**CLAIMS**

1. A method of depositing a titanium dioxide encapsulation layer over memory stacks on a semiconductor substrate, comprising:

(a) receiving a substrate having a plurality of magnetoresistive random access memory (MRAM) stacks or phase change random access memory (PCRAM) stacks thereon in a reaction chamber;

(b) flowing a titanium-containing reactant into the reaction chamber and allowing the titanium-containing reactant to adsorb onto the surface of the substrate;

(c) flowing an oxygen-containing reactant into the reaction chamber and allowing the oxygen-containing reactant to adsorb onto the surface of the substrate;

(d) exposing the reaction chamber to plasma for a duration of about 0.5 seconds or less to drive a surface reaction between the titanium-containing reactant and the oxygen-containing reactant to thereby conformally deposit a titanium dioxide encapsulation layer over the plurality of MRAM stacks or PCRAM stacks, wherein the plasma is generated using an RF power density of about 1750 $W/m^2$ or less;

(e) repeating (b)-(d) until the encapsulation layer reaches a final thickness;

(f) after (e), flowing a second titanium-containing reactant into the reaction chamber and allowing the second titanium-containing reactant to adsorb onto the surface of the substrate;

(g) flowing a second oxygen-containing reactant into the reaction chamber and allowing the second oxygen-containing reactant to adsorb onto the surface of the substrate;

(h) exposing the reaction chamber to a second plasma to drive a second surface reaction between the second titanium-containing reactant and the second oxygen-containing reactant to thereby conformally deposit a titanium dioxide second encapsulation layer over the encapsulation layer, wherein the second encapsulation layer is deposited under different plasma conditions than the encapsulation layer; and

(i) repeating (f)-(h) until the second encapsulation layer reaches a second final thickness.

2. The method of claim 1, wherein the oxygen-containing reactant comprises a weak oxidant.

3. The method of claim 2, wherein the oxygen-containing reactant does not include oxygen ($O_2$).

4. The method of claim 1, wherein during deposition of the encapsulation layer, the oxygen-containing reactant comprises a weak oxidant.

5. The method of claim 4, wherein during deposition of the encapsulation layer, the oxygen-containing reactant is substantially free of strong oxidants.

6. The method of claim 4, wherein during deposition of the second encapsulation layer, the oxygen-containing reactant is selected from the group consisting of oxygen, nitrous oxide, carbon monoxide, carbon dioxide, nitric oxide, nitrogen dioxide, ozone, sulfur oxide, sulfur dioxide, oxygen-containing hydrocarbons, water, hydrogen peroxide, alkyl alcohols, and combinations of the foregoing.

7. The method of claim 1, wherein during (h), an RF power density used to generate the second plasma is maintained above about 7075 $W/m^2$, and wherein during each iteration of (h), the second plasma is exposed to the substrate for a duration of about 0.5 seconds or greater.

8. The method of claim 4, wherein during (h), an RF power density used to generate the second plasma is maintained above about 7075 $W/m^2$, and wherein during each iteration of (h), the second plasma is exposed to the substrate for a duration of about 0.5 seconds or greater.

9. The method of claim 1, further comprising after depositing the titanium dioxide encapsulation layer, depositing dielectric material in gaps between adjacent MRAM or PCRAM stacks.

10. The method of claim 9, wherein depositing the encapsulation layer and depositing material in gaps are performed in the same reaction chamber without removing the substrate.

11. The method of claim 10, wherein the gaps are filled with titanium dioxide through the same reaction and reaction conditions used to deposit the encapsulation layer.

12. The method of claim 10, wherein the gaps are filled with titanium dioxide through different reaction conditions than used to deposit the encapsulation layer.

13. The method of claim 12, wherein the gaps are filled at a higher deposition rate than used to deposit the encapsulation layer.

14. The method of claim 1, wherein the final thickness of the encapsulation layer is between about 20-500Å.

15. The method of claim 1, wherein the encapsulation layer is a hermetic seal.

16. The method of claim 1, wherein the method is performed at a temperature of about 250°C or less.

17. The method of claim 1, wherein depositing the encapsulation layer does not substantially or selectively oxidize any of the materials in the MRAM or PCRAM stacks.

