feature bottom and feature sidewalls in a deposition chamber, the feature having a conformal liner layer. The conformal liner layer lines the feature such that the feature has a lined feature bottom surface and lined feature sidewall surfaces. The method further includes selectively depositing a metal film on the lined feature bottom surface using a metal precursor and a reducing agent to form a metal film base; preferentially etching the conformal liner layer from the feature sidewalls over etching the metal film base with the metal precursor; and using the metal precursor, depositing metal in the feature on the metal film base.

[0006] In some embodiments, the reducing agent is hydrogen, hydrazine, ammonia, silane, disilane, diborane, or a combination thereof.

[0007] In some embodiments, the conformal liner layer is titanium nitride, titanium silicide nitride, tungsten carbon nitride, or a combination thereof.

[0008] In some embodiments, the metal precursor is a molybdenum halide, a molybdenum oxyhalide, or a combination thereof.

[0009] In some embodiments, forming the metal film base and etching the conformal liner layer from the feature sidewalls occur sequentially.

[0010] In some embodiments, forming the metal film base and etching the conformal liner layer from the feature sidewalls occur simultaneously.

[0011] In some embodiments, the molybdenum halide is molybdenum dichloride, molybdenum trichloride, molybdenum tetrachloride, molybdenum pentachloride, molybdenum hexachloride, or molybdenum fluoride.

[0012] In some embodiments, the molybdenum oxyhalide is molybdenum dichloride dioxide, molybdenum tetrachloride oxide, molybdenum tetrafluoride oxide, or molybdenum dibromide dioxide.

[0013] In some embodiments, the temperature of the substrate during deposition is from about 350°C to about 550°C.

[0014] In some embodiments, the pressure in the deposition chamber is from about 10 Torr to about 50 Torr.

[0015] In some embodiments, depositing comprises filling the feature with metal.

[0016] In some embodiments, the substrate includes a top surface, and the top surface is coated with titanium disilicide.

[0017] In some embodiments, the method also includes pre-treating the conformal liner layer to clean it prior to deposition of the metal film.

[0027] In a fourth aspect, the present disclosure encompasses an apparatus for filling a feature on a substrate. In some embodiments, the apparatus includes at least one deposition chamber having a pedestal for holding a substrate that has a feature with a feature bottom and feature sidewalls, the feature having a conformal liner layer of a lined feature bottom surface and lined feature sidewall surfaces; at least one inlet port for delivering gas phase metal precursors to the deposition chamber; and a controller for controlling operations in the apparatus, including machine-readable instructions for: causing deposition of a molybdenum film on the lined feature bottom surface with a molybdenum precursor and a reducing agent; preferentially etching the conformal liner layer with the molybdenum precursor to remove the lined feature sidewall surfaces over etching the lined feature bottom surface feature; and after preferentially etching, depositing molybdenum in the feature with the molybdenum precursor.

[0028] These and other aspects are discussed further below with reference to the drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0029] **FIGS. 1A** and **1B** are schematic examples of material stacks that include molybdenum (Mo) in accordance with certain disclosed embodiments.

[0030] **FIGS. 2A–2L** are schematic examples of various structures into which molybdenum may be deposited in accordance with certain disclosed embodiments.

[0031] **FIG. 3** is a flow diagram showing certain operations of filling a feature with metal in accordance with certain disclosed embodiments.

[0032] **FIGS. 4A–4D** are schematic diagrams showing cross-sectional depictions of features during fill processes in accordance with certain disclosed embodiments.

[0033] **FIGS. 5A–5C** are schematic diagrams showing cross-sectional depictions of features during fill processes in accordance with certain disclosed embodiments.

[0034] **FIG. 6** shows an example of an apparatus that may be used to perform the methods described herein in accordance with certain disclosed embodiments.

[0035] **FIGS. 7A** and **7B** show examples of apparatuses that may be used to perform the methods described herein in accordance with certain disclosed embodiments.

