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(54) APPARATUS FOR AVOIDING PARTICLE ACCUMULATION IN ELECTROCHEMICAL PROCESSING

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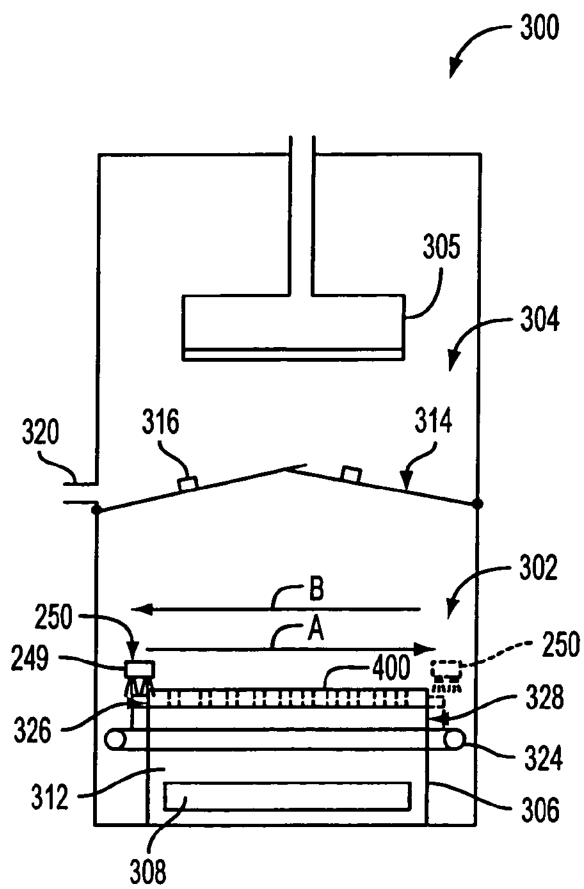
(57) ABSTRACT

Systems and methods to remove or lessen the size of metal particles that have formed on, and to limit the rate at which metal particles form or grow on, workpiece surface influencing devices used during electrodeposition are presented. According to an exemplary method, the workpiece surface influencing device is occasionally placed in contact with a conditioning substrate coated with an inert material, and the bias applied to the electrodeposition system is reversed. According to another exemplary method, the workpiece surface influencing device is conditioned using mechanical contact members, such as brushes, and conditioning of the workpiece surface influencing device occurs, for example, through physical brushing of the workpiece surface influencing device with the brushes. According to a further exemplary method, the workpiece surface influencing device is rotated in different direction during electrodeposition.