18. The method of claim 1, wherein the encapsulation layer does not substantially desorb hydrogen up to a temperature of at least about 500°C.

19. An apparatus for depositing material on partially fabricated semiconductor substrates, comprising:

a reaction chamber;

an inlet to the reaction chamber for introducing gas phase reactants;

an outlet to the reaction chamber for removing material from the reaction chamber;

a plasma generator configured to expose the reaction chamber to plasma; and

a controller configured to:

receive a partially fabricated semiconductor substrate having a plurality of magnetoresistive random access memory (MRAM) stacks or phase change random access memory (PCRAM) stacks thereon in the reaction chamber;

flow a first titanium-containing reactant into the reaction chamber and allow the first titanium-containing reactant to adsorb onto the surface of the substrate;

flow a first oxygen-containing reactant into the reaction chamber and allow the first oxygen-containing reactant to adsorb onto the surface of the substrate; and

generate a first plasma with the plasma generator, and expose the reaction chamber to the first plasma for a duration of about 0.5 seconds or less to drive a surface reaction between the first titanium-containing reactant and the first oxygen-containing reactant to thereby conformally deposit a first titanium dioxide encapsulation layer over the plurality of MRAM stacks or PCRAM stacks, wherein the first plasma is generated using an RF power density of about 1750 $W/m^2$ or less

flow a second titanium-containing reactant into the reaction chamber and allow the second titanium-containing reactant to adsorb onto the surface of the substrate;

flow an second oxygen-containing reactant into the reaction chamber and allow the second oxygen-containing reactant to adsorb onto the surface of the substrate; and

generate a second plasma with the plasma generator, and expose the reaction chamber to the second plasma to drive a surface reaction between the second titanium-containing reactant and the second oxygen-containing reactant to thereby conformally deposit a second titanium dioxide encapsulation layer over the first titanium dioxide encapsulation layer,

wherein the first titanium dioxide encapsulation layer is deposited under different conditions than the second encapsulation layer.

20. The apparatus of claim 19, wherein the first oxygen-containing reactant comprises a weak oxidant, and wherein the second oxygen-containing reactant comprises $O_2$ and/or $N_2O$.

21. The apparatus of claim 19, wherein the controller is configured to generate the first plasma at an RF power density of about 1750 $W/m^2$ or less, and expose the first plasma to the reaction chamber for a duration of about 0.5 seconds or less per plasma exposure, and wherein the controller is configured to generate the second plasma at an RF power density of about 7075

$W/m^2$ or more, and expose the reaction chamber to the second plasma for a duration of about 0.5 seconds or more per plasma exposure.

22. A method of forming titanium dioxide encapsulation layers over memory stacks on a semiconductor substrate, comprising:

(a) receiving the substrate having a plurality of magnetoresistive random access memory (MRAM) stacks or phase change random access memory (PCRAM) stacks thereon in a reaction chamber;

(b) depositing a first encapsulation layer comprising titanium dioxide on the plurality of MRAM stacks or PCRAM stacks using a first plasma-assisted atomic layer deposition reaction;

(c) after (b), depositing a second encapsulation layer comprising titanium dioxide on the first encapsulation layer using a second plasma-assisted atomic layer deposition reaction, wherein the second plasma-assisted atomic layer deposition reaction is performed under different plasma conditions than the first plasma-assisted atomic layer deposition reaction, wherein the first plasma-assisted atomic layer deposition reaction comprises exposing the substrate to a first plasma, wherein the first plasma is generated at an RF power density of about 1750 $W/m^2$ or less, the second plasma-assisted atomic layer deposition reaction comprises exposing the substrate to a second plasma, wherein the second plasma is generated at an RF power density of about 7075 $W/m^2$ or greater, and further wherein plasma duration during each cycle of the first plasma-assisted atomic layer deposition reaction is 0.5 seconds or less and plasma duration during each cycle of the second plasma-assisted atomic layer deposition reaction is 0.5 seconds or more.

