PLANARIZATION OF METAL CONTAINER SRUCTURES

FIELD OF THE INVENTION

The present invention relates generally to the fabrication of semiconductive devices, and more particularly, to a method of forming conductive material in an opening in a semiconductive device. The invention also relates to the structures formed according to the various embodiments of the method herein set forth.

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BACKGROUND OF THE INVENTION

In the fabrication of integrated circuits, various layers, e.g. conductive layers and insulative layers, are formed. For example, during the formation of semiconductive devices, such as dynamic random access memories (DRAMs), insulating layers are used to electrically separate conductive layers such as doped polycrystalline silicon, aluminum, metal silicides, etc. It is often required that the conductive layers be interconnected through holes or openings in the insulating layers. Such openings are commonly referred to as contact holes, e.g. when the opening extends through an insulating layer to an active area, or vias, e.g. when the opening extends through an insulating layer between two conductive layers. The profile of an opening is of particular importance such that specific characteristics can be achieved when a contact hole or via is provided and then filled with one or more conductive materials.

Conductive materials are also formed in openings when providing certain storage cell capacitors for use in semiconductive devices, e.g. DRAMs. Storage capacity and size are important characteristics of a storage cell. Generally, a storage cell

is formed with a dielectric constant material interposed between two conductive electrodes. One or more layers of various conductive materials may be used as the electrode material.

Container-type cell capacitor structures generally include the formation of an insulative layer over existing topography which has been formed over a substrate, and then openings are etched into the insulative layer. These openings allow access to the underlying topography, e.g. for a cell capacitor, which may include conductive regions, e.g. conductive plugs, active substrate regions, etc. Thereafter, a conductive layer to be used for forming the bottom electrode of the cell capacitor is formed within the openings, and may also be formed on the upper surface of the insulative layer as well. A layer of oxide material may then be used to fill the opening over the conductive material. Thereafter, this oxide material is removed to expose the layer of conductive material. The exposed layers of conductive material which are outside of the opening, e.g. which are over the top surface of the insulative layer, are then removed to separate neighboring conductive openings, thereby forming individual containers with exposed insulative material between them. Next, the oxide material still filling the conductive opening is removed, leaving the opening lined with a bottom electrode for use in forming the container-type cell capacitor.

Storage capacity and size are important characteristics in a storage cell. One way to retain the storage capacity of a device and decrease its size is to increase the dielectric constant of the dielectric layer of the storage cell capacitor. Therefore, preferably a high dielectric constant material is utilized in applications interposed between two electrodes. Many conductive metals such as platinum, rhodium, iridium, osmium, as well as other Group VIII metals, and other transition element metals, e.g.

copper, silver and gold, and Group IIIa and IVa metals, e.g. aluminum, and their alloys are desirable electrode materials for such high dielectric constant capacitors.

However, many of the foregoing metals, e.g. Group VIII metals such as platinum or platinum alloys such as platinum-rhodium, are not easily planarized. An illustrative planarization problem is shown in Figure 1A. Figure 1A shows a cross-sectional portion of a semiconductive device 10. An insulative layer 12 is formed over a substrate 11. An opening 15 is formed in the insulative layer 12 which stops on the surface of the substrate 11. To form a lower electrode or bottom electrode of a capacitor-type structure, a metal layer 20 is formed over the insulative layer and as a lining in opening 15. Thereafter, a photoresist layer 25 is formed over the metal layer 20 to completely fill the opening 15. Upon planarization, the upper portion of photoresist layer 25 is removed along with the portion of the metal layer 20 which is outside of the opening 15, resulting in the non-dashed lining portion 30. However, as shown in Figure 1A, the metal is often deformed or smeared at the upper region or edge of the opening 15. The metal material is pushed into the center of the container opening 15 as represented by projection 35 during the planarization process. Such deformation of the metal in the container opening 15 produces an undesirable profile and is further problematic in removing the resist material 25 from within the opening 15.

As shown in Figure 1B, a further problem associated with the use of a metal is shown wherein the metal layer 20 is not planarized, but instead is etched. However, upon wet etching the metal layer 20 back to the insulative layer 12, the photoresist layer 25 is pulled back away from the metal layer, thereby allowing for undesirable removal of portions of the metal layer as shown by the undesirably etched regions 40 in Figure 1B.

Thus, there exists a need in the art for a new method of forming conductive material in openings in semiconductive devices. There is also a need for better structures containing conductive material formed therein.

SUMMARY OF THE INVENTION

In accordance with the invention, there is set forth a method of providing a conductive material in an opening. The process involves first forming a conductive material in the opening and over at least a portion of the insulative material which is outside of the opening. Next, a metal-containing fill material is formed over at least a portion of the conductive material such that at least some of the metal-containing material is located in the opening. At least a portion of the conductive material outside of the opening is then removed. Thereafter, at least a portion of the metal-containing fill material which is inside the opening is then removed.

The invention further provides a method of forming a bottom electrode of a capacitor. A second conductive material is provided within an opening in contact the first conductive material. The second conductive material is also provided over at least a portion of an insulative material which is outside of the opening. Next, a metal-containing fill material is provided over at least a portion of the conductive material which is inside the opening and which is over the insulative layer as well. At least a portion of the metal-containing fill material which is inside the opening is next removed and the second conductive material thereby forms the bottom electrode of a capacitor.

