Claims

[Claim 1] 1. A transistor comprising:
a first buffer layer;
an oxide semiconductor layer on and in contact with the first buffer layer, the oxide semiconductor layer including a channel region; and
a second buffer layer on and in contact with the oxide semiconductor layer;
wherein each of the first buffer layer and the second buffer layer comprises an oxide of one or more elements selected from aluminum, gallium, zirconium, hafnium, and a rare earth element.

[Claim 2] 2. The transistor according to claim 1, wherein the oxide semiconductor layer has at least one region containing oxygen in excess of the stoichiometric ratio in a crystalline state.

[Claim 3] 3. The transistor according to claim 1, wherein the oxide semiconductor layer is a crystalline semiconductor layer.

[Claim 4] 4. The transistor according to claim 1,
wherein the oxide semiconductor layer comprises a crystal part,
wherein a c-axis of the crystal part is aligned in the direction parallel to a normal vector of a surface where the oxide semiconductor layer is formed or a normal vector of a surface of the oxide semiconductor layer.

[Claim 5] 5. The transistor according to claim 1, wherein the oxide semiconductor layer comprises at least indium (In) or zinc (Zn).

[Claim 6] 6. The transistor according to claim 1, wherein the oxide semiconductor layer includes low-resistance regions between which the channel region is sandwiched.

[Claim 7] 7. A transistor comprising:
a first buffer layer;
an oxide semiconductor layer on and in contact with the first buffer layer, the oxide semiconductor layer including a channel region; and
a second buffer layer on and in contact with the oxide semiconductor layer, the second buffer layer covering a side surface of the oxide semiconductor layer;
wherein each of the first buffer layer and the second buffer layer comprises an oxide of one or more elements selected from aluminum, gallium, zirconium, hafnium, and a rare earth element.

[Claim 8] 8. The transistor according to claim 7, wherein the oxide semiconductor

layer has at least one region containing oxygen in excess of the stoichiometric ratio in a crystalline state.

[Claim 9] 9. The transistor according to claim 7, wherein the oxide semiconductor layer is a crystalline semiconductor layer.

[Claim 10] 10. The transistor according to claim 7,
wherein the oxide semiconductor layer comprises a crystal part,
wherein a c-axis of the crystal part is aligned in the direction parallel to a normal vector of a surface where the oxide semiconductor layer is formed or a normal vector of a surface of the oxide semiconductor layer.

[Claim 11] 11. The transistor according to claim 7, wherein the oxide semiconductor layer comprises at least indium (In) or zinc (Zn).

[Claim 12] 12. The transistor according to claim 7, wherein the oxide semiconductor layer includes low-resistance regions between which the channel region is sandwiched.

[Claim 13] 13. A transistor comprising:
a first buffer layer;
an oxide semiconductor layer on and in contact with the first buffer layer, the oxide semiconductor layer including a channel region; and
a second buffer layer on and in contact with the oxide semiconductor layer, the second buffer layer covering a side surface of the first buffer layer and a side surface of the oxide semiconductor layer;
wherein each of the first buffer layer and the second buffer layer comprises an oxide of one or more elements selected from aluminum, gallium, zirconium, hafnium, and a rare earth element.

[Claim 14] 14. The transistor according to claim 13, wherein the oxide semiconductor layer has at least one region containing oxygen in excess of the stoichiometric ratio in a crystalline state.

[Claim 15] 15. The transistor according to claim 13, wherein the oxide semiconductor layer is a crystalline semiconductor layer.

[Claim 16] 16. The transistor according to claim 13,
wherein the oxide semiconductor layer comprises a crystal part,
wherein a c-axis of the crystal part is aligned in the direction parallel to a normal vector of a surface where the oxide semiconductor layer is formed or a normal vector of a surface of the oxide semiconductor layer.

[Claim 17] 17. The transistor according to claim 13, wherein the oxide semiconductor layer comprises at least indium (In) or zinc (Zn).

[Claim 18] 18. The transistor according to claim 13, wherein the oxide semiconductor layer includes low-resistance regions between which the channel region is sandwiched.

CLAIMS

1. A semiconductor device comprising:

a first insulating layer over a substrate;

a first buffer layer over the first insulating layer;

an oxide semiconductor layer over and in contact with the first buffer layer, the oxide semiconductor layer including a channel region;

a second buffer layer in contact with side surfaces of the oxide semiconductor layer, wherein the side surfaces of the oxide semiconductor layer are opposed to each other in a channel length direction;

a gate insulating film over the second buffer layer;

a gate electrode over the gate insulating film;

a second insulating layer over the gate electrode, the second insulating layer comprising a first opening and a second opening;

a source electrode over the second insulating layer, the source electrode electrically connected to the oxide semiconductor layer through the first opening; and

a drain electrode over the second insulating layer, the drain electrode electrically connected to the oxide semiconductor layer through the second opening,

wherein the second buffer layer is in direct contact with a top surface of the oxide semiconductor layer and a top surface of the first buffer layer,

wherein each of the first buffer layer and the second buffer layer comprises an oxide of one or more elements selected from a group comprising aluminum, gallium, zirconium, hafnium, and a rare earth element, and

wherein the second buffer layer is a single layer.