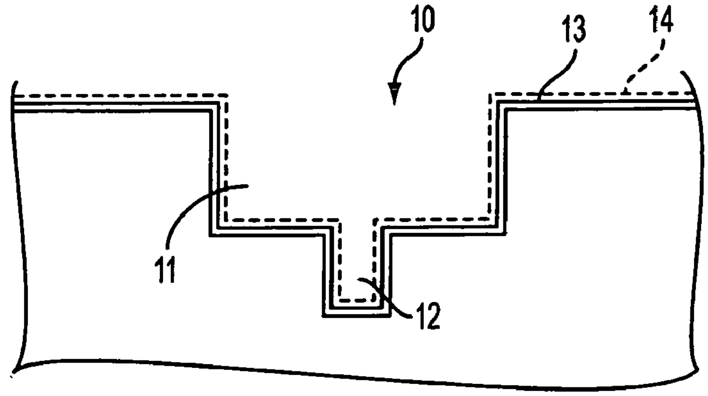


FIGURE 1

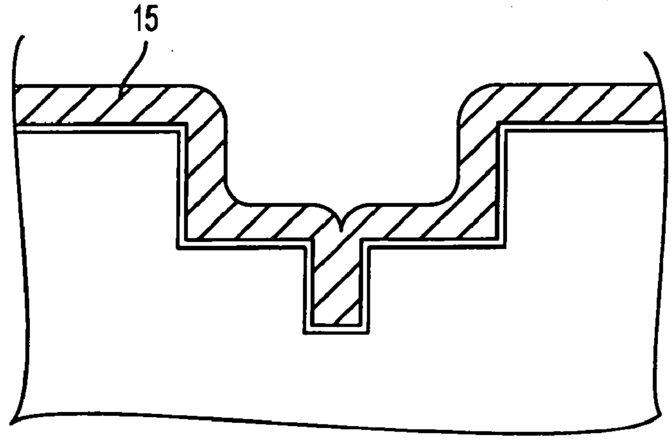


FIGURE 2

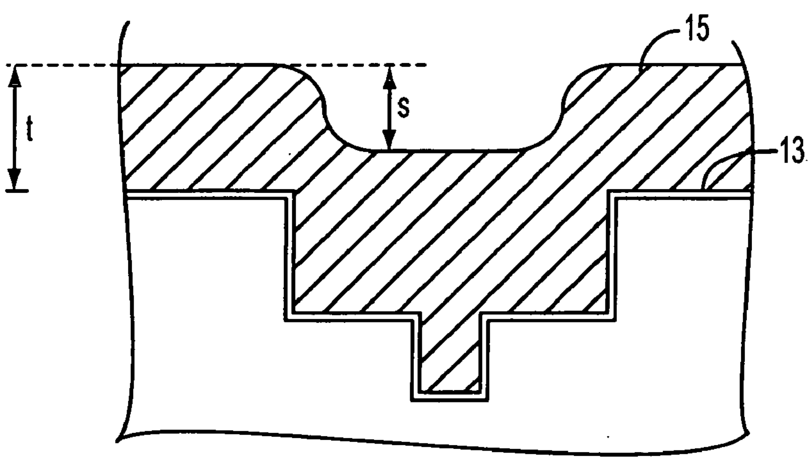


FIGURE 3

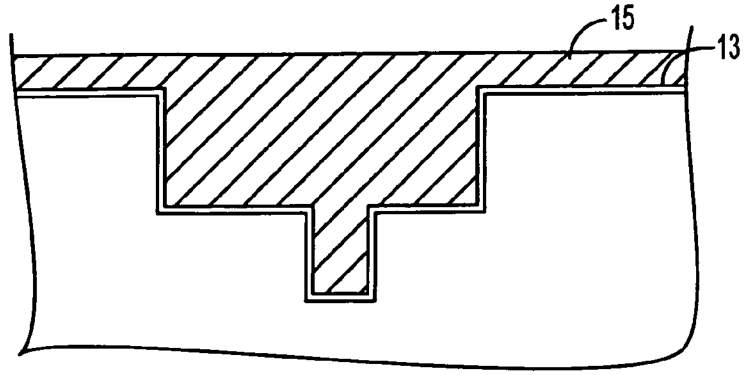


FIGURE 4

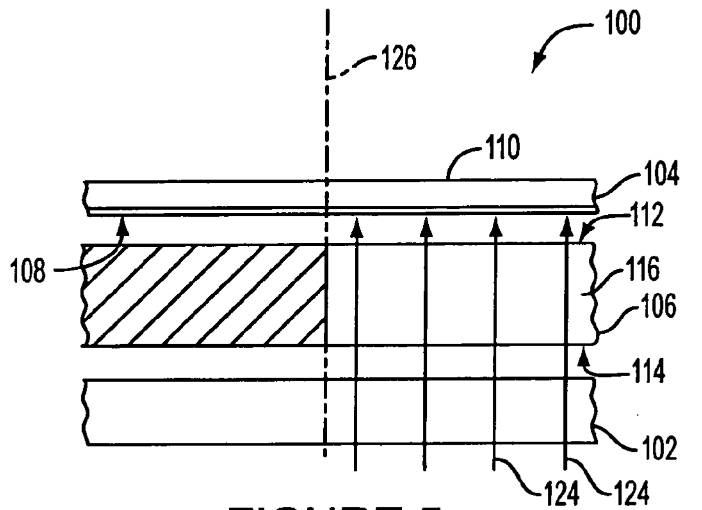


FIGURE 5

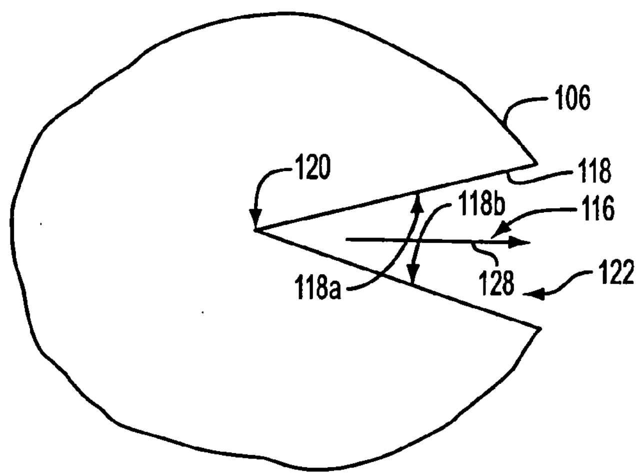


FIGURE 6

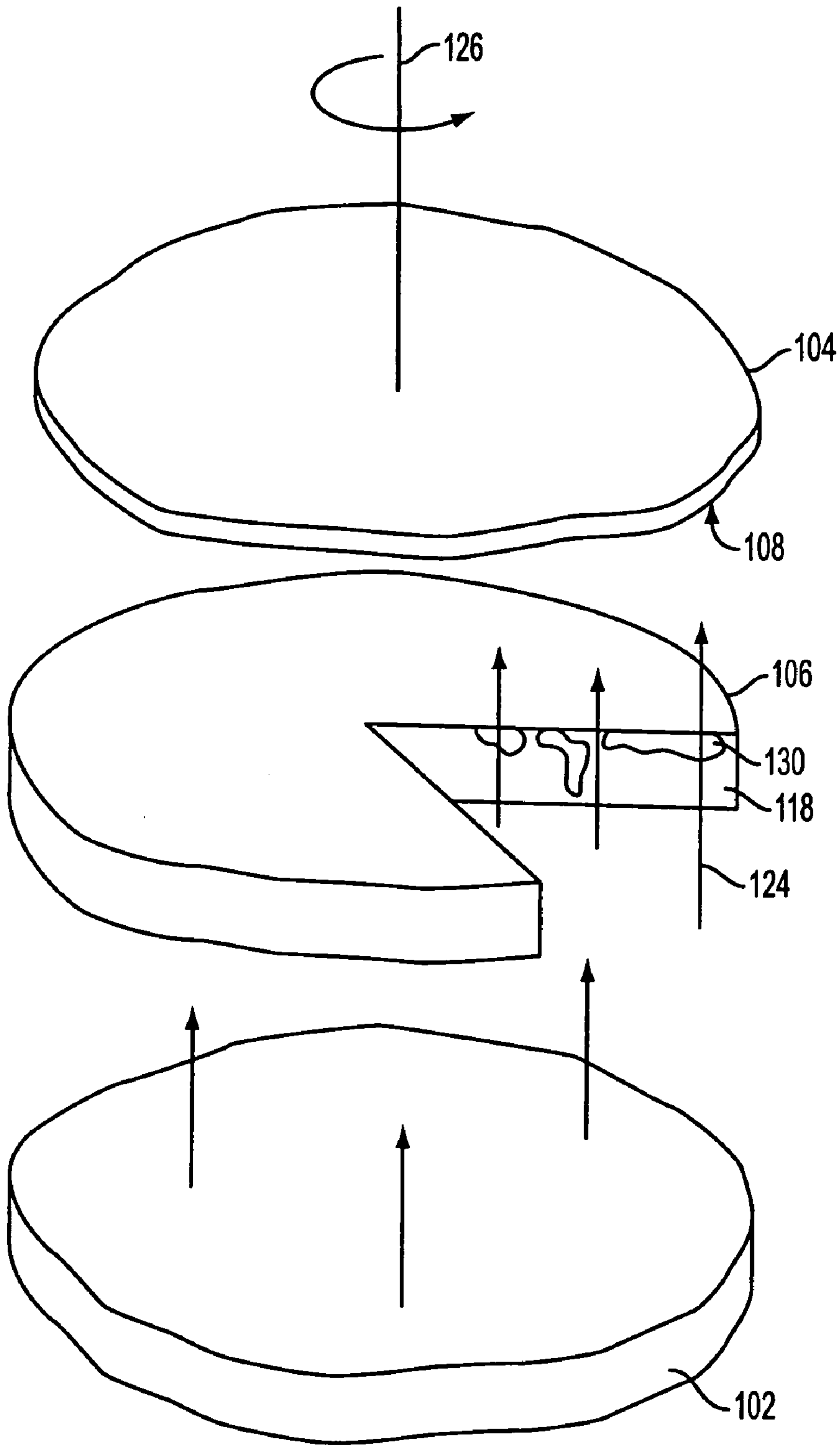


FIGURE 7A

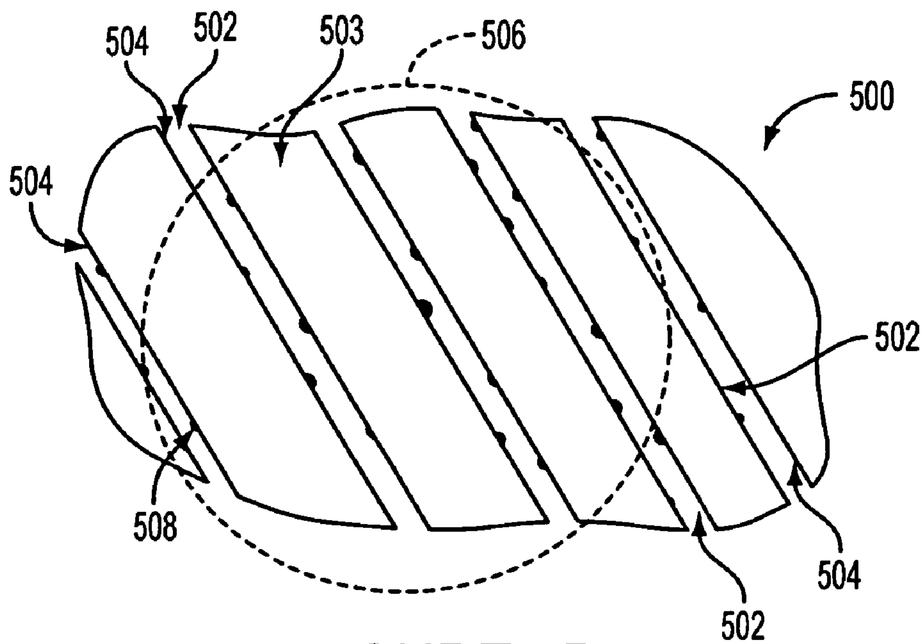


FIGURE 7B

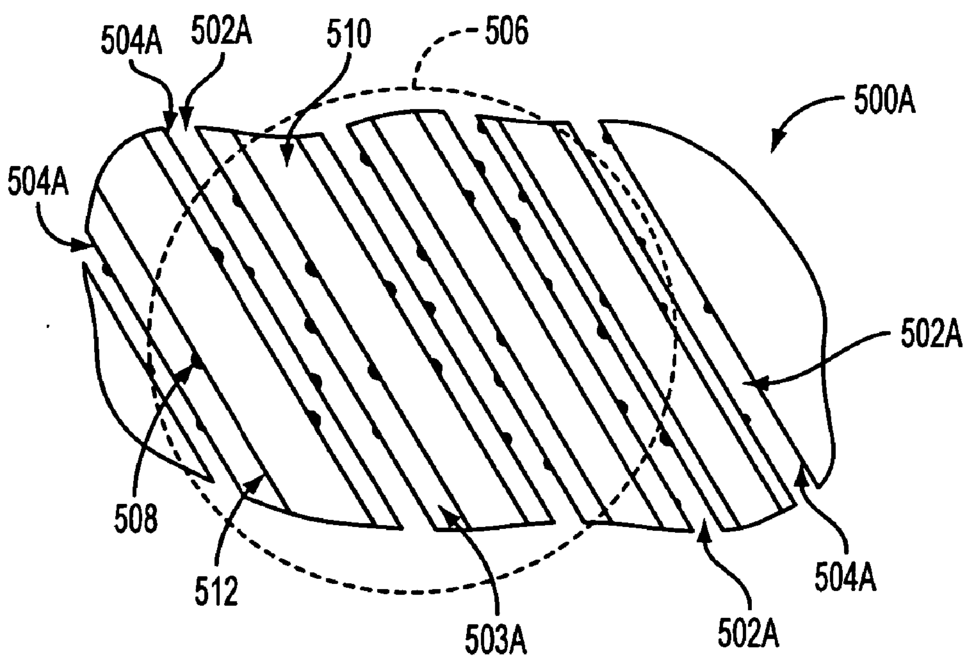


FIGURE 7C

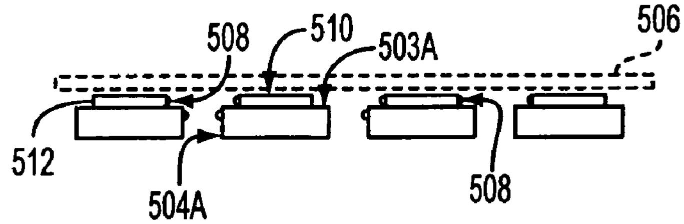


FIGURE 7D

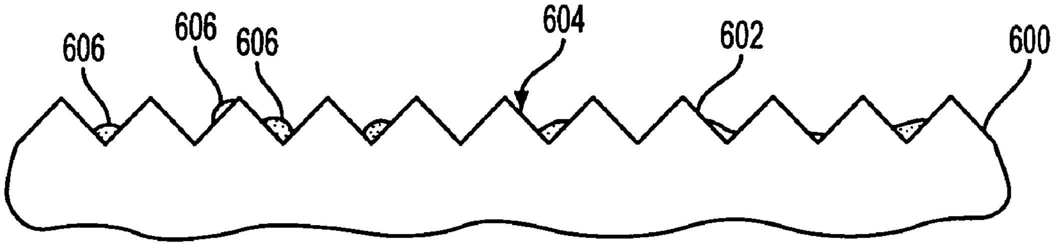


FIGURE 7E

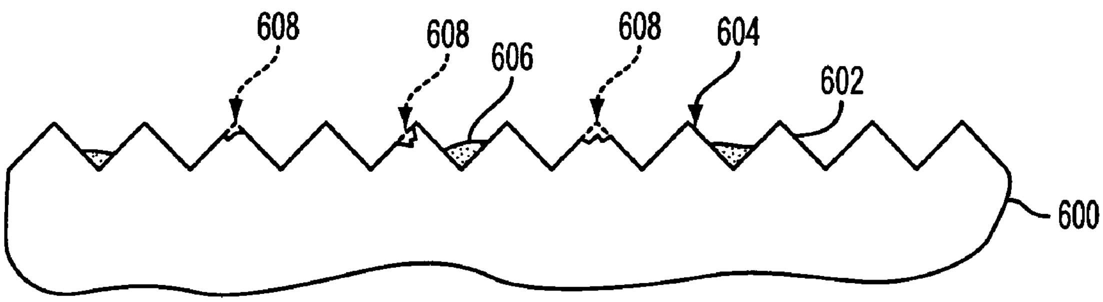


FIGURE 7F

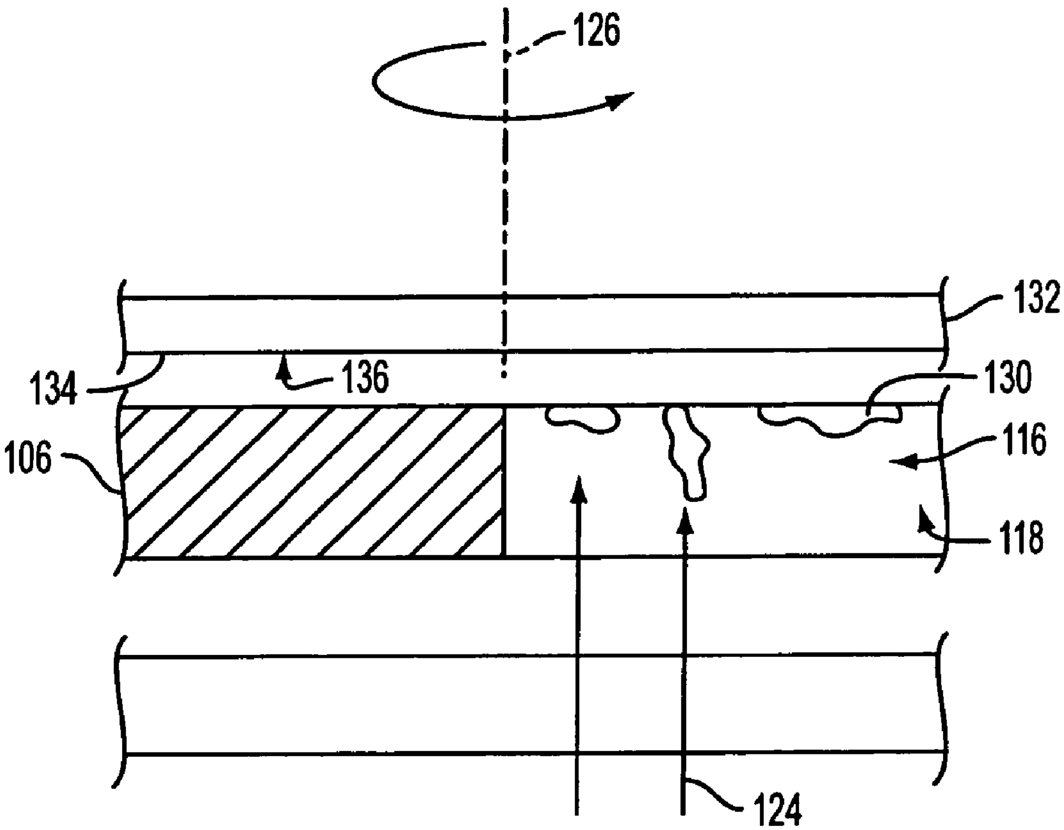


FIGURE 8

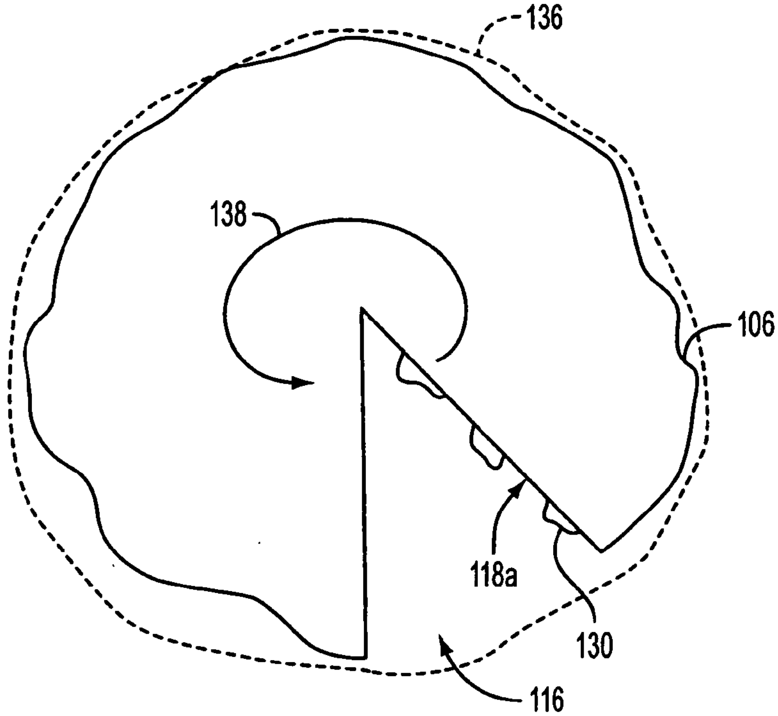


FIGURE 9

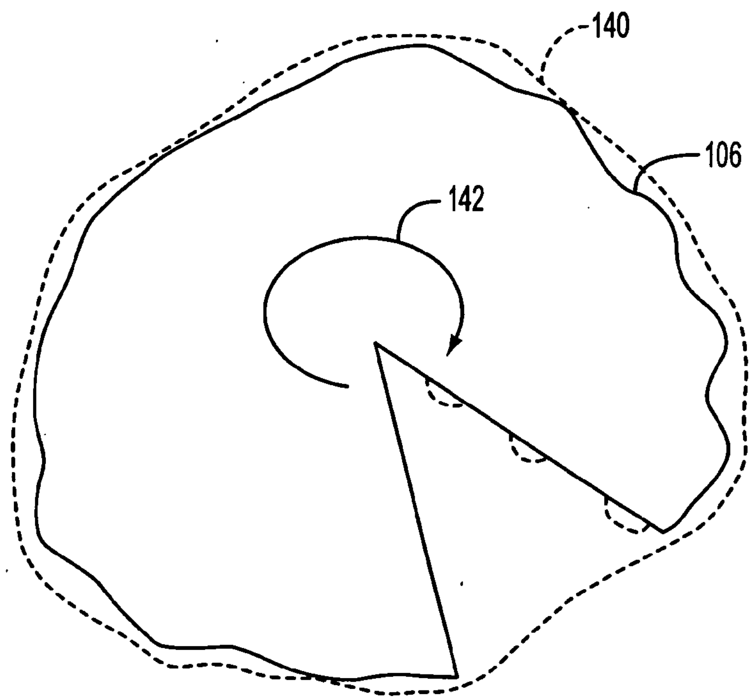


FIGURE 10

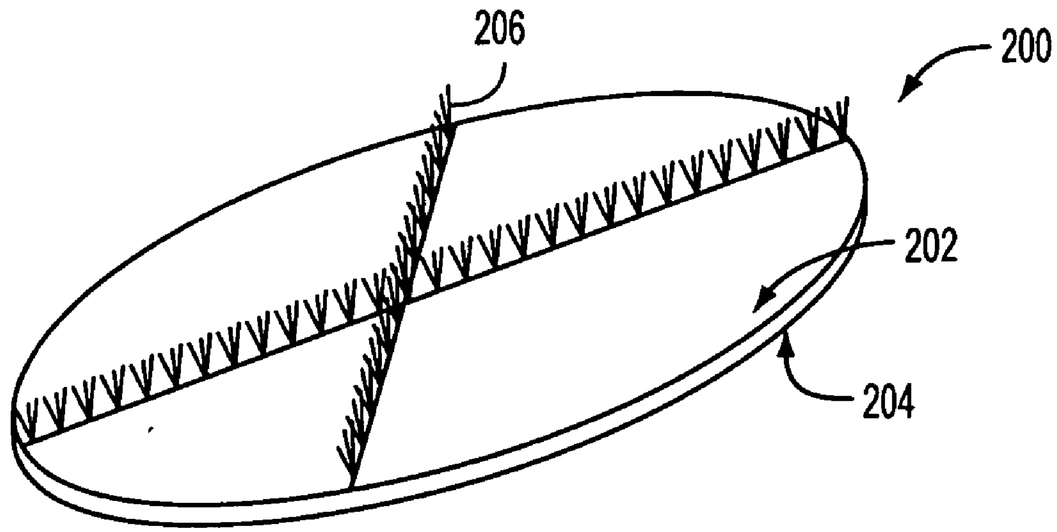


FIGURE 11A

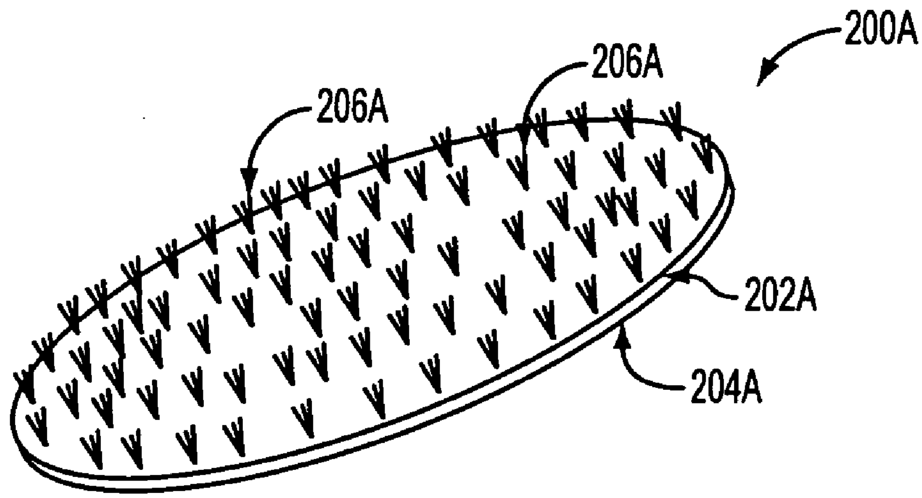


FIGURE 11B

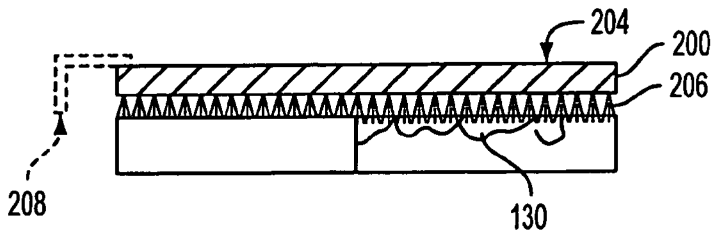


FIGURE 12

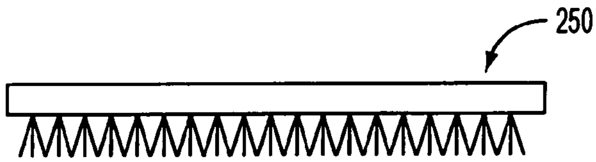


FIGURE 13

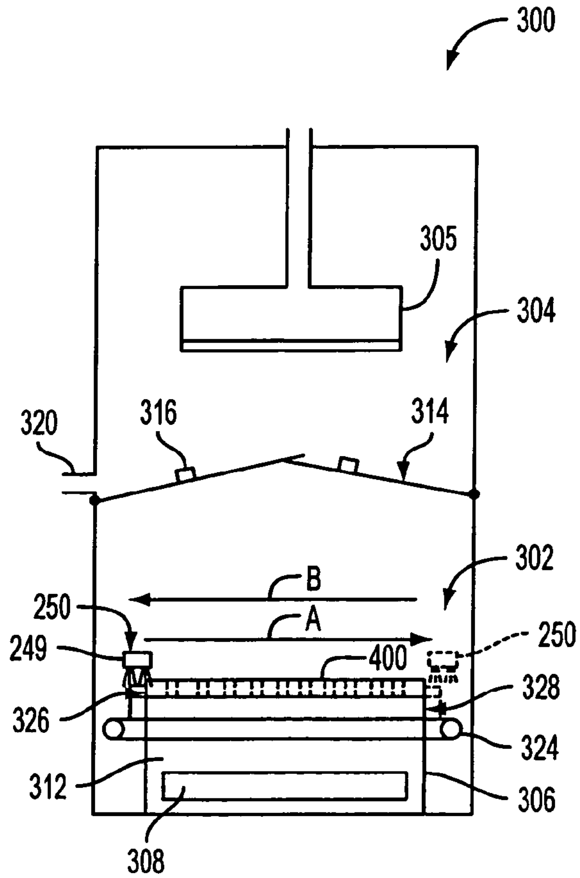


FIGURE 14

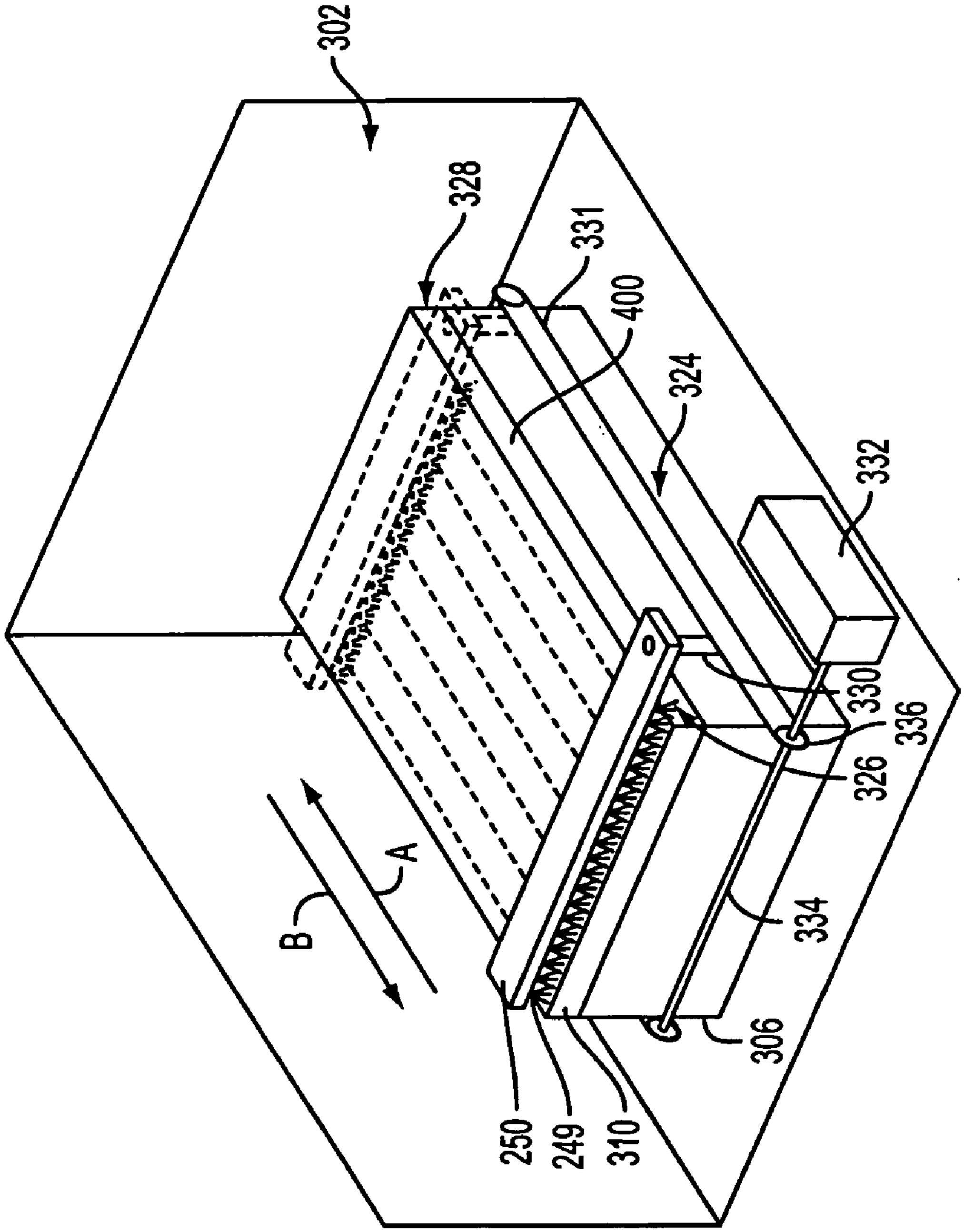


FIGURE 15

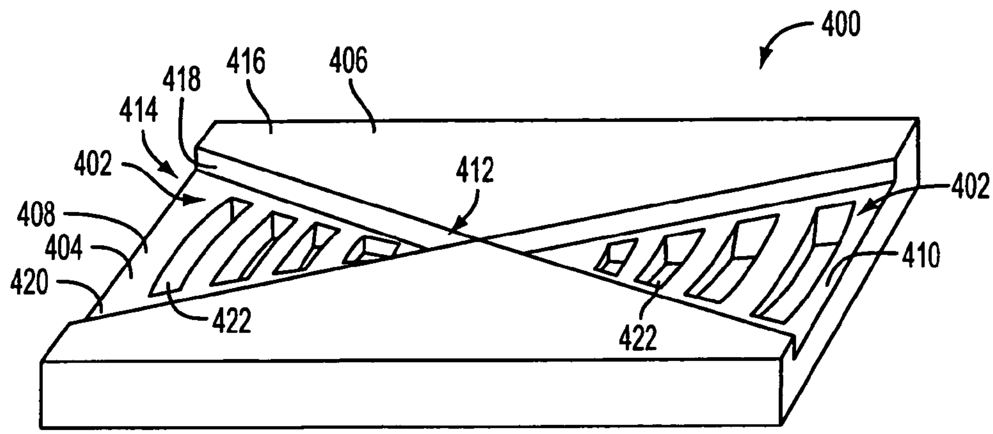


FIGURE 16

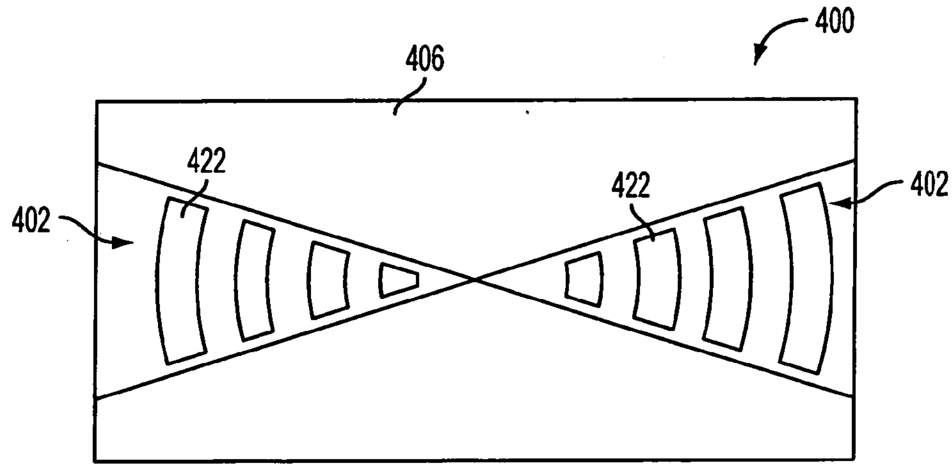


FIGURE 17

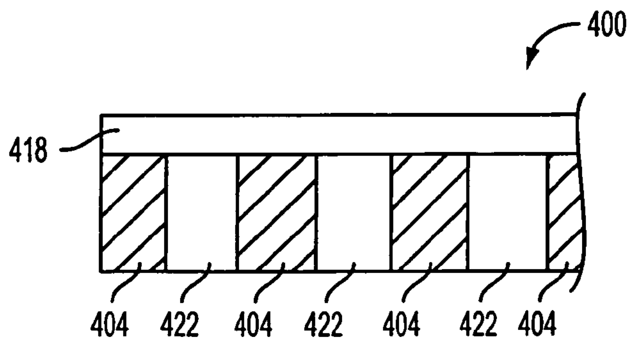


FIGURE 18

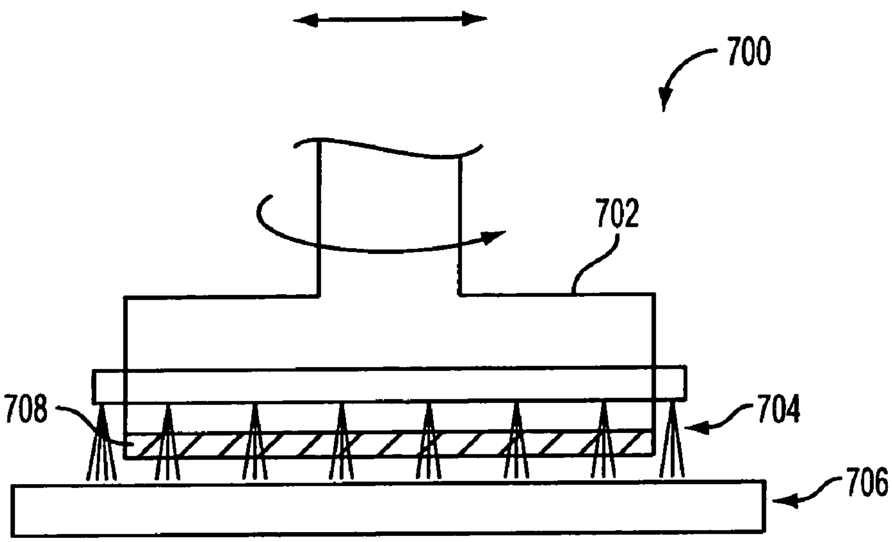


FIGURE 19

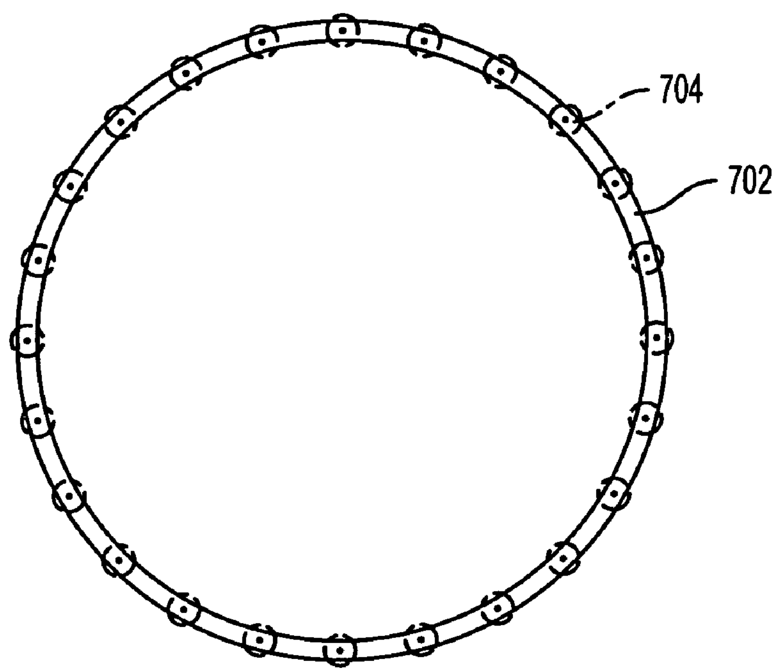


FIGURE 20

APPARATUS FOR AVOIDING PARTICLE ACCUMULATION IN ELECTROCHEMICAL PROCESSING

PRIOR APPLICATIONS

[0001] This is a divisional application of U.S. application Ser. No. 09/982,558 filed Oct. 17, 2001 entitled Method and Apparatus for Avoiding Particle Accumulation in Electrodeposition, which claims the benefit of priority to U.S. Provisional Application Ser. No. 60/280,524 filed Mar. 30, 2001.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a method and apparatus for removing particles from surfaces, and avoiding particle accumulation on surfaces during, electrochemical mechanical processing.

[0004] 2. Description of the Related Art

[0005] Conventional semiconductor devices generally include a semiconductor substrate, usually a silicon substrate, and a plurality of sequentially formed dielectric interlayers such as silicon dioxide and conductive paths or interconnects made of conductive materials. The interconnects are usually formed by filling a conductive material in trenches etched into the dielectric interlayers. In an integrated circuit, multiple levels of interconnect networks laterally extend with respect to the substrate surface. The interconnects formed in different layers can be electrically connected using vias or contacts. A conductive material filling process of such features, i.e., via openings, trenches, pads or contacts can be called out by depositing a conductive material over the substrate including such features.