Also included is a method of providing a conductive material in an opening which has been provided in an insulative material over a substrate, wherein the opening

contacts a surface portion of the substrate. First, a conductive material is deposited over at least a portion of the inside of the opening and over at least a portion of the surface of the insulative material which is outside the opening. Next, a tungsten-containing fill material is deposited over at least a portion of the conductive material which is over the surface portion of the substrate and which is over the insulative material outside of the opening. At that point, the tungsten material at least partially fills the opening. At least a portion of the tungsten-containing fill material and the conductive material which is over the insulative material outside the opening is then removed. The removal is effected by planarization. Next, at least a portion of the tungsten-containing fill material is removed from the opening.

According to another aspect of the invention, a structure comprises a substrate with an insulative material over the substrate. There is also a conductive material formed over at least a portion of the surface of the opening and over at least a portion of the insulative material which is outside the opening. A tungsten-containing fill material is formed over at least a portion of the conductive material which is inside the opening and which is over the insulative material outside the opening, such that the tungsten-containing fill material at least partially fills the opening.

Another structure of the invention also contains a substrate and an insulative material over the substrate. A conductive material is formed over substantially all of the inside surface of the opening. A tungsten-containing fill material is formed over the conductive material and substantially fills the opening. The conductive material and the tungsten-containing material are substantially co-planar at the top of the opening.

A further method of the invention is useful in forming a bottom electrode of a capacitor and a bit line conductive plug in a semiconductive device. A first opening is

provided through the surface of an insulative material provided over a substrate in the device, such that at least a portion of the opening contacts a first conductive material. A second conductive material is then provided over at least a portion of the surface of the opening which is in contact with the first conductive material, as well as over at least a portion of the surface of the insulative material which is outside the opening. A protective layer is next provided over the second conductive material. A second opening is then provided through the protective layer and through the second conductive material which is over the insulative material, as well as through the insulative material. At least a portion of the second opening contacts a third conductive material. The protective layer is then removed. A metal-containing fill material is next provided over the second conductive material which is inside the first opening and which is over the insulative material outside of the opening.

The metal-containing fill material is further provided over the second opening such that the metal-containing fill material at least partially fills both the first and second openings. A bit line conductive plug is thereby formed in the second opening. Next, at least a portion of the metal-containing fill material and the conductive material which is over the insulative material outside of both openings is removed. Thereafter, at least a portion of the metal-containing fill material from the first opening is removed so as to form the bottom electrode of the capacitor.

The invention also provides a method of planarizing a conductive material formed over an opening without substantially deforming the material. The conductive material is contacted with a metal-containing fill material such that the fill material is over the conductive material and at least partially fills the opening. The conductive material and the metal-containing fill material are then planarized such that a top

portion of the conductive material and the fill material are substantially co-planar with a top portion of the opening.

Additional advantages and features of the present invention will become more readily apparent from the following detailed description and drawings which illustrate various exemplary embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A and 1B illustrate problems associated with planarizing conductive metal devices.

Figure 2A is a cross-sectional view of a semiconductive device in an intermediate stage of fabrication.

Figure 2B is a cross-sectional view of the device shown in Figure 2A in a further stage of fabrication.

Figure 2C is a cross-sectional view of the device shown in Figure 2B in a further stage of fabrication.

Figure 2D is also a cross-sectional view of device shown in Figure 2B in a further stage of fabrication.

Figure 2E is a cross-sectional view of the device shown in Figure 2C in a further stage of fabrication.

Figure 2F is a cross-sectional view of the device shown in Figure 2F in a further stage of fabrication.

Figure 3A is a cross-sectional view of a further embodiment of a semiconductive device in an intermediate stage of fabrication.

Figure 3B is a cross sectional view of the device shown in Figure 3A in a further stage of fabrication.

Figure 3C is a cross sectional view of the device shown in Figure 3B in a further stage of fabrication.

Figure 3D is a cross sectional view of the device shown in Figure 3C in a further stage of fabrication.

Figure 4A is a cross-sectional view of a further embodiment of a semiconductive device in an intermediate stage of fabrication.

Figure 4B is a cross sectional view of the device shown in Figure 4A in a further stage of fabrication.

Figure 4C is a cross sectional view of the device shown in Figure 4B in a further stage of fabrication.

Figure 4D is a cross sectional view of the device shown in Figure 4C in a further stage of fabrication.

Figure 5A is a cross-sectional view o a further embodiment of a semiconductive device in an intermediate stage of fabrication.

Figure 5B is a cross sectional view of the device shown in Figure 5A in a further stage of fabrication.

Figure 5C is a cross sectional view of the device shown in Figure 5B in a further stage of fabrication.

Figure 5D is a cross sectional view of the device shown in Figure 5C in a further stage of fabrication.

Figure 5E is a cross sectional view of the device shown in Figure 5D in a further stage of fabrication.

Figure 5F is a cross sectional view of the device shown in Figure 5E in a further stage of fabrication.

Figure 5G is a cross sectional view of the device shown in Figure 5F in a further stage of fabrication.

Figure 6 is a block diagram of a processor-based system which includes integrated circuits that utilize the structures constructed in accordance with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The invention in its broadest embodiment is directed to a method of providing a conductive material in an opening in a semiconductive device, and to the structures formed therefrom.

Reference herein shall be made to the terms "substrate" and "wafer", which are to be understood as including silicon, a silicon-on-insulator (SOI) or silicon-on-sapphire (SOS) structures, doped and undoped semiconductives, epitaxial layers of silicon supported by a base semiconductive foundation, and other semiconductive structures. In addition, when reference is made to a "substrate" or "wafer" in the following description, previous process steps may have been utilized to form arrays, regions or junctions in or over the base semiconductive structure or foundation. In addition, the semiconductive material need not be silicon-based, but could be based on silicon-germanium, germanium, indium phosphide, or gallium arsenide. The term "substrate" as used herein may also refer to any type of generic base or foundation structure.