DETAILED DESCRIPTION

[0036] In the following description, numerous specific details are set forth to provide a thorough understanding of the presented embodiments. The disclosed embodiments may be practiced without some or all of these specific details. In other instances, well-known process operations have not been described in detail to not unnecessarily obscure the disclosed embodiments. While

layer. Examples include Mo on a metal nitride layer (e.g., TiN, WN, WCN, or MoN), Mo on a metal silicide layer (e.g., $TiSi_x$, or tungsten silicide (WSi_x)), or Mo on a metal layer (e.g., W). In still some other embodiments of a stack (not shown), the stack may include a substrate and a Mo layer deposited directly on the substrate, including directly on a semiconducting surface, on a dielectric surface, or on a conductive surface. **FIGS. 1A** and **1B** illustrate examples of order of materials in a particular stack and may be used with any appropriate architecture and application, as described further below with respect to **FIGS. 2A—2L**.

[0051] The methods described herein are performed on a substrate that may be housed in a chamber. The substrate may be a silicon or other semiconductor wafer, including wafers having one or more layers of material, such as dielectric, conducting, or semi-conducting material deposited thereon. The methods are not limit to semiconductor substrates and may be performed to fill any feature with molybdenum.

[0052] Substrates may have features such as vias or contact holes, which may be characterized by one or more of narrow and/or re-entrant openings, constrictions within the feature, and high aspect ratios. A feature may be formed in one or more of the above-described stacks or layers within a stack. For example, the feature may be formed at least partially in a dielectric layer. In some embodiments, a feature may have an aspect ratio of at least about 2:1, at least about 4:1, at least about 6:1, at least about 10:1, at least about 25:1, or higher. One example of a feature is a hole or via in a semiconductor substrate or a layer on the substrate.

[0053] **FIG. 2A** depicts a schematic example of a Dynamic Random-Access Memory (DRAM) architecture including a Mo buried wordline (bWL) 208 in a silicon substrate 202. The Mo bWL is formed in a trench etched in the silicon substrate 202. Lining the trench is a conformal barrier layer 206 and an insulating layer 204. The conformal barrier 206 is disposed between the insulating layer 204 and the silicon substrate 202. In this example, the insulating layer 204 may be a gate oxide layer, formed from a high-k dielectric material such as a silicon oxide or silicon nitride material. In some embodiments disclosed herein the conformal barrier layer 206 is TiN or a tungsten-containing layer. In embodiments in which TiN is used as a conformal barrier layer, a conformal tungsten-containing growth initiation layer (not shown) may be present between the conformal barrier layer 206 and the Mo bWL 208. Alternatively, the Mo bWL 208 may be deposited directly on a TiN or other diffusion barrier. In some embodiments, one or both of layers 204 and 206 is not present.

[0054] The bWL structure shown in **FIG. 2A** is one example of an architecture that includes a Mo fill layer. During fabrication of the bWL, Mo is deposited into a feature that may be defined by an etched recess in the silicon substrate 202 that is conformally lined with layers 206 and 204,

if present.

[0055] **FIGS. 2B–2H** are additional schematic examples of various structures into which Mo may be deposited in accordance with disclosed embodiments. **FIG. 2B** shows an example of a cross-sectional depiction of a vertical feature 201 to be filled with Mo. The feature can include a feature hole 205 in a substrate 202. The feature hole 205 may have a conformal liner layer 203 lining the sidewall or interior of the feature hole 205 and may form the interior surfaces. The hole 205 or other feature may have a dimension near the opening, e.g., an opening diameter or line width of between about 10 nm to 500 nm, for example between about 25 nm and about 300 nm. The feature hole 205 can be referred to as an unfilled feature or simply a feature. The feature 201, and any feature, may be characterized in part by an axis 218 that extends through the length of the feature, with vertically oriented features having vertical axes and horizontally-oriented features having horizontal axes.

[0056] In some embodiments, features are wordline features in a 3D NAND structure. For example, a substrate may include a wordline structure having an arbitrary number of wordlines (e.g., 50 to 150) with vertical channels at least 200Å deep. Examples of wordline features are described further below. Another example of a feature is a trench in a substrate or layer. Features may be of any depth. In various embodiments, the feature may have an under-layer, such as a barrier layer or adhesion layer. Non-limiting examples of under-layers include dielectric layers and conducting layers, e.g., silicon oxides, silicon nitrides, silicon carbides, metal oxides, metal nitrides, metal carbides, and metal layers.

