or less.

[0060]

Aspect 46: the method of producing a treatment liquid for a semiconductor according to any one of Aspects 43 to 45, wherein the concentration of carbon dioxide in the tetraalkylammonium hydroxide solution in the reaction step is 0.001 ppm or more and 500 ppm or less.

Effects of the Invention

[0061]

The present invention makes it possible to subject ruthenium to wet etching stably at a sufficiently high rate and inhibit the generation of RuO_4 gas in semiconductor formation steps. This makes it possible not only to enhance the wafer treatment efficiency per unit time, but also to inhibit the yield rate from being decreased by RuO_2 particles, and to carry out treatment safe for the human body, thus satisfying both the production cost and safety.

[0062]

Furthermore, the method according to the present invention makes it possible to directly oxidize a bromine-containing compound with an oxidizing agent in an alkaline treatment liquid and thus promptly produce bromine, hypobromous acid, hypobromite ion, bromous acid, bromite ion, bromic acid, bromate ion, perbromic acid, and perbromate ion. A treatment liquid produced in this manner contains a hypobromite ion, thus making it possible to etch ruthenium immediately without waiting the generation of bromine gas for a long time and to shorten the time required for semiconductor production.

[0063]

Furthermore, the pH of the treatment liquid does not need to be adjusted from acidity to alkalinity, thus making it possible to significantly decrease the amount of the basic compound to be added to the treatment liquid, and making the handling of the treatment liquid easier.

DESCRIPTION OF THE EMBODIMENTS

[0064]

(Treatment liquid for a semiconductor)

The treatment liquid according to the present invention is characterized by containing a

[0077]

The acid dissociation constant (pK_a) of a hypobromous acid (HBrO) and a hypobromite ion (BrO^-) is 8.6, and thus, HBrO and BrO^- coexist in some cases depending on the pH of the treatment liquid, for example, in cases where the pH is low. In cases where the treatment liquid contains HBrO and BrO^-, the total concentration of HBrO and BrO^- can be regarded as the above-mentioned hypobromite ion concentration.

[0078]

The detail of the mechanism by which a hypobromite ion dissolves ruthenium is not necessarily clear, but the inference is that a hypobromite ion or hypobromous acid generated from a hypobromite ion oxidizes ruthenium in the treatment liquid to form RuO_4, RuO_4^-, or RuO_4^{2-}, which are dissolved in the treatment liquid. Causing ruthenium to be dissolved in the form of RuO_4^- or RuO_4^{2-} makes it possible to decrease the generation amount of RuO_4 gas and inhibit the generation of RuO_2 particles. To dissolve ruthenium in the form of RuO_4^- or RuO_4^{2-}, the pH of the treatment liquid is preferably alkaline, the pH of the treatment liquid is more preferably 8 or more and 14 or less, the pH is still more preferably 12 or more and 14 or less, and the pH is most preferably 12 or more and less than 13. The treatment liquid having a pH of 12 or more and less than 13 causes ruthenium to be dissolved in the form of RuO_4^- or RuO_4^{2-} in the treatment liquid, thus making it possible to significantly decrease the generation amount of RuO_4 gas and inhibit the generation of RuO_2 particles. In addition, in cases where the pH of the treatment liquid is less than 8, ruthenium is more easily oxidized to RuO_2 or RuO_4, thus increasing the amount of RuO_2 particles and tending to increase the generation amount of RuO_4 gas. In addition, the pH of more than 14 causes ruthenium to be dissolved less easily, making it difficult to obtain a sufficient ruthenium etching rate, and thus, decreases the production efficiency in semiconductor production.

[0079]

To adjust the pH of the treatment liquid, acid or alkali can be added to the treatment liquid. The acid may be either an inorganic acid or an organic acid, examples of which include hydrofluoric acid, hydrochloric acid, hydrobromic acid, nitric acid, sulfuric acid,

[0117]

In cases where Br^- is generated by the decomposition of the above-mentioned chemical species effective for etching of ruthenium, in other words, Br_2, HBrO, BrO^-, $HBrO_2$, BrO_2^-, $HBrO_3$, BrO_3^-, $HBrO_4$, or BrO_4^-, or by the reaction between ruthenium and the chemical species, it is preferable that the treatment liquid contains an oxidizing agent which can oxidize Br^- back into the chemical species effective for etching of ruthenium. Having such an oxidizing agent present in the treatment liquid enables the concentration of the chemical species effective for etching of ruthenium to be kept high and makes it possible to maintain the etching rate of ruthenium. In cases where BrO^- or the like is decomposed by disproportionation, $HBrO_3$ or BrO_3^- and Br^- are generated via $HBrO_2$ or BrO_2^- in some cases. Even in cases where a treatment liquid according to the present invention contains one or more of $HBrO_2$, BrO_2^-, $HBrO_3$, BrO_3^-, Br^-, and the like in addition to BrO^- or the like, the treatment liquid can be suitably used for etching of ruthenium. Also in cases where the treatment liquid contains a plurality of chemical species effective for etching of ruthenium, it is preferable that the treatment liquid contains an oxidizing agent which can oxidize Br^- back into a chemical species effective for etching of ruthenium.

In addition, in cases where the treatment liquid contains not only BrO^- but also a decomposition product of BrO^- (for example, $HBrO_2$, BrO_2^-, $HBrO_3$, BrO_3^-, Br^-, or the like), a change in the concentration of BrO^- in the treatment liquid is moderate, stabilizing the etching rate of ruthenium. Accordingly, a treatment liquid according to the present invention may contain one or more kinds of the above-mentioned decomposition products of BrO^-. A treatment liquid according to the present invention containing, for example, BrO^- or BrO_3^- can be suitably used for etching of ruthenium.

[0118]

To etch ruthenium efficiently, the proportion of BrO^- in 1 mol of bromine element contained in the treatment liquid is preferably more than 0.5 mol.

[0119]

Both the oxidization of a bromine-containing compound or Br^- into a chemical species