WHAT IS CLAIMED IS:

1. A method of fabricating a metal hard mask, the method comprising:

flowing at least one metal reactant gas into a reaction chamber configured to perform chemical vapor deposition (CVD), wherein the at least one metal reactant gas includes a metal-halogen gas or a metal-organic gas; and

depositing a hard mask metal layer by CVD using the at least one metal reactant gas.

2. The method of claim 1, wherein the at least one metal reactant gas is selected from the group consisting of a titanium-halogen gas, a titanium-organic gas, a tantalum-halogen gas, and a tantalum-organic gas.

3. The method of claim 1, wherein the depositing of the hard mask metal layer includes depositing a titanium layer, a titanium nitride layer, a tantalum layer, or a tantalum nitride layer by plasma enhanced CVD (PECVD) or metal-organic CVD (MOCVD).

4. The method of claim 1, further comprising tuning a stress and/or a density of the deposited hard mask metal layer with a plasma treatment on the deposited hard mask metal layer

5. The method of claim 4, wherein the stress of the hard mask metal layer is tuned to be between about 1E9 dyne/cm^2 and about -1E9 dyne/cm^2 and the density of the hard mask metal layer is tuned to be greater than about 4 g/cm^3.

6. The method of claim 4, wherein the plasma treatment includes stopping flow of the at least one metal reactant gas into the reaction chamber and bombarding the deposited hard mask metal layer with plasma formed from nitrogen, ammonia, argon, helium, hydrogen, or a combination thereof.

7. The method of claim 4, further comprising performing multiple cycles of hard mask metal layer CVD and plasma treatment to form a plurality of hard mask metal layers, each hard mask metal layer deposited one above the other.

8. The method of claim 1, further comprising flowing a second reactant gas into the reaction chamber, wherein the second reactant gas is selected from the group consisting of nitrogen and ammonia.

9. The method of claim 1, further comprising flowing a carrier gas into the reaction chamber, wherein the carrier gas is selected from the group consisting of helium, argon, and hydrogen.

10. A method of fabricating a titanium nitride (TiN) hard mask, the method comprising:

flowing at least one metal reactant gas and at least one carrier gas into a reaction chamber configured to perform chemical vapor deposition (CVD), wherein the at least one metal reactant gas includes a titanium-halogen gas or a titanium-organic gas; and

depositing a hard mask TiN layer by CVD using the at least one metal reactant gas and the at least one carrier gas.

11. The method of claim 10, wherein flowing the at least one metal reactant gas includes flowing a metal reactant gas selected from the group consisting of a titanium-chloride gas and a titanium-carbon gas, and wherein flowing the carrier gas into the reaction chamber includes flowing a carrier gas selected from the group consisting of helium, argon, and hydrogen.

12. The method of claim 10, wherein the depositing of the hard mask TiN layer includes depositing a titanium nitride layer by plasma enhanced CVD (PECVD) or metal-organic CVD (MOCVD).

13. The method of claim 10, further comprising:

tuning a stress and/or a density of the deposited hard mask TiN layer with a plasma treatment on the deposited hard mask TiN layer, wherein the plasma treatment includes stopping flow of the at least one metal reactant gas and bombarding the deposited hard mask TiN layer with a plasma formed from the at least one carrier gas; and

performing multiple cycles of hard mask TiN layer CVD and plasma treatment to form a plurality of hard mask TiN layers, each hard mask TiN layer deposited one above the other

14. The method of claim 13, wherein the stress of the hard mask TiN layer is tuned to be between about 1E9 dyne/cm^2 and about -1E9 dyne/cm^2 and the density of the hard mask TiN layer is tuned to be greater than about 4 g/cm^3.

15. The method of claim 13, wherein each cycle of plasma treatment includes bombarding the deposited hard mask TiN layer with plasma formed from nitrogen, ammonia, argon, helium, hydrogen, or a combination thereof, with RF power between about 0 Watts and about 200 Watts, for between about 0 seconds and about 20 seconds.

16. The method of claim 10, further comprising flowing a second reactant gas into the reaction chamber, wherein the second reactant gas is selected from the group consisting of nitrogen and ammonia.

17. A metal hard mark, comprising:

a titanium hard mask metal layer or a tantalum hard mask metal layer deposited by chemical vapor deposition (CVD) from at least one metal reactant gas including a metal-chlorine gas or a metal-carbon gas,

wherein the titanium hard mask metal layer is deposited by plasma enhanced CVD (PECVD) or metal-organic CVD (MOCVD) using a titanium-halogen precursor or a titanium-organic precursor, and

wherein the tantalum hard mask metal layer is deposited by PECVD or MOCVD using a tantalum-halogen precursor or a tantalum-organic precursor.

18. The hard mask of claim 17, wherein the titanium hard mask metal layer or the tantalum hard mask metal layer is comprised of titanium nitride or tantalum nitride, respectively, having a density greater than about 4 g/cm^3 and having a stress between about 1E9 dyne/cm^2 and about 1E9 dyne/cm^2.

19. The hard mask of claim 17, wherein the stress and/or the density of the hard mask metal layer has been tuned by a plasma treatment on the hard mask metal layer, the plasma treatment including bombardment with a plasma formed from hydrogen, nitrogen, ammonia, or a combination thereof.

