder. An additional drying operation may be performed at optional operation 440. The holder may be dried in order to reduce, limit, or minimize liquid on the surface of the holder prior to a treatment operation. For example, with a UV operation as discussed below, drying

the substrate holder of excess liquid may increase the effectiveness of the UV treatment. Residual fluid on the substrate holder may impede conversion of metal ionic species, and removal may thus enhance the operations performed.

[0035] Additional substrates may be similarly processed in some embodiments, and subsequent removal of each substrate, or after a certain number of substrates have been processed, at least a portion of the substrate holder may be exposed to UV light in operation 450. The exposure to UV light may modify or adjust metal or metal-containing material located on the substrate holder to produce a material that may not provide nucleation sites for subsequent formation of metal material. For example, the UV light may adjust the metal-containing material from a first oxidation state to a second oxidation state, which may produce materials that may be less likely to reduce to a metallic state on the surface of the substrate holder. For example, increasing the oxidation state of residual particles may increase the energy to reduce the material to a metallic state. Accordingly, the current to which excess material on the substrate holder may be exposed may be insufficient to fully reduce the ionic species, metal oxides, or metal hydroxides that may be present subsequent deposition operations. In this way, removal of the residual species from the surface of the substrate holder may be facilitated. Additionally, further thieving of metal from the substrate may be maintained, reduced, or prevented by reducing the amount of metal residue on the substrate holder.

[0036] Without intending to bind the present disclosure to any particular mechanism, a discussion of possible reactions in a tin-containing electrolyte solution may aid comprehension of the present technology. It is to be understood that formation of different metal-containing materials may also proceed by similar processes, or by different processes that may still benefit from the present technology. An electrolyte bath may include tin ions, such as Sn^{+2} . These ions may adsorb to the surface of the substrate holder, such as onto annular member 24, during an electroplating operation. Additionally, compounds including these ions may also adsorb to the surface of the substrate holder, such as tin(II) oxide, or SnO , as well as tin(II) hydroxide, or $\text{Sn}(\text{OH})_2$. An amount of leakage current, or current from the substrate holder or substrate, may reduce these ions or compounds on the substrate holder, and may form metallic tin. Metallic deposition may also be accelerated by the presence of additional metal or metal-containing materials, such as silver, copper, or other metals that may be exposed on the substrate or included within the electroplating solution. These metals

may act as further nucleation sites and catalysts that may attract additional tin ions exacerbating the formation on the substrate holder instead of the substrate.

[0037] When these deposited materials are exposed to UV light, Sn^{+2} and other compounds, such as tin oxide, may be converted to other species, such as Sn^{+4} or other compounds such as tin(IV) oxide, or SnO_2 , or tin(IV) hydroxide, or $\text{Sn}(\text{OH})_4$. Tin(IV) oxide, or tin dioxide, as well as tin(IV) hydroxide, may be more stable in solution than tin(II) oxide, and may be less likely to reduce on exposure to stray current sources. By limiting or preventing the conversion to metallic tin, the material may then be cleaned from the holder without further affecting deposition on the substrate by creating nucleation sites as previously discussed. By oxidizing the tin from an oxidation state of +2 to an oxidation state of +4, the formation of subsequent plating on the substrate holder may be reduced or limited.

[0038] As previously explained, the formation of metal or metal-containing material on the substrate holder may occur initially as a small number of ions, which may not be initially visible on the substrate holder or annular member. If this material is not removed, it may not expand linearly, and may quickly form metal or metal-containing deposits that affect substrate yield and device quality when exposed to process currents that may cause reduction to a metallic state. Accordingly, exposure to UV light of the annular member or some other portion of the substrate holder on which formation may occur, may be performed after each substrate is processed. In other embodiments, the exposure to UV light may be performed after two substrates have been processed, or after greater than or about 3, 4, 5, 6, 7, 8, 9, 10, or more substrates have been processed in an electrochemical deposition process.

[0039] The exposure to UV light may be performed in an oxygen-containing environment in some embodiments. The oxygen-containing environment may be a process open to ambient conditions, which may be open to untreated air, or an oxygen-containing material may be delivered to the processing system during the UV light exposure to enhance the transition of the metal or metal-containing materials. For example, oxygen, ozone, or some oxygen-containing compound may be flowed towards the annular member in some embodiments, although in some embodiments the amount of oxygen in air at ambient conditions may be sufficient.

