Claims

1. A non-volatile memory device comprising:

a first electrode;

a second electrode;

a switching stacked arrangement between the first electrode and the second electrode;

an oxygen scavenger layer between the switching stacked arrangement and the second electrode; and

a diffusion barrier layer between the oxygen scavenger layer and the second electrode;

wherein the switching stacked arrangement comprises alternating tunneling barrier layers and active layers, wherein the tunneling barrier layers are a plurality of layers comprising a first material selected from a group consisting of aluminum oxide, silicon oxide, magnesium oxide, calcium oxide, hafnium silicate and any combination thereof, and the active layers are a plurality of layers comprising a second material different from the first material, the second material selected from a group consisting of tantalum oxide, hafnium oxide, zirconium oxide, titanium oxide, lanthanum oxide and any combination thereof;

wherein a first tunneling barrier layer of the tunneling barrier layers is in physical contact with the first electrode;

wherein a last active layer of the active layers is in physical contact with the oxygen scavenger layer; and

wherein a bandgap of each of the tunneling barrier layers is greater than a bandgap of each of the active layers.

2. The non-volatile memory device according to claim 1,

wherein the diffusion barrier layer has a thickness selected from a range from 1 nm to 10 nm.

3. The non-volatile memory device according to claim 1 or claim 2,
wherein an interatomic bonding energy of the first material is greater than an interatomic bonding energy of the second material.

4. The non-volatile memory device according to any one of claims 1 to 3,
wherein the tunneling barrier layers comprise a first metal oxide; and
wherein the active layers comprise a second metal oxide different from the first metal oxide.

5. The non-volatile memory device according to any one of claims 1 to 4,
wherein the tunneling barrier layers are more stable than the active layers.

6. The non-volatile memory device according to any one of claims 1 to 5,
wherein the first electrode comprises a metal or a conductive nitride.

7. The non-volatile memory device according to any one of claims 1 to 6,
wherein the first electrode comprises one or more materials selected from a group consisting of tungsten (W), aluminum (Al), copper (Cu), molybdenum (Mo), cobalt (Co), nickel (Ni), iron (Fe), platinum (Pt), palladium (Pd), gold (Au), iridium (Ir), ruthenium (Ru), rhodium (Rh), titanium tungsten (TiW), tantalum tungsten (TaW), titanium nitride (TiN) and tantalum nitride (TaN).

8. The non-volatile memory device according to any one of claims 1 to 7,
wherein the second electrode comprises a metal or a conductive nitride.

9. The non-volatile memory device according to any one of claims 1 to 8,
wherein the second electrode comprises one or more materials selected from a group consisting of platinum (Pt), palladium (Pd), gold (Au), iridium (Ir),

ruthenium (Ru), rhodium (Rh), titanium nitride (TiN) and tantalum nitride (TaN).

10. The non-volatile memory device according to any one of claims 1 to 9,
wherein an oxygen concentration layer of the oxygen scavenger layer is lower than an oxygen concentration layer of the last active layer.

11. The non-volatile memory device according to any one of claims 1 to 10,
wherein the oxygen scavenger layer comprises a metal oxide.

12. The non-volatile memory device according any one of claims 1 to 11, further comprising:
a further oxygen scavenger layer between the oxygen scavenger layer and the diffusion barrier layer;
wherein an oxygen concentration layer of the further oxygen scavenger layer is lower than the oxygen scavenger layer.

13. The non-volatile memory device according to any one of claims 1 to 12,
wherein the oxygen scavenger layer comprises TaO_z, wherein $0 < z < 1$.

14. The non-volatile memory device according to any one of claims 1 to 13,
wherein each of the tunneling barrier layers has a thickness selected from a range from 0.5 nm to 1.5 nm.

15. The non-volatile memory device according to any one of claims 1 to 14,
wherein each of the active layers has a thickness selected from a range from 1 nm to 3 nm.