[0006] Copper and copper alloys have recently received considerable attention as interconnect materials because of their superior electromigration and low resistivity characteristics. The preferred method of copper deposition is electrodeposition. During fabrication, copper is deposited on the substrate that has been previously coated with a barrier layer and then a seed layer. The barrier layer coats the vias and the trench as well as the surface of the dielectric layer to ensure good adhesion and acts as a barrier material to prevent diffusion of the copper into the semiconductor devices through the dielectric insulation layer. Typically, seed layer forms a conductive material base for copper film growth during the subsequent copper deposition. Typical barrier materials generally include tungsten, tantalum, titanium, their alloys, and their nitrides. The deposition process can be carried out using a variety of processes. After depositing copper into the features on the semiconductor wafer surface, an etching, an electropolishing (also called electroetching), an electrochemical mechanical etching (ECME) or a chemical mechanical polishing (CMP) step may be employed. These processes remove the conductive materials off the field regions of the surface, thereby leaving the conductive materials only within vias, trenches and other features.

[0007] In conventional electrodeposition techniques, copper is coated on the wafer surface in a conformal manner. As shown in **FIGS. 1-3**, when, for example, a dual damascene structure on the wafer surface is coated with copper using conventional plating, it yields a rather conformal film. **FIGS. 1-3** show three possible stages in the conventional process. In a first stage shown in **FIG. 1**, the dual damascene structure **10** with a wide trench **11**, a small via **12** covered with a barrier layer **13** and a copper seed layer **14** is shown. As the copper film is electroplated in a second stage shown in **FIG. 2**, the copper **15** quickly fills the small via **12** but coats the wide trench and the surface in a conformal manner. When the deposition process is continued, the wide trench is also filled with copper in a third stage shown in **FIG. 3**, but with a resulting large step 'S' and a thick surface copper layer 't'. Thick copper on the surface presents a problem during the material removal step such as a CMP step, which is expensive and time consuming. Techniques that can yield thin surface copper overburden and small or no 'S' step are very attractive, which is exemplified in **FIG. 4**.