[0040] An additional cleaning operation may be performed at optional operation 460 in which the annular member or portion of the substrate holder may be further cleaned. For example, a contact cleaning operation may be performed in which residual material on the

substrate holder may be wiped or scrubbed. Although conventional cleaning solutions may be utilized, in some embodiments the additional cleaning operation may be performed with a sponge, cloth, or cleaning pad that includes water or an aqueous solution. Unlike some conventional cleaners that may affect the bath, the present technology may use a pad wet with water to remove residual particles. Additionally, the additional cleaning operation may be performed more quickly than conventional cleaning techniques. Because the exposure to UV light may modify all residual material, such as from tin(II) to tin (IV) compounds, particles or materials that are not fully removed in an additional cleaning operation may not pose issues similar to residual materials that have not been treated with UV exposure, which may be more easily reduced to a metallic state.

[0041] For example, cleaning operations in conventional technologies may not fully remove the metal-containing materials, which may exacerbate further formation on the substrate holder as previously discussed. Accordingly, more thorough and more frequent cleaning with more reactive materials may be needed. In the present technology, by converting the metal-containing material with UV light, should the additional cleaning operation not fully remove particulates from the substrate holder, these materials may simply desorb into the electrolyte bath for filtration. For example, when tin or tin(II) oxide is oxidized to tin(IV) oxide, the tin(IV) oxide may be less likely to reduce to metallic tin with the amount of available current that may interact with the substrate holder. The same may occur with the conversion of tin(II) hydroxide being oxidized to tin(IV) hydroxide. Accordingly, residual tin(IV) oxide on the substrate holder subsequent an additional cleaning operation may be cleaned, rinsed, or wiped from the substrate holder without requiring deplating operations to oxidize metallic tin to allow removal.

[0042] The additional cleaning operation may then be performed less frequently than the UV exposure in operations. For example, in some embodiments the UV exposure may be performed after every substrate is processed to reduce the compounding effects of residual materials. An additional cleaning operation as discussed may be performed less frequently, and may be performed after every processing operation, or may be performed after greater than or about 2 processing operations, greater than or about 3 processing operations, greater than or about 5 processing operations, greater than or about 7 processing operations, greater than or about 10 processing operations, or more depending on the amount of residual material on the substrate holder. Queue times may then be improved by performing cleaning operations less frequently or less intensely.

[0043] The UV light exposure may be performed with any type of UV light. For example, any light providing device may be used that produces wavelengths below or about 400 nm. The UV light source may be within a number of ranges such as within the far and middle UV spectrums up to about 300 nm, to the near ultraviolet spectrum up to about 400 nm. The UV light source may provide UVA, UVB, or UVC light to the residual metal-containing material. UV light may provide more energy at lower wavelengths, and thus in some embodiments the UV light may operate at a wavelength below or about 380 nm, below or about 360 nm, below or about 340 nm, below or about 320 nm, below or about 300 nm, below or about 280 nm, below or about 260 nm, below or about 240 nm, below or about 220 nm, below or about 200 nm, below or about 180 nm, or lower. In some embodiments the UV light may operate at wavelengths between about 150 and about 380 nm, between about 200 and about 360 nm, between about 220 and about 340 nm, or between about 200 and about 300 nm, although the source may be operated at any of the wavelengths discussed. The UV light source may be any known source including mercury-based lamps, noble gas-containing lamps, UV light emitting diodes, or other sources capable of producing UV light in the ranges described.

[0044] The type of UV device utilized, and the wavelengths produced, may affect the amount of time for exposure. For example, the UV light source may be large enough to expose the entire substrate holder, or entire annular member, at a single time. In some embodiments, because the substrate holder may be rotated, the annular member or portion of the substrate holder may be rotated across a UV light source. The exposure of any particular portion of the annular member or substrate holder may be performed for a time period greater than or about 1 second, and may be performed for a time period greater than or about 5 seconds, greater than or about 10 seconds, greater than or about 20 seconds, greater than or about 40 seconds, greater than or about 1 minute, greater than or about 2 minutes, greater than or about 5 minutes, greater than or about 10 minutes, or more. For example, a lower wavelength source may be applied for a shorter amount of time than a higher wavelength source in embodiments. Also, a rotating annular member across a UV source may be treated for a time period longer than a source that may expose the entire substrate holder or annular member at a single time, although energy of exposure at any discrete segment of the substrate holder or annular member may be similar, greater, or less, in embodiments.

