# CLAIMS

1. A semiconductor device comprising:

an oxide semiconductor film over a substrate;

a source electrode and a drain electrode over the oxide semiconductor film;

a gate insulating film over the oxide semiconductor film, wherein the gate insulating film comprises an oxide containing silicon; and

a gate electrode over the gate insulating film,

wherein the oxide semiconductor film comprises:

a first region in which a concentration of silicon is lower than or equal to 1.0 at.%; and

a pair of second regions, each of the pair of second regions comprising a dopant,

wherein the first region is located at an interface between the oxide semiconductor film and the gate insulating film and in contact with the gate insulating film, and

wherein the first region comprises a crystal portion.

2. A semiconductor device comprising:

an oxide semiconductor film over a substrate;

a source electrode and a drain electrode over the oxide semiconductor film;

a gate insulating film over the oxide semiconductor film, wherein the gate insulating film comprises an oxide containing silicon; and

a gate electrode over the gate insulating film,

wherein the oxide semiconductor film comprises:

a first region in which a concentration of silicon is lower than or equal to 1.0 at.%; and

a pair of second regions, each of the pair of second regions comprising a dopant,

wherein the first region is located at an interface between the oxide semiconductor film and the gate insulating film and in contact with the gate insulating film,

wherein the first region comprises a crystal portion, and

wherein the dopant comprises argon.

3. The semiconductor device according to claim 1 or 2, wherein an end portion of the oxide semiconductor film is tapered at an angle of 20° to 50°.

4. The semiconductor device according to claim 1 or 2, further comprising a base insulating film between the substrate and the oxide semiconductor film,

wherein in the crystal portion, a c-axis is aligned in a direction perpendicular to an interface between the base insulating film and the oxide semiconductor film.

5. The semiconductor device according to claim 1 or 2, wherein the concentration of silicon in the first region is lower than or equal to 0.1 at.%.

6. The semiconductor device according to claim 1 or 2, further comprising an interlayer insulating film over the gate insulating film and the gate electrode.

7. The semiconductor device according to claim 1 or 2, wherein a concentration of carbon in the first region is lower than or equal to $1.0 \times 10^{20}$ atoms/cm$^3$.

8. The semiconductor device according to claim 1 or 2, wherein the first region has a thickness less than or equal to 5 nm.

9. The semiconductor device according to claim 1 or 2, wherein the dopant comprises one or more elements selected from the group consisting of phosphorus, arsenic, antimony, boron, aluminum, nitrogen, argon, helium, neon, indium, fluorine, chlorine, titanium, and zinc.

10. The semiconductor device according to claim 1 or 2, wherein a concentration of dopant in each of the pair of second regions is higher than or equal to $5 \times 10^{18}$ atoms/cm$^3$ and lower than or equal to $1 \times 10^{22}$ atoms/cm$^3$.

11. The semiconductor device according to claim 1 or 2, wherein the pair of second regions and the gate electrode do not overlap each other.

12. A semiconductor device comprising:

an oxide semiconductor film over a substrate; and

an insulating film over the oxide semiconductor film, wherein the insulating film comprises an oxide containing silicon,

wherein the oxide semiconductor film comprises a region in which a concentration of silicon is lower than or equal to 1.0 at.%, and

wherein the region is located at an interface between the oxide semiconductor film and the insulating film and in contact with the insulating film.

13. The semiconductor device according to claim 12, wherein the oxide semiconductor film comprises a crystal portion.

14. The semiconductor device according to claim 13, further comprising a base insulating film between the substrate and the oxide semiconductor film,

wherein in the crystal portion, a c-axis is aligned in a direction perpendicular to an interface between the base insulating film and the oxide semiconductor film.

15. The semiconductor device according to claim 12, further comprising a source electrode and a drain electrode being in contact with the oxide semiconductor film.

16. The semiconductor device according to claim 12, further comprising a gate electrode overlapping with the oxide semiconductor film.

17. A semiconductor device comprising:

a first transistor comprising:

a channel formation region comprising silicon;

a gate insulating film over the channel formation region; and

a gate electrode; and

a second transistor over the first transistor, the second transistor comprising:

an oxide semiconductor film; and

an insulating film over the oxide semiconductor film, wherein the insulating film comprises an oxide containing silicon,

wherein the oxide semiconductor film comprises a region in which a concentration of silicon is lower than or equal to 1.0 at.%, and

wherein the region is located at an interface between the oxide semiconductor film and the insulating film and in contact with the insulating film.

18. The semiconductor device according to claim 12 or 17, wherein an end portion of the oxide semiconductor film is tapered at an angle of 20° to 50°.

19. The semiconductor device according to claim 17, wherein the oxide semiconductor film comprises a crystal portion.

20. The semiconductor device according to claim 12 or 17, wherein the concentration of silicon in the region is lower than or equal to 0.1 at.%.

