Claims

What is claimed is

~~**1.** A method for depositing vanadium-containing films comprising the steps of:~~

~~**(i)** contacting a substrate with vanadium oxytrichloride vapor in a deposition reactor;~~

~~**(ii)** purging unreacted vanadium oxytrichloride with a first inert gas;~~

~~**(iii)** contacting the substrate with a nitrogen containing reactant in the deposition reactor; and~~

~~**(iv)** optionally purging unreacted nitrogen containing reactant with a second inert gas.~~

~~**2.** A method for depositing vanadium-containing films consisting essentially of the steps of:~~

~~**(i)** contacting a substrate with vanadium oxytrichloride vapor in a deposition reactor;~~

~~**(ii)** purging unreacted vanadium oxytrichloride with a first inert gas;~~

~~**(iii)** contacting the substrate with a nitrogen containing reactant in the deposition reactor; and~~

~~**(iv)** optionally purging unreacted nitrogen containing reactant with a second inert gas.~~

~~**3.** A method for depositing vanadium-containing films consisting of the steps of:~~

~~**(i)** contacting a substrate with vanadium oxytrichloride vapor in a deposition reactor;~~

~~**(ii)** purging unreacted vanadium oxytrichloride with a first inert gas;~~

~~**(iii)** contacting the substrate with a nitrogen containing reactant in the deposition reactor; and~~

~~**(iv)** optionally purging unreacted nitrogen containing reactant with a second inert gas.~~

~~4~~**1.** A method for depositing vanadium-containing films comprising the steps of:

(i) contacting a substrate with vanadium oxytrichloride vapor in a deposition reactor;

(ii) purging unreacted vanadium oxytrichloride with a first inert gas;

(iii) contacting the substrate with a nitrogen containing reactant in the deposition reactor;

(iv) optionally purging unreacted nitrogen containing reactant with a second inert gas; and

(v) optionally treating the substrate with plasma.

~~**5.** A method for depositing vanadium-containing films consisting essentially of the steps of:~~

~~**(i)** contacting a substrate with vanadium oxytrichloride vapor in a deposition reactor;~~

~~**(ii)** purging unreacted vanadium oxytrichloride with a first inert gas;~~

~~**(iii)** contacting the substrate with a nitrogen containing reactant in the deposition reactor; and~~

~~**(iv)** optionally purging unreacted nitrogen containing reactant with a second inert gas and~~

~~**(v)** treating the substrate with plasma.~~

~~**6.** A method for depositing vanadium-containing films consisting of the steps of:~~

~~**(i)** contacting a substrate with vanadium oxytrichloride vapor in a deposition reactor;~~

~~**(ii)** purging unreacted vanadium oxytrichloride with a first inert gas;~~

~~**(iii)** contacting the substrate with a nitrogen containing reactant in the deposition reactor; and~~

~~**(iv)** optionally purging unreacted nitrogen containing reactant with a second inert gas and~~

~~**(v)** treating the substrate with plasma to remove residual oxygen from oxynitride film.~~

~~7~~**2.** The method of ~~any one of claims 1-6~~claim 1, wherein the step of (i) contacting the substrate with vanadium oxytrichloride vapor comprises pulsing the vanadium oxytrichloride vapor for about 0.1 seconds to about 3 seconds.

~~**8.** The method of any one of claims 1-6, wherein the step of (i) contacting the substrate with vanadium oxytrichloride vapor comprises pulsing the vanadium oxytrichloride vapor for about 1 second.~~

~~9~~**3.** The method of ~~any one of claims 1-6~~claim 1, wherein the step of (ii) purging unreacted vanadium oxytrichloride with the first inert gas comprises a purge time of about 1 seconds to about 90 seconds.