Referring again to the drawings, Figure 2A illustrates a semiconductive device 200 in an intermediate stage of fabrication. Shown is a substrate 212 and a layer 214 of material, preferably insulative material such as, for example, silicon dioxide or Boro-Phospho-Silicate Glass (BPSG), formed over the substrate 212. The layer 214 has a top surface 215. An opening 216 is formed in the layer 214 using methods known in the art, for example, wet and/or dry etching. The opening 216 can represent a contact opening or via, or even a trench or recess, and may or may not extend to the substrate surface (as represented by the dotted lines 217). The opening 216 includes a bottom surface 218 and side walls 220. Preferably, the bottom surface 218 is a generally horizontal surface from which the side walls 220 extend. The side walls 220 may be substantially orthogonal to the bottom surface 218, as shown in Figure 2A, or they may be of another desired angle or shape, depending upon the particular environment of use for the opening. Moreover, the opening 216 defined by bottom surface 218 and side walls 220 can be any shape suitable to the needs of the skilled artisan, including a generally cylindrical shape.

Referring now to Figure 2B, one illustrative method of forming a conductive material in the opening 216 is described. A conductive material 222 is formed over the surfaces 218, 220 which define the opening 216. The conductive material is formed over at least a portion of the surfaces 218, 220, and more desirably is formed over a majority or even substantially all of the inside surfaces 218, 220. The conductive material 222 is shown as a substantially conformal, single layer of material in Figure 2B, but those skilled in the art will recognize that the conductive material 222 may or may not be conformal, and may also be comprised of two or more layers. The conductive material 222 is desirably made up of one or more Group VIII metals, together with their alloys and composites, and thus can include platinum, palladium, ruthenium,

iridium, osmium and rhodium, and such alloys as platinum-rhodium. Platinum is the preferred conductive material 222 for use in the method of the invention. Other suitable conductive materials include other transition element metals, e.g. gold, copper and silver, as well as the Group IIIa and IVa metals, e.g. aluminum, together with their alloys and composites.

The conductive material 212 may be formed in the opening 216 using any suitable method, such as sputtering, chemical vapor deposition (CVD) or low pressure chemical vapor deposition (LPCVD), physical vapor deposition (PVD), electroplating and electroless plating. Preferably, the conductive material 222 is formed to a thickness within the range of a few Angstroms to several hundred Angstroms, which can vary according to the needs of the skilled artisan.

As further shown in Figure 2B, the conductive material 222 preferably extends outside of the contact opening 216 and over the top surface 215 of the layer 214. The conductive material 222 is preferably formed over substantially the entire surface of the layer 214 as shown in Figure 2B, or may be formed over any fraction thereof and subsequently etched back. Also shown in Figure 2B are upper edges 223a and 223b of the conductive material 222. The upper edges 223a, 223b extend above the plane formed by the upper surface 215 of the layer 214, and they are bounded by the respective planes of the vertical lines extending upwards from the sidewalls 220 of the opening 216.

Referring now to Figures 2C and 2D, after forming the conductive material 222, a fill material 224 is next deposited over the conductive material 222. The fill material 224 may be any suitable material which will protect the conductive material 222 from substantially deforming or smearing during a planarization step, hereinafter described. The fill material 224 should also be one which is itself capable of ultimate

removal and/or planarization. The fill material 224 should also be substantially harder than the conductive material 222, and even more preferably, should be substantially harder than typical photoresist materials used in the semiconductive industry. Preferably, the fill material 224 is comprised substantially of a hard metal, and more desirably, a tungsten-containing metal, which can therefore include tungsten, tungsten alloys, tungsten composites as well as tungsten compounds. For example, tungsten nitride (WN_x) is one tungsten compound highly suitable as a fill material 224. The fill material 224 may be deposited using suitable deposition techniques such as CVD or LPCVD, using WF_6 and silane (SiH_4), for examples, as reactants. Other suitable fill material can include titanium-containing metals, which can include titanium, titanium alloys, titanium composites as well as titanium compounds such as, for example, titanium nitride (TiN).

Preferably, the fill material 224 extends into at least a portion of the opening 216 as shown in Figure 2D, or substantially fills the opening 216 as illustrated in Figure 2C. More preferably, the fill material 224 will substantially cover, or be substantially co-extensive with, the upper edges 223a, 223b of the conductive material 222. This particular embodiment is illustrated in both Figures 2C and 2D. Even more desirably, the fill material 224 will be substantially co-extensive with the conductive material 222 over the top surface 215 of the insulative layer 214. The fill material 224 will be distributed to have a thickness that is typically within the range of a few hundred Angstroms to several thousand Angstroms.

Referring now to Figure 2E, the portions of the conductive material 222 and the fill material 224 which are outside of the opening 216 and which are over the top surface 215 of the layer 214 are next removed from the device 210. Preferably, removal is effected using a planarization technique which in general refers to the

mechanical removal of material at a surface, and typically involves a flattening and polishing process used during semiconductive wafer fabrication. For example, such planarization may include chemical mechanical planarization (CMP), chemical mechanical polishing, planarization using pads and abrasive slurries, planarization using fixed abrasive pads- either alone or in combination with slurries or other fluid compositions. Planarization is used to remove surface material for providing a flattening of surfaces of a wafer during the wafer fabrication process. The preferred method of removal is CMP. The removal or planarization process may also involve any number of actual process steps, e.g. repeated planarization for several periods of time, alternated by cleaning steps, etc.