[0057] **FIG. 2C** shows an example of a feature 201 that has a re-entrant profile. A re-entrant profile is a profile that narrows from a bottom, closed end, or interior of the feature to the feature opening. According to various implementations, the profile may narrow gradually and/or include an overhang at the feature opening. **FIG. 2C** shows an example of the latter, with a conformal liner layer 213 lining the sidewall and bottom surfaces of the feature hole 205. The conformal liner layer 213 can be a diffusion barrier layer, an adhesion layer, a nucleation layer, a combination of thereof, or any other applicable material. Non-limiting examples of liner layers can include dielectric layers and conducting layers. Examples of dielectric materials include oxides, such as silicon oxide (SiO_2) and aluminum oxide (Al_2O_3); nitrides, such as silicon nitride (SiN); carbides, such as nitrogen-doped silicon carbide (NDC) and oxygen-doped silicon carbide (ODC); and low k dielectrics, such as carbon-doped SiO_2. In certain implementations, a liner layer can be one or more of titanium, titanium nitride, tungsten nitride, titanium aluminide, tungsten, and molybdenum.

[0058] The conformal liner layer 213 forms an overhang 215 such that the conformal liner layer

material can be deposited in the region of voids 275. Apparent from **FIGS. 2H** and **2I** is that void-free molybdenum fill relies on migration of sufficient quantities of deposition precursor down through vertical structure 230, through openings 222, past the constricting pillars 255, and into the furthest reaches of wordline features 220, prior to the accumulated deposition of molybdenum around pillars 255 causing a pinch-off of the openings 222 and preventing further precursor migration into wordline features 220. Similarly, **FIG. 2J** exhibits a single wordline feature 220 viewed cross-sectionally from above and illustrates how a generally conformal deposition of molybdenum material begins to pinch-off the interior of wordline feature 220 due to the fact that the significant width of pillars 255 acts to partially block, and/or narrow, and/or constrict what would otherwise be an open path through wordline feature 220. (It should be noted that the example in **FIG. 2J** can be understood as a 2-D rendering of the 3-D features of the structure of the pillar constrictions shown in **FIG. 2I**, thus illustrating constrictions that would be seen in a plan view rather than in a cross-sectional view.)

[0064] Three-dimensional structures may need longer and/or more concentrated exposure to precursors to allow the innermost and bottommost areas to be filled. Three-dimensional structures can be particularly challenging when employing molybdenum halide and/or molybdenum oxyhalide precursors because of their proclivity to etch, with longer and more concentrated exposure allowing for more etch as parts of the structure.

[0065] **FIGS. 2K** and **2L** show examples of an asymmetric trench structure DRAM bWL. Some fill processes for DRAM bWL trenches can distort the trenches such that the final trench width and resistance Rs are significantly non-uniform. **FIG. 2K** shows an unfilled 261 and filled 265 narrow asymmetric trench structure DRAM bWL that exhibit line bending after fill. As shown, multiple features 283 are depicted on a substrate. These features 283 are spaced apart, and in some embodiments, adjacent features have a pitch between about 20 nm and about 60 nm or between about 20 nm and 40 nm. The pitch is defined as the distance between the middle axis of one feature to the middle axis of an adjacent feature. The unfilled features 283 may be generally V-shaped as shown in feature 283, having sloped sidewalls where the width of the feature narrows from the top of the feature to the bottom of the feature. The features widen from the feature bottom 273b to the feature top 273a. After some fill operations, line bending may be observed within the feature 283, as shown in substrate 202. Without being bound by a particular theory, it is believed that a cohesive force between opposing surfaces of a trench pulls the trench sides together as depicted by arrows 267. This phenomenon is illustrated in **FIG. 2L** and may be characterized as “zipping up” the feature. As the feature 283 is filled, more force is exerted from a center axis 299 of the feature 283, causing line bending. For example, molybdenum may be deposited on the sidewalls

process pressures reduce the selectivity of the deposited gas. For example, at higher temperatures, a precursor gas such as $MoCl_5$ may lose its selectivity and deposit Mo film on both a metal surface and dielectric surface within a feature.

