CLAIMS

1. A method, comprising:

providing a substrate comprising a feature having a feature bottom and feature sidewalls;

depositing an initial molybdenum film in the feature using a molybdenum halide precursor and a reducing agent; and

after depositing the initial molybdenum film, at least partially filling the feature with molybdenum using a molybdenum oxyhalide precursor.

2. The method of claim 1, wherein the feature bottom comprises an oxidized metal silicide surface and the feature sidewalls comprises oxidized metal surfaces, and the method further comprising removing oxide from at least the oxidized metal silicide surface of the feature bottom to leave a metal silicide surface such that the initial molybdenum film is deposited directly on the metal silicide surface.

~~3. The method of claim 2, wherein the metal silicide surface is one of: titanium silicide ($TiSi_x$), nickel silicide ($NiSi_x$), molybdenum silicide ($MoSi_x$), cobalt silicide ($CoSi_x$), platinum silicide ($PtSi_x$), ruthenium silicide ($RuSi_x$), and nickel platinum silicide ($NiPt_ySi_x$).~~

43. The method of claim 2, wherein removing oxide from the oxidized metal silicide surface of the feature bottom comprises a clean with a Cl-based plasma, HF vapor clean, or an ammonium fluoride clean.

~~5. The method of claim 1, wherein the feature bottom comprises an oxidized semiconductor surface.~~

~~6. The method of claim 5, wherein the semiconductor surface is silicon (Si).~~

~~7. The method of claim 5, wherein the semiconductor surface is silicon-germanium (SiGe).~~

~~8. The method of claim 5, wherein removing oxide from the oxidized semiconductor surface of the feature bottom comprises, a clean with a Cl-based plasma, HF vapor clean, or an ammonium fluoride clean.~~

~~9. The method of any of claims 1–8, wherein the initial molybdenum film is no more than five nanometers thick.~~

~~10. The method of any of claims 1–8, wherein the initial molybdenum film is no more than two nanometers thick.~~

~~11. The method of any of claims 1–8, wherein the molybdenum halide precursor is a molybdenum chloride precursor.~~

~~12. The method of any of claims 1–8, wherein the molybdenum halide precursor is molybdenum pentachloride ($MoCl_5$).~~

~~13. The method of any of claims 1–8, wherein the molybdenum halide precursor is molybdenum hexachloride ($MoCl_6$).~~

~~14. The method of any of claims 1–8, wherein the initial molybdenum film is deposited at a substrate temperature that is at least 300°C and no more than 500°C.~~

~~15. The method of any of claims 1–8, wherein the initial molybdenum film is deposited at a substrate temperature that is at least 350°C and no more than 450°C.~~

~~16. The method of any of claims 1–8, wherein the initial molybdenum film is deposited in a chamber, the chamber having a pressure of at least 30 Torr.~~

~~17. The method of any of claims 1–8, wherein the molybdenum oxyhalide precursor is a molybdenum oxychloride (MoO_xCly).~~

~~18. The method of any of claims 1–8, wherein the molybdenum oxyhalide precursor is a molybdenum oxyfluoride (MoO_xF_y).~~

~~19~~20. The method of ~~any of~~ claim~~s~~ 1~~–8~~, wherein depositing the initial molybdenum film is performed in a first station of a multi-station chamber and depositing at least partially filling the feature is performed in at least a second station of the multi-station chamber.

~~20~~21. A method comprising:

providing a substrate comprising a feature having a feature bottom and feature sidewalls, wherein the feature bottom comprises an oxidized surface;

soaking the feature in a molybdenum halide precursor to remove oxide from the oxidized surface to leave an unoxidized surface; and

depositing molybdenum into the feature, including directly on the unoxidized surface, using the molybdenum halide precursor and a reducing agent.

~~21. The method of claim 20, wherein depositing molybdenum into the feature comprises depositing a non-selective molybdenum layer in the feature.~~

~~22. The method of claim 20, wherein depositing molybdenum into the feature comprises selectively depositing a molybdenum layer on the unoxidized surface relative to the feature sidewalls.~~

~~23~~6. The method of claim ~~21 or 22~~5, further comprising, after depositing the molybdenum into the feature depositing a bulk molybdenum layer in the feature using a molybdenum oxyhalide precursor.

~~24~~7. The method of claim ~~20~~5, wherein:

the feature bottom comprises a metal-containing surface,

the feature sidewalls comprise a dielectric surface, and

depositing molybdenum further comprises selectively depositing molybdenum on the metal-containing surface relative to the dielectric surface.

~~25~~8. The method of claim ~~20~~5, wherein depositing molybdenum into the feature comprises depositing a bulk molybdenum layer in the feature using the molybdenum halide precursor.

~~26. The method of claim 20, wherein the oxidized surface is an oxidized titanium nitride surface.~~

~~27~~9. The method of ~~any of~~ claim~~s 20–22~~5, wherein soaking the feature in the molybdenum halide precursor is performed in a first chamber and depositing molybdenum into the feature is performed in a second chamber, wherein the first chamber and the second chamber are different chambers.