23. A method of depositing a titanium dioxide encapsulation layer over memory stacks on a semiconductor substrate, comprising:

(a) receiving a substrate having a plurality of magnetoresistive random access memory (MRAM) stacks or phase change random access memory (PCRAM) stacks thereon in a reaction chamber;

(b) flowing a titanium-containing reactant into the reaction chamber and allowing the titanium-containing reactant to adsorb onto the surface of the substrate;

(c) flowing an oxygen-containing reactant into the reaction chamber and allowing the oxygen-containing reactant to adsorb onto the surface of the substrate;

(d) exposing the reaction chamber to plasma for a duration of about 0.5 seconds or less to drive a surface reaction between the titanium-containing reactant and the oxygen-containing reactant to thereby conformally deposit an encapsulation layer over the plurality of MRAM stacks or PCRAM stacks, wherein the encapsulation layer comprises titanium dioxide, and wherein the plasma is generated using an RF power density of about 1750 $W/m^2$ or less;

(e) repeating (b)-(d) until the encapsulation layer reaches a final thickness;

(f) flowing a second titanium-containing reactant into the reaction chamber and allowing the second titanium-containing reactant to adsorb onto the surface of the substrate;

(g) flowing a second oxygen-containing reactant into the reaction chamber and allowing the second oxygen-containing reactant to adsorb onto the surface of the substrate; and

(h) generating a second plasma with the plasma generator, and exposing the reaction chamber to the second plasma to drive a surface reaction between the second titanium-containing reactant and the second oxygen-containing reactant to thereby conformally deposit a second encapsulation layer over the encapsulation layer, the second encapsulation layer comprising titanium dioxide,

wherein the encapsulation layer is deposited at a higher rate of deposition than the second encapsulation layer.

24. The method of claim 23, wherein the oxygen-containing reactant comprises a weak oxidant.

25. The method of claim 24, wherein the oxygen-containing reactant does not include oxygen ($O_2$).

26. The method of claim 23, wherein the oxygen-containing reactant is substantially free of strong oxidants.

27. The method of claim 23, further comprising after depositing the titanium dioxide encapsulation layer, depositing dielectric material in gaps between adjacent MRAM or PCRAM stacks.

28. The method of claim 27, wherein depositing the encapsulation layer and depositing material in gaps are performed in the same reaction chamber without removing the substrate.

29. The method of claim 28, wherein the gaps are filled with titanium dioxide through the same reaction and reaction conditions used to deposit the encapsulation layer.

30. The method of claim 28, wherein the gaps are filled with titanium dioxide through different reaction conditions than used to deposit the encapsulation layer.

31. The method of claim 30, wherein the gaps are filled at a higher deposition rate than used to deposit the encapsulation layer.

32. The method of claim 23, wherein the final thickness of the encapsulation layer is between about 20-500Å.

33. The method of claim 23, wherein the encapsulation layer is a hermetic seal.

34. The method of claim 23, wherein the method is performed at a temperature of about 250°C or less.

35. The method of claim 23, wherein depositing the encapsulation layer does not substantially or selectively oxidize any of the materials in the MRAM or PCRAM stacks.

36. The method of claim 23, wherein the encapsulation layer does not substantially desorb hydrogen up to a temperature of at least about 500°C.

37. An apparatus for depositing material on partially fabricated semiconductor substrates, comprising:

a reaction chamber;

an inlet to the reaction chamber for introducing gas phase reactants;

an outlet to the reaction chamber for removing material from the reaction chamber;

a plasma generator configured to expose the reaction chamber to plasma; and

a controller configured to:

receive a partially fabricated semiconductor substrate having a plurality of magnetoresistive random access memory (MRAM) stacks or phase change random access memory (PCRAM) stacks thereon in the reaction chamber;

flow a first titanium-containing reactant into the reaction chamber and allow the first titanium-containing reactant to adsorb onto the surface of the substrate;