[0008] The importance of overcoming the various deficiencies of the conventional electrodeposition techniques is evidenced by technological developments directed to the deposition of planar copper layers. For example, U.S. Pat. No. 6,176,992, entitled "Method and Apparatus for Electrochemical Mechanical Deposition" and commonly owned by the assignee of the present invention, describes in one aspect an electro chemical mechanical deposition technique (ECMD) that achieves deposition of the conductive material into the cavities on the substrate surface while minimizing deposition on the field regions by polishing the field regions with a pad as the conductive material is deposited, thus yielding planar copper deposits. In another aspect, this application describes an electrochemical mechanical etching (ECME) or electroetching or electropolishing technique that removes conductive material from the surface of a workpiece.

[0009] U.S. Pat. No. 6,534,116 for "Plating Method and Apparatus that Creates a Differential Between Additive Disposed on a Top Surface and a Cavity Surface of a Workpiece Using an External Influence," also assigned to the same assignee as the present invention, describes in one aspect another ECMD method and apparatus for plating a conductive material onto the substrate by creating an external influence, such as causing relative movement between a workpiece and a mask, to cause a differential in additives to exist for a period of time between a top surface and a cavity surface of a workpiece. While the differential is maintained, power is applied between an electrode (in this case anode) and the substrate to cause greater relative plating of the cavity surface than the top surface.

[0010] These ECMD methods can deposit metals in and over cavity sections on a workpiece in a planar manner. Some methods even have the capability to provide deposits with excess metal in and over the cavities. In such abovementioned processes, a pad, a mask or a sweeper, hereinafter collectively referred to as a workpiece-surface-influencing device (WSID), can be used during at least a portion of the electrodeposition process when there may be physical contact between the workpiece surface and the WSID. The physical contact, polishing, or the external influence affects the growth of the metal by effectively reducing the growth rate on the top surface with respect to the features. During the process step that involves the WSID being in close proximity to, and typically in contact with, the metal surface, small particles of the metal may attach onto the WSID material. These particles may exist because of the fact that they may be just physically removed from the substrate surface or they may originate from the plating solution due to poor filtration of the plating solution. In any case once the conductive metal particles attach themselves to a location on the WSID, they may start growing in size because they become cathodic with respect to the electrode. Further, since they are conductive they receive coating and thus grow in size.

