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Translation from Japanese to English
MultiLing Project Number: GBPLC1710001HQ-S
Client: Greenblum & Bernstein, P.L.C.

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Original Document Identifier: Awaya (1998) (03005811); JPH08250596A (03005939); JPH09293690A (03002312); JPH10125627A (03005938); JPH10256256A (03002313).
Translated Document Identifier: Awaya (1998) (03005811)_en-US; JPH08250596A (03005939)_en-US; JPH09293690A (03002312)_en-US; JPH10125627A (03005938)_en-US; JPH10256256A (03002313)_en-US.

Signed this 10th day of February 2017.

Michael Degn, VP Sales/Marketing

ACKNOWLEDGMENT BEFORE NOTARY

State of Utah
}ss.
County of Utah

(19) Japan Patent Office (JP)

(12) JAPANESE UNEXAMINED PATENT APPLICATION PUBLICATION (A)

(11) Patent Application Disclosure No.
JPA H10-125627

(43) **Publication Date: May 15, 1998 (Heisei 10)**

(51) Int. Cl.^{6}		Ident. Code	FI		
H01L	21/285	301	H01L	21/285	301R
					S
C23C	14/06		C23C	14/06	A
	14/34			14/34	S
H01L			H01L	21/203	S

Examination Request: Not Yet **No. of Claims**: 23 OL (Total 14 pages)

(21) Application No. JPA H8-282211

(22) Date of Filing: October 24, 1996 (Heisei 8)

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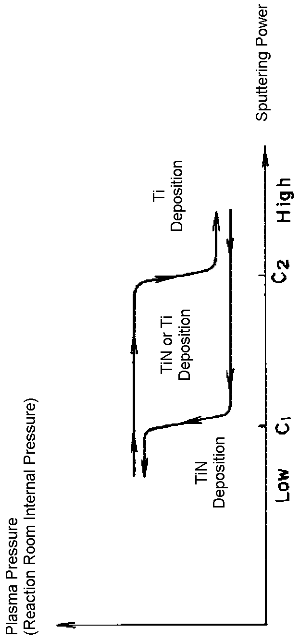
(54) [Title of Invention] METHOD FOR FABRICATING SEMICONDUCTOR DEVICE AND METHOD FOR FORMING HIGH MELTING POINT NITROGEN FILM

(57) Abstract

[Problem] To provide a method for fabricating a semiconductor wherein a fine, low resistance TiN diffusion barrier layer can be formed with high through-put by Ti reactive sputtering.
[Resolution Means] After depositing a TiN film under first conditions wherein TiN can be surely sputtered using a Ti target, continually perform TiN sputtering under second condition wherein Ti is generally sputtered using the same Ti target.

Diagram describing the principles of the present invention schematically illustrating the hysteresis in FIG. 2.



Specification
Title of the Invention: METHOD FOR FABRICATING SEMICONDUCTOR DEVICE AND METHOD FOR FORMING HIGH MELTING POINT NITROGEN FILM

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field of the Invention] The present invention relates to the general fabrication of a semiconductor device, and more particularly relates to a method for fabricating a semiconductor device including a metalization step.

In regards to the fabrication of semiconductors, a metalization step is necessary in which wiring made up of Al or an Al alloy is connected to a semiconductor device formed in a semiconductor substrate.

Generally, this metalization step is performed using a sputtering method.

[0002]

[Conventional Art] In a general fabrication process of a Si semiconductor device, a diffusion barrier layer such as TiW, TiC, TiN or the like is provided between a wiring pattern made up of Al or Al alloy and a connection region formed in a Si substrate that connects this wiring pattern prior to the metalization step of this wiring pattern, the Al in the Al wiring diffuses in the Si substrate in the connection region, preventing, for example, the formation of an alloy spike breaking through a thin diffusion region.

[0003]

Generally, when forming a diffusion barrier layer with TiN, a Ti target is used, and a TiN film is formed by carrying out sputtering in an N_2 atmosphere, or in other words, a so-called reactive sputtering method is used.

It is possible to form the TiN film by sputtering directly using a TiN target, but there are the problems of the thickness of the TiN film formed on the substrate becoming too thick, and being easy to strip off when a TiN target is used, so sputtering using a TiN target is generally not used.

Because the diffusion barrier layer is formed on a connection region that connects the semiconductor device to the wiring pattern, it is desirable for it to have low electric resistance, and have high density to act as an effective diffusion barrier layer.

[0004]

Furthermore, the TiN film is widely used as a so-called glue layer when causing a W layer to grow, or as an antireflection film on the Al wiring, and it is requested that corrosion due to WF_6 supplied as a W layer vapor raw material is small particularly when using as a glue layer of the W layer.

For this same reason, it is also requested that the TiN film has high density.

[0005]

[Problem to be Solved by the Invention] However, in a reactive sputtering method using a conventional Ti target, conditions for the TiN film to be stably formed are extremely limited, and it was difficult to quickly form a desirable TiN film with low resistance and high density as a diffusion barrier.

[0006]

Generally, when forming a TiN diffusion barrier layer with a sputtering method, sputtering is first performed on a dummy substrate, and impurities on the Ti target are removed to clean the Ti target prior to sputtering.

However, the phenomenon of reactive sputtering is not yet sufficiently explained, and for example, when conventionally using a pure Ti target that has been cleaned in this manner for sputtering the TiN diffusion barrier layer, there were problems such as the conditions for TiN being formed on the substrate being substantially limited.

