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Signed this 10th day of February 2017.

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**(54) [Title of Invention] METAL WIRING FORMATION METHOD OF SEMICONDUCTOR DEVICE**


**(57) Abstract**

[Problem] To improve step coverage of a diffusion prevention film, reduce particles, and raise yield and reliability.

[Resolution Means] After a contact hole is formed in a predetermined site on a semiconductor substrate whereon an insulating film is formed, a titanium and titanium nitride film are formed at a predetermined thickness on the entire surface of the insulating film including the contact hole by using a chemical vapor deposition method.

Thereafter, the formed titanium nitride film is heat treated at a predetermined temperature and for a predetermined time in a nitrogen atmosphere to phase transition to a three-layer titanium nitride film having a different phase and nitrogen content.

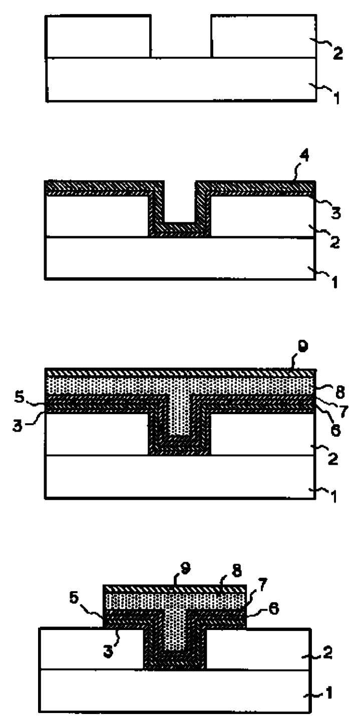
Thereafter, the metal wiring for electrically connecting the contact hole portion is formed.


(a)

(b)

(c)

(d)



Specification
Title of the Invention: METAL WIRING FORMATION METHOD OF SEMICONDUCTOR DEVICE

[DETAILED DESCRIPTION OF THE INVENTION]
[0001]
[Technical Field of the Invention] The present invention relates to a formation method of a semiconductor device, and particularly relates to a formation method of a metal wiring including a metal layer for preventing diffusion.
[0002]
[Prior Art] In recent years, research relating to a wiring design that is easily and freely carried out by increasing the degree of integration of a semiconductor device, and a metal wiring technique where the wiring resistance, current capacity, and the like is made discretionary, has been active.

In general, aluminum having a low resistance is widely used as a material for metal wiring of a semiconductor device.

Since the width of such an aluminum wiring is miniaturized as the degree of integration of the device increases, the current density increases.

The increase of the current density causes wiring failure due to electron movement, irregular reflection, and movement of stress; this causes a problem in that the reliability of the semiconductor device is lowered.
[0003]
In order to solve the aforementioned problems, conventionally, disconnection of the metal wiring can be prevented by laminating a copper (Cu) or titanium (Ti) film or the like on an aluminum wiring film and reducing the movement of electrons and movement of stress, but a phenomenon such as hillock and whisker occurs, generating problems such as mutual short circuit of a wiring and breakdown of an insulating film.
[0004]
FIG. 2 is a cross-sectional view illustrating a state in which a metal wiring is formed after a diffusion prevention film is formed to solve problems such as hillock and whiskers in the metal wiring formation step of a semiconductor element according to a conventional example.

This method, as illustrated in FIG. 2, first forms a contact hole in a predetermined site of an insulating film 2 after forming the insulating film 2 on a semiconductor substrate 1.

In the step for forming the contact hole, the contact hole is etched at a depth where the surface of the lower portion of the semiconductor 1 is exposed.

Then, a titanium film 3 and a titanium nitride film 4 is sequentially laminated as a diffusion prevention film on the entire surface of the deposit, including a contact hole in a predetermined site in the insulating film 2, using a physical vapor deposition (PVD) method.

Thereafter, a metal layer 8 is formed on the upper portion of the titanium nitride film 4.
[0005]
[Problem to be Solved by the Invention] However, as the current high degree of integration is advanced, the size of the contact hole decreases, and in comparison, the difference in level of the contact hole relatively increases.

Therefore, when the metal wiring is formed by laminating the diffusion prevention film as described above using the physical vapor deposition method, step coverage is decreased and the diffusion prevention film cannot be uniformly vapor deposited on the lower portion of the contact hole, and furthermore, when the thickness of the metal layer is increased, a shadow effect is increased in the top corner of the top portion of the contact hole, making it impossible to carry out subsequent steps.

[0006]

In addition, when $TiCl_4$ is reacted with $NH_3$ or the like by using a chemical vapor deposition method to improve the step coverage of the diffusion prevention film, a particle is generated inside the titanium film and the titanium nitride film, resulting in a problem where the yield of the elements is reduced and the reliability of the device is reduced.