[0011] ECME methods also use a WSID, and during usage of these methods, the WSID is also in close proximity to, and typically in contact with, the metal surface of the workpiece. During ECME, the potential applied between the workpiece surface and the electrode is reversed rendering the workpiece surface anodic. Therefore, material is removed from the workpiece surface. If WSID is not used during this material removal step, i.e. if there is no mechanical action on the workpiece surface, the process is referred to as just electrochemical etching or polishing. It should be noted that in general both ECMD and ECME processes are referred to as electrochemical mechanical processing (ECMPR) hereinafter, since both involve electrochemical processes and mechanical action.

[0012] In addition to conductive particles, there are also non-conductive particles that may accumulate on the WSID material. The non-conductive particles may originate from other parts of the system, such as from the plating solution due to the poor filtration or from the WSID material itself due to the wear and tear during processing.

[0013] Presence of such particles on or in close proximity of the surface of the WSID is undesirable because if they become loose and find their way to the interface between the WSID and the workpiece surface, they can cause scratches, inclusions, or other defects on the workpiece surface or they can actually cause scratches on the surface of the WSID, especially if the WSID has a non-flat surface profile.

[0014] Therefore, elimination of such particles, or process steps to limit their growth, are very important to increase process yield and the lifetime of the WSID used in planar metal deposition techniques in which particles may come close to or touch the workpiece surface, and particularly when particles are disposed on a WSID that touches the workpiece surface.

SUMMARY OF THE INVENTION

[0015] It is an object of the invention to remove or reduce the size of particles that have formed on pads, masks, sweepers or WSIDs used during electrochemical mechanical processing (ECMPR).

[0016] It is another object of the invention to limit the rate at which conductive particles form or grow on WSID used during ECMPR.

[0017] It is yet another object of the invention to reduce defects on the workpiece.

[0018] Certain of the above objects of the invention, among others, either singly or in combination, are achieved in one embodiment by occasionally conditioning the WSID used during ECMPR.

[0019] In one embodiment, this involves placing the WSID in the presence of a conditioning substrate and applying a bias that will cause removal of, or reduction in the size of, conductive particles on the WSID.

[0020] In another embodiment, the WSID is conditioned using mechanical contact members, such as brushes, and conditioning occurs, for example, through physical brushing of the WSID with the brushes.

[0021] In another embodiment, conditioning occurs by rotating the WSIDs used during electrodeposition in different directions, or by rotating successive substrates or workpieces in different directions.