16. A method of forming a non-volatile memory device, the method comprising:
forming a first electrode;

forming a second electrode;

forming a switching stacked arrangement between the first electrode and the second electrode;

forming an oxygen scavenger layer between the switching stacked arrangement and the second electrode; and

forming a diffusion barrier layer between the oxygen scavenger layer and the second electrode;

wherein the switching stacked arrangement comprises alternating tunneling barrier layers and active layers, wherein the tunneling barrier layers are a plurality of layers comprising a first material selected from a group consisting of aluminum oxide, silicon oxide, magnesium oxide, calcium oxide, hafnium silicate and any combination thereof, and the active layers are a plurality of layers comprising a second material different from the first material, the second material selected from a group consisting of tantalum oxide, hafnium oxide, zirconium oxide, titanium oxide, lanthanum oxide and any combination thereof;

wherein a first tunneling barrier layer of the tunneling barrier layers is in physical contact with the first electrode;

wherein a last active layer of the active layers is in physical contact with the oxygen scavenger layer; and

wherein a bandgap of the tunneling barrier layers is greater than a bandgap of the active layers.

17. The method according to claim 16,

wherein the switching stacked arrangement is formed after forming the first electrode;

wherein the oxygen scavenger layer is formed after forming the switching stacked arrangement;

wherein the diffusion barrier layer is formed after forming the oxygen scavenger layer; and

wherein the second electrode is formed after forming the diffusion barrier layer.

18. The method according to claim 16 or claim 17,

wherein the tunneling barrier layers, the active layers, the oxygen scavenger layer and the diffusion barrier layer are formed via sputtering, chemical vapor deposition (CVD), atomic layer deposition (ALD), electron-beam deposition, thermal evaporation, or molecular beam epitaxy.

19. A non-volatile memory device comprising:

a first electrode;

a second electrode;

a switching stacked arrangement between the first electrode and the second electrode;

an oxygen scavenger layer between the switching stacked arrangement and the second electrode; and

a diffusion barrier layer between the oxygen scavenger layer and the second electrode;

wherein the diffusion barrier layer is configured to prevent or reduce diffusion of metal atoms from the second electrode into the oxygen scavenger layer and the switching stacked arrangement, the diffusion barrier layer comprising one or more materials selected from a group consisting of tantalum, titanium, hafnium, zirconium, iridium oxide, ruthenium oxide and indium tin oxide;

wherein the switching stacked arrangement comprises alternating tunneling barrier layers and active layers, wherein the tunneling barrier layers are a plurality of layers comprising a first material selected from a group consisting of aluminum oxide, silicon oxide, magnesium oxide, calcium oxide, hafnium silicate and any combination thereof, and the active layers are a plurality of layers comprising a second material different from the first material, the second material selected from a group consisting of tantalum oxide, hafnium oxide, zirconium oxide, titanium oxide, lanthanum oxide and any combination thereof;

wherein a first tunneling barrier layer of the tunneling barrier layers is in physical contact with the first electrode;

wherein a last active layer of the active layers is in physical contact with the oxygen scavenger layer; and

wherein a bandgap of each of the tunneling barrier layers is greater than a bandgap of each of the active layers.

20. A method of forming a non-volatile memory device, the method comprising:

forming a first electrode;

forming a second electrode;

forming a switching stacked arrangement between the first electrode and the second electrode;

forming an oxygen scavenger layer between the switching stacked arrangement and the second electrode; and

forming a diffusion barrier layer between the oxygen scavenger layer and the second electrode;

wherein the diffusion barrier layer is configured to prevent or reduce diffusion of metal atoms from the second electrode into the oxygen scavenger layer and the switching stacked arrangement, the diffusion barrier layer comprising one or more materials selected from a group consisting of tantalum, titanium, hafnium, zirconium, iridium oxide, ruthenium oxide and indium tin oxide;

wherein the switching stacked arrangement comprises alternating tunneling barrier layers and active layers, wherein the tunneling barrier layers are a plurality of layers comprising a first material selected from a group consisting of aluminum oxide, silicon oxide, magnesium oxide, calcium oxide, hafnium silicate and any combination thereof, and the active layers are a plurality of layers comprising a second material different from the first material, the second material selected from a group consisting of tantalum oxide, hafnium oxide, zirconium oxide, titanium oxide, lanthanum oxide and any combination thereof;

wherein a first tunneling barrier layer of the tunneling barrier layers is in physical contact with the first electrode;

wherein a last active layer of the active layers is in physical contact with the oxygen scavenger layer; and

wherein a bandgap of the tunneling barrier layers is greater than a bandgap of the active layers.