Description

The present invention relates to a semiconductor wafer surface treatment method and, more particularly, to a method of treating a surface of a semiconductor wafer so that one surface of the wafer may be mechanically damaged for gettering of contaminants.

Along the development of micropatterning of semiconductor elements, it becomes important that influence due to various types of contamination