[0022] The above and other embodiments can also be combined, as described in further detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] These and other objects, features and advantages of the present invention are better understood by reading the following detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, in which:

[0024] **FIGS. 1-4** illustrate various process stages during the plating of a metal on a semiconductor substrate using electrodeposition techniques;

[0025] **FIG. 5** shows various components of an exemplary electrochemical mechanical processing system;

[0026] **FIG. 6** illustrates an exemplary WSID;

[0027] **FIG. 7A** illustrates the accumulation of particles on an exemplary WSID that can be operated upon according to the present invention;

[0028] **FIG. 7B** illustrates the accumulation of particles on another exemplary WSID;

[0029] **FIG. 7C** illustrates the accumulation of particles on yet another exemplary WSID;

[0030] **FIG. 7D** shows a cross-sectional view of the WSID shown in **FIG. 7C**;

[0031] **FIG. 7E** shows the accumulation of particles on the surface of an exemplary WSID;

[0032] **FIG. 7F** shows the accumulation of particles on a fatigued surface of an exemplary WSID;

[0033] **FIG. 8** illustrates usage of an exemplary conditioning substrate according to an embodiment of the present invention;

[0034] **FIGS. 9-10** illustrate another exemplary embodiment of the present invention;

[0035] **FIG. 11A** illustrates an exemplary conditioning member according to another embodiment of the present invention;

[0036] **FIG. 11B** illustrates another exemplary embodiment of the conditioning member shown in **FIG. 11A**;

[0037] **FIG. 12** illustrates usage of the conditioning member of **FIG. 11A**;

[0038] **FIGS. 13-15** illustrate an exemplary mechanical contact member and the incorporation of the mechanical contact member into a plating system having a WSID;

[0039] **FIGS. 16-18** show an exemplary WSID that can be cleaned or conditioned with the present invention; and

[0040] **FIGS. 19 and 20** illustrate a conditioning substrate apparatus that can condition a WSID while also performing electrochemical mechanical processing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0041] One way of eliminating the growth of conductive, and typically metallic, or other particles on the workpiece surface influencing device (WSID) surface is to use a "particle elimination step" during electrochemical mechanical processing, either simultaneous with the electrochemical mechanical processing or when intermittently stopping the electrochemical mechanical processing. This step involves using a conditioning system, with a conditioning member that can assist in removing particles. As described hereinafter, this conditioning member can take the form of a conditioning substrate with a plurality of brushes that operates mechanically, a conductive conditioning substrate with conductive brushes that operates both mechanically and electrically, or a conditioning conductor layer that operates electrically. Of course, modifications of these embodiments can also exist. When operating electrically, as described hereinafter, the conductor used to coat is preferably an inert material that cannot be anodized or etched in the plating solution, under a bias, as will be described further hereinafter.

[0042] Reference will now be made to the drawings wherein like numerals refer to like parts throughout. **FIG. 5** schematically shows an exemplary electrochemical mechanical processing (ECMPR) system **100** which can be used for ECMD and ECME processes. The system **100** in our example has an electrode **102** and the workpiece **104** and a WSID portion **106**. When used for ECMD, it will include a plating solution, containing the ionic species of the metal to be deposited, that touches the electrode **102** and the work piece **104**. An exemplary copper plating solution may be copper sulfate solution that is commonly used in the industry. The workpiece **104** may be an exemplary substrate, preferably a silicon wafer portion, to be plated with a conductor metal, preferably copper. The substrate **104** comprises a front surface **108** to be plated with copper and a bottom surface **110** to be held by a carrier head (not shown). The front surface **108** may comprise the features shown in **FIG. 1**.

[0043] **FIG. 6** illustrates in more detail an exemplary WSID portion **106**, which may comprise a top surface **112** and a bottom surface **114**. The WSID **106** also comprises an exemplary channel **116** extending between the top and the bottom surfaces **112**, **114** and defined by sidewall **118** having a first wall **118***a* and a second wall **118***b*. The channel also laterally extends between a closed end **120** and an open end **122**. Although the channel in this example is V-shaped, it is understood that any shape channel that allows fluid communication between the wafer and the electrode can be used.

[0044] During an ECMD process, the front surface **108** of substrate **104** is brought into close proximity, or contact with, the top surface **112** of the WSID **106** for planar metal deposition. As a plating solution, depicted by arrows **124**, is delivered to the channel **116**, the substrate **104** is rotated about a rotation axis **126** while the front surface **108** contacts the top surface **112** of the WSID **106** or is in close proximity of the top surface **112**. For the purpose of clarification, the rotation axis **126** may be the point at which the closed end **120** of the channel **116** is located, thereby ensuring that rotation of the substrate **104** will result in the entire front surface **108** of the substrate **104** having uniform contact with the channel **116**. As the solution is delivered and fills the channel **116**, it wets the front surface **108** of the substrate **104**. Under an applied potential between the substrate and the electrode **102**, in the presence of the solution **124** that fills the channel **116**, the conductor or metal, such as copper, is plated on the front surface **108** of the substrate and the front surface **108** of the substrate **104** is also swept by the top surface **112** of the WSID **106**. This sweeping of the top surface **112** of the WSID **106** assists in obtaining planar deposition of the metal. The solution **124**, which is continuously delivered under pressure, will then flow through the channel **116** in the direction of the arrow **128** towards the open end **122** of the channel **116**, and exits the WSID **106**.

[0045] It is noted that the above description described rotation and movement of the substrate **104**, assuming that the WSID **106** was stationary. It is understood that the system **100**, as described above, will allow for either the substrate or the WSID to move, or for both of them to move, thereby creating the same relative effect. For ease of description, however, the invention was described and will continue to be described in terms of movement of the substrate. Furthermore, the shapes and forms of the channels may be different. When the system **100** is used for ECME, although the same plating solution that is used for the ECMD can still be used, it can be replaced with an electroetching solution or an electropolishing solution or an etching solution. In the ECME case, the WSID will typically contact the workpiece as described above, but the applied potential between the substrate and the electrode **102** will be opposite to that which is used for plating, and will be of the same polarity as that used when conditioning the WSID with a conditioning substrate that uses an applied potential, as discussed hereinafter.

[0046] **FIG. 7A** exemplifies how the planar plating process through the channel **116** progresses as the substrate **104** is rotated about the rotation axis **126** on the WSID **106** as described above. It should be understood that, for cathodic ECMD, the ionic species in the solution **124** are positively charged. Therefore, during deposition the substrate surface **108** upon which deposition is carried out is rendered cathodic (more negative) with respect to the electrode **102**, which becomes the anode. It should be noted that the electrode may be an inert electrode (such as Pt, graphite or Pt-coated Ti etc.) or it may be made of the same metal that is being deposited onto the substrate surface **108** (consumable electrode). When a cathodic voltage is applied to the substrate surface **108** metal deposits out of the plating solution **126** onto the substrate surface **108**. However, as mentioned above, as the process progresses, particles **130** may form on the sidewalls **118** of the channel **116**. In the process of the present invention, the above ECMD process may be repeated coating metal on certain number of substrate surfaces until the metal particle growth on the WSID becomes a problem. The rate at which particle growth occurs depends upon many factors, in particular how the plating is performed and the applied voltage used during plating in particular. Generally, however, after processing 10-100 wafers or typically after processing 20-50 wafers, undesired particles may start becoming a problem. Similarly, in an ECME process, particles can also attach to the WSID and become a problem. As previously mentioned, presence of such particles on or in close proximity of the surface of the WSID is undesirable because if they become loose and find their way to the WSID/substrate surface interface, they can cause scratches, inclusions, or other defects on the surface or they can actually cause scratches on the surface of the WSID, especially if the WSID has a non-flat profile. For example, when such particles grow beyond 0.5 micron size, it is advantageous to remove them or at least reduce their size using the teachings of the present invention.

[0047] It should be understood that ECMD, ECME, and other processes can occur in succession, and that any number of such processes can occur, with a conditioning step occurring thereafter, and then any number of such processes can occur again. For example, an ECMD process, followed by an ECME process, followed by an ECMD process is typical. It may then be desirable to perform conditioning of the WSID according to the present invention, and then resume with some number of processes, for instance another set of ECMD, ECME, and ECMD processes. Alternately, conditioning may be done after the ECMD process before the ECME process, etc.

[0048] As mentioned above, channels in a WSID may have different shapes and sizes. **FIG. 7B** exemplifies a WSID **500** having channels **502** that are shaped as slits, preferably substantially parallel slits, and a top surface **503** or a sweeping surface. Channels **502** may have side walls **504**. Channels allow an electrolyte, or another solution to flow between an electrode (not shown) and a front surface of a wafer **506** (shown in dotted lines) which may be rotated and also moved in lateral direction. In this example the top surface **503** of the WSID performs the sweeping action. As the ECMD or ECME process progresses, particles **508** may get attached on the side walls **504**. However, as can be seen in **FIG. 7C** in top view and in **FIG. 7D** in cross sectional view, a WSID **500**A may have a raised surface **510** which is smaller in comparison to the top surface **503**A of the WSID **500**A. In this embodiment the sweeping function is performed by the raised surface **510**. As in the previous case, as the ECMPR progresses, particles **508** may get attached on side walls **512** of the raised surfaces **510**. As will be described more fully below, such undesired particles are removed using the teachings of the present invention.

[0049] In the above examples, channel and raised surface side-walls are described as the main particle growth or presence sites. However, such unwanted particle may be on other locations of a WSID for example on the top surface of a WSID. **FIG. 7E** shows a WSID portion **600**. A top surface **602** of the WSID **600** may have various surface features **604** that may enhance mechanical sweeping of a wafer surface (not shown). Features **604** may comprise abrasive particles. As shown in **FIG. 7E**, particles may get attached or in some cases grow over various locations on the surface features as well, and the particles should be removed using the teachings of the present invention. As shown in **FIG. 7F**, during the process, portions **608** of the top surface **602** of the WSID may be fatigued and break loose, forming the particles **606**, and damage a wafer surface.

[0050] Therefore, a cleaning process according to the teachings of the present invention not only cleans such fatigued portions **608** after they are broken off the surface but also removes them safely once they are weakly attached to the top surface before they are broken off.

[0051] To that effect, in one embodiment, a conditioning substrate **132**, shown in **FIG. 8**, is coated with a conditioning conductor layer **134** and is substituted in place of the substrate **104**. This embodiment of the conditioning substrate **132** may perform the electrochemical cleaning of the WSID **106** to remove conductive particles. As will be described below an alternative embodiment of the conditioning substrate may have mechanical contact members so as to mechanically sweep the WSID **106** (see **FIG. 11A**) and remove both conductive and non-conductive particles. As will be described below mechanical contact members may mechanically dislodge the particles from the locations where they are accumulated. The surface **136** of the conditioning conductor layer **134** in **FIG. 8** is rendered anodic or more positive compared to the electrode **102** and an anodic current density of, for example 0.1-100 mA/cm2 and typically in the range of 1-20 mA/cm2 is applied. This anodic current may be passed for a period of time sufficient to reduce or eliminate such particles. This time period may typically be in the range of 2-10 seconds. The conditioning conductor is a material that does not get, or at least does not substantially get, anodized or etched or otherwise change its character in the plating solution under anodic conditions. It should also not shed any particles. It should, therefore, be preferably made of a hard coating. Inert nitrides of titanium (Ti), tungsten (W) and tantalum (Ta), or platinum (Pt) or Pt-containing alloys, or iridium (Ir) or Ir-containing alloys are good examples of such conditioning conductors for metal deposition processes that deposit common metals or metal alloys containing Cu, Ni, Co or the like. It is noted that this conditioning conductor does not need to have very low resistance like copper. A sheet resistance of 0.1-10 ohms per square is adequate although lower resistances can also be used. In this respect, the conditioning substrate **132** may be a semiconductor wafer coated with the conditioning conductor layer **134**. When an anodic voltage is applied to the conditioning conductor layer **134** on the conditioning substrate **132**, the metal particles on or near proximity of the WSID **106** also become anodic with respect to the electrode **102**. Preferably, during this process, the surface of the conditioning conductor layer makes physical contact to the surface of the WSID. As described above, the conditioning conductor layer **134** on the conditioning substrate **132** does not become substantially affected by the anodic voltage, however, the metal particles **130** become anodized and etched into the plating solution **124**. This etching process either causes the particles **130** to completely dissolve into the solution **124** or to become smaller in size, and thereby typically loosen from the sites on which they are located, such as side walls **118** to which they attach themselves, so that the flowing plating solution **124** can wash them out.