As shown in Figure 2E, the fill material 224 functions to support and protect the underlying conductive material 222 during the removal/planarization step so that the conductive material 222 is substantially prevented from being smeared, scratched and pushed out of shape, e.g. caused to form the undesirable overhang into the opening 216, as was illustrated in Figure 1A. Thus, the conductive material 222 remains substantially undeformed. After planarization is completed, the segments of the conductive material 222 and the overlying fill material 224 which were above the top surface 215 of the layer 214 are substantially all removed. Thus, in a preferred embodiment, the conductive material 222 at the top of the respective sidewalls 220 is substantially coplanar with the top surface 215 of the layer 214. In another preferred embodiment, the fill material left inside the opening 216 is also substantially co-planar with the top surface 215 of the layer 214.

Thereafter, as shown in Figure 2F, substantially all of the remaining portion of the fill material 224 which is inside the opening 216 is removed from the device. Any method of removing the fill material may be utilized in the present invention.

Preferably, a wet etch or dry etch process, or a combination thereof may be utilized to remove the fill material. If the fill material 224 is made up of the preferred tungsten or tungsten-containing material, e.g. tungsten nitride, then stripping in piranha can be used to remove this tungsten material from inside the opening 216. As a result of the removal step in Figure 2F, the conductive material 222 is left intact inside the opening 216, substantially without being smeared or overhanging into the opening 216. Preferably, a conformal layer of conductive material 222 is left over the sidewalls 220 and the bottom surface 218 of the opening 216 as shown in Figure 2F. The top surfaces of the side walls are still desirably substantially co-planar with the top surface 215 of the layer 214. The device 200 is now ready for further processing as desired by the person skilled in the art.

Referring now to Figure 3A, there is shown an additional embodiment of the invention in another environment. A portion of a semiconductive device structure 300 is fabricated in accordance with conventional processing techniques through the formation of a contact opening 302 prior to metallization of the exposed contact area 304 of the surface portion 305 of the substrate 307. The contact opening 302 may be formed through layer 308, which is preferably a layer of insulative material such as BPSG or other suitable material, using suitable etching techniques, such as wet etching with hydrogen fluoride (HF) for example. Layer 308 has a top surface portion 309. Also shown are gate stack transistors 321 and 322 which each may alternately function as a word line or field effect transistor. The sides of the gate stack 321, 322 may be used to align the opening 302 to the substrate 307, and therefore the opening may be described as a self-aligned contact (SAC) opening. The device 300 further includes a field oxide region 325 formed in the substrate. Suitably doped source/drain regions 330 and 335 are formed in the substrate 307 between the gate stack transistors

according to processes available to the skilled artisan. The opening 302 in Figure 3A is further shown with side walls 340.

With reference now to Figure 3B, a conductive material 350 is deposited inside the opening 302 in the manner as heretofore described. As previously set forth, the conductive material is preferably a transition element metal, e.g. a Group VIII material, and more desirably is platinum, a platinum compound or a platinum alloy, but other conductive material metals as previously mentioned may also be utilized. The conductive material is formed over the sidewalls 340 of the layer 308, as well as over the sides of the gate stacks 321 and 322, and over the exposed portion 304 of the top surface 305 of the substrate 307. Preferably, the conductive material substantially covers the top surface portion 309 of the insulative layer 308. Further shown in Figure 3B is a fill material 360 which is next deposited over the conductive material 350, again as previously described. The fill material 360 is desirably tungsten or a tungsten compound such as tungsten nitride, or any other suitable material which is harder than the underlying conductive material 350, and can thus include titanium and titanium compounds such as titanium nitride. As shown in Figure 3B, the fill material preferably substantially covers the top edge portions 375 of the conductive material 350. Even more preferably, the fill material 360 is substantially co-extensive with the conductive material 350 over the top surface 309 of the layer 308.

As now shown in Figure 3C, the portions of the conductive material 350 and the overlying fill material 360 outside of the contact opening 302 are then removed, preferably by one or more planarization techniques as described above. As a result, the top portions of the conductive material 350 are desirably substantially coplanar with the top surface 309 of the layer 308.

In Figure 3D the fill material 360 is now removed from the inside of the contact opening 302. It is desirable that substantially all of the fill material 360 be removed from the device 300 using a technique such as etching, etc., as heretofore described. The device shown in Figure 3D is now ready for further fabrication according to the needs of the skilled artisan, including further metallization or additional deposition of other conductive materials inside contact opening 302 over conductive material 350. As shown in Figure 3D, the top portions of the conductive material 350 are still preferably substantially coplanar with the top surface 309 of the layer 308, and are not substantially deformed, bent or overhanging into the opening 302.

Referring now to Figure 4A, there is set forth a further embodiment of the invention. A semiconductive device 400 is shown fabricated using conventional processing techniques through the formation of an opening 402. Such processing is performed prior to depositing a bottom electrode structure on the surfaces defining the opening 402 using one of the methods described in accordance with the present invention. The device 400 includes field oxide region 425 formed in substrate 407, as well as source and drain regions 430, 435 which may be suitably doped. Also shown are gate stack transistors 421 and 422, which each may alternately function as a word line or field effect transistor. A first layer 440 of an insulative material, e.g. BPSG, has been formed over the substrate 407 of the structure 400. A plug 445 of electrically conductive material, e.g. polysilicon, has been formed in an opening 447 provided in layer 440 to provide electrical communication between a top surface 448 of the active source/drain region 430 of the substrate 407 and a storage cell capacitor to be later formed thereover. One or more barrier layers may be formed over the polysilicon plug 445, including layers 449a and 449b as shown in Figure 4A. For example, one or

more of the barrier layers may be comprised of such compounds as titanium nitride, tungsten nitride, titanium silicide, or any other metal nitride or metal silicide layer which can function as a barrier layer. A second insulative layer 443 is formed over the first insulative layer 440. The opening 402 is defined in the second layer 443 using available methods such as etching.

