

Claims

1. A DRAM capacitor including a lower electrode which is made of a TiN-based material and a dielectric film, wherein
5 the lower electrode comprises:

first TiON films provided at opposite outer sides, the first TiON films having a relatively low oxygen concentration; and

a second TiON film provided between the first TiON
10 films, the second TiON film having a relatively high oxygen concentration,

wherein the dielectric film is provided on the lower electrode.

15 2. The DRAM capacitor of claim 1, wherein the lower electrode has a three-layer structure in which the first TiON films are formed at opposite outer sides of the second TiON film.

20 3. The DRAM capacitor of claim 1, wherein the lower electrode has a five-layer structure in which a TiN film is provided between the first TiON films, and the second TiON film is provided between the TiN film and each of the first TiON films.

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4. The DRAM capacitor of claim 1, wherein the lower

electrode has a five-layer structure in which a third TiON film having an oxygen concentration lower than the oxygen concentration of the second TiON film is provided between the first TiON films, and the second TiON film is provided
5 between the third TiON film and each of the first TiON films.

5. The DRAM capacitor of any one of claims 1 to 4, wherein the lower electrode has a film structure symmetrical in a thickness direction.
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6. The DRAM capacitor of any one of claims 1 to 5, wherein the oxygen concentration of each of the first TiON films is within a range from 30 at.% to 40 at.%.
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7. The DRAM capacitor of any one of claims 1 to 6, wherein a film thickness of each of the first TiON films is within a range from 0.5 nm to 5 nm.
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8. The DRAM capacitor of any one of claims 1 to 7, wherein the oxygen concentration of the second TiON film is higher than 40 at.%.
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9. The DRAM capacitor of any one of claims 1 to 8, wherein a film thickness of the second TiON film is within a range from 0.5 nm to 5 nm.

10. A method of manufacturing a lower electrode which is made of a TiN-based material and provided at a base of a dielectric film in a DRAM capacitor, the method comprising:

accommodating a target substrate in a processing chamber, maintaining an inside of the processing chamber in a depressurized state, and forming a first TiON film having a relatively low oxygen concentration by repeating a predetermined number of times a cycle of forming a unit nitride film at a predetermined processing temperature by alternately supplying a Ti-containing gas and a nitriding gas multiple times with a process of purging the inside of the processing chamber interposed therebetween and then oxidizing the unit nitride film by supplying an oxidizing agent;

forming a second TiON film having a relatively high oxygen concentration on the first TiON film by repeating a predetermined number of times a cycle of forming a unit nitride film by alternately supplying the Ti-containing gas and the nitriding gas multiple times with the process of purging the inside of the processing chamber interposed therebetween and then oxidizing the unit nitride film by supplying the oxidizing agent; and

forming another first TiON film as an uppermost layer, wherein oxygen concentrations of the first TiON film and the second TiON film are controlled by at least one of the number of alternate supply of the Ti-containing gas and

the nitriding gas in the case of forming the unit nitride film, an oxidation time of the unit nitride film, and a flow rate of the oxidizing agent in the oxidation process.

- 5 11. A method of manufacturing a lower electrode which is made of a TiN-based material and provided at a base of a dielectric film in a DRAM capacitor, the method comprising:

 accommodating a target substrate in a processing chamber, maintaining an inside of the processing chamber in
10 a depressurized state, and forming a first TiON film having a relatively low oxygen concentration by repeating a predetermined number of times a cycle of forming a unit nitride film at a predetermined processing temperature by alternately supplying a Ti-containing gas and a nitriding
15 gas multiple times with a process of purging the inside of the processing chamber interposed therebetween and then oxidizing the unit nitride film by supplying an oxidizing agent;

 forming a second TiON film having a relatively high
20 oxygen concentration on the first TiON film by repeating a predetermined number of times a cycle of forming a unit nitride film by alternately supplying the Ti-containing gas and the nitriding gas multiple times with the process of purging the inside of the processing chamber interposed
25 therebetween and then oxidizing the unit nitride film by supplying the oxidizing agent;

forming a TiN film on the second TiON film by alternately supplying the Ti-containing gas and the nitriding gas with the process of purging the inside of the processing chamber interposed therebetween;

- 5 forming another second TiON film on the TiN film; and
 forming another first TiON film on the another second TiON film,

 wherein oxygen concentrations of the first and the second TiON film are controlled by at least one of the
10 number of alternate supply of the Ti-containing gas and the nitriding gas in the case of forming the unit nitride film, an oxidation time of the unit nitride film, and a flow rate of the oxidizing agent in the oxidation process.

- 15 12. The method of claim 10 or 11, wherein the Ti-containing gas is TiCl_4 gas and the nitriding gas is NH_3 gas.

 13. The method of any one of claims 10 to 12, wherein the oxidizing agent is an oxygen-containing gas selected from a
20 group consisting of O_2 gas, O_3 gas, H_2O and NO_2 or a plasma of the oxygen-containing gas.

 14. The method of any one of claims 10 to 13, wherein the processing temperature is within a range from 300°C to 500°C .