[0052] In another embodiment, a conditioning member may be used to mechanically dislodge particles of both natures, conductive or nonconductive. As shown in **FIG. 11A**, a conditioning member **200** is a plate, preferably disk shaped, having a front surface **202** and a back surface **204**. The front surface **202** may have mechanical contact members **206** to mechanically clean the WSID **106**. The mechanical contact members **206** may be brushes, wipers or the like. In this embodiment, two lines of brushes **206** are attached on the front surface **202** in a near-perpendicular array so that they cross each other at the center of the front surface **202**. As shown in **FIG. 11B**, in another embodiment, a conditioning member **200**A has a front surface **202**A and a back surface **204**A. In this embodiment, the front surface may comprise a plurality of mechanical contact members **206**A that are distributed across the front surface **202**A of the conditioning member **200**A. Other brush variations can also be used effectively.

[**0053**] Brushes **206** and the conditioning member **200** may be made of a conductive material or an insulator, depending upon whether conditioning that requires them to conduct is required, as explained herein. When the WSID needs to be cleaned, the conditioning member is placed on the wafer carrier, workpiece holder, or carrier head, and the conditioning member is lowered onto the WSID while being rotated or otherwise moved. As shown in **FIG. 12**, in operation, the mechanical action between the brushes **206** and the particles **130** dislodges the particles, whether conductive or non conductive, from the sites where they are located, such as side walls **118**. The plating solution flow is preferably kept on during this process to wash away any particles that may be dislodged. Although the conditioning member **200** can be used to mechanically clean the WSID, it can also be used for electrochemical cleaning as in the first embodiment above. In this case the conditioning member and the brushes **206** must be made of conductive materials or they must be coated with conductors that would not be anodized in the plating solution. An electrical contact **208** is slidably or otherwise connected to an edge portion of the back surface **204** so that an anodic potential can be applied to the conditioning member. Contact may also be made right at the edge or on the front surface. During the process, application of the potential allows conductive particles, which contact the conductive brushes, to be dissolved selectively electrochemically, while the mechanical action of the brushes removes both the conductive and non-conductive particles mechanically.

[**0054**] In the above embodiments, when a work piece is subsequently processed using the plating solution **124**, particles do not present a threat to the integrity of the film because the surface of the WSID is substantially free of particles. If copper is being deposited, for example, without the use of the conditioning process, particles can grow to more than 10 microns in size after running more than 20-50 wafers with WSID touching, with the location of these particles being concentrated along the edges of the channels. Particle size and the growth rate may vary depending on the charge used per substrate and the duration of the process per wafer. In general, a conditioning process may be carried out after processing some number of wafers, such as 10 to 50 wafers, although it is understood that the number of wafers to be processed prior to using the conditioning system requires a balance between the desired throughput and the concentration of undesired particles that can be tolerated.

[**0055**] In another embodiment of the present invention, elimination of particle accumulation and growth, or at least a reduction in the formation and/or growth of such particles, along the channels of the WSID **106** is achieved by controlling the rotation direction of a substrate or a wafer in the process from run to run. As shown in **FIG. 9**, in this embodiment, a first substrate **136** or a wafer is first rotated in a first direction **138** during the processing of the first substrate **136**. As shown in **FIG. 10**, during the processing of a second substrate **140** or a wafer, the substrate **140** is rotated in a second direction **142** that is directly opposite to the first direction **138**. This way, the particles **130**, conductive or non-conductive, which may start to accumulate along the first sidewall **118***a* of the channel **116** will loosen and be pushed into the channels during the processing cycle of the second substrate **140** without giving them chance to grow and deleteriously affect the quality of the coating on the substrates. This method has particular application to ECMD, although it can also be used with ECME.

[**0056**] The embodiments described above can also be used together to further reduce the presence of undesired particles.

[**0057**] As previously mentioned, the WSID may have different channel configurations and shapes. As shown in **FIGS. 13, 14** and **15**, in another embodiment, a conditioning device **249** comprising a brush member **250** may be incorporated into an electrochemical mechanical processing (ECMPR) system **300** having a WSID **400**.

[**0058**] **FIGS. 16-18** show an exemplary WSID **400** that can be cleaned or conditioned with the present invention, although any shape WSID, such as the one shown in **FIG. 7B** or **7**C, may be used as suitable. The WSID comprises a channel system **402** comprising recessed channel regions **404** and raised sweeping or polishing regions **406**. The channel system **402** may preferably be comprised of more than one channel, such as a first channel **408** and a second channel **410**, and more than one polishing region **406**. Each channel **408**, **410** is comprised of a closed end **412** and an open end **414**. Closed ends **412** form a center of the WSID **400**. The open ends **414** may also be shaped in other ways without adversely affecting the unique nature of the invention. Preferably, raised polishing regions **406** are comprised of a top surface **416** and a side wall **418**. The side wall **418** elevates the top surface from a surface **420** of the recessed region **404**. The top surfaces of the raised polishing regions are preferably formed in a coplanar fashion. The top surfaces **416**, which may be abrasive, sweeps the wafer surface during the processing, whether that is ECMD or ECME. The top surface may be textured such as shown in **FIG. 7E**. A number of holes **422** extend between a bottom surface of the WSID **400** and the recessed regions. Holes **422** within the channel regions are formed with a shape so that the inner and outer walls of the holes **422** correspond to the arc at a given radius from the center of the WSID, and are progressively smaller in size as they get closer to the center of the WSID, and are distributed on opposite sides from the center of the WSID in a staggered manner (hole lines up with space as shown) to ensure that the entire wafer will receive a uniform application of electrolyte.

[**0059**] Referring back to **FIG. 14**, the system **300** comprises a lower chamber **302**, an upper chamber **304** and a carrier head **305** holding the wafer. The lower chamber **302** is comprised of a chamber that includes an electro chemical mechanical processing (ECMPR) unit **306**. The ECMPR unit **306** comprises an electrode **308** and a WSID **400**. As mentioned before, during processing, an electrolyte solution **312** contacts the electrode **308** and flows onto and through the WSID **400**. Description of aspects of one such system can be found in U.S. Pat. No. 6,532,623 entitled "A Vertically Configured Chamber Used For Multiple Processes" which is commonly owned by the assignee of the present invention The conditioning device is also incorporated in the ECMPR unit **306**. The upper chamber **304** is separated from the lower chamber **302** by movable guards or flaps **314**. In this embodiment, the wafer is loaded in the upper chamber **304** and lowered into the lower chamber **302** for ECMPR. Once the ECMPR is over, the carrier head retaining the wafer is raised into the upper chamber **304** and the flaps **314** are closed. While the wafer is rinsed and dried in the upper chamber **304**, the WSID is conditioned in the lower chamber **302** using a brush member **250**.

[0060] Also referring to **FIG. 14**, the brush member **250** may be moved on the WSID **400** by a brush assembly **324** which enables the brush member **250** to move between a first end **326** of the WSID and a second end of the WSID **328**, in the directions of arrows A and B. The brush assembly is also a part of the conditioning device. The lateral movement of the brush member on the WSID surface mechanically cleans the surface from the conductive and non-conductive particles. The first position is home position of the brush member **250**, where the brush member is held when the conditioning process is over. Although the brush member **250** can be used to mechanically clean the WSID, it can also be used for electrochemical cleaning as in one embodiment above. In this case the brush member **250** must be made of conductive materials or it must be coated with conductors that would not be anodized in the plating solution. An electrical contact (not shown) may be connected to the brush member **250** so that an anodic potential can be applied to it. During the process, application of the potential allows conductive particles, which contact the conductive brushes, to be dissolved selectively electrochemically, while the mechanical action of the brushes removes both the conductive and non-conductive particles mechanically

[0061] As shown in **FIG. 15**, the brush member **250** is mechanically connected by connectors **330** to the belts **331** of the brush assembly **324**. A driving motor **332** moves the belts **331** simultaneously along the side of the processing unit **306**. The motor **332** moves the belts **331**, the connectors **330**, and hence the brush member **250** connected to them in the direction of arrows A and B. Belts **324** are connected to the motor **332** through a shaft **334** and wheels **336**. As mentioned above, the lower chamber **302** is separated from the upper chamber **304** by movable flaps **314**. The upper surface of the flaps **314** comprises cleaning and rinsing fluid nozzles **316**. In this embodiment, the cleaning and rinsing is performed in the upper chamber **304** while the cleaning and rinsing solution is delivered to the wafer surface through the nozzles **316**. Used solution leaves the system through a drain opening **320**. During the process the substrate carrier or carrier head **305** is rotated. Once the ECMPR process is over, the wafer is rinsed and dried in the upper chamber **304** while the WSID is conditioned at the lower chamber **302**. During the WSID conditioning, the brush assembly is brought into the operational position and moved across the WSID to sweep the WSID surface. As shown in **FIG. 15**, upon completion of the process, the brush assembly is moved back into its home position. Although a specific design is disclosed in **FIG. 15**, it should be understood that many different mechanisms can be used to move the brush members over the WSID to practice the conditioning invention disclosed here.

