

CLAIMS

What is claimed is:

1. A method comprising:

providing a substrate comprising one or more features, each of the one or more
5 feature having at least one opening and an interior region fluidically accessible
through the at least one opening;

depositing a first layer of molybdenum in the one or more features; and

treating the first layer non-conformally such that that the treatment is
preferentially applied at portions of the first layer near the at least one opening of
10 the one or more features relative to portions of the first layer that are further in the
interior region of the feature.
2. The method of claim 1, wherein treating the first layer non-conformally comprises
inhibiting the first layer non-conformally.
3. The method of claim 1, wherein treating the first layer non-conformally comprises
15 etching the first layer non-conformally.
4. The method of claim 2 or 3, wherein treating the first layer is performed during
depositing the first layer of molybdenum.
5. The method of claim 4, wherein the method comprises exposing the one or more
features to a molybdenum precursor under conditions such that the precursor flux
20 or concentration is nearer the at least one opening of the one or more features.
6. The method of claim 5, wherein the molybdenum precursor is a molybdenum
oxyhalide.
7. The method of claim 6, wherein the molybdenum oxyhalide has a lower growth
rate near the one or more openings of the one or more features than in the interior
25 region due to etch reactions.
8. The method of claim 6, wherein the molybdenum oxyhalide has a lower growth
rate near the one or more openings of the one or more features than in the interior
region due to an inhibition treatment.

9. The method of claim 2 or 3, wherein treating the first layer is performed after the first layer of molybdenum is deposited.
10. The method of claim 9, wherein treating the first layer comprises exposing it to an inhibition chemistry.
- 5 11. The method of claim 10, wherein the inhibition chemistry is a nitrogen-containing chemistry.
12. The method of claim 11, wherein treating the first layer comprises, after exposing it to a nitrogen-containing chemistry, exposing it to one or more of hydrogen gas and a molybdenum precursor.
- 10 13. The method of claim 9, wherein treating the first layer comprises exposing it to an etch chemistry.
14. The method of claim 13, wherein the etch chemistry is a halogen-containing chemistry.
- 15 15. The method of claim 14, wherein treating the first layer comprises, after exposing it to a halogen-containing chemistry, purging a chamber housing the substrate.
16. The method of any of claims 1–9, wherein treating the first layer comprises exposing it to nitrogen-containing compound.
17. The method of any of claims 1–9, wherein treating the first layer comprises exposing it to halogen-containing compound.
- 20 18. The method of any of claims 1–9, wherein the treating the first layer comprises exposing it to ammonia or nitrogen trifluoride.
19. The method of any of claims 1–18, wherein treating the first layer is a non-plasma thermal process.
- 25 20. The method of any of claims 1–18, wherein treating the first layer is a plasma process.

21. The method of any of claims 1–20, wherein depositing the first layer of molybdenum comprises an atomic layer deposition process using H₂ as a reducing agent for a molybdenum oxyhalide or molybdenum halide precursor.
22. The method of any of claims 1–21, further comprising, after treating the first layer non-conformally, further comprising depositing a second layer of molybdenum.
23. The method of claim 22, where depositing the second layer comprises an atomic layer deposition process using H₂ as a reducing agent for a molybdenum oxyhalide or molybdenum halide precursor.
24. The method of any of claims 1–23, wherein the substrate comprises a 3-D structure having sidewalls, wherein the one or more openings of the one or more features are openings in the sidewalls.
25. The method of any of claims 1–23, wherein the one or more features have a closed end.
26. A method comprising:
- (a) depositing a conformal layer of a molybdenum (Mo) in a feature using a Mo precursor at first Mo precursor flow rate, Mo precursor partial pressure, and Mo precursor dose time; and
- (b) increasing at least one of Mo precursor flow rate, Mo precursor partial pressure, and Mo precursor dose time to increase the Mo precursor flux at the feature opening, to thereby deposit a second layer of Mo on the conformal layer of Mo.
27. The method of claim 26, wherein the Mo precursor is a molybdenum oxychloride.
28. An apparatus comprising:
- a process chamber having one or more stations each configured to hold a substrate;
- one or more process gas inlets for coupling to a hydrogen (H₂) gas source, a molybdenum precursor gas source, an inert purge gas source, and a treatment gas source; and
- a controller for controlling operations in the apparatus, comprising machine-readable instructions for:
- (a) alternating H₂ and molybdenum precursor pulses into the process chamber via the one or more process gas inlets to deposit a first molybdenum layer on a substrate;
- (b) after (a), inletting a treatment gas to treat the first molybdenum layer; and
- (c) after (b), alternating H₂ and molybdenum precursor pulses into the process chamber via the one or more process gas inlets to deposit a first molybdenum layer on a substrate.
29. An apparatus comprising:

- a process chamber having one or more stations each configured to hold a substrate;
one or more process gas inlets for coupling to a hydrogen (H₂) gas source, a
molybdenum precursor gas source, an inert purge gas source, and a treatment gas source; and
a controller for controlling operations in the apparatus, comprising machine-readable
5 instructions for:
- (a) inletting H₂ and molybdenum precursor into the process chamber via the one or
more process gas inlets to deposit a first molybdenum layer on a substrate;
 - (b) after (a), changing one or more of Mo precursor flow rate or dose time to deposit a
first molybdenum layer on a substrate.

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