With reference now to Figure 4B, a conductive material 450 is deposited inside the opening 402 in the manner as heretofore described. As previously set forth, the conductive material is preferably a transition element metal or a Group IIIa or IVa metal, and more desirably is a Group VIII material, including platinum, platinum compounds and platinum alloys. The conductive material is formed over the sidewalls 457 of the layer 443, and over the bottom portion 458 of the opening 402. Even more preferably the conductive material 450 extends over the top surface 459 of the insulative layer 443.

Further shown in Figure 4B is a fill material 465 which is next deposited over the conductive material 450, again as previously described. The fill material 465 is desirably tungsten or a tungsten compound such as tungsten nitride, or any other suitable material which is harder than the underlying conductive material 450. Desirably, the fill material 465 substantially covers, e.g. is co-extensive with the top corner segments 475 of the conductive material. More desirably, the fill material is substantially co-extensive with the conductive material which is formed on the top surface 459 of the layer 443.

As shown in Figure 4C, the portions of the conductive material 450 and the overlying fill material 465 outside of the contact opening 402 are now removed, preferably by one or more planarization techniques as described above. As a result, the

top portions of the conductive material 450 are desirably substantially coplanar with the top surface 459 of the layer 443.

In Figure 4D the fill material 465 is removed from the inside of the contact opening 402. It is desirable that substantially all of the fill material 465 be removed from the device 400 using a technique such as etching, etc., as heretofore described. The conductive material 450 thus functions as a capacitor bottom electrode as shown in Figure 4D. A dielectric material layer 470 is formed over the bottom electrode 450 using a process known in the art. For example, the dielectric layer may be any material having a suitable dielectric constant such as $Ba_xSr_{(1-x)}TiO_3$ [BST], $BaTiO_3$, $SrTiO_3$, $PbTiO_3$, Pb(Zr,Ti)O_3 [PZT], (Pb,La)(Zr,Ti)O_3 [PLZT], (Pb,La)TiO_3 [PLT], KNO_3, Al_2O_3, Si_3N_4, SiO_2, Ta_2O_5, TiO_2, ZrO_2, HfO_2 and $LiNbO_3$, among others. Thereafter, a second or top electrode 475 is formed over the dielectric material 470. In one embodiment of the invention, the second electrode 475 may also be formed of a Group VIII metal, preferably platinum or a platinum alloy, as well as other conductive material metals as heretofore described. It will be recognized by one skilled in the art, however, that either one or both of the electrodes may be formed of any conductive material generally used for capacitor electrode structures. It is also within the scope of the invention that each electrode be one of several layers forming an electrode stack. The structure in Figure 4D can thus function as a typical storage capacitor.

Referring now to Figure 5A, there is shown another embodiment of the present invention. According to this embodiment, it is possible to fabricate a bit line conductive plug. A semiconductive device 500 is shown fabricated using conventional processing techniques through the formation of openings 502 and 504 over the substrate 507. The device 500 includes field oxide regions 508. Also shown are gate stack transistors 509, which each may alternately function as a word line or field effect

transistor. The device 500 further includes suitably doped source/drain regions 510 which are formed in the substrate 507 according to processes available to the skilled artisan. A first layer 512 of an insulative material, e.g. BPSG, has been formed over the substrate 507. A first conductive plug 514 has been formed in an opening provided in layer 512 to provide electrical communication between the source/drain region 510 in the substrate 507 and a bit line conductive plug to be later formed thereover.

The first conductive plug 514 may be formed of a suitably conductive material, such as polysilicon for example. Second and third conductive plugs 516, 518 have also been formed in openings provided in layer 512 to provide electrical communication between the source/drain regions 510 and a storage cell capacitor which may formed thereover. The second and third conductive plugs are also formed of suitably conductive material which may be the same or different, but is preferably polysilicon. One or more barrier layers 520, 522 have been formed over the second and third conductive plugs 516, 518. As set forth above, the barrier layer(s) may be formed from such compounds as titanium nitride, tungsten nitride, titanium silicide, or any other metal nitride or metal silicide layer. Thereafter, a second insulative layer 525 is formed with openings 502, 504 defined therein according to methods known in the art. Openings 502, 504 are preferably contact openings which are formed using available etching, e.g. wet or dry etching, techniques.

With reference now to Figure 5B, a conductive material 530 is deposited inside the openings 502, 504 in the manner as heretofore described. As previously set forth, the conductive material is preferably a Group VIII material, and more desirably is platinum or a platinum alloy, but other transition element metals (e.g., copper, silver and gold), as well as Group IIIa and IVa metals, e.g. aluminum, may also be utilized. The conductive material is formed over the sidewalls 532 inside of the openings 502,

504 in the insulative layer 525, and over the bottom portions 534 of the openings. The conductive material is also preferably formed over the top surface 536 of the layer 525.