[0045] The present technology utilizes UV light exposure to modify metal-containing materials on a substrate holder. This modification may allow the modified material to be naturally released into the electrolyte solution for filtration, or may facilitate reduced cleaning

operations. By utilizing the present technology, electrodeposition operations may be performed with more uniformity and reduced defects along an edge region of the substrate. Additionally, further formation or deposition along the substrate holder may be inhibited by conversion of the materials with UV light.

5 **[0046]** In the preceding description, for the purposes of explanation, numerous details have been set forth in order to provide an understanding of various embodiments of the present technology. It will be apparent to one skilled in the art, however, that certain embodiments may be practiced without some of these details, or with additional details.

10 **[0047]** Having disclosed several embodiments, it will be recognized by those of skill in the art that various modifications, alternative constructions, and equivalents may be used without departing from the spirit of the embodiments. Additionally, a number of well-known processes and elements have not been described in order to avoid unnecessarily obscuring the present technology. Accordingly, the above description should not be taken as limiting the scope of the technology.

15 **[0048]** Where a range of values is provided, it is understood that each intervening value, to the smallest fraction of the unit of the lower limit, unless the context clearly dictates otherwise, between the upper and lower limits of that range is also specifically disclosed. Any narrower range between any stated values or unstated intervening values in a stated range and any other stated or intervening value in that stated range is encompassed. The
20 upper and lower limits of those smaller ranges may independently be included or excluded in the range, and each range where either, neither, or both limits are included in the smaller ranges is also encompassed within the technology, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included. Where multiple values are
25 provided in a list, any range encompassing or based on any of those values is similarly specifically disclosed.

30 **[0049]** As used herein and in the appended claims, the singular forms “a”, “an”, and “the” include plural references unless the context clearly dictates otherwise. Thus, for example, reference to “a material” includes a plurality of such materials, and reference to “the agent” includes reference to one or more agents and equivalents thereof known to those skilled in the art, and so forth.

[0050] Also, the words “comprise(s)”, “comprising”, “contain(s)”, “containing”, “include(s)”, and “including”, when used in this specification and in the following claims, are intended to specify the presence of stated features, integers, components, or operations, but they do not preclude the presence or addition of one or more other features, integers,

5 components, operations, acts, or groups.

WHAT IS CLAIMED IS:

- 1 1. A method of cleaning an electroplating device, the method comprising:
2 exposing at least a portion of a substrate holder of the electroplating device to UV
3 light, wherein the UV light is configured to adjust metal-containing material on the substrate
4 holder from a first oxidation state to a second oxidation state.
- 1 2. The method of cleaning an electroplating device of claim 1, further
2 comprising:
3 processing a substrate coupled with the substrate holder prior to the exposure,
4 wherein the processing causes the metal-containing material to form on at least a portion of the
5 substrate holder; and
6 removing the substrate from the substrate holder prior to the exposure.
- 1 3. The method of cleaning an electroplating device of claim 2, wherein the
2 processing comprises forming the metal-containing material on the substrate by an
3 electrochemical deposition process.
- 1 4. The method of cleaning an electroplating device of claim 1, wherein the
2 metal-containing material comprises tin.
- 1 5. The method of cleaning an electroplating device of claim 4, wherein the
2 first oxidation state comprises +2, and wherein the second oxidation state comprises +4.
- 1 6. The method of cleaning an electroplating device of claim 4, wherein
2 exposing at least a portion of the substrate holder is performed in an oxygen-containing
3 environment, and wherein the oxygen-containing environment comprises ambient conditions.
- 1 7. The method of cleaning an electroplating device of claim 6, wherein the
2 tin is oxidized to tin(IV) oxide.
- 1 8. The method of cleaning an electroplating device of claim 1, wherein the
2 UV light operates at a wavelength below or about 300 nm.