[0081] Described below are examples of deposition of Mo film within a feature using a $MoCl_5$ precursor and different process controls. In a first example, the $MoCl_5$ precursor is reacted with hydrogen (H_2) reducing agent using the deposition methods described above. Process temperatures for selective deposition of the Mo film may be between 400ºC to 800ºC. At these temperatures, the Mo film is selectively deposited on conductive metal or metal compound surfaces, such as a TiN surface, in a feature relative to dielectric surfaces. The Mo film grows from the locations where the conductive surfaces are located in a feature. If the conductive surface is a TiN plug at the bottom of the feature, the Mo film may be deposited and grown from the bottom of the feature. In a second example, the Mo film may be deposited using the $MoCl_5$ precursor and the H_2 reactant, but at higher temperatures, i.e., above 800ºC. This process window may have the Mo film deposited on both the dielectric and conductive surfaces within the feature.

[0082] A $MoCl_x$ precursor may be used for both deposition and etch operations. For example, in certain process windows, a $MoCl_5$ precursor may concurrently grow a Mo film and etch away a metal or metal compound film in the feature. The process is considered an etch operation if the rate of material removed is greater than that of the material deposited by the precursor. The speed at which the precursor deposits material and etches material may be controlled by a variety of process conditions, including the type of reactant used and the process temperature. Generally speaking, the lower the temperature, the higher the ratio of etching away material is relative to deposition of material. At higher temperatures, the same precursor and reactant may be used as a deposition operation, i.e., the amount of material deposited is greater than the material removed. For example, $MoCl_5$ precursor and H_2 reactant may be used in an etch operation when the process temperature is below 400ºC. The same precursor of $MoCl_5$ and H_2 reactant may be used in a deposition operation when the process temperature is above 550ºC. In some embodiments, etching is performed by supplying $MoCl_5$ or other $MoCl_x$ precursor without a co-reactant. And, as described further below, net etching and/or deposition is controllably varied throughout a feature by implementing a concentration gradient of precursor in a feature. In some embodiments, $MoCl_x$ precursors are used for oxygen-free, fluoride-free deposition. However, other molybdenum halides and molybdenum oxyhalides may be used as described herein for etch and deposition.

[0083] A feature may have surface oxide or contaminants on it. For example, the surface of an underlying TiN, WCN, WN, or W layer may be oxidized. If incorporated into the device, the oxidized surface can result in higher resistivity. Clean operations are used to remove such oxides

stack 410 below the feature bottom surface. The TiN liner layer may act as a diffusion barrier, prevent etching of the underlying material, and prevent the underlying material from oxidizing. Other protective layers may be used in alternate embodiments.

[0106] The feature 401 may be cleaned as discussed above with reference to operation 302. This may involve flowing a $MoCl_x$ precursor, such as $MoCl_5$, into the chamber housing the substrate. In some embodiments, the flow of the precursor may be continuous. In still some other embodiments, the flow may be multiple cycles of alternating doses of the $MoCl_x$ precursor and a purge gas. The $MoCl_x$ precursor effectively removes any oxide on the surface. For example, the TiN liner layer 415 may have oxide to form TiO_xN_y. The precursor removes the oxide. This may be done without etching any or more than a negligible amount of TiN.

[0107] **FIG. 4B** depicts the feature 401 after a metal film base such as molybdenum film base 409 is deposited in the bottom portion of the feature 401 as described above in operation 303 of **FIG. 3**. Mo 409 is deposited into the feature by reacting the $MoCl_x$ precursor, such as $MoCl_5$, and a reactant, such as H_2. For ease of discussion, the description of **FIGS. 4A–4D** describes $MoCl_5$ as the $MoCl_5$ precursor and H_2 as the reactant. However, other molybdenum halides and/or other co-reactants may be employed.