~~**10.** The method of any one of claims 1-6, wherein the step of (ii) purging unreacted vanadium oxytrichloride with the first inert gas comprises a purge time of about 15 seconds to about 60 seconds~~

~~**11.** The method of any one of claims 1-6, wherein the step of (ii) purging unreacted vanadium oxytrichloride with the first inert gas comprises a purge time of about 30 seconds.~~

~~**12.** The method of any one of claims 1-6, wherein the step of (ii) purging unreacted vanadium oxytrichloride with the first inert gas comprises a purge time of about 60 seconds.~~

~~**13.** The method of any one of claims 1-6, wherein the step of (ii) purging unreacted vanadium oxytrichloride with the first inert gas comprises a purge time of about 90 seconds.~~

~~**14.** The method of any one of claims 1-6, wherein the step of (ii) purging unreacted vanadium oxytrichloride with the first inert gas comprises purging with an inert gas comprising argon.~~

~~**15.** The method of any one of claims 1-6, wherein the step of (ii) purging unreacted vanadium oxytrichloride with the first inert gas comprises purging with an inert gas comprising nitrogen.~~

~~16~~**4.** The method of ~~any one of claims 1-6~~claim 1, wherein the step (iii) nitrogen containing reactant comprises one or more of ammonia, hydrazine, monoalkylhydriazine and dialkylhydrazine.

~~17~~**5.** The method of ~~any one of claims 1-6~~claim 1, wherein the step (iii) nitrogen containing reactant comprises ammonia.

~~18~~**6.** The method of ~~any one of claims 1-6~~claim 1, wherein the step of (iii) contacting the substrate with ammonia gas comprises pulsing the nitrogen containing reactant for about 0.5 seconds to about 5 seconds.

~~**19.** The method of any one of claims 1-6, wherein the step of (iii) contacting the substrate with ammonia gas comprises pulsing the nitrogen containing reactant for about 2.5 seconds.~~

~~**20.** The method of any one of claims 1-6, wherein the step of (iii) contacting the substrate with ammonia gas comprises pulsing the nitrogen containing reactant for about 5 seconds.~~

~~**21**~~**7.** The method of ~~any one of claims 1-6~~claim 1, wherein the step of (iv) optionally purging of any unreacted nitrogen containing reactant with the second inert gas comprises a purge time of about 15 seconds to about 90 seconds.

~~**22.** The method of any one of claims 1-6, wherein the step of (iv) optionally purging of any unreacted nitrogen containing reactant with the second inert gas comprises a purge time of about 15 seconds to about 60 seconds.~~

~~**23.** The method of any one of claims 1-6, wherein the step of (iv) optionally purging of any unreacted nitrogen containing reactant with the second inert gas comprises a purge time of about 30 seconds.~~

~~**24.** The method of any one of claims 1-6, wherein the step of (iv) optionally purging of any unreacted nitrogen containing reactant with the second inert gas comprises a purge time of about 60 seconds.~~

~~**25.** The method of any one of claims 1-6, wherein the step of (iv) optionally purging of any unreacted nitrogen containing reactant with the second inert gas comprises a purge time of about 90 seconds.~~

~~**26.** The method of any one of claims 1-6, wherein the step of (iv) optionally purging of any unreacted nitrogen containing reactant with the second inert gas comprises purging with an inert gas comprising argon.~~

~~**27.** The method of any one of claims 1-6, wherein the step of (iv) optionally purging of any unreacted nitrogen containing reactant with the second inert gas comprises purging with an inert gas comprising nitrogen.~~

~~**28**~~**8.** The method of ~~any one of claims 4-6~~claim 1, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises treatment with nitrogen (N_2) plasma or hydrogen (H_2) plasma.