1 9. The method of cleaning an electroplating device of claim 1, wherein the
2 exposure to UV light occurs for at least about 10 seconds at each discrete segment of the at least
3 a portion of the substrate holder.

1 10. A method of cleaning an electroplating device, the method comprising:
2 processing a substrate coupled with the electroplating device, wherein the
3 substrate is coupled with a substrate holder of the electroplating device, wherein the substrate
4 holder comprises an annular component disposed about the substrate, wherein a surface of the
5 annular component is exposed to an electroplating solution with the substrate, and wherein the
6 processing forms a metal-containing material on the annular component;
7 removing the substrate from the substrate holder of the electroplating device; and
8 exposing the annular component of the substrate holder of the electroplating
9 device to UV light, wherein the UV light is configured to modify the metal-containing material.

1 11. The method of cleaning an electroplating device of claim 10, wherein the
2 metal-containing material comprises tin, wherein the tin is modified by the UV light to form
3 tin(IV) oxide, and wherein the tin is modified in ambient conditions.

1 12. The method of cleaning an electroplating device of claim 10, further
2 comprising rotating the annular component during the exposure to the UV light, wherein each
3 segment of the annular component is exposed to the UV light for at least about 5 seconds.

1 13. The method of cleaning an electroplating device of claim 10, wherein the
2 UV light operates at a wavelength below or about 300 nm.

1 14. A method of cleaning an electroplating device, the method comprising:
2 processing a substrate coupled with the electroplating device, wherein the
3 substrate is coupled with a substrate holder of the electroplating device, wherein the substrate
4 holder comprises an annular component disposed about the substrate, wherein a surface of the
5 annular component is exposed to an electroplating solution with the substrate, and wherein the
6 processing forms a metal-containing material on the annular component;
7 removing the substrate from the substrate holder of the electroplating device;
8 rotating the annular component; and

9 while rotating the annular component, exposing the annular component of the
10 substrate holder of the electroplating device to a fixed UV light source producing UV light,
11 wherein the UV light configured to modify the metal-containing material.

1 15. The method of cleaning an electroplating device of claim 14, wherein
2 exposing the annular component is performed in an oxygen-containing environment, wherein the
3 metal-containing material comprises tin, and wherein the tin is modified by the UV light to form
4 tin(IV) oxide.