[0108] When depositing Mo, the $MoCl_5$ precursor is flowed into the feature. One or more of partial pressure, reactant flow rate, reactant concentration, and reactant dose time are controlled such that there is a concentration gradient of the $MoCl_5$ in the feature with higher concentration at the top of the feature and lower concentration at the feature bottom.

[0109] At the feature bottom, $MoCl_5$ reacts with H_2 to form the Mo on the bottom surface 405. The reaction is mass transport limited, allowing deposition without significant etching. Higher in the feature, $MoCl_5$ also reacts with H_2. However, as there is more $MoCl_5$ present than at the bottom, the deposited Mo is etched. In some embodiments, no Mo is deposited on the sidewalls. However, in some embodiments, a thin conformal layer is deposited on the sidewalls as shown in **FIG. 4B**. There is net deposition, but to a much lesser extent than at the feature bottom. This is referred to as selective deposition of Mo at the feature bottom and forms a Mo film base.

[0110] In some other embodiments, the H_2 reactant is continuously flowed while the $MoCl_5$ precursor flow is pulsed. This facilitates selective deposition at the bottom of the feature as depicted in **FIG. 4B**.

[0111] The temperature of the substrate and the pressure of a chamber may be controlled. In some embodiments, the substrate may be heated between 350°C and 550°C, e.g., between 400°C and 500°C. In some embodiments, the chamber may be pressurized to at least 10 Torr, e.g., to at

least 30 Torr, or to at least 50 Torr.

[0112] **FIG. 4C** depicts the feature 401 after part of the TiN liner layer 415 is etched from the sidewall surfaces 411 as described with reference to operation 305 of **FIG. 3**. The $MoCl_5$ precursor is used to etch away the Mo and the TiN liner layer 415 on the sidewall surfaces 411 in an upper portion of the feature 401. The $MoCl_5$ etches the thin Mo on the sidewall surfaces 411 before etching away the TiN liner layer. In embodiments where no Mo is deposited on the sidewall surface 411, the $MoCl_5$ etches the TiN liner layer at the top portion of the feature directly The Mo 409 in the bottom portion of the feature 401, due to its thickness, protects the TiN liner layer 415 from being etched away by the $MoCl_5$ precursor. The TiN liner layer 415 remains at the bottom surface 405 and protects the underlying stack 410 during subsequent processing. As shown, the dielectric material 413 forms the sidewall surfaces 411 after the etch. The remaining TiN layer 415 forms a "cup" around the Mo 409. Together, they protect the underlying stack 410 in subsequent processing and provide a layer on which more Mo can be selectively deposited in a bottom-up process.

[0113] **FIG. 4D** shows the feature 401 after a Mo gap fill of the feature. The feature 401 is filled with a Mo fill 423. The TiN layer 415 remains between the Mo fill 423 and the underlying stack 410 at the bottom of the feature but is not between the Mo fill 423 and the dielectric material 413. The feature 401 may be filled using an ALD or a CVD process. The fill may be done with a Mo oxyhalide precursor containing oxygen, a Mo halide precursor not containing oxygen, or a combination thereof. The fill is a bottom-up fill and grows from the Mo film base 409 deposited in the feature bottom. In some embodiments, the fill may be performed in a single stage deposition, where the fill is continued using the same parameters, such as temperature and pressure, as the initial fill. In some other embodiments, the fill may be performed in multi-stage Mo deposition, where parameters may be changed during the deposition. For example, the deposition at a first stage may have a first temperature. After the first stage, the deposition may continue in a second stage and may have a second temperature higher than the first temperature. The increase in temperature may be used to increase the rate of Mo bulk fill, decreasing processing time. In another example of multi-stage deposition, the Mo precursor and reactant concentrations may be varied at different stages. For example, a Mo halide precursor may start the Mo fill, followed by a Mo oxyhalide precursor. The Mo oxyhalide precursor may be used to increase processing speed.

