

CLAIMS

What is claimed is:

1. A method for processing substrates, the method comprising:
providing a substrate having an oxide material thereon;
5 depositing at least a portion of an elemental molybdenum layer over the oxide material
using a first atomic layer deposition (ALD) process by exposing the oxide material
to alternating pulses of a first oxygen-containing molybdenum precursor and a first
reducing agent using a first set of process conditions; and
modulating the first set of process conditions to increase non-molybdenum content when
10 depositing the portion of the elemental molybdenum layer.
2. The method of claim 1, wherein the first set of process conditions comprise using a flow
rate of at least about 1000 sccm of the first reducing agent during the first ALD process.
3. The method of claim 1, wherein the first set of process conditions comprise exposing the
substrate to the first reducing agent for at least 1 second during a cycle of the first ALD
15 process.
4. The method of claim 1, further comprising prior to depositing the portion of the
elemental molybdenum layer, performing one of the following operations:
exposing the oxide material to a soak gas selected from the group consisting of boron-
containing gases, tungsten-containing gases, fluorine-containing gases, oxygen-
20 containing gases, chlorine-containing gases, and combinations thereof; or
exposing the oxide material to alternating pulses of a boron-containing gas and a
tungsten-containing gas; or
depositing a first layer on the oxide material using a second oxygen-containing
molybdenum precursor and a second reducing agent using a second ALD process on
25 the oxide material under a second set of process conditions.
5. The method of claim 4, wherein at least the second reducing agent is a nitrogen-
containing gas, hydrogen, or combinations thereof; or at least one of the first and the second
oxygen-containing molybdenum precursor is a molybdenum oxyhalide; or the second set of
process conditions comprises increasing flow of a nitrogen-containing gas during the second
30 ALD process; or less than half of the first layer is converted to a converted elemental
molybdenum layer during or prior to the first ALD process.
6. The method of claim 4, further comprising one of the following operations: flowing

nitrogen during depositing of the first layer; soaking the substrate having the oxide material thereon with a soak gas prior to depositing the first layer; or soaking the substrate having the oxide material thereon with a soak gas after depositing the first layer.

- 5 7. The method of any of claims 1-6, wherein the first layer is a crystalline layer or an amorphous layer.
8. The method of any of claims 1-6, wherein the first layer is a template for metal grain growth in the elemental molybdenum layer.
9. An apparatus for processing substrates, the apparatus comprising:
- 10 first and second process chambers each configured to house a substrate, the first and second process chambers optionally being chambers within a multi-chamber apparatus;
- a substrate support in each of the first and the second process chambers;
- gas inlets configured to direct gas into each of the first and the second process chambers via one or more single or dual plenum showerheads;
- 15 a heater configured to heat the substrate support in each process chamber; and
- a controller comprising program instructions for:
- (a) causing sequentially inletting of an oxygen-containing molybdenum precursor and a nitrogen-containing gas into the first process chamber while a substrate is housed in the first process chamber;
- 20 (b) after (a), causing transfer of the substrate to the second process chamber;
- (c) after (b), causing sequentially inletting of an oxygen-containing molybdenum precursor and hydrogen into the second process chamber while the substrate is housed in the second process chamber; and
- (d) causing implementation of one or more of the program instructions selected
- 25 from the group consisting of:
- causing nitrogen to be inletted into the first process chamber when the substrate is housed in the first process chamber,
- causing temperature of the substrate support in the second process chamber to be at two different temperatures while the substrate is housed in the
- 30 second process chamber,
- causing delivery of a soak gas to the first process chamber before or after sequentially inletting the oxygen-containing molybdenum precursor and the nitrogen-containing gas into the first process chamber, and

causing reduced flow of hydrogen into the second process chamber while the substrate is housed in the second process chamber.

10. An apparatus for processing substrates, the apparatus comprising:
- 5 a process chamber configured to house a substrate, the process chamber optionally being a chamber within a multi-chamber apparatus;
- a substrate support in the process chambers;
- a first gas box comprising a gas source for containing hydrogen gas;
- a second gas box comprising a gas source for containing a molybdenum-containing gas;
- 10 a third gas box comprising a gas source for containing a boron-containing or tungsten-containing gas;
- gas inlets configured to direct gas from each of the first gas box, second gas box, and third gas box into the process chamber via one or more single or dual plenum showerheads; and
- 15 a heater configured to heat the substrate support in each process chamber.