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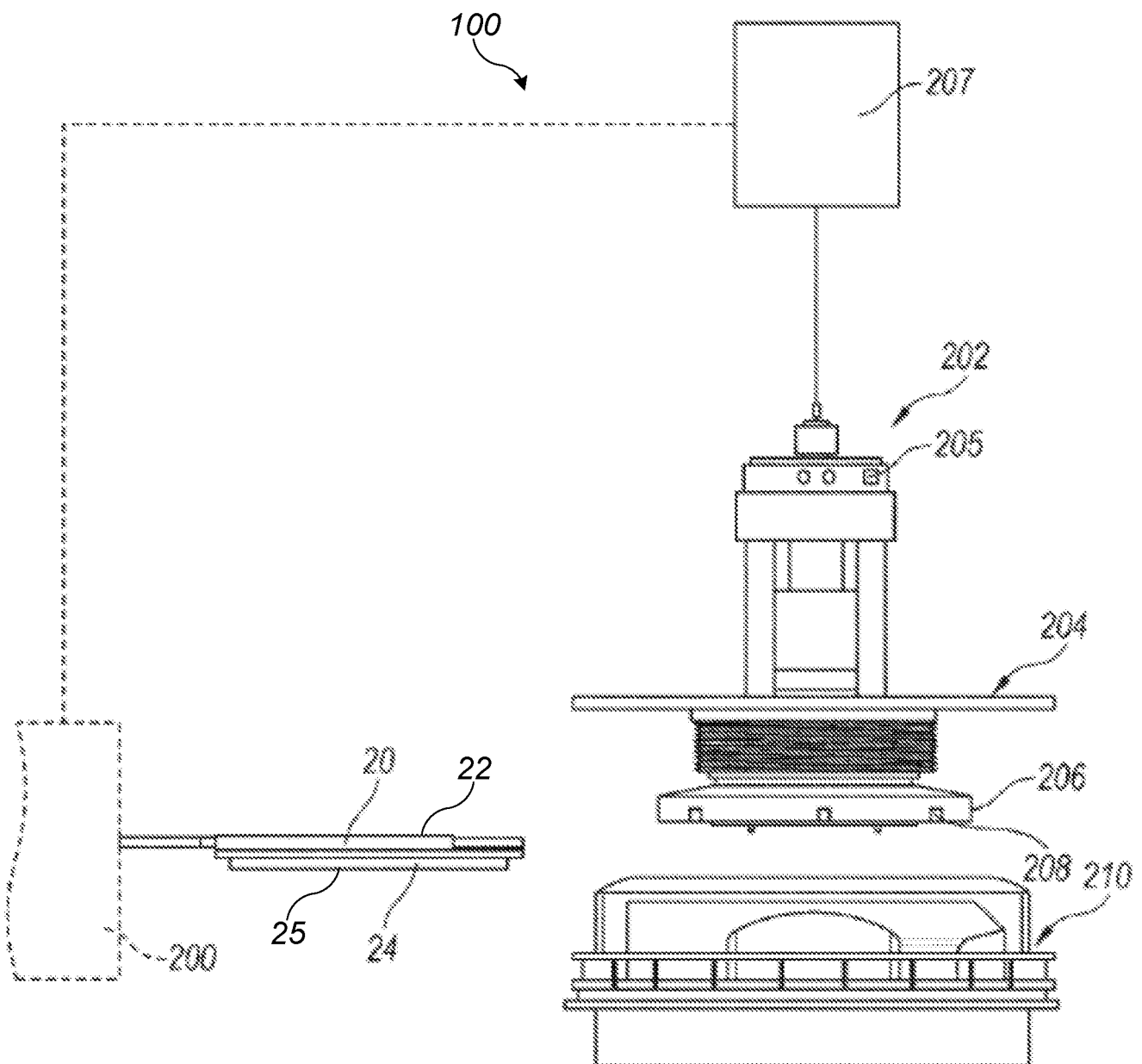


FIG. 1

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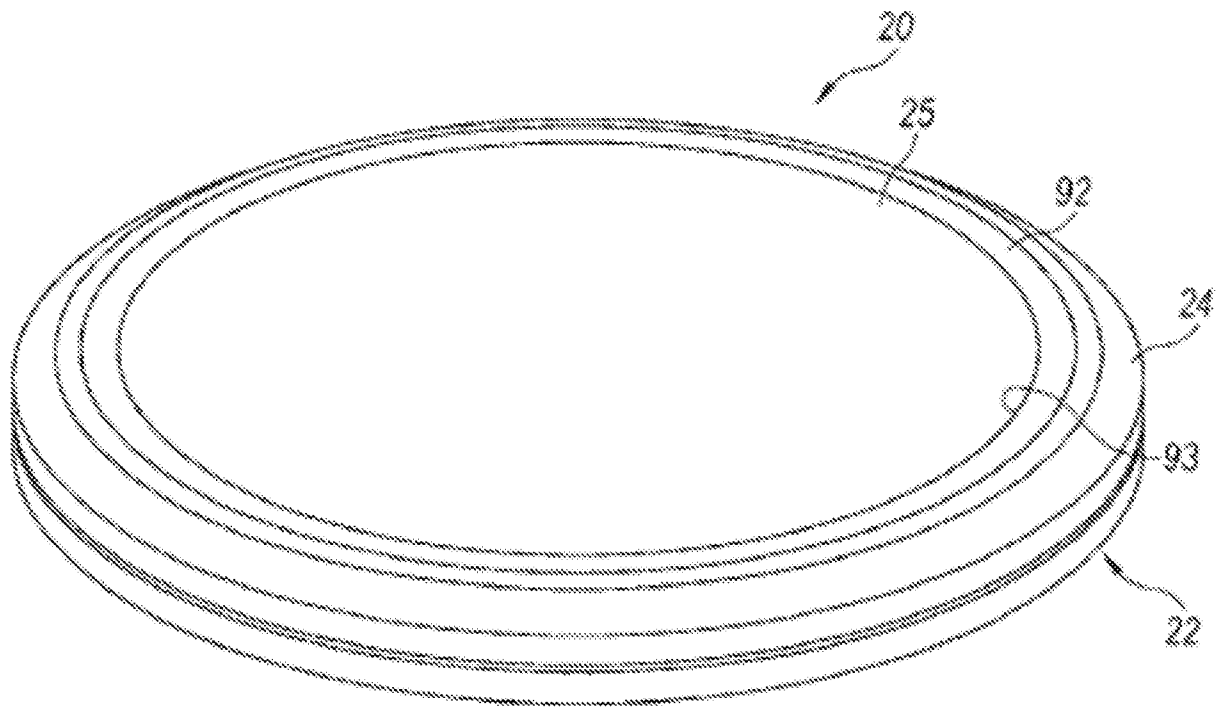


