

CLAIMS

What is claimed is:

1. A method for providing a metal-containing layer, the method comprising:
providing a substrate on a substrate holder in a processing chamber;
exposing a top surface portion of the substrate to a molybdenum-containing precursor and one or more optional deposition precursors; and
depositing a metal-containing layer on the top surface portion of the substrate in a presence or an absence of a plasma within the processing chamber.
2. The method of claim 1, wherein the metal-containing layer comprises a molybdenum-containing layer or a molybdenum-doped layer.
3. The method of claim 1, wherein the processing chamber comprises a plasma-enhanced chemical vapor deposition chamber.
4. The method of claim 1, wherein said exposing comprises delivering the molybdenum-containing precursor and the one or more optional deposition precursors either sequentially or simultaneously.
5. The method of claim 1, wherein said exposing further comprises delivering a reactant gas, a reducing agent, or a carrier gas to the processing chamber.
6. The method of claim 5, wherein the reducing agent comprises water, alcohol, H₂S, a hydrocarbon, a thiol, or a combination thereof.
7. The method of claim 1, further comprising, before said depositing:
providing an interfacial layer on the top surface portion of the substrate, thereby disposing the interfacial layer between the substrate and the metal-containing layer after said depositing.
8. The method of claim 7, wherein the interfacial layer comprises an adhesion layer, an initiation layer, or a growth layer.

9. The method of claim 7, wherein the interfacial layer comprises boron (B), carbon (C), titanium (Ti), tungsten (W), tantalum (Ta), nickel (Ni), molybdenum (Mo), a nitride thereof, a silicide thereof, an oxynitride thereof, a carbide thereof, or a carbonitride thereof.

10. The method of claim 1, further comprising, before said depositing:
pretreating the top surface portion of the substrate, thereby providing a pretreated surface being disposed between the substrate and the metal-containing layer after said depositing.

11. The method of claim 1, wherein the substrate further comprises a material layer disposed on the top surface portion of the substrate, and wherein said depositing comprises depositing the metal-containing layer on a top surface portion of the material layer.

12. The method of claim 11, wherein the material layer comprises at least one of an oxide or a nitride.

13. The method of claim 1, wherein said depositing comprises applying at least one of a low frequency (LF) radiofrequency component or a high frequency (HF) radiofrequency component.

14. A method for providing a metal-containing layer, the method comprising:
providing a substrate in a processing chamber; and
depositing by a plasma enhanced chemical vapor deposition (PECVD) process a molybdenum-containing layer on a surface portion of the substrate.

15. A method for processing a substrate, the method comprising:
depositing a molybdenum-containing layer on a top surface portion of a substrate;
forming a defined pattern within the molybdenum-containing layer; and
transferring the defined pattern to a material layer disposed beneath the molybdenum-containing layer.

16. The method of claim 15, wherein said depositing comprises:
exposing the top surface portion of the substrate to a molybdenum-containing precursor and one or more optional deposition precursors, thereby forming the molybdenum-containing layer.

17. The method of claim 16, wherein said exposing comprises delivering the molybdenum-containing precursor and the one or more optional deposition precursors sequentially, and further comprising optionally at least one of purging after delivery of the molybdenum-containing precursor or after the delivery of the one or more optional deposition precursors.

18. The method of claim 16, wherein said exposing comprises delivering the molybdenum-containing precursor and the one or more optional deposition precursors simultaneously.

19. The method of claim 16, wherein said exposing further comprises delivering a reactant gas, a reducing agent, or an inert gas.

20. The method of claim 15, wherein said depositing comprises chemical vapor deposition, atomic layer deposition, or a plasma-enhanced form thereof.

21. The method of claim 15, wherein said forming the defined pattern comprises:
depositing a resist layer on a top surface portion of the molybdenum-containing layer to form a resist mask having a pattern; and
transferring the pattern of the resist mask to the top surface portion of the molybdenum-containing layer to form a hardmask having one or more openings to provide the defined pattern.

22. The method of claim 21, wherein said transferring the defined pattern comprises:
etching the material layer through the one or more openings of the hardmask.

23. The method of claim 15, further comprising, before said depositing the molybdenum-containing layer:
providing an interfacial layer on the top surface portion of the substrate, thereby disposing the interfacial layer between the substrate and the molybdenum-containing layer.

24. The method of claim 23, wherein the interfacial layer comprises an adhesion layer, an initiation layer, or a growth layer.

25. The method of claim 23, wherein the interfacial layer comprises boron (B), carbon (C), titanium (Ti), tungsten (W), tantalum (Ta), nickel (Ni), molybdenum (Mo), a nitride thereof, a silicide thereof, an oxynitride thereof, a carbide thereof, or a carbonitride thereof.

26. The method of claim 23, further comprising, before said transferring the defined pattern to the material layer:

etching the interfacial layer through the defined pattern within the molybdenum-containing layer.

27. The method of claim 15, further comprising, before said depositing the molybdenum-containing layer:

pretreating the top surface portion of the substrate, thereby providing a pretreated surface being disposed between the substrate and the molybdenum-containing layer.

28. The method of claim 27, further comprising, before said transferring the defined pattern to the material layer:

etching the pretreated surface through the defined pattern within the molybdenum-containing layer.

29. The method of claim 15, wherein said transferring the defined pattern comprises: etching the material layer through the defined pattern within the molybdenum-containing layer.

