Moreover, a composition for semiconductor polishing containing a cationic polymer and a surfactant is known (for example, see Japanese Patent Application Laid-Open (JP-A) No. 2006-352042).

DISCLOSURE OF INVENTION

TECHNICAL PROBLEM

[0004] In the technique disclosed in JP-A No. 2009-503879 above, there is a case in which a surfactant having no micelle structure enters into a pore in the side wall surface of a groove, and thus the relative dielectric constant increases. In addition, there is a case in which adhesion between the interlayer dielectric layer and the wiring material is deteriorated by a micelle.

In addition, in the technique disclosed in WO 09/012184 above, a bulky layer is prone to be formed by hydrogen bonding between the polyvinyl alcohol-based amphiphilic polymers, and by virtue of this, the relative dielectric constant of the interlayer dielectric layer increases in some cases or the adhesion between the interlayer dielectric layer and the wiring material deteriorates in some case.

[0005] In addition, a sealing composition for a semiconductor exhibiting a superior sealing property with respect to an interlayer dielectric layer is desired in some cases.

Accordingly, an object of the ~~invention~~ present disclosure is to provide a sealing composition for a semiconductor excellent in a sealing property with respect to an interlayer dielectric layer, a semiconductor device in which the sealing composition for a semiconductor is used and a method of producing the semiconductor device, and a polymer suitable for the sealing composition for a semiconductor and a method of producing the polymer.

SOLUTION TO PROBLEM

[0006] The inventors have conducted intensive investigations, and as a result thereof, have found out that a sealing property with respect to an interlayer dielectric layer is significantly improved by adjusting the branching degree in a specific polymer to a certain value or higher, thereby completing the ~~invention~~present disclosure.

In other words, the concrete means for solving the problems is as follows.

[0007] <1> In an aspect, there is provided a~~A~~ sealing composition for a semiconductor, comprising a polymer that includes two or more cationic functional groups including at least one of a tertiary nitrogen atom or a quaternary nitrogen atom, that has a weight average molecular weight of from 2,000 to 1,000,000, and that has a branching degree of 48% or more, wherein a content of sodium and a content of potassium in the sealing composition are each 10 ppb by weight or

less on an element basis.

<2> The sealing composition for a semiconductor according to <1>, wherein the polymer includes a structural unit that is derived from an alkyleneimine having from 2 to 8 carbon atoms and that includes a tertiary nitrogen atom as a cationic functional group.

<3> The sealing composition for a semiconductor according to <2>, wherein the polymer further includes a structural unit that is derived from an alkyleneimine having from 2 to 8 carbon atoms and that includes a secondary nitrogen atom as a cationic functional group.

[0008] <4> The sealing composition for a semiconductor according to any one of <1> to <3>, wherein the polymer includes primary nitrogen atoms, and a proportion of the primary nitrogen atoms to all the nitrogen atoms in the polymer is 33% by mole or more.

<5> The sealing composition for a semiconductor according to any one of <1> to <4>, wherein the branching degree of the polymer is 55% or more.

<6> The sealing composition for a semiconductor according to any one of <1> to <5>, wherein the sealing composition has an average particle diameter measured by a dynamic light scattering method of 150 nm or less.

<7> The sealing composition for a semiconductor according to any one of <1> to <6>, wherein the polymer is a polyethyleneimine or a derivative of a polyethyleneimine.

<8> The sealing composition for a semiconductor according to any one of <1> to <7>, wherein the polymer has a cationic functional group equivalent of from 27 to 430.

[0009] <9> In another aspect, there is provided a~~A~~ method of producing a semiconductor device, comprising a sealing composition application process of applying the sealing composition for a semiconductor as disclosed above ~~according to any one of <1> to <8>~~ to an interlayer dielectric layer formed on a substrate.

<10> The method of producing a semiconductor device according to <9>, wherein the interlayer dielectric layer includes a porous silica and has a silanol residue derived from the porous silica on a surface thereof.

<11> The method of producing a semiconductor device according to <9> or <10>, the method further comprising a process of forming a concave groove having a width of from 10 nm to 32 nm in the interlayer dielectric layer, wherein the sealing composition application process includes bringing the sealing composition for a semiconductor into contact with the interlayer dielectric layer at at least a side surface of the concave groove.