Further shown in Figure 5C is a protective layer 540 which is next deposited over the structure 500, including the conductive material 530, using available techniques. Preferably, the protective layer 540 is a photoresist layer. The protective layer 540 is used to pattern an opening in the insulative layer 525 which will serve as the contact opening 542 with the polysilicon plug 514 for the bit line conductive plug to be subsequently formed. The contact opening 542 is then etched using suitable etching techniques, for example, a dry etch using CF_4, CHF_3 and argon gases. In Figure 5B, the etch stop is the top surface of the polysilicon plug 514.

Thereafter, as shown in Figure 5D, the protective layer 540, e.g. the photoresist layer, is removed. Next, fill material 545 is deposited over the structure 500 as heretofore described. The fill material is desirably a hard metal, metal alloy or metal compound, such as tungsten or a tungsten compound like tungsten nitride, or any other suitable material which is harder than the underlying conductive material 530. If desired, the fill material deposition step may be preceded by a titanium or titanium nitride deposition step in the contact opening 542. The titanium material will coat the inside of the contact opening 542 to improve the adhesion of metal within the insulative layer 525. The titanium material may be deposited using a CVD process, for example.

As next shown in Figure 5E, the portions of the conductive material 530 and the overlying fill material 545 outside of the contact openings 502, 504, 542 are then removed, preferably by one or more planarization techniques, e.g. CMP, as described above. The metal-containing fill material 545 functions to protect the

conductive material from spreading or smearing into the contact openings 502, 504. As a result of planarization, the top portions of the conductive material 530 are desirably substantially coplanar with the top surface 536 of the insulative layer 525. In addition, the top portion of the fill material 545 inside the contact openings 502, 504, and 542 is also preferably substantially co-planar with the top surface 536 of the layer 525.

Referring now to Figures 5F and 5G, the fill material inside contact opening 542 now forms a bit line conductive plug 545a in contact with the conductive polysilicon plug 514. Next, a protective cap 555 is deposited over the bit line conductive plug 545a. The protective cap is desirably formed from a substantially non-conductive material such as an oxide. Thereafter as shown in Figure 5G, the fill material 545 is removed from the inside of the contact openings 502, 504. It is desirable that substantially all of the fill material 545 be removed from the contact openings 502, 504 using a technique such as etching, etc., as heretofore described. The conductive material 530 can thus function as a capacitor bottom electrode as was illustrated in Figures 4A through 4D.

Due at least in part to their improved electrical characteristics, the structures herein described have wide applicability in the semiconductor industry. A typical processor system which includes integrated circuits that utilize one or more of the structures formed in accordance with the present invention is illustrated generally at 600 in Fig. 6. A processor system, such as a computer system, for example, generally comprises a central processing unit (CPU) 610, for example, a microprocessor, that communicates with one or more input/output (I/O) devices 640, and a hard drive 650 over a bus system 670 which may include one or more busses and/or bus bridges. The computer system 600 also includes a hard disk drive 620, a floppy disk drive 630,

a random access memory (RAM) 660, a read only memory (ROM) 680 and, in the case of a computer system may include other peripheral devices such as a compact disk (CD) ROM drive 630 which also communicate with CPU 610 over the bus 670. The invention may be used in one or more of the processor, RAM and ROM, or a chip containing a processor and on board memory. While Fig. 6 shows one exemplary computer system architecture, many others are also possible.

The foregoing description is illustrative of exemplary embodiments which achieve the objects, features and advantages of the present invention. It should be apparent that many changes, modifications, substitutions may be made to the described embodiments without departing from the spirit or scope of the invention. The invention is not to be considered as limited by the foregoing description or embodiments, but is only limited by the scope of the appended claims.

What is claimed is:

CLAIMS:

1. A method of providing a conductive material in an opening, comprising:

forming said conductive material in said opening and over at least a portion of an insulative material outside of said opening;

forming a metal-containing fill material over at least a portion of said conductive material such that at least some of said metal-containing fill material is located in said opening;

removing at least a portion of said conductive material which is over said insulative material outside of said opening; and

removing at least a portion of said metal-containing fill material from said opening.

2. The method of claim 1, wherein said metal-containing fill material is harder than said conductive material.

3. The method of claim 2, wherein said metal-containing fill material is a tungsten-containing fill material.

4. The method of claim 3, wherein said tungsten-containing fill material is tungster or tungsten nitride.

5. The method of claim 2, wherein said metal-containing fill material is a titanium-containing fill material.

6. The method of claim 5, wherein said titanium-containing fill material is titanium nitride.

7. The method of claim 1, wherein said removing is performed by planarization.

8. The method of claim 7, wherein said removing is performed by chemical mechanical planarization.

9. The method of claim 1, wherein said forming of said conductive material is performed over a majority of the surface of said opening.

10. The method of claim 1, wherein said forming of said conductive material is performed over substantially all of the surface of said opening.

11. The method of claim 1, wherein said forming of said metal-containing fill material is performed over substantially all of said conductive material.

12. The method of claim 11, wherein said conductive material has a top edge portion once formed over said insulative material, and said forming of said metal-containing fill material is performed so as to substantially cover said top edge portion.

13. The method of claim 1, whereupon after said removal of said metal-containing fill material and said conductive material which is over said insulative material, said conductive material is substantially co-planar with a top surface portion of said insulative material.

14. The method of claim 13, wherein said metal-containing fill material is substantially co-planar with a top surface portion of said insulative material.

15. The method of claim 1, wherein substantially all of said metal-containing fill material is removed from said opening.