FIG. 2

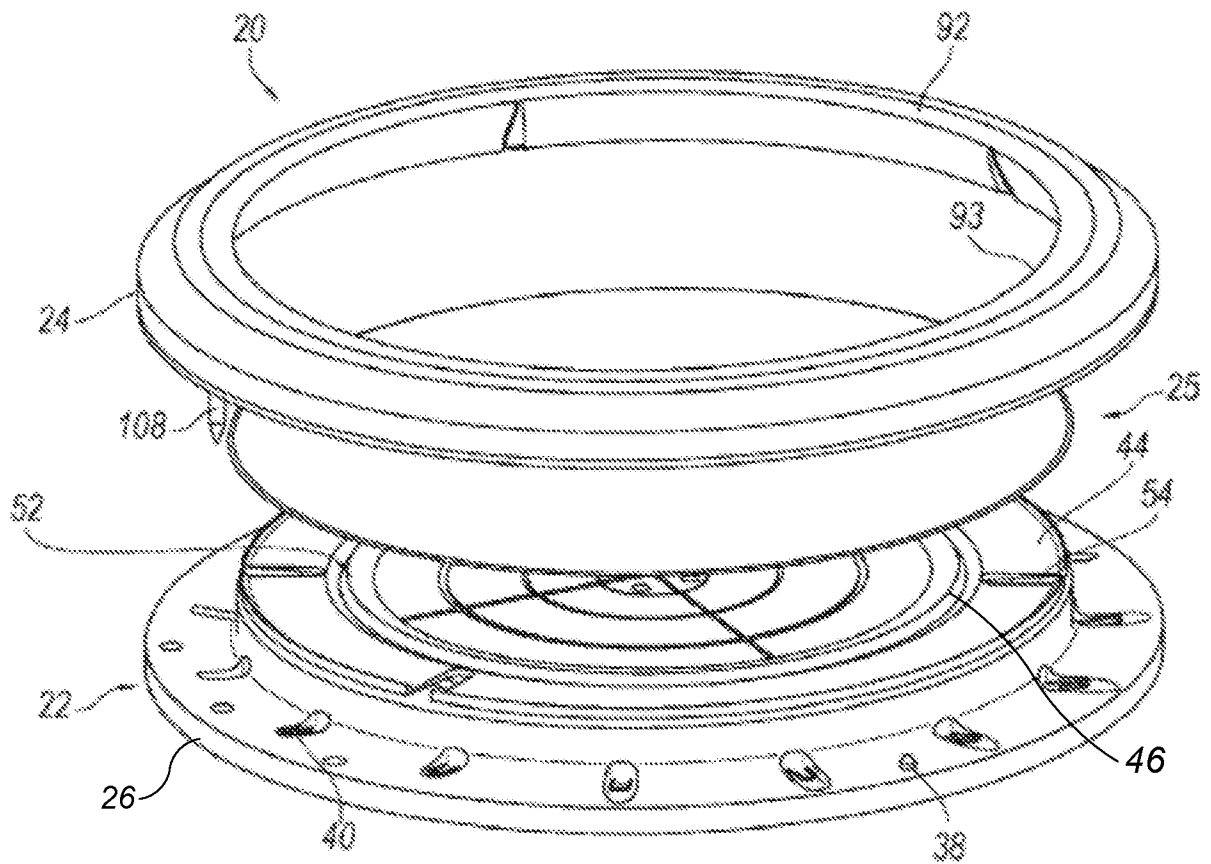
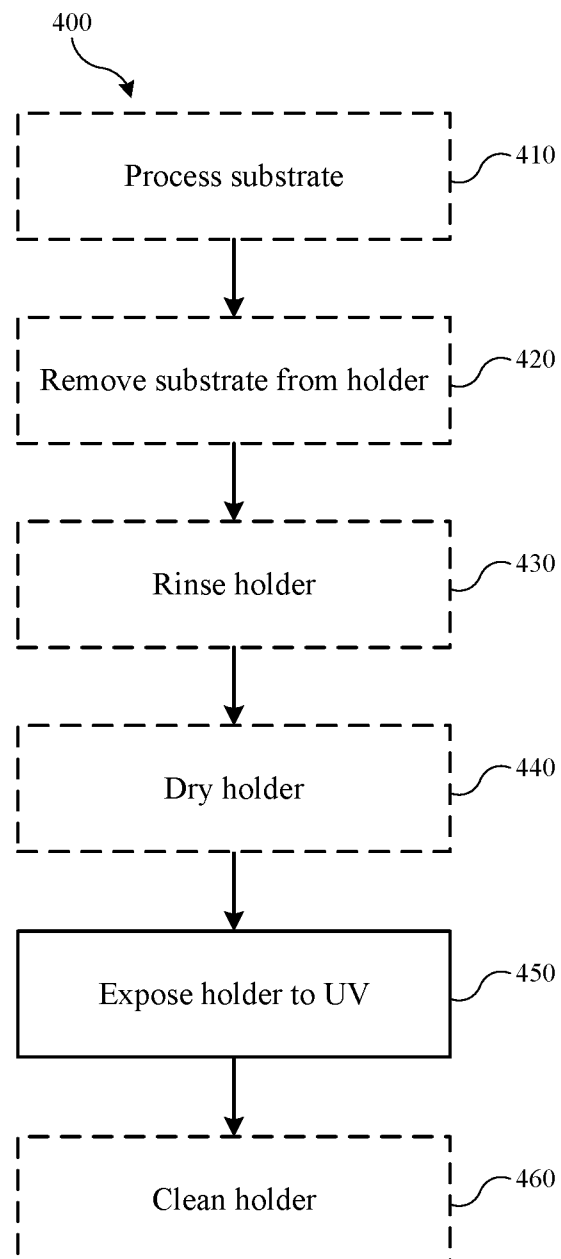