~~**29.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises a plasma directly generated in the reactor.~~

~~**30.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises a plasma generated outside of the reactor.~~

~~**31.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises treatment with a nitrogen plasma.~~

~~**32.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises a nitrogen plasma generated from a nitrogen source comprising one or more of nitrogen (N_2), ammonia, hydrazine, monoalkylhydriazine and dialkylhydrazine.~~

~~**33.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises a nitrogen plasma generated from a nitrogen source comprising nitrogen (N_2).~~

~~**34.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises a nitrogen plasma generated from a nitrogen source comprising ammonia.~~

~~**35.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises a nitrogen plasma generated from a nitrogen source comprising hydrazine.~~

~~**36.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises a nitrogen plasma generated from a nitrogen source comprising monoalkylhydriazine.~~

~~**37.** The method of any one of claims 4-6, wherein the step of (v) treating the substrate with plasma to remove residual oxygen from oxynitride film comprises a nitrogen plasma generated from a nitrogen source comprising dialkylhydrazine.~~

~~**38**~~**9.** The method of ~~any one of claims 1-6~~claim 1, wherein the substrate comprises silicon oxide.

~~**39**~~**10.** The method of ~~any one of claims 1-6~~claim 1, wherein the substrate comprises aluminum oxide.

~~**40**~~**11.** The method of ~~any one of claims 1-6~~claim 1, wherein the substrate comprises titanium nitride.

~~**41**~~**12.** The method ~~of any one of claims 1-6~~claim 1, wherein the substrate comprises titanium oxide.

~~**42**~~**13.** The method ~~of any one of claims 1-6~~claim 1, wherein the substrate comprises zirconium oxide.

~~**43**~~**14.** The method of ~~any one of claims 1-6~~claim 1, wherein the substrate is heated to a temperature from about 300 ^{O}C to about 600 ^{O}C.

~~**44.** The method of any one of claims 1-6, wherein the substrate is heated to a temperature from about 350 ^{O}C to about 550 ^{O}C.~~

~~**45.** The method of any one of claims 1-6, wherein the substrate is heated to a temperature from about 400 ^{O}C to about 500 ^{O}C.~~

~~**46**~~**15.** The method of ~~any one of claims 1-6~~claim 1, wherein the deposition reactor is at a pressure ≤ about 50 torr.

~~**47.** The method of any one of claims 1-6, wherein the deposition reactor is at a pressure ≤ about 40 torr.~~

~~**48.** The method of any one of claims 1-6, wherein the deposition reactor is at a pressure ≤ about 30 torr.~~

~~**49.** The method of any one of claims 1-6, wherein the deposition reactor is at a pressure ≤ about 20 torr.~~

~~**50**~~**16.** A vanadium-containing film deposited by the process of ~~any of claims 1-51~~claim 1.

~~**51**~~**17.** A vanadium-containing film deposited by the process of ~~any of claims 1-51~~claim 1, wherein the film has an aspect ratio of about 1 to about 60.

~~**52.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has an aspect ratio of about 1 to about 50.~~

~~**53.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has an aspect ratio of about 1 to about 40.~~

~~**54.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has an aspect ratio of about 1 to about 30.~~

~~**55.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has an aspect ratio of about 1 to about 20.~~

~~**56.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has an aspect ratio of greater than about 2.~~

~~**57.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has an aspect ratio of greater than about 5.~~

~~**58**~~**18.** A vanadium-containing film deposited by the process of ~~any of claims 1-51~~claim 1, wherein the film has a resistivity of between about 150 to about 500 μOhm cm.

~~**59.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has a resistivity of between about 175 to about 450 μOhm cm.~~

~~**60.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has a resistivity of between about 175 to about 400 μOhm cm.~~

~~**61.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has a resistivity of between about 175 to about 350 μOhm cm.~~

~~**62.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has a resistivity of between about 175 to about 300 μOhm cm.~~

~~**63.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has a resistivity of between about 175 to about 250 μOhm cm.~~

~~**64.** A vanadium-containing film deposited by the process of any of claims 1-51, wherein the film has a resistivity of about 175 µOhm cm.~~

~~**65**~~**19.** A vanadium-containing film deposited by the process of ~~any of claims 1-51~~claim 1, wherein the film ~~has a resistivity of about 200 µOhm cm~~comprises vanadium nitride.

~~**66**~~**20.** A vanadium-containing film deposited by the process of ~~any of claims 1-51~~claim 1, wherein the film ~~has a resistivity of about 250 µOhm cm~~comprises vanadium oxynitride.