20. The hard mask of claim 17, further comprising a plurality of titanium or tantalum metal layers, each metal layer deposited one above the other by cyclic metal layer CVD and plasma treatment.

CLAIMS

1. A method of fabricating a metal hard mask, the method comprising:

flowing at least one metal reactant gas into a reaction chamber configured to perform chemical vapor deposition (CVD), wherein the at least one metal reactant gas is selected from the group consisting of a tantalum-halogen gas, a tantalum-organic gas, a titanium-halogen gas, and a titanium-organic gas;

applying a first radio frequency (RF) power between a first electrode and a second electrode in the reaction chamber to deposit a hard mask metal layer by CVD using the at least one metal reactant gas;

stopping flow of the at least one metal reactant gas into the reaction chamber;

after stopping the flow of the at least one metal reactant gas, applying a second RF power, which is different than the first RF power, between the two electrodes in the reaction chamber to treat the hard mask metal layer with a plasma formed from a carrier gas.

2. The method of claim 1, wherein the depositing of the hard mask metal layer includes depositing a titanium layer, a titanium nitride layer, a tantalum layer, or a tantalum nitride layer by plasma enhanced CVD (PECVD) or metal-organic CVD (MOCVD).

3. The method of claim 1, wherein the plasma treatment tunes a stress and/or a density of the deposited hard mask metal layer.

4. The method of claim 3, wherein the stress of the hard mask metal layer is tuned to be between about 1E9 dyne/cm2 and about -1E9 dyne/cm2 and the density of the hard mask metal layer is tuned to be greater than about 4 g/cm3.

5. The method of claim 3, wherein the carrier gas comprises nitrogen, ammonia, argon, helium, hydrogen, or a combination thereof.

6. The method of claim 3, further comprising performing multiple cycles of hard mask metal layer CVD and plasma treatment to form a plurality of hard mask metal layers, each hard mask metal layer deposited one above the other.

7. The method of claim 1, further comprising flowing a second reactant gas into the reaction chamber, wherein the second reactant gas is selected from the group consisting of nitrogen and ammonia.

8. The method of claim 1, further comprising flowing the carrier gas into the reaction chamber, wherein the carrier gas is selected from the group consisting of helium, argon, and hydrogen.

9. The method of claim 1, wherein the first electrode functions as an anode and is supplied with low frequency RF from a first RF power source, and the second electrode functions as a cathode and is supplied with high frequency RF from a second RF power source.

10. The method of claim 9, wherein the first RF power source is operated between 10-400 kHz and the second RF power source is operated at 13.56 MHz.

11. A method of fabricating a titanium nitride (TiN) or tantalum nitride (TaN) hard mask, the method comprising:

flowing at least one metal reactant gas and at least one carrier gas into a reaction chamber configured to perform chemical vapor deposition (CVD), wherein the at least one metal reactant gas includes a titanium-halogen gas, a titanium-organic gas, tantalum-halogen gas or a tantalum-organic gas;

applying a radio frequency (RF) power between a first electrode and a second electrode in the reaction chamber to deposit a hard mask TiN or TaN layer by CVD using the at least one metal reactant gas and the at least one carrier gas;

stopping flow of the at least one metal reactant gas into the reaction chamber;

after stopping the flow of the at least one metal reactant gas, changing the RF power between the two electrodes in the reaction chamber to treat the hard mask TiN or TaN layer with a plasma formed from the at least one carrier gas.

12. The method of claim 11, wherein flowing the carrier gas into the reaction chamber includes flowing a carrier gas selected from the group consisting of helium, argon, and hydrogen.

13. The method of claim 11, wherein the depositing of the hard mask TiN or TaN layer includes depositing a titanium nitride or tantalum nitride layer by plasma enhanced CVD (PECVD) or metal-organic CVD (MOCVD).

14. The method of claim 11, further comprising:

tuning a stress and/or a density of the deposited hard mask TiN or TaN layer with the plasma treatment on the deposited hard mask TiN or TaN layer; and

performing multiple cycles of hard mask TiN or TaN layer CVD and plasma treatment to form a plurality of hard mask TiN or TaN layers, each hard mask TiN or TaN layer deposited one above the other.

15. The method of claim 14, wherein the stress of the hard mask TiN or TaN layer is tuned to be between about 1E9 dyne/cm^2 and about -1E9 dyne/cm^2 and the density of the hard mask TiN or TaN layer is tuned to be greater than about 4 g/cm^3.

16. The method of claim 14, wherein each cycle of plasma treatment includes bombarding the deposited hard mask TiN or TaN layer with plasma formed from nitrogen, ammonia, argon, helium, hydrogen, or a combination thereof, with RF power between about 0 Watts and about 200 Watts, for between about 0 seconds and about 20 seconds.

17. The method of claim 11, further comprising flowing a second reactant gas into the reaction chamber, wherein the second reactant gas is selected from the group consisting of nitrogen and ammonia.

18. The method of claim 11, wherein the first electrode functions as an anode and is supplied with low frequency RF from a first RF power source, and the second electrode functions as a cathode and is supplied with high frequency RF from a second RF power source.