# CLAIMS

1. A method for manufacturing a semiconductor device, comprising the step of holding a substrate placed in a treatment chamber at a first temperature, introducing a source gas into the treatment chamber, and supplying a high-frequency power to an electrode in the treatment chamber so that an insulating film is formed over the substrate,

wherein the first temperature is higher than or equal to 180 °C and lower than or equal to 260 °C,

wherein a pressure in the treatment chamber is set to be higher than or equal to 100 Pa and lower than or equal to 250 Pa when the source gas is introduced, and

wherein the high-frequency power is higher than or equal to 0.17 W/cm$^2$ and lower than or equal to 0.5 W/cm$^2$.

2. The method for manufacturing a semiconductor device according to claim 1,

wherein the insulating film is a silicon oxide film or a silicon oxynitride film, and

wherein the source gas comprises a deposition gas containing silicon and an oxidation gas.

3. The method for manufacturing a semiconductor device according to claim 1,

wherein the insulating film is a silicon oxynitride film, and

wherein the source gas comprises silane and dinitrogen monoxide.

4. The method for manufacturing a semiconductor device according to claim 1,

wherein the substrate includes:

a gate electrode;

a gate insulating film adjacent to the gate electrode;

an oxide semiconductor film overlapping with a part of the gate electrode with the gate insulating film interposed therebetween; and

a pair of electrodes in contact with the oxide semiconductor film,

wherein the insulating film is formed over the oxide semiconductor film and

the pair of electrodes as a protective film.

5. The method for manufacturing a semiconductor device according to claim 4, wherein the gate insulating film is over the gate electrode, and wherein the pair of electrodes is over the oxide semiconductor film.

6. The method for manufacturing a semiconductor device according to claim 4, wherein the pair of electrodes is over the oxide semiconductor film, and wherein the gate insulating film is over the oxide semiconductor film and the pair of electrodes.

7. The method for manufacturing a semiconductor device according to claim 4, further comprising the step of performing a heat treatment at a second temperature higher than or equal to the first temperature after forming the insulating film.

8. The method for manufacturing a semiconductor device according to claim 7, wherein the second temperature is higher than or equal to 250 °C and lower than a strain point of the substrate.

9. The method for manufacturing a semiconductor device according to claim 4, wherein the oxide semiconductor film includes indium, gallium, and zinc.

10. The method for manufacturing a semiconductor device according to claim 4, wherein the oxide semiconductor film includes a c-axis aligned crystal part.

11. A semiconductor device comprising:
a gate electrode over an insulating surface;
a gate insulating film over the gate electrode;
an oxide semiconductor film overlapping with a part of the gate electrode with the gate insulating film interposed therebetween;
a pair of electrodes in contact with the oxide semiconductor film; and

a protective film over the oxide semiconductor film and the pair of electrodes,

wherein the protective film is an oxide insulating film in which a spin density of a signal at g = 2.001, measured by electron spin resonance, is lower than $1.5 \times 10^{18}$ spins/$cm^3$.

12. The semiconductor device according to claim 11,

wherein the protective film is a silicon oxide film or a silicon oxynitride film.

13. The semiconductor device according to claim 11,

wherein the oxide semiconductor film includes indium, gallium, and zinc.

14. The semiconductor device according to claim 11,

wherein the oxide semiconductor film includes a c-axis aligned crystal part.

15. A semiconductor device comprising:

an oxide semiconductor film over an insulating surface;

a pair of electrodes in contact with the oxide semiconductor film;

a gate insulating film over the oxide semiconductor film;

a gate electrode overlapping with the oxide semiconductor film with the gate insulating film interposed therebetween; and

a protective film over the gate insulating film and the gate electrode,

wherein the protective film is an oxide insulating film in which a spin density of a signal at g = 2.001, measured by electron spin resonance, is lower than $1.5 \times 10^{18}$ spins/$cm^3$.

16. The semiconductor device according to claim 15,

wherein the protective film is a silicon oxide film or a silicon oxynitride film.

17. The semiconductor device according to claim 15, wherein the pair of electrodes is between the gate insulating film and the oxide semiconductor film.

18. The semiconductor device according to claim 15, wherein the pair of electrodes is between the oxide semiconductor film and the protective film.

19. The semiconductor device according to claim 15,
wherein the oxide semiconductor film includes indium, gallium, and zinc.