FIG. 3

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A. CLASSIFICATION OF SUBJECT MATTER**C25D 21/00(2006.01)i, C25D 17/06(2006.01)i, C25D 17/00(2006.01)i, C23G 5/00(2006.01)i, B08B 7/00(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)

C25D 21/00; C25D 17/06; C25D 21/08; C25F 1/00; G01N 27/00; G01N 33/20; G03C 5/00; H01L 21/288; H01L 21/302; C25D 17/00; C23G 5/00; B08B 7/00

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: electroplating device, substrate holder, UV light, oxidation state, tin, substrate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0256146 A1 (CHUA et al.) 03 October 2013 See paragraphs [0003]-[0019], [0042]-[0056]; claims 1-9; and figures 1A-1D, 3.	1-15
Y	US 2004-0067444 A1 (WAKABAYASHI et al.) 08 April 2004 See paragraphs [0038]-[0055]; claims 1-10; and figures 1-4.	1-15
A	US 2014-0020720 A1 (EBARA CORPORATION) 23 January 2014 See paragraphs [0039]-[0110]; and figures 4-6.	1-15
A	US 2014-0230855 A1 (NOVELLUS SYSTEMS, INC.) 21 August 2014 See paragraphs [0023]-[0067]; and figures 1-2.	1-15
A	KR 10-2015-0002712 A (NOVELLUS SYSTEMS, INC.) 07 January 2015 See paragraphs [0047]-[0112]; and figures 3a-3b.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"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

"&" document member of the same patent family

Date of the actual completion of the international search

22 October 2018 (22.10.2018)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/038298

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