16. The method of claim 15, wherein said metal-containing fill material is removed from said opening by etching.

16. The method of claim 1, wherein said insulative material is comprised of at least one member selected from the group consisting of silicon dioxide and Boro-Phospho-Silicate Glass.

17. The method of claim 1, wherein said conductive material is formed over said opening using a chemical vapor deposition or low pressure chemical vapor deposition process.

18. The method of claim 1, wherein said conductive material is formed over said opening using a physical vapor deposition process.

19. The method of claim 1, wherein said conductive material is formed over said opening using electroless plating.

20. The method of claim 1, wherein said conductive material is formed over said opening using electroplating.

21. The method of claim 18, wherein said conductive material is formed in a substantially conformal layer over said opening.

22. A method of forming a bottom electrode of a capacitor, comprising:

locating a second conductive material with an opening in contact with a first conductive material and over at least a portion of an insulative material outside of said opening;

providing a metal-containing fill material over at least a portion of said conductive material which is inside said opening and which is over said insulative material outside of said opening

removing at least a portion of said metal-containing fill material from inside said opening such that said second conductive material forms said bottom electrode.

23. The method of claim 22, wherein said at least a portion of said opening contacts a first conductive material which is under said opening.

24. The method of claim 23, wherein said first conductive material is a conductive plug under said opening.

25. The method of claim 24, wherein said first conductive material contacts said substrate of said device.

26. The method of claim 22, wherein said second conductive material is a bottom electrode of a container capacitor.

27. The method of claim 22, wherein said second conductive material is formed over substantially all of the surface of said opening.

28. The method of claim 27, wherein said second conductive material is formed over substantially all of the surface of said insulative material outside of said opening.

29. The method of claim 28, wherein said second conductive material forms a conformal layer over said first conductive material.

30. The method of claim 22, wherein said second conductive material is provided by chemical vapor deposition or low pressure chemical vapor deposition.

31. The method of claim 22, wherein said second conductive material is provided by physical vapor deposition.

32. The method of claim 22, wherein said second conductive material is provided by electroplating.

33. The method of claim 22, wherein said second conductive material is provided by electroless plating.

34. The method of claim 30, wherein said second conductive material is provided to a depth within the range of a few hundred Angstroms to a several thousand Angstroms.

35. The method of claim 22, wherein said metal-containing fill material is tungsten or tungsten nitride and is provided to be substantially co-extensive with said second conductive material.

36. The method of claim 22, wherein substantially all of said conductive material and said metal-containing fill material which is over said insulative material is removed.

37. The method of claim 22, wherein substantially all of said metal-containing fill material is removed from said opening.

38. The method of claim 22, wherein said metal-containing fill material is titanium nitride.

39. A method of providing a conductive material in an opening provided in an insulative material over a substrate, wherein said opening is in contact with a surface portion of said substrate, comprising:

depositing a conductive material over at least a part of the inside of said opening and over at least a portion of the surface of said insulative material outside of said opening;

depositing a tungsten-containing fill material over at least a portion of said conductive material which is over said surface portion of said substrate and which is over said insulative material outside of said opening, wherein said tungsten-containing fill material at least partially fills said opening and supports said conductive material;

removing at least a portion of said tungsten containing fill material and said conductive material which is over said insulative material outside of said opening, said removal being effected by planarization ; and

removing at least a portion of said tungsten-containing fill material from said opening.

40. The method of claim 39, wherein said conductive material is formed to contact an active region formed within said substrate.

41. The method of claim 40, wherein said conductive material is further formed over the sides of said opening.

42. The method of claim 39, wherein said conductive material is at least member selected from the group consisting of transition element metals, Group IIIa metals and Group IVa metals.

43. The method of claim 42, wherein said conductive material is at least one member selected from the group consisting of Group VIII metals, copper, silver, gold and aluminum.

44. The method of claim 43, wherein said conductive material is selected from the group consisting of the Group VIII metals platinum, osmium, iridium and rhodium.

45. The method of claim 44, wherein said conductive material is platinum or a platinum alloy.

46. The method of claim 39, wherein said tungsten-containing fill material is formed to be substantially co-extensive with said conductive material.

47. The method of claim 39, wherein said tungsten-containing fill material is formed so as to substantially fill said opening.

48. The method of claim 47, wherein during said planarization of said tungsten-containing fill material, said conductive material is substantially undeformed.

49. The method of claim 48, wherein said planarization is performed so that the top of said conductive material is substantially co-planar with the top surface of said insulative layer.

50. The method of claim 49, wherein said planarization is performed so that said conductive material is substantially co-planar with said tungsten-containing fill material.

51. The method of claim 39, wherein said planarization is chemical mechanical planarization.

52. The method of claim 39, wherein substantially all of said tungsten-containing fill material is removed from said opening.

53. A structure for use in providing a conductive material in an opening, comprising:

a substrate;

an insulative material over said substrate;

a conductive material formed over at least a portion of the surface of said opening and over at least a portion of the surface of said insulative material outside of said opening;

a tungsten-containing fill material formed over at least a portion of said conductive material which is inside said opening and which is over said insulative material outside of said opening, wherein said tungsten-containing fill material at least partially fills said opening.

54. The structure of claim 53, wherein said opening further comprises a pair of opposing side walls and a bottom surface.

55. The structure of claim 54, wherein said conductive material is formed over substantially all of the surface of said opening.

56. The structure of claim 53, wherein said conductive material is substantially co-extensive with the surface of said insulative material outside of said opening.

57. The structure of claim 53, wherein said insulative material is at least one member selected from the group consisting of silicon dioxide and BPSG.