2. The semiconductor device according to claim 1, wherein the oxide semiconductor layer has at least one region containing oxygen in excess of the stoichiometric ratio in a crystalline state.

3. The semiconductor device according to claim 1, wherein the oxide semiconductor layer is a crystalline semiconductor layer.

4. The semiconductor device according to claim 1,

wherein the oxide semiconductor layer comprises a crystal part,

wherein a c-axis of the crystal part is aligned in a direction parallel to a normal vector of a surface where the oxide semiconductor layer is formed or a normal vector of a surface of the oxide semiconductor layer.

5. The semiconductor device according to claim 1, wherein the oxide semiconductor layer comprises at least indium (In) or zinc (Zn).

6. The semiconductor device according to claim 1, wherein the oxide semiconductor layer includes low-resistance regions between which the channel region is sandwiched.

7. The semiconductor device according to claim 1, wherein an end portion of the second buffer layer and an end portion of the first buffer layer are aligned.

8. A semiconductor device comprising:

an insulating layer;

a first buffer layer over the first insulating layer;

an oxide semiconductor layer over and in contact with the first buffer layer, the oxide semiconductor layer including a channel region;

a second buffer layer in contact with side surfaces of the oxide semiconductor layer, wherein the side surfaces of the oxide semiconductor layer are opposed to each other in a channel length direction,

wherein the second buffer layer is in direct contact with a top surface of the oxide semiconductor layer and side surfaces of the first buffer layer, wherein the side surfaces of the first buffer layer are opposed to each other in the channel length direction,

wherein each of the first buffer layer and the second buffer layer comprises an oxide of one or more elements selected from a group comprising aluminum, gallium, zirconium, hafnium, and a rare earth element,

wherein the second buffer layer is a single layer, and

wherein the second buffer layer is in direct contact with a top surface of the insulating layer.

9. The semiconductor device according to claim 8, wherein the oxide semiconductor layer has at least one region containing oxygen in excess of the stoichiometric ratio in a crystalline state.

10. The semiconductor device according to claim 8, wherein the oxide semiconductor layer is a crystalline semiconductor layer.

11. The semiconductor device according to claim 8,

wherein the oxide semiconductor layer comprises a crystal part,

wherein a c-axis of the crystal part is aligned in a direction parallel to a normal vector of a surface where the oxide semiconductor layer is formed or a normal vector of a surface of

the oxide semiconductor layer.

12. The semiconductor device according to claim 8, wherein the oxide semiconductor layer comprises at least indium (In) or zinc (Zn).

13. The semiconductor device according to claim 8, wherein the oxide semiconductor layer includes low-resistance regions between which the channel region is sandwiched.

14. A semiconductor device comprising:

a first insulating layer over a substrate;

a first buffer layer over the first insulating layer;

an oxide semiconductor layer over and in contact with the first buffer layer, the oxide semiconductor layer including a channel region;

a second buffer layer in contact with side surfaces of the oxide semiconductor layer, wherein the side surfaces of the oxide semiconductor layer are opposed to each other in a channel length direction;

a gate insulating film over the second buffer layer;

a gate electrode over the gate insulating film;

a second insulating layer over the gate electrode, the second insulating layer comprising a first opening and a second opening;

a source electrode over the second insulating layer, the source electrode electrically connected to the oxide semiconductor layer through the first opening; and

a drain electrode over the second insulating layer, the drain electrode electrically connected to the oxide semiconductor layer through the second opening,

wherein the second buffer layer is in direct contact with a top surface of the oxide semiconductor layer and side surfaces of the first buffer layer, wherein the side surfaces of the first buffer layer are opposed to each other in the channel length direction,

wherein each of the first buffer layer and the second buffer layer comprises an oxide of one or more elements selected from a group comprising aluminum, gallium, zirconium, hafnium, and a rare earth element, and

wherein the second buffer layer is a single layer.

15. The semiconductor device according to claim 14, wherein the oxide semiconductor layer has at least one region containing oxygen in excess of the stoichiometric ratio in a crystalline state.

16. The semiconductor device according to claim 14, wherein the oxide semiconductor layer is a crystalline semiconductor layer.

17. The semiconductor device according to claim 14,

wherein the oxide semiconductor layer comprises a crystal part,

wherein a c-axis of the crystal part is aligned in a direction parallel to a normal vector of a surface where the oxide semiconductor layer is formed or a normal vector of a surface of the oxide semiconductor layer.

18. The semiconductor device according to claim 14, wherein the oxide semiconductor layer comprises at least indium (In) or zinc (Zn).

19. The semiconductor device according to claim 14, wherein the oxide semiconductor layer includes low-resistance regions between which the channel region is sandwiched.