<12> In yet another aspect, there is provided a~~A~~ semiconductor device comprising a structure in which:

an interlayer dielectric layer;

a polymer layer containing a polymer that includes two or more cationic functional groups including at least one of a tertiary nitrogen atom or a quaternary nitrogen atom, that

has a weight average molecular weight of from 2,000 to 600,000, and that has a branching degree of 48% or more; and

a layer including copper

are disposed in this order.

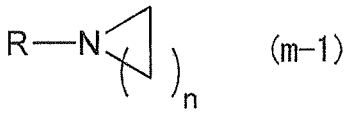
In the semiconductor device according to <12>, it is preferable that a copper barrier layer is further disposed between the polymer layer and the layer including copper. In addition, in the semiconductor device according to <12>, the interlayer dielectric layer is preferably a porous interlayer dielectric layer (that is, an interlayer dielectric layer having a porous structure).

[0010] <13> A polymer that comprises two or more cationic functional groups including at least one of a tertiary nitrogen atom or a quaternary nitrogen atom, that has a weight average molecular weight of from 2,000 to 1,000,000, and that has a branching degree of 48% or more, wherein the polymer includes primary nitrogen atoms and secondary nitrogen atoms, and a proportion of the primary nitrogen atoms to all the nitrogen atoms in the polymer is 33% by mole or more.

<14> The polymer according to <13>, wherein the polymer is a polyethyleneimine or a derivative of a polyethyleneimine.

<15> A method of producing the polymer according to <13> or <14>, the method comprising a process of reacting a raw material polymer containing a secondary nitrogen atom with a compound represented by the following Formula (m-1):

[0011]



(m-1)

[0012] wherein, in Formula (m-1), R represents a protective group, and n represents an integer from 1 to 4.

ADVANTAGEOUS EFFECTS OF INVENTION

[0013] According to the ~~invention~~present disclosure, it is possible to provide a sealing composition for a semiconductor excellent in a sealing property with respect to an interlayer dielectric layer, a semiconductor device in which the sealing composition for a semiconductor is used and a method of producing the semiconductor device, and a polymer suitable for the sealing composition for a semiconductor and a method of producing the polymer.

BRIEF DESCRIPTION OF DRAWINGS

[0014] Fig. 1 is isothermal lines of toluene gas adsorption and desorption in Examples 1 and 2 and Comparative Examples 1 to 4.

9. A method of producing a semiconductor device, comprising a sealing composition application process of applying the sealing composition for a semiconductor according to any one of claim 1 to claim 8 to an interlayer dielectric layer formed on a substrate.

10. The method of producing a semiconductor device according to claim 9, wherein the interlayer dielectric layer includes a porous silica and has a silanol residue derived from the porous silica on a surface thereof.

11. The method of producing a semiconductor device according to claim 9 or claim 10, the method further comprising a process of forming a concave groove having a width of from 10 nm to 32 nm in the interlayer dielectric layer, wherein the sealing composition application process includes bringing the sealing composition for a semiconductor into contact with the interlayer dielectric layer at at least a side surface of the concave groove.

12. A semiconductor device comprising a structure in which:

an interlayer dielectric layer;

a polymer layer containing a polymer that includes two or more cationic functional groups including at least one of a tertiary nitrogen atom or a quaternary nitrogen atom, that has a weight average molecular weight of from 2,000 to 600,000, and that has a branching degree of 48% or more; and

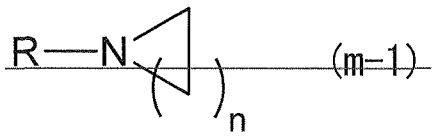
a layer including copper

are disposed in this order.

~~13. A polymer that comprises two or more cationic functional groups including at least one of a tertiary nitrogen atom or a quaternary nitrogen atom, that has a weight average molecular weight of from 2,000 to 1,000,000, and that has a branching degree of 48% or more, wherein the polymer includes primary nitrogen atoms and secondary nitrogen atoms, and a proportion of the primary nitrogen atoms to all the nitrogen atoms in the polymer is 33% by mole or more.~~

~~14. The polymer according to claim 13, wherein the polymer is a polyethyleneimine or a derivative of a polyethyleneimine.~~

~~15. A method of producing the polymer according to claim 13 or claim 14, the method comprising a process of reacting a raw material polymer containing a secondary nitrogen atom with a compound represented by the following Formula (m-1):~~



(m-1)

wherein, in Formula (m-1), R represents a protective group, and n represents an integer from 1 to 4.