[0062] **FIGS. 19 and 20** illustrate a side view of yet another conditioning apparatus **700** that includes a carrier head **702** with brushes **704**, and a bottom view of the conditioning apparatus **700**. As illustrated, the brushes **704** are disposed around the periphery of the carrier head **702**. The brushes **704** provide for conditioning of the WSID **706** through mechanical movement, in the same manner as has been discussed previously. In this embodiment, however, ECMPR of the workpiece **708**, whether ECMD or ECME, and conditioning of the WSID **706** can occur at the same time, during the same process. In this particular situation, in order to condition the entire WSID **706**, the lateral movement the WSID **706** should preferably be equal or greater than the radius of the carrier head **702** so that the WSID portion it covers can effectively be cleaned.

[0063] While the present invention has been described herein with reference to particular embodiments thereof, a latitude of modification, various changes and substitutions are intended in the foregoing disclosure. It will thus be appreciated that in some instances some features of the invention will be employed without a corresponding use of other features without departing from the spirit and scope of the invention.

What is claimed is:

1. A processing apparatus for electrochemical mechanical processing of a workpiece using a solution comprising:

an electrochemical mechanical processing system adapted to operate on the workpiece, the system including an electrode, a holder adapted to hold the workpiece, a terminal adapted to make electrical contact with the workpiece, and a workpiece surface influencing device, wherein the electrochemical mechanical processing system is adapted to operate upon the workpiece using the solution, with the workpiece surface influencing device being disposed in proximity to the workpiece for a period of time during the electrochemical mechanical processing, the electrochemical mechanical processing also resulting in accumulation of particles onto the workpiece surface influencing device; and

a system adapted to operate on the workpiece surface influencing device and thereby result in one of the number of accumulated particles being reduced and the size of the accumulated particles being reduced.

2. The apparatus according to claim 1, wherein the system is attached to the holder and adapted to permit both the conditioning of the workpiece surface influencing device and the electrochemical mechanical processing on the workpiece to occur simultaneously.

3. The apparatus according the claim 1, wherein electrochemical mechanical processing comprises an electrochemical mechanical deposition process.

4. The apparatus according to claim 1, wherein electrochemical mechanical processing comprises an electrochemical mechanical polishing process.

5. The apparatus according to claim 1, wherein the system is adapted to condition the workpiece surface influencing device by at least one of electrochemically etching the accumulated particles and mechanically contacting the accumulated particles.

6. The apparatus according to claim 1, wherein the particles are conductive particles.

7. The apparatus according to claim 1, wherein the particles are non-conductive particles.

8. The apparatus according to claim 1, wherein the system includes a conditioning substrate with a plurality of brushes thereon, the plurality of brushes adapted to mechanically contact the workpiece surface influencing device.

9. The apparatus according to claim 8, wherein the conditioning substrate attaches to the holder upon removal of the workpiece from the holder.

10. The apparatus according to claim 1, wherein the system includes a conditioning conductor layer that will not anodize in the solution, and the conditioning conductor layer is adapted to be electrically connected to a potential difference that will cause the one of the number of accumulated particles to be reduced and the size of the accumulated particles to be reduced.

11. The apparatus according to claim 10, wherein the conditioning conductor layer attaches to the holder upon removal of the workpiece from the holder.

12. The apparatus according to claim 1, wherein the system and the electrochemical mechanical processing system are located within a lower chamber of a vertically configured chamber system, the vertically configured chamber system also including an upper chamber that includes a cleaning system that cleans the workpiece and a moveable guard adapted to separate the lower chamber from the upper chamber when the upper chamber is being used.

13. The apparatus according to claim 12, wherein the system includes a plurality of brushes attached to a conditioning substrate and a brush movement assembly, the brush movement assembly configured to move the plurality of brushes over the workpiece surface influencing device to operate on the workpiece surface influencing device.

14. The apparatus according to claim 13, wherein the system is adapted to operate on the workpiece surface influencing device at the same time the cleaning system is adapted to operate upon the workpiece.

15. The apparatus according to claim 13, wherein the plurality of brushes and the conditioning substrate have a conductive coating that will not anodize in the solution disposed within the lower chamber, the conditioning substrate adapted to be electrically connected to a potential difference that will cause the one of the number of accumulated particles to be reduced and the size of the accumulated particles to be reduced.

16. The apparatus according to claim 15, wherein the system is adapted to operate on the workpiece surface influencing device at the same time the cleaning system is adapted to operate upon the workpiece.

17. The apparatus according to claim 15, wherein the conductive coating is comprised of an inert conductor.

18. The apparatus according to claim 12, wherein the system includes a conditioning conductor layer that will not anodize in the solution disposed within the lower chamber, the conditioning conductor layer adapted to be electrically connected to a potential difference that will cause the one of the number of accumulated particles to be reduced and the size of the accumulated particles to be reduced.

19. The apparatus according to claim 18, wherein the conditioning conductor layer is comprised of an inert conductor.

20. The apparatus according to claim 12, wherein the system is adapted to operate on the workpiece surface influencing device at the same time the cleaning system is adapted to operate upon the workpiece.

21. The apparatus according to claim 1, wherein the electrochemical mechanical processing system is located within a lower chamber of a vertically configured chamber system, the vertically configured chamber system also including an upper chamber and a moveable guard adapted to separate the lower chamber from the upper chamber when the upper chamber is being used.

22. The apparatus according to claim 21, further including a cleaning system that cleans the workpiece disposed in the upper chamber.

23. The apparatus according to claim 21, wherein the holder is further adapted to hold the system when the holder is no longer holding the workpiece.

24. The apparatus according to claim 23, wherein the system includes a plurality of brushes attached to a conditioning substrate, the plurality of brushes configured for relative movement with the workpiece surface influencing device to condition the workpiece surface influencing device.

25. The apparatus according to claim 24, wherein the plurality of brushes and the conditioning substrate have a conductive coating that will not anodize in the solution disposed within the lower chamber, the conditioning substrate adapted to be electrically connected to a potential difference that will cause the one of the number of accumulated particles to be reduced and the size of the accumulated particles to be reduced.

26. The apparatus according to claim 25, wherein the conductive coating is comprised of an inert conductor.

27. The apparatus according to claim 26, wherein the system includes a conditioning conductor layer that will not anodize in the solution disposed within the lower chamber, the conditioning conductor layer adapted to be electrically connected to a potential difference that will cause the one of the number of accumulated particles to be reduced and the size of the accumulated particles to be reduced.

28. The apparatus according to claim 27, wherein the conditioning conductor layer is comprised of an inert conductor.

29. A system for processing a workpiece and removing particles on a workpiece surface influencing device, the workpiece surface influencing device being used in conjunction with a plating solution to process the workpiece, comprising:

a holder adapted to receive the workpiece and to move the workpiece proximate to the workpiece surface influencing device;

an apparatus adapted to deposit, via the plating solution, conductive material onto the workpiece using a first potential difference that is applied between an electrode and the workpiece with the workpiece surface influencing device in close proximity to the workpiece; and

a member having a conditioning conductor layer adapted to assist in removing at least a first portion of the particles that accumulate on the workpiece surface influencing device during the depositing of the conductive material using a second potential difference that is applied between the electrode and the conditioning conductor layer of the member, the second potential difference being of an opposite polarity to the first potential difference.

30. The system according to claim 29, wherein the member further comprises a mechanical contact member to

mechanically remove at least a second portion of the particles that accumulate on the workpiece surface influencing device.

31. The system according to claim 29, wherein the holder is further adapted to hold the member when the holder is no longer holding the workpiece.

32. A system for processing a workpiece and removing particles on a workpiece surface influencing device, the workpiece surface influencing device being used in conjunction with a plating solution to process the workpiece, comprising:

an apparatus adapted to deposit, via the plating solution and with the workpiece surface influencing device in close proximity to the workpiece, conductive material onto the workpiece in the presence of a first potential difference that is applied between an electrode and the workpiece;

a holder adapted to receive the workpiece, to move the workpiece in close proximity to the workpiece surface influencing device so that the depositing of the conductive material by the apparatus can take place, and to remove the workpiece from being in close proximity to the workpiece surface influencing device upon completion of the depositing by the apparatus; and

a member having at least one mechanical contact member and adapted to move against a top surface of the workpiece surface influencing device so that at least a portion of the particles that accumulate on the workpiece surface influencing device during the depositing of the conductive material are mechanically removed from the workpiece surface influencing device.

33. The system according to claim 32, wherein the apparatus is further adapted to remove at least a second portion of the particles that accumulate on the workpiece surface influencing device during the depositing of the conductive material, and the at least one mechanical contact layer being comprised of an inert conductor so that the at least one mechanical contact layer conductor will not anodize in the plating solution.

34. The apparatus according to claim 32, wherein the holder is further adapted to hold the member when the holder is no longer holding the workpiece.

35. A system for processing a workpiece and removing particles on a workpiece surface influencing device, the workpiece surface influencing device being used in conjunction with a plating solution to process the workpiece, comprising:

a deposition apparatus positioned in a lower chamber for depositing conductive material from the plating solution onto the workpiece with the workpiece surface influencing device in close proximity to the workpiece; and

a member adapted to be positioned in the lower chamber and to remove at least a portion of the particles that accumulate on the workpiece surface influencing device during the depositing of the conductive material by the deposition apparatus; and

a holder adapted to position the workpiece in the lower chamber while the deposition apparatus is being used.

36. The system according to claim 35, further comprising a cleaning system disposed in the upper chamber and wherein the upper and lower chamber are capable of being separated using a moveable guard.

37. The system according to claim 35, wherein the member is adapted for relative movement with the workpiece surface influencing device so that the conductive particles are mechanically removed from the workpiece surface influencing device.

38. The system according to claim 35, wherein the member is adapted to apply a potential difference between the member and the workpiece surface influencing device to assist in removing the particles from the workpiece surface influencing device.

39. The system according to claim 35, wherein the holder is adapted to rotate about a first axis.

40. The system according to claim 39, wherein the holder is further adapted to move side to side within the lower chamber.

41. The system according to claim 35, wherein the deposition apparatus comprises an electrochemical mechanical deposition apparatus.

42. The system according to claim 35, wherein the member comprises a brush member.

43. The system according to claim 42, further comprising a brush assembly that moves the brush member connected thereto in a lateral direction and wherein the brush assembly is disposed in the lower chamber.

44. The apparatus according to claim 43 wherein the member is adapted to operate on the workpiece surface influencing device at the same time another system is operating upon the workpiece in the upper chamber.

45. The system according to claim 44, wherein the brush assembly comprises a drive apparatus that moves the brush member in the lateral direction.

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