In addition, since the phase of the titanium nitride film is amorphous during vapor deposition of the titanium nitride film, there are problems in that the internal resistance of the titanium nitride film increases thereby lowering the conduction speed of the device.

Therefore, an object of the present invention is to provide a metal wiring formation method of a semiconductor device, wherein the step coverage of the diffusion prevention film can be improved, and the yield and reliability of the semiconductor device can be improved by reducing the resistance inside of the diffusion prevention film and the particles of the diffusion prevention film.

[0007]

[Means for Solving the Problems] In order to achieve the object of the present invention as described above, the method of the present invention first forms a contact hole in a predetermined site on the semiconductor substrate whereon an insulating film is formed, then sequentially forms a titanium film and a titanium nitride film at a predetermined thickness on the entire surface of the insulating film including the contact hole using a chemical vapor deposition method, thereafter, heat treats the formed titanium nitride film in a nitrogen atmosphere, and phase transitions to a titanium nitride film having a three-layer structure in which the nitrogen content and the phase differ from each other.

Thereafter, the metal wiring for electrically connecting the contact hole portion is formed.

The present invention can also include a step for vapor depositing an arc thin film after the metal wiring is formed.

[0008]

[Embodiment of the Invention] Preferred embodiments of the present invention will be described below with reference to appended drawings.

FIG. 1 (a) through (d) are cross-sectional diagrams illustrating the steps for forming the metal wiring according to the embodiment of the present invention.

First, as illustrated in FIG. 1 (a), a contact hole is formed in a predetermined portion of the insulating film 2 using a photo-lithography method, by vapor depositing the insulating film 2 on the upper portion of the semiconductor substrate 1 including an active region.

The contact hole is formed by etching a predetermined portion of the insulating film 2 until the surface of the semiconductor substrate 1 is exposed.

[0009]

Thereafter, as illustrated in FIG. 1 (b), the titanium film is vapor deposited in the inner portion of the contact hole and on the entire surface of the insulating film 2.

The titanium film 3 is formed by using a chemical vapor deposition (CVP) method via a reaction between $TiCl_4$ and $NH_3$ or $NF_3$, and that is formed sufficiently thin to maintain the shape of the contact hole.

The chemical vapor deposition method is a vapor deposition method for improving the step coverage of the inner portion of the contact hole.

Thereafter, the titanium nitride film 4 is formed on the upper portion of the titanium film 3.

Here, in order to suppress generation of particles, the titanium nitride film 4 is formed by using a chemical vapor deposition method using only tetradimethylaminotitanium ($Ti(N(CH_3)_2)_4$) or tetracetyl aminotitanium ($Ti(N(C_2H_5)_4)$ as a raw material, and a feed gas for forming the titanium nitride film 4 is nitrogen and/or helium.

In addition, when vapor depositing the titanium nitride film, the temperature is 300 to 500°C, the pressure is adjusted in a range of 5 to 10 mTorr, and the film quality formed at this time is in an amorphous phase.

[0010]

Then, the semiconductor substrate whereon the layer in the aforementioned state was formed, is heat treated in a nitrogen atmosphere at a temperature range of 400 to 600°C for 30 to 60 minutes.

The titanium nitride film 4 is divided into three titanium nitride films having different physical properties via this heat treatment.

That is, as illustrated in FIG. 1 (c), it is divided into an amorphous first titanium nitride film 5 from a lower layer, a crystalline second titanium nitride film 6 in an intermediate layer, and a nitrogen rich crystalline third titanium nitride film 7.

Furthermore, when using a rapid thermal process (RTP) method instead of the heat treatment, the heat treatment is carried out in a temperature range of 700 to 900°C for 10 to 30 seconds.

[0011]

Since the single titanium nitride film 4 illustrated in FIG. 1 (b) is amorphous, the resistance is extremely high, but the internal resistance of the titanium nitride film can be decreased by phase transitioning the single titanium nitride film 4 to the three-layered titanium nitride film each having different physical properties by the heat treatment under the above conditions.

Subsequently, as illustrated in FIG. 1 (c), copper, aluminum, or an alloy thereof is vapor deposited on the entire surface of the diffusion prevention film (titanium nitride film) using a common physical vapor deposition method, forming the metal layer 8.

Thereafter, an arc thin film (arc-metal layer) 9 is vapor deposited on the metal layer 8.

The arc thin film 9 is vapor deposited using a chemical vapor deposition method.

The arc thin film 9 serves to block reflected light from the metal wiring pattern when a photo-resist film for forming a metal wiring pattern is exposed.

Tetradimethylaminotitanium or tetradiethylaminotitanium are examples of the raw material of the arc thin film 9, and the vapor deposition temperature is 300 to 450°C.

The formation step of the arc thin film 9 can also be omitted in some cases.

[0012]

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