20. The semiconductor device according to claim 15,
wherein the oxide semiconductor film includes a c-axis aligned crystal part.

# CLAIMS

1. A method for manufacturing a semiconductor device, comprising the step of holding a substrate placed in a treatment chamber at a first temperature, introducing a source gas into the treatment chamber, and supplying a high-frequency power to an electrode in the treatment chamber so that an insulating film is formed over the substrate,

wherein the first temperature is higher than or equal to 180 °C and lower than or equal to 260 °C,

wherein a pressure in the treatment chamber is set to be higher than or equal to 100 Pa and lower than or equal to 250 Pa when the source gas is introduced,

wherein the high-frequency power is higher than or equal to 0.17 $W/cm^2$ and lower than or equal to 0.5 $W/cm^2$, and

wherein the insulating film contains oxygen which is released by heating.

2. The method for manufacturing a semiconductor device according to claim 1,

wherein the insulating film is a silicon oxide film or a silicon oxynitride film, and

wherein the source gas comprises a deposition gas containing silicon and an oxidation gas.

3. The method for manufacturing a semiconductor device according to claim 1,

wherein the insulating film is a silicon oxynitride film, and

wherein the source gas comprises silane and dinitrogen monoxide.

4. The method for manufacturing a semiconductor device according to claim 1,

wherein the substrate includes:

a gate electrode;

a gate insulating film adjacent to the gate electrode;

an oxide semiconductor film overlapping with a part of the gate electrode with the gate insulating film interposed therebetween; and

a pair of electrodes in contact with the oxide semiconductor film,

wherein the insulating film is formed over the oxide semiconductor film and the pair of electrodes as a protective film.

5. The method for manufacturing a semiconductor device according to claim 4,
wherein the gate insulating film is over the gate electrode, and
wherein the pair of electrodes is over the oxide semiconductor film.

6. The method for manufacturing a semiconductor device according to claim 4,
wherein the pair of electrodes is over the oxide semiconductor film, and
wherein the gate insulating film is over the oxide semiconductor film and the pair of electrodes.

7. The method for manufacturing a semiconductor device according to claim 4, further comprising the step of performing a heat treatment at a second temperature higher than or equal to the first temperature after forming the insulating film.

8. The method for manufacturing a semiconductor device according to claim 7,
wherein the second temperature is higher than or equal to 250 °C and lower than a strain point of the substrate.

9. The method for manufacturing a semiconductor device according to claim 4,
wherein the oxide semiconductor film includes indium, gallium, and zinc.

10. The method for manufacturing a semiconductor device according to claim 4,
wherein the oxide semiconductor film includes a c-axis aligned crystal part.

11. A semiconductor device comprising:
a gate electrode over an insulating surface;
a gate insulating film over the gate electrode;
an oxide semiconductor film overlapping with a part of the gate electrode with the gate insulating film interposed therebetween;
a pair of electrodes in contact with the oxide semiconductor film; and
a protective film over the oxide semiconductor film and the pair of electrodes,
wherein the protective film is an oxide insulating film in which a spin density of a signal at $g = 2.001$, measured by electron spin resonance, is lower than $1.5 \times 10^{18}$ spins/cm$^3$, and
wherein the protective film contains oxygen which is released by heating.

12. The semiconductor device according to claim 11,
wherein the protective film is a silicon oxide film or a silicon oxynitride film.

13. The semiconductor device according to claim 11,
wherein the oxide semiconductor film includes indium, gallium, and zinc.

14. The semiconductor device according to claim 11,
wherein the oxide semiconductor film includes a c-axis aligned crystal part.

15. A semiconductor device comprising:
an oxide semiconductor film over an insulating surface;
a pair of electrodes in contact with the oxide semiconductor film;
a gate insulating film over the oxide semiconductor film;
a gate electrode overlapping with the oxide semiconductor film with the gate insulating film interposed therebetween; and
a protective film over the gate insulating film and the gate electrode,
wherein the protective film is an oxide insulating film in which a spin density of a signal at g = 2.001, measured by electron spin resonance, is lower than $1.5 \times 10^{18}$ spins/$cm^3$, and
wherein the protective film contains oxygen which is released by heating.

16. The semiconductor device according to claim 15,
wherein the protective film is a silicon oxide film or a silicon oxynitride film.

17. The semiconductor device according to claim 15, wherein the pair of electrodes is between the gate insulating film and the oxide semiconductor film.

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