[0007] More specifically, reactive sputtering of TiN is generally carried out in a mixed gas plasma of Ar and N_2, but TiN is not formed when the amount of Ar in the plasma is large, and the ratio of N_2 is small.

In comparison, TiN is easily formed when the ratio of N_2 in the mixed gas atmosphere is increased, but characteristics demanded in a diffusion barrier layer are often not met, such as having low density and high resistance, and the scope of optimal sputtering conditions (mixed gas composition, sputtering power and the like), wherein a TiN layer suitable for a diffusion barrier layer can be obtained, is limited.

TiN is a non-stoichiometric compound expressed by TiN_x, but when there is a lot of N_2 in the plasma, a low density, rough-textured TiN film is formed made up of TiN crystals in which the large particles have been <111> oriented.

In comparison to this, when N_2 in the plasma is reduced, and the ratio of Ti in the TiN structure is increased, a fine-textured TiN film made up of uniform TiN crystals in which the small particles have been <200> oriented.

Additionally, the fine-textured TiN film obtained in this manner has a surface with favorable flatness.

However, as described earlier, when the plasma composition is set so that the ratio of N_2 is less, there is a possibility of TiN not forming.

[0008]

Furthermore, it is known that a high density TiN film suitable for a diffusion barrier can be obtained by making the plasma power larger when plasma sputtering on TiN, but TiN cannot be obtained when the plasma power is made larger unless the ratio of N_2 in the plasma is increased.

However, as described earlier, a TiN film formed in these conditions has the problems of having low density and high electric resistance.

[0009] In light of the above, a general object of the present invention is to provide a method for fabricating a new and useful semiconductor device.

A more specific object of the present invention is to provide a method for fabricating a semiconductor device including a reactive sputtering step of a TiN diffusion barrier layer, with a larger scope of optimal sputtering conditions wherein a TiN film having exceptional film properties as a diffusion barrier film can be obtained.

[0010]

[Means for Solving the Problem] In light of the above, the present invention solves the above problems by, as described in claim 1, a method for fabricating a semiconductor device including a step for forming a high melting point metal nitride film by reactive sputtering, wherein the reactive sputtering step is made up of (A) a first step that has a high melting point metal nitride film sputtered on a substrate using a high melting point metal target under a first sputtering condition wherein reactive sputtering of high melting point metal nitride occurs even if a high melting point metal target is used, and (B) a second step after the step (A) that has a high melting point metal nitride film sputtered on the high melting point metal nitride film using the high melting point metal target under a second sputtering condition wherein reactive sputtering of high melting point metal nitride does not occur even if a high melting point metal target is used, or as described in claim 2, by the method for fabricating a semiconductor device according to claim 1, wherein the high melting point metal target used in the step (A) is made up of pure Ti, or as described in claim 3, by the method for fabricating a semiconductor device according to claim 1 or 2, including a cleaning step for cleaning the high melting point metal target by performing sputtering under a condition wherein high melting point metal is sputtered in a same reaction room wherein the steps (A) and (B) are executed, prior to the step (A), or as described in claim 4, by the method for fabricating a semiconductor device according to any one of claims 1 to 3, wherein the step (B) follows the step (A), and is executed in the same reaction room without breaking the decompression environment, or as described in claim 5, by the method for fabricating a semiconductor device according to any one of claims 1 to 3, wherein after the step (A), the reactive sputtering step is suspended until the step (B) is started, or as described in claim 6, by the method for fabricating a semiconductor device according to any one of claims 1 to 5, wherein in the first sputtering condition, a first plasma power is charged wherein reactive sputtering of high melting point metal nitride occurs even if a high melting point metal target is used, and in the second sputtering condition, a higher second plasma power is charged wherein reactive sputtering of high melting point metal nitride does not occur when a high melting point metal target is used, or as described in claim 7, by the method for fabricating a semiconductor device according to any one of claims 1 to 6, wherein in the first sputtering condition, N_2 partial pressure of the reaction room wherein reactive sputtering is executed is set to a first value wherein reactive sputtering of high melting point metal nitride occurs even if a high melting point metal target is used, and in the second sputtering condition, is set to a lower second value wherein reactive sputtering of high melting point metal nitride does not occur when a high melting point metal target is used, or as described in claim 8, by the method for fabricating a semiconductor device according to any one of claims 1 to 7, wherein in the step (B), high melting point metal nitride is formed on the surface of the high melting point metal target, or as described in claim 9, by the method for fabricating a semiconductor device according to any one of claims 1 to 8, wherein the step (A) includes a step for depositing an insulation film on the substrate, and a step for forming a contact hole in the insulation film so that an active region in the substrate is exposed, and the deposition of high melting point metal nitride in the step (A) is executed so that the high melting point metal nitride film electrically contacts the active region in the contact hole on the insulation film, or as described in claim 10, by the method for fabricating a semiconductor device according to claim 9, wherein the step (A) further includes a step for depositing a high melting point metal film on the insulation film prior to the deposition of the high melting point metal nitride film on the insulation film so that the high melting point metal film contacts the active region, and the step for depositing the high melting point metal nitride film in the step (A) follows the step for depositing the high melting point metal film, and is executed in the same reaction room without breaking a decompression environment, or as described in claim 11, by the method for fabricating a semiconductor device according to claim 10, wherein the step for depositing the high melting point metal film is executed under a different deposition condition than the deposition step of the high melting point metal nitride film in the step (A), or as described in claim 12, by the method for fabricating a semiconductor device according to claim 11, wherein the step for depositing the high melting point metal film is executed in a same composition of plasma gas with the deposition step of the high melting point metal nitride film in the step (A), but with a different plasma power, or

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