[0114] **FIGS. 5A–5C** show a second schematic example of the process of **FIG. 3**. **FIG. 5A** shows the feature 501 with a TiN liner layer 515 that forms a bottom surface 505 and sidewall surfaces 511. In **FIG. 5A**, the TiN liner includes the lined feature bottom surface 505 and the lined feature sidewall surfaces 511. In some embodiments, the TiN layer 515 may be oxidized on a top

between 350°C and 550°C, e.g., between 400°C and 500°C. In some embodiments, the chamber may be pressurized to at least 10 Torr, e.g., to at least 30 Torr, or to at least 50 Torr. In some embodiments, process parameters such as temperature and pressure, may be used to control selectivity.

[0118] **FIG. 5C** shows the feature 501 after a Mo gap fill of the feature. The feature 501 is filled with a Mo fill 523. The feature may be filled using a CVD or ALD process. The fill is a bottom-up fill and grows from the initial Mo film base 509 deposited in the feature bottom. The fill is similar to the fill described in FIG. 4D. The TiN layer 515 remains between the Mo fill 523 and the underlying stack 510.

[0119] **FIG. 6** depicts a schematic illustration of an embodiment of a process station 600 having a process chamber 602 for maintaining a low-pressure environment. In some embodiments, a plurality of process stations may be included in a common low-pressure process tool environment. For example, **FIG. 7A** depicts an embodiment of a multi-station processing tool 700. In some embodiments, one or more hardware parameters of process station 600, including those discussed in detail below, may be adjusted programmatically by one or more computer controllers 650. In some other embodiments, a process chamber may be a single station chamber.

[0120] Process station 600 fluidly communicates with reactant delivery system 601 for delivering process gases to a distribution showerhead 606. Reactant delivery system 601 includes a mixing vessel 604 for blending and/or conditioning process gases, such as a Mo precursor-containing gas, a hydrogen-containing gas, an argon or other carrier gas, or other reactant-containing gas, for delivery to showerhead 606. One or more mixing vessel inlet valves 620 may control introduction of process gases to mixing vessel 604. In various embodiments, deposition of an initial Mo layer is performed in process station 600 and in some embodiments, other operations such as in-situ clean or Mo gap fill may be performed in the same or another station of the multi-station processing tool 600 as further described below with respect to **FIG. 7**.

[0121] As an example, the embodiment of **FIG. 6** includes a vaporization point 603 for vaporizing liquid reactant to be supplied to the mixing vessel 604. In some embodiments, vaporization point 603 may be a heated vaporizer. In some embodiments, a liquid precursor or liquid reactant may be vaporized at a liquid injector (not shown). For example, a liquid injector may inject pulses of a liquid reactant into a carrier gas stream upstream of the mixing vessel 604. In one embodiment, a liquid injector may vaporize the reactant by flashing the liquid from a higher pressure to a lower pressure. In another example, a liquid injector may atomize the liquid into dispersed microdroplets that are subsequently vaporized in a heated delivery pipe. Smaller droplets may vaporize faster than larger droplets, reducing a delay between liquid injection and

CLAIMS

1. A method for filling a feature, the method comprising:

providing a substrate comprising a feature having a feature bottom and feature sidewalls in a deposition chamber, the feature having a conformal liner layer comprising a lined feature bottom surface and lined feature sidewall surfaces;

selectively depositing a metal film on the lined feature bottom surface using a metal precursor and a reducing agent to form a metal film base;

preferentially etching the conformal liner layer from the feature sidewalls over etching the metal film base with the metal precursor; and

using the metal precursor, depositing metal in the feature on the metal film base.

2. The method of claim 1, wherein the reducing agent comprises hydrogen, hydrazine, ammonia, silane, disilane, diborane, or a combination thereof.

3. The method of claim 1, wherein the conformal liner layer comprises titanium nitride, titanium silicide nitride, tungsten carbon nitride, or a combination thereof.

4. The method of claim 1, wherein the metal precursor comprises a molybdenum halide, a molybdenum oxyhalide or a combination thereof

5. The method of claim 1, wherein forming the metal film base and etching the conformal liner layer from the feature sidewalls occur sequentially.

6. The method of claim 1, wherein forming the metal film base and etching the conformal liner layer from the feature sidewalls occur simultaneously.