~~28~~10. The method of ~~any of~~ claim~~s 20–22~~5, wherein soaking the feature in the molybdenum halide precursor and depositing the molybdenum into the feature are performed in the same chamber.

~~29~~11. The method of claim ~~28~~10, wherein the chamber is a multi-station chamber, soaking of the feature in the molybdenum halide precursor is performed in a first station of the multi-station chamber and depositing molybdenum into the feature is performed in at least a second station of

the multi-station chamber.

~~30. The method of any of claims 20–22 wherein soaking the feature in the molybdenum halide precursor lasts at least 10 seconds in duration.~~

~~31. The method of any of claims 20–22, wherein soaking the feature in the molybdenum halide precursor lasts at least 60 seconds in duration.~~

~~32. The method of any of claims 21 or 22, wherein the molybdenum layer is no more than five nanometers thick.~~

~~33. The method of any of claims 21 or 22, wherein the molybdenum layer is no more than two nanometers thick.~~

~~34. The method of any of claims 20–22, wherein the molybdenum halide precursor is a molybdenum chloride precursor.~~

~~35. The method of any of claims 20–22, wherein depositing molybdenum into the feature is deposited at a substrate temperature that is at least 300°C and no more than 500°C.~~

~~36. The method of any of claims 20–22, wherein depositing molybdenum into the feature is deposited at a substrate temperature that is at least 350°C and no more than 450°C.~~

~~37. The method of any of claims 20–22, wherein depositing molybdenum into the feature is deposited in a chamber, the chamber having a pressure of at least 10 Torr.~~

~~38. The method of any of claims 20–22, wherein depositing molybdenum into the feature is deposited in a chamber, the chamber having a pressure of at least 30 Torr.~~

~~39~~12. The method of ~~any of~~ claim~~s 20–22~~5, further comprising, prior to soaking the feature, exposing the feature to an oxygen-containing chemistry to form the oxidized surface.

~~40. The method of claim 34, wherein the molybdenum chloride precursor is molybdenum pentachloride ($MoCl_5$) or molybdenum hexachloride ($MoCl_6$).~~

~~41~~13. The method of claim ~~40~~12, wherein the oxidized surface is oxidized silicon, the molybdenum ~~chloride~~halide precursor is molybdenum pentachloride, and soaking the feature in the molybdenum halide precursor removes oxide from the oxidized silicon, leaving silicon.

~~42~~14. The method of claim ~~40~~12, wherein the oxidized surface is oxidized silicon germanium,

the molybdenum ~~chloride~~halide precursor is molybdenum pentachloride, and soaking the feature in a molybdenum halide precursor removes oxide from the silicon germanium, leaving silicon germanium.

~~43~~15. The method of claim ~~40~~5, wherein the feature has a titanium nitride layer, the molybdenum ~~chloride~~halide precursor is molybdenum pentachloride, and soaking the feature in a molybdenum halide precursor etches the titanium nitride layer.

~~44~~16. The method of claim ~~43~~15, wherein the etch of the titanium nitride layer can be controlled to leave the titanium nitride layer at a desired thickness.

~~45~~17. The method of claim ~~43~~15, wherein the titanium nitride layer is completely removed.

~~46~~18. The method of claim ~~23~~6, wherein soaking of the feature in the molybdenum halide precursor and depositing the molybdenum into the feature is performed in a first station of a multi-station chamber and further comprising depositing a bulk molybdenum layer into the feature, wherein the depositing the bulk molybdenum layer is performed in at least a second station of the multi-station chamber.

~~47. The method of any of claims 20–22, wherein soaking the feature comprises continuously exposing the feature to the molybdenum halide precursor.~~

~~48. The method of any of claims 20–22, wherein soaking the feature comprises exposing the feature alternating doses of the molybdenum halide precursor and an inert gas.~~

~~49~~19. A method comprising:

providing a substrate comprising a feature having a feature bottom and feature sidewalls; wherein the feature bottom comprises a metal nitride surface;

depositing an initial molybdenum film on the feature sidewalls and the metal nitride surface of the feature bottom using a molybdenum halide precursor and a reducing agent;

removing molybdenum film from the feature sidewalls, leaving a molybdenum film on the metal nitride surface feature bottom; and

at least partially filling the feature with molybdenum.

~~50. The method of claim 49, wherein the metal nitride is titanium nitride (TiN).~~

~~51. The method of claim 49, wherein the metal nitride is titanium silicide nitride (TiSiN).~~

~~52. The method of claim 49, wherein the metal nitride of the feature bottom overlies a stack comprising a semiconductor surface and a titanium silicide (TiSi) layer.~~

~~53. The method of claim 52, wherein the semiconductor surface is silicon (Si).~~

~~54. The method of claim 52, wherein the semiconductor surface is silicon-germanium (SiGe).~~

~~55~~20. The method of claim ~~49~~ 19, further comprising removing at least some metal nitride from the feature sidewalls before depositing an initial molybdenum film on the sidewalls and the metal nitride surface of the feature bottom.