flow a first oxygen-containing reactant into the reaction chamber and allow the first oxygen-containing reactant to adsorb onto the surface of the substrate;

generate a first plasma with the plasma generator, and expose the reaction chamber to the first plasma for a duration of about 0.5 seconds or less to drive a surface reaction between the first titanium-containing reactant and the first oxygen-containing reactant to thereby conformally deposit a first titanium dioxide encapsulation layer over the plurality of MRAM stacks or PCRAM stacks, wherein the first plasma is generated using an RF power density of about 1750 $W/m^2$ or less;

flow a second titanium-containing reactant into the reaction chamber and allow the second titanium-containing reactant to adsorb onto the surface of the substrate;

flow a second oxygen-containing reactant into the reaction chamber and allow the second oxygen-containing reactant to adsorb onto the surface of the substrate; and

generate a second plasma with the plasma generator, and expose the reaction chamber to the second plasma to drive a surface reaction between the second titanium-containing reactant and the second oxygen-containing reactant to thereby conformally deposit a second titanium dioxide encapsulation layer over the first titanium dioxide encapsulation layer,

wherein the first titanium dioxide encapsulation layer is deposited at a higher rate of deposition than the second encapsulation layer.

38. The apparatus of claim 37, wherein the first oxygen-containing reactant comprises a weak oxidant, and wherein the second oxygen-containing reactant comprises $O_2$ and/or $N_2O$.

39. The apparatus of claim 37, wherein the controller is configured to generate the first plasma at an RF power density of about 1750 $W/m^2$ or less, and expose the first plasma to the reaction chamber for a duration of about 0.5 seconds or less per plasma exposure, and wherein the controller is configured to generate the second plasma at an RF power density of about 7075 $W/m^2$ or more, and expose the reaction chamber to the second plasma for a duration of about 0.5 seconds or more per plasma exposure.

40. The apparatus of claim 37, wherein the controller is configured to deposit dielectric material in gaps between adjacent MRAM or PCRAM stacks after depositing the first titanium dioxide encapsulation layer.

41. The apparatus of claim 37, wherein the controller is configured to deposit the first titanium dioxide encapsulation layer to a final thickness between about 20-500Å.

42. A method of depositing a titanium dioxide bilayer over a plurality of structures on a substrate, the method comprising:

(a) receiving the substrate in a reaction chamber, the substrate being a semiconductor substrate and comprising the plurality of structures on a surface of the substrate;

(b) flowing a first titanium-containing reactant into the reaction chamber and allowing the first titanium-containing reactant to adsorb onto the surface of the substrate;

(c) flowing a first oxygen-containing reactant into the reaction chamber and allowing the first oxygen-containing reactant to adsorb onto the surface of the substrate;

(d) exposing the reaction chamber to plasma for a duration of about 0.5 seconds or less to drive a surface reaction between the first titanium-containing reactant and the first oxygen-containing reactant to thereby conformally deposit a first titanium dioxide layer over the plurality of structures, wherein the plasma is generated using an RF power density of about 1750 $W/m^2$ or less;

(e) repeating (b)-(d) until the first titanium dioxide layer reaches a final thickness;

(f) after (e), flowing a second titanium-containing reactant into the reaction chamber and allowing the second titanium-containing reactant to adsorb onto the surface of the substrate;

(g) flowing a second oxygen-containing reactant into the reaction chamber and allowing the second oxygen-containing reactant to adsorb onto the surface of the substrate;

(h) exposing the reaction chamber to a second plasma to drive a second surface reaction between the second titanium-containing reactant and the second oxygen-containing reactant to thereby conformally deposit a second titanium dioxide layer over the first titanium dioxide layer, wherein the second titanium dioxide layer is deposited under different plasma conditions than the first titanium dioxide layer; and

(i) repeating (f)-(h) until the second titanium dioxide layer reaches a second final thickness, wherein the first titanium dioxide layer and the second titanium dioxide layer together form the titanium dioxide bilayer.