21. The semiconductor device according to claim 12 or 17, wherein a concentration of carbon in the region is lower than or equal to $1.0 \times 10^{20}$ atoms/cm$^3$.

22. The semiconductor device according to claim 12 or 17, wherein the region has a thickness less than or equal to 5 nm.

23. The semiconductor device according to claim 17, wherein the second transistor further comprises a source electrode and a drain electrode being in contact with the oxide semiconductor film.

24. The semiconductor device according to claim 17, wherein the second transistor further comprises a gate electrode overlapping with the oxide semiconductor film.

# CLAIMS

1. A semiconductor device comprising:

an oxide semiconductor film over a substrate;

a source electrode and a drain electrode over the oxide semiconductor film;

a gate insulating film over the oxide semiconductor film, wherein the gate insulating film comprises an oxide containing silicon; and

a gate electrode over the gate insulating film,

wherein the oxide semiconductor film comprises:

a first region in which a concentration of silicon is lower than or equal to 1.0 at.%; and

a pair of second regions, each of the pair of second regions comprising a dopant,

wherein the first region is located at an interface between the oxide semiconductor film and the gate insulating film and in contact with the gate insulating film, and

wherein the first region comprises a crystal portion.

2. The semiconductor device according to claim 1, wherein an end portion of the oxide semiconductor film is tapered at an angle of 20° to 50°.

3. The semiconductor device according to claim 1, further comprising a base insulating film between the substrate and the oxide semiconductor film,

wherein in the crystal portion, a c-axis is aligned in a direction perpendicular to an interface between the base insulating film and the oxide semiconductor film.

4. The semiconductor device according to claim 1, wherein the concentration of silicon in the first region is lower than or equal to 0.1 at.%.

5. The semiconductor device according to claim 1, further comprising an interlayer insulating film over the gate insulating film and the gate electrode.

6. The semiconductor device according to claim 1, wherein a concentration of

carbon in the first region is lower than or equal to $1.0 \times 10^{20}$ atoms/cm$^3$.

7. The semiconductor device according to claim 1, wherein the first region has a thickness less than or equal to 5 nm.

8. The semiconductor device according to claim 1, wherein the dopant comprises one or more elements selected from the group consisting of phosphorus, arsenic, antimony, boron, aluminum, nitrogen, argon, helium, neon, indium, fluorine, chlorine, titanium, and zinc.

9. The semiconductor device according to claim 1, wherein a concentration of dopant in each of the pair of second regions is higher than or equal to $5 \times 10^{18}$ atoms/cm$^3$ and lower than or equal to $1 \times 10^{22}$ atoms/cm$^3$.

10. The semiconductor device according to claim 1, wherein the pair of second regions and the gate electrode do not overlap each other.

11. A semiconductor device comprising:

an oxide semiconductor film over a substrate;

a source electrode and a drain electrode over the oxide semiconductor film;

a gate insulating film over the oxide semiconductor film, wherein the gate insulating film comprises an oxide containing silicon; and

a gate electrode over the gate insulating film,

wherein the oxide semiconductor film comprises:

a first region in which a concentration of silicon is lower than or equal to 1.0 at.%; and

a pair of second regions, each of the pair of second regions comprising a dopant,

wherein the first region is located at an interface between the oxide semiconductor film and the gate insulating film and in contact with the gate insulating film,

wherein the first region comprises a crystal portion, and

wherein the dopant comprises argon.

12. The semiconductor device according to claim 11, wherein an end portion of the oxide semiconductor film is tapered at an angle of 20° to 50°.

13. The semiconductor device according to claim 11, further comprising a base insulating film between the substrate and the oxide semiconductor film,

wherein in the crystal portion, a c-axis is aligned in a direction perpendicular to an interface between the base insulating film and the oxide semiconductor film.

14. The semiconductor device according to claim 11, wherein the concentration of silicon in the first region is lower than or equal to 0.1 at.%.

15. The semiconductor device according to claim 11, further comprising an interlayer insulating film over the gate insulating film and the gate electrode.

16. The semiconductor device according to claim 11, wherein a concentration of carbon in the first region is lower than or equal to $1.0 \times 10^{20}$ atoms/cm$^3$.

17. The semiconductor device according to claim 11, wherein the first region has a thickness less than or equal to 5 nm.

18. The semiconductor device according to claim 11, wherein the dopant comprises one or more elements selected from the group consisting of phosphorus, arsenic, antimony, boron, aluminum, nitrogen, argon, helium, neon, indium, fluorine, chlorine, titanium, and zinc.

19. The semiconductor device according to claim 11, wherein a concentration of dopant in each of the pair of second regions is higher than or equal to $5 \times 10^{18}$ atoms/cm$^3$ and lower than or equal to $1 \times 10^{22}$ atoms/cm$^3$.

20. The semiconductor device according to claim 11, wherein the pair of second regions and the gate electrode do not overlap each other.