7. The method of claim 4, wherein the molybdenum halide comprises molybdenum dichloride, molybdenum trichloride, molybdenum tetrachloride, molybdenum pentachloride, molybdenum hexachloride, or molybdenum fluoride.

8. The method of claim 4, wherein the molybdenum oxyhalide comprises molybdenum dichloride dioxide, molybdenum tetrachloride oxide, molybdenum tetrafluoride oxide, or molybdenum dibromide dioxide.

9. The method of claim 1, wherein a temperature of the substrate during deposition is from

about 350°C to about 550°C.

10. The method of claim 1, wherein a pressure in the deposition chamber is from about 10 Torr to about 50 Torr.

11. The method of claim 1, wherein depositing comprises filling the feature with metal.

12. The method of claim 11, wherein the substrate further comprises a top surface, and wherein the top surface is coated with titanium disilicide.

13. The method of claim 1, further comprising pre-treating the conformal liner layer to clean it prior to deposition of the metal film.

14. The method of claim 1, wherein preferentially etching comprises etching the conformal liner layer from the feature sidewalls without etching the metal film base.

15. A method for filling a feature, the method comprising:

providing a substrate comprising a feature having a feature bottom and feature sidewalls in a deposition chamber, the feature having a conformal liner layer comprising a lined feature bottom surface and lined feature sidewall surfaces;

selectively depositing a molybdenum film on the lined feature bottom surface with a molybdenum precursor and a reducing agent to form a molybdenum film base;

preferentially etching the conformal liner layer with the molybdenum precursor to remove the lined feature sidewall surfaces over etching the molybdenum film base; and

depositing molybdenum in the feature on the molybdenum film base with the molybdenum precursor.

16. The method of claim 15, wherein the molybdenum precursor comprises a molybdenum halide or a molybdenum oxyhalide.

17. The method of claim 16, wherein the molybdenum oxyhalide comprises molybdenum dichloride dioxide, molybdenum tetrachloride oxide, molybdenum tetrafluoride oxide, or molybdenum dibromide dioxide.

18. The method of claim 16, wherein the molybdenum halide comprises molybdenum dichloride, molybdenum trichloride, molybdenum tetrachloride, molybdenum

pentachloride, molybdenum hexachloride, or molybdenum fluoride.

19. The method of claim 18, wherein the molybdenum halide comprises molybdenum pentachloride.

20. The method of claim 15, wherein preferentially etching comprises etching the conformal liner layer from the feature sidewalls without etching the molybdenum film base.

21. A method for filling a feature, the method comprising:

providing a substrate comprising a feature having a feature bottom and feature sidewalls in a deposition chamber, the feature having a conformal liner layer comprising a lined feature bottom surface and lined feature sidewall surfaces;

selectively depositing a molybdenum film on the lined feature bottom surface with a first molybdenum precursor and a reducing agent to form a molybdenum film base;

preferentially etching the conformal liner layer with a second molybdenum precursor to remove the lined feature sidewall surfaces over etching the molybdenum film base; and

depositing molybdenum in the feature on the molybdenum film base with the first molybdenum precursor.

22. The method of claim 21, wherein preferentially etching comprises etching the conformal liner layer from the feature sidewalls without etching the molybdenum film base.

23. An apparatus for filling a feature on a substrate, the apparatus comprising:

at least one deposition chamber including a pedestal for holding a substrate comprising a feature having a feature bottom and feature sidewalls, the feature having a conformal liner layer comprising a lined feature bottom surface and lined feature sidewall surfaces;

at least one inlet port for delivering gas phase metal precursors to the deposition chamber; and

a controller for controlling operations in the apparatus, including machine-readable instructions for:

(a) causing deposition of a molybdenum film on the lined feature bottom surface with a molybdenum precursor and a reducing agent;

(b) preferentially etching the conformal liner layer with the molybdenum precursor to

remove the lined feature sidewall surfaces over etching the lined feature bottom surface; and

(c) after (b), depositing molybdenum in the feature with the molybdenum precursor.