43. The method of claim 42, wherein the first oxygen-containing reactant comprises a weak oxidant.

44. The method of claim 43, wherein the first oxygen-containing reactant does not include oxygen ($O_2$).

45. The method of claim 43, wherein during deposition of the first titanium dioxide layer, the first oxygen-containing reactant is substantially free of strong oxidants.

46. The method of claim 43, wherein during deposition of the second titanium dioxide layer, the second oxygen-containing reactant is selected from the group consisting of oxygen, nitrous oxide, carbon monoxide, carbon dioxide, nitric oxide, nitrogen dioxide, ozone, sulfur oxide, sulfur dioxide, oxygen-containing hydrocarbons, water, hydrogen peroxide, alkyl alcohols, and combinations of the foregoing.

47. The method of claim 42, wherein during (h), an RF power density used to generate the second plasma is maintained above about 7075 $W/m^2$, and wherein during each iteration of (h), the second plasma is exposed to the substrate for a duration of about 0.5 seconds or greater.

48. The method of claim 43, wherein during (h), an RF power density used to generate the second plasma is maintained above about 7075 $W/m^2$, and wherein during each iteration of (h), the second plasma is exposed to the substrate for a duration of about 0.5 seconds or greater.

49. The method of claim 42, wherein the final thickness of the first titanium dioxide layer is between about 20-500Å.

50. The method of claim 42, wherein the first titanium dioxide layer hermetically seals the substrate after the first titanium dioxide layer is deposited in (d)-(e).

51. The method of claim 42, wherein the method is performed at a temperature between about 50-300°C.

52. The method of claim 42, wherein depositing the first titanium dioxide layer does not substantially or selectively oxidize any of the materials in the structures on the substrate.

53. The method of claim 42, wherein the first titanium dioxide layer does not substantially desorb hydrogen up to a temperature of at least about 500°C.

54. An apparatus for depositing a titanium dioxide bilayer on partially fabricated semiconductor substrates, comprising:

a reaction chamber;

an inlet to the reaction chamber for introducing gas phase reactants;

an outlet to the reaction chamber for removing material from the reaction chamber;

a plasma generator configured to expose the reaction chamber to plasma; and

a controller configured to:

receive a partially fabricated semiconductor substrate having a plurality of structures thereon in the reaction chamber;

flow a first titanium-containing reactant into the reaction chamber and allow the first titanium-containing reactant to adsorb onto the surface of the partially fabricated semiconductor substrate;

flow a first oxygen-containing reactant into the reaction chamber and allow the first oxygen-containing reactant to adsorb onto the surface of the partially fabricated semiconductor substrate;

generate a first plasma with the plasma generator, and expose the reaction chamber to the first plasma for a duration of about 0.5 seconds or less to drive a surface reaction between the first titanium-containing reactant and the first oxygen-containing reactant to thereby conformally deposit a first titanium dioxide layer over the plurality of structures on the partially fabricated semiconductor substrate, wherein the first plasma is generated using an RF power density of about 1750 $W/m^2$ or less;

flow a second titanium-containing reactant into the reaction chamber and allow the second titanium-containing reactant to adsorb onto the surface of the partially fabricated semiconductor substrate;

flow an second oxygen-containing reactant into the reaction chamber and allow the second oxygen-containing reactant to adsorb onto the surface of the partially fabricated semiconductor substrate; and

generate a second plasma with the plasma generator, and expose the reaction chamber to the second plasma to drive a surface reaction between the second titanium-containing reactant and the second oxygen-containing reactant to thereby conformally deposit a second titanium dioxide layer over the first titanium dioxide layer,

wherein the first titanium dioxide layer is deposited under different conditions than the second titanium dioxide layer, and wherein the first titanium dioxide layer and the second titanium dioxide layer together form the titanium oxide bilayer.

55. The apparatus of claim 54, wherein the first oxygen-containing reactant comprises a weak oxidant, and wherein the second oxygen-containing reactant comprises $O_2$ and/or $N_2O$.

56. The apparatus of claim 54, wherein the controller is configured to generate the second plasma at an RF power density of about 7075 $W/m^2$ or more, and to expose the reaction chamber to the second plasma for a duration of about 0.5 seconds or more per plasma exposure.