30. A method for processing a substrate, the method comprising:

providing a substrate having a material layer disposed on a top surface portion of the substrate;

depositing a molybdenum-containing layer on a top surface portion of the material layer, wherein said depositing comprises delivering a molybdenum-containing precursor and one or more optional deposition precursors;

forming a patterned mask over the molybdenum-containing layer;

transferring a pattern of the patterned mask to the molybdenum-containing layer, thereby forming a defined pattern within the molybdenum-containing layer; and transferring the defined pattern to the material layer.

31. The method of claim 30, wherein the one or more optional deposition precursors is selected from the group consisting of a carbon-containing precursor, a silicon-containing precursor, and a boron-containing precursor.

32. The method of claim 31, wherein the carbon-containing precursor comprises at least one of a hydrocarbon, methane (CH_4), acetylene (C_2H_2), ethylene (C_2H_4), propylene (C_3H_6), propyne (C_3H_4), allene (C_3H_4), cyclopropene (C_3H_4), butane (C_4H_{10}), cyclohexane (C_6H_{12}), benzene (C_6H_6), or toluene (C_7H_8).

33. The method of claim 31, wherein the silicon-containing precursor comprises a silane compound, an organosilane compound, an alkyl silane compound, an alkoxy silane compound, a silanol compound, a siloxane compound, an aminosilane compound, a cyclic azasilane compound, a halosilane compound, or an inorganic silane compound.

34. The method of claim 31, wherein the boron-containing precursor comprises an organoborane compound, a boron halide compound, a borate compound, or an inorganic boron compound.

35. The method of claim 30, wherein the molybdenum-containing precursor comprises an organomolybdenum compound, a molybdenum halide compound, a molybdenum oxyhalide compound, an inorganic molybdenum compound, or a compound comprising a structure having one of formulas (I)-(V):

MoL_n (I),

wherein each L is independently hydrogen (H), halo, oxide ($=\text{O}$), imido ($=\text{NR}^1$), carbonyl (CO), amine (NR^1R^2), an organic ligand, a monodentate ligand, or a bidentate ligand;

n is selected from 2-6; and

R^1 and R^2 are each independently aliphatic, haloaliphatic, haloheteroaliphatic, heteroaliphatic, aromatic, aliphatic-aromatic, or heteroaliphatic-aromatic;

$\text{Mo}(\text{X})_m(\text{L})_n$ (II),

wherein each X is independently a halo, oxide ($=\text{O}$), imido ($=\text{NR}^1$), or carbonyl (CO); each L is an organic ligand;

R^1 is aliphatic, haloaliphatic, haloheteroaliphatic, heteroaliphatic, aromatic, aliphatic-aromatic, or heteroaliphatic-aromatic;

m is selected from 0-6; and

n is selected from 0-6, wherein at least one of m and n is not zero;

Mo_2L_n (III),

wherein each L is a bidentate ligand; and

n is selected from 2-5;

$\text{Mo}(\text{L}1)_m(\text{L}2)_n(\text{X})_p$ (IV),

wherein each L1 is, independently, a bidentate ligand;

each L2 is independently a neutral ligand;

each X is independently an anionic ligand;

m is selected from 1-3;

n is selected from 0-4; and

p is selected from 0-4; or

$\text{Mo}(\text{X})_m(\text{L})_n$ (V),

wherein each X is independently a halo;

each L is an organic ligand;

m is selected from 1-6; and

n is selected from 1-4;

or a salt thereof.

36. The method of claim 30, wherein the molybdenum-containing layer comprises Mo_xC_y , Mo_xSi_y , Mo_xB_y , $\text{Mo}_x\text{C}_y\text{O}_z$, $\text{Mo}_x\text{Si}_y\text{B}_z$, $\text{Mo}_x\text{C}_y\text{N}_z$, $\text{Mo}_x\text{Si}_y\text{C}_z$, $\text{Mo}_x\text{B}_y\text{C}_z$, Mo_xN_y , or $\text{Mo}_x\text{O}_y\text{N}_z$.

37. The method of claim 36, wherein the molybdenum-containing layer is a hardmask, an etch stop layer, a conformal layer, or a step coverage layer.

38. The method of claim 30, wherein the molybdenum-containing layer has a low fluorine content.

39. The method of claim 30, wherein the molybdenum-containing layer has a low stress.

40. The method of claim 30, wherein the molybdenum-containing layer comprises a high etch selectivity.

41. An apparatus for processing a substrate, the apparatus comprising:
a processing chamber comprising a substrate holder;
a process gas source connected with the processing chamber and associated flow-control hardware;
substrate handling hardware connected with the process chamber; and
a controller having a processor and a memory, wherein the processor and the memory are communicatively connected with one another, the processor is at least operatively connected with the flow-control hardware and substrate handling hardware, and the memory stores computer-executable instructions for conducting the operations recited in the method of claim 1.
42. The apparatus of claim 41, wherein the computer-executable instructions comprises instructions configured to:
cause exposure of a top surface portion of a substrate to a molybdenum-containing precursor and one or more deposition precursors within the processing chamber; and
cause deposition of a metal-containing layer or a molybdenum-containing layer on the top surface portion of the substrate.
43. The apparatus of claim 41, further comprising:
a plasma source connected with the processing chamber.
44. The apparatus of claim 43, wherein the computer-executable instructions comprises instructions configured to:
cause exposure of a top surface portion of a substrate to a molybdenum-containing precursor and one or more deposition precursors within the processing chamber;
cause supply of a plasma to the processing chamber; and
cause deposition of a metal-containing layer or a molybdenum-containing layer on the top surface portion of the substrate.