58. The structure of claim 57, wherein said insulative material is BPSG.

59. The structure of claim 53, wherein said tungsten-containing fill material is substantially harder than said conductive material and is substantially co-extensive with said conductive material which is over said insulative material.

60. The structure of claim 59, wherein said tungsten-containing fill material is tungsten or tungsten nitride.

61. The structure of claim 53, wherein said tungsten-containing fill material is co-extensive with said conductive material on said insulative material.

62. The structure of claim 61, wherein said conductive material is at least one member selected from the group consisting of transition element metals, Group IIIa metals and Group IVa metals.

63. The structure of claim 62, wherein said conductive material is at least one member selected from the group consisting of platinum, rhodium, iridium osmium, copper, silver, gold and aluminum.

64. The structure of claim 63, wherein said tungsten-containing fill material substantially fills said opening.

65. A structure for use in providing a conductive material in an opening, comprising:

a substrate;

an insulative material over said substrate;

a conductive material formed over substantially all of the inside surface of said opening;

a tungsten-containing fill material formed over said conductive material, wherein said tungsten-containing fill material substantially fills said opening, and further wherein said conductive material and said tungsten-containing fill material are substantially co-planar at the top of said opening.

66. The structure of claim 65, wherein said inside surface of said opening comprises a pair of opposing side walls and a bottom surface.

67. The structure of claim 66, wherein said bottom surface of said opening is over a conductive plug.

68. The structure of claim 65, wherein said insulative material has a top surface such that said conductive material and said tungsten-containing fill material are substantially co-planar with said top surface.

69. The structure of claim 65, wherein said conductive material is platinum or a platinum alloy.

70. The structure of claim 69, wherein said conductive material is planarized together with said tungsten-containing fill material.

71. The structure of claim 70, wherein said conductive material is substantially undeformed.

72. A method of forming a bottom electrode of a capacitor and a bit line conductive plug in a semiconductive device, comprising:

providing a first opening through the surface of an insulative material provided over a substrate in said device, wherein at least a portion of said opening contacts a first conductive material;

providing a second conductive material over at least a portion of the surface of said opening in contact with said first conductive material and over at least a portion of the surface of said insulative material outside of said opening;

providing a protective layer over said second conductive material;

providing a second opening through said protective layer, and through said second conductive material which is over said insulative material as well as through said insulative material, wherein at least a portion of said second opening contacts a third conductive material;

removing said protective layer;

providing a metal-containing fill material over said second conductive material which is inside said first opening and which is over said insulative material outside of said opening, wherein said metal-containing fill material is further provided over said second opening such that said metal-containing fill material at least partially fills said openings so as to form a bit line conductive plug in said second opening;

removing at least a portion of said metal-containing fill material and said conductive material which is over said insulative material outside of said openings; and

removing at least a portion of said metal-containing fill material from said first opening so as to form said bottom electrode of said capacitor.

73. The method of claim 72, wherein said second conductive material is provided over substantially all of the surface of said first opening in contact with a first conductive material.

74. The method of claim 73, wherein said second conductive material is at least one member selected from the group consisting of the Group VIII metals platinum, rhodium, osmium, and iridium, the transition element metals gold, silver and copper, and aluminum, and is provided using a chemical vapor deposition process.

75. The method of claim 74, wherein said protective layer is a photoresist layer.

76. The method of claim 75, wherein said photoresist layer is provided over substantially all of said second conductive material so as to be substantially co-extensive therewith.

77. The method of claim 76, wherein said second opening is provided by etching.

78. The method of claim 77, wherein said etching is dry etching.

79. The method of claim 78, wherein said dry etching is performed so as to produce an etch stop on the surface of said third conductive material.

80. The method of claim 79, wherein said third conductive material is a polysilicon plug.

81. The method of claim 80, wherein said metal-containing fill material is provided to be co-extensive with said second conductive material outside of said first opening

82. The method of claim 81, wherein said metal-containing fill material is provided in said second opening to substantially fill said opening.

83. The method of claim 82, wherein said removing of said metal-containing fill material and said conductive material from over said insulative material is performed by planarization.

84. The method of claim 83, wherein said planarization is chemical mechanical planarization.

85. The method of claim 84, wherein substantially all of said metal-containing fill material is removed from said first opening so as to form said bottom electrode of said capacitor.

86. The method of claim 85, wherein prior to said removal of substantially all of said metal-containing fill material from said first opening, an oxide layer is deposited over said second opening containing said bit line conductive plug.

87. The method of claim 86, further comprising providing a dielectric material over said bottom electrode.

88. The method of claim 87, further comprising providing a fourth conductive material over said dielectric.

89. A method of planarizing a conductive material formed over an opening without substantially deforming said material, comprising:

contacting said conductive material with a metal-containing fill material such that said fill material is over said conductive material and at least partially fills said opening; and

planarizing said conductive material and said metal-containing fill material wherein a top portion of said conductive material and said fill material are substantially co-planar with a top portion of said opening.

90. The method of claim 89, wherein said planarizing is performed using chemical mechanical planarization.

91. The method of claim 89, wherein said contacting is performed so as to support said conductive material during said planarization.

92. The method of claim 89, wherein said conductive material is further formed outside of said opening prior to performing said contacting.

93. The method of claim 92, wherein said fill material is further formed outside of said opening prior to performing said planarization.

94. The method of claim 93, wherein said contacting is performed so as to substantially fill said opening with said fill material.

95. The method of claim 94, further comprising removing substantially all of said fill material from said opening after said planarization.