57. A method of forming a titanium dioxide bilayer over a plurality of structures on a substrate, comprising:

(a) receiving the substrate in a reaction chamber, the substrate comprising the plurality of structures on a surface of the substrate;

(b) depositing a first titanium dioxide layer on the plurality of structures using a first plasma-assisted atomic layer deposition reaction;

(c) after (b), depositing a second titanium dioxide layer on the first titanium dioxide layer using a second plasma-assisted atomic layer deposition reaction, wherein the second plasma-assisted atomic layer deposition reaction is performed under different plasma conditions than the first plasma-assisted atomic layer deposition reaction, and wherein the first titanium dioxide layer and the second titanium dioxide layer together form the titanium dioxide bilayer, wherein the first plasma-assisted atomic layer deposition reaction comprises exposing the substrate to a first plasma, wherein the first plasma is generated at an RF power density of about 1750 $W/m^2$ or less, the second plasma-assisted atomic layer deposition reaction comprises exposing the substrate to a second plasma, wherein the second plasma is generated at an RF power density of about 7075 $W/m^2$ or greater, and further wherein the substrate is exposed to the first plasma for durations of about 0.5 seconds or less, and the substrate is exposed to the second plasma for durations of about 0.5 seconds or more.

58. The method of claim 57, wherein the first titanium dioxide layer is deposited using a first set of reactants, wherein the second titanium dioxide layer is deposited using a second set of reactants, and wherein the first set of reactants differs from the second set of reactants.

59. An apparatus for depositing a titanium dioxide bilayer over a plurality of structures on a substrate, the apparatus comprising:

a reaction chamber;

an inlet to the reaction chamber for introducing gas phase reactants;

an outlet to the reaction chamber for removing material from the reaction chamber;

a plasma generator configured to expose the reaction chamber to plasma; and

a controller configured to cause:

(a) receiving the substrate in a reaction chamber, the substrate comprising the plurality of structures on a surface of the substrate;

(b) depositing a first titanium dioxide layer on the plurality of structures using a first plasma-assisted atomic layer deposition reaction;

(c) after (b), depositing a second titanium dioxide layer on the first titanium dioxide layer using a second plasma-assisted atomic layer deposition reaction, wherein the second plasma-assisted atomic layer deposition reaction is performed under different plasma conditions than the first plasma-assisted atomic layer deposition reaction, and wherein the first titanium dioxide layer and the second titanium dioxide layer together form the titanium dioxide bilayer, wherein the controller is configured to cause depositing the first titanium dioxide layer by causing the substrate to be exposed to a first plasma generated at an RF power density of about 1750 $W/m^2$ or less, and to cause depositing the second titanium dioxide layer by causing the substrate to be exposed to a second plasma generated at an RF power density of about 7075 $W/m^2$ or greater, and further wherein the controller is configured to cause depositing the first titanium dioxide layer by causing the substrate to be exposed to the first plasma for a duration of about 0.5 seconds or less during each iteration of the first atomic layer deposition reaction, and to cause depositing the second titanium dioxide layer by causing the substrate to be exposed to the second plasma for a duration of about 0.5 seconds or greater during each iteration of the second atomic layer deposition reaction.

60. The apparatus of claim 59, wherein the controller is configured to cause depositing the first titanium dioxide layer by causing a weak oxidant to flow into the reaction chamber, and to cause depositing the second titanium dioxide layer by causing $O_2$ and/or $N_2O$ to flow into the reaction chamber.

61. The apparatus of claim 60, wherein the controller is configured to cause depositing the first titanium dioxide layer without exposing the substrate to a strong oxidant.

62. The apparatus of claim 59, wherein the controller is configured to cause depositing the first titanium dioxide layer such that the first titanium dioxide layer has a final thickness between about 20-500Å.

63. The apparatus of claim 59, wherein the plasma generator is configured to generate plasma in the reaction chamber.

64. The apparatus of claim 59, wherein the plasma generator is a remote plasma generator that is configured to deliver plasma to the reaction chamber.

65. The apparatus of claim 59, wherein the plasma generator is configured to generate a capacitively coupled plasma.

66. The apparatus of claim 59, wherein the plasma generator is configured to generate an inductively coupled plasma.

67. The apparatus of claim 59, wherein the controller is configured to cause depositing the first titanium dioxide layer by causing a first set of reactants to flow into the reaction chamber, and to cause depositing the second titanium dioxide layer by causing a second set of reactants to flow into the reaction chamber, wherein the first and second sets of reactants differ from one another.

68. The apparatus of claim 59, further comprising a vaporizer.

69. The apparatus of claim 68, further comprising piping between the vaporizer and the reaction chamber, wherein the piping between the vaporizer and reaction chamber is configured to be heat traced.

70. A method of depositing a metal oxide bilayer over a plurality of structures on a substrate, the method comprising:

(a) receiving the substrate in a reaction chamber, the substrate being a semiconductor substrate and comprising the plurality of structures on a surface of the substrate;

(b) flowing a first metal-containing reactant into the reaction chamber and allowing the first metal-containing reactant to adsorb onto the surface of the substrate;

(c) flowing a first oxygen-containing reactant into the reaction chamber and allowing the first oxygen-containing reactant to adsorb onto the surface of the substrate;

(d) exposing the reaction chamber to plasma for a duration of about 0.5 seconds or less to drive a surface reaction between the first metal-containing reactant and the first oxygen-containing reactant to thereby conformally deposit a first metal oxide layer over the plurality of structures, wherein the plasma is generated using an RF power density of about 1750 $W/m^2$ or less;

(e) repeating (b)-(d) until the first metal oxide layer reaches a final thickness;

(f) after (e), flowing a second metal-containing reactant into the reaction chamber and allowing the second metal-containing reactant to adsorb onto the surface of the substrate;

(g) flowing a second oxygen-containing reactant into the reaction chamber and allowing the second oxygen-containing reactant to adsorb onto the surface of the substrate;

(h) exposing the reaction chamber to a second plasma to drive a second surface reaction between the second metal-containing reactant and the second oxygen-containing reactant to thereby conformally deposit a second metal oxide layer over the first metal oxide layer, wherein the second metal oxide layer is deposited under different plasma conditions than the first metal oxide layer; and

(i) repeating (f)-(h) until the second metal oxide layer reaches a second final thickness, wherein the first metal oxide layer and the second metal oxide layer together form the metal oxide bilayer.

71. The method of claim 70, wherein the first and second metal-containing reactants comprise a group 4 metal, and wherein the metal oxide bilayer is a group 4 metal oxide bilayer.

72. A method of forming a metal oxide bilayer over a plurality of structures on a substrate, comprising:

(a) receiving the substrate in a reaction chamber, the substrate comprising the plurality of structures on a surface of the substrate;

(b) depositing a first metal oxide layer on the plurality of structures using a first plasma-assisted atomic layer deposition reaction;

(c) after (b), depositing a second metal oxide layer on the first metal oxide layer using a second plasma-assisted atomic layer deposition reaction, wherein the second plasma-assisted atomic layer deposition reaction is performed under different plasma conditions than the first plasma-assisted atomic layer deposition reaction, and wherein the first metal oxide layer and the second metal oxide layer together form the metal oxide bilayer, wherein the first plasma-assisted atomic layer deposition reaction comprises exposing the substrate to a first plasma, wherein the first plasma is generated at an RF power density of about 1750 $W/m^2$ or less, the second plasma-assisted atomic layer deposition reaction comprises exposing the substrate to a second plasma, wherein the second plasma is generated at an RF power density of about 7075 $W/m^2$ or greater, and further wherein plasma duration during each cycle of the first plasma-assisted atomic layer deposition reaction is 0.5 seconds or less and plasma duration during each cycle of the second plasma-assisted atomic layer deposition reaction is 0.5 seconds or more.

73. The method of claim 72, wherein the first and second metal oxide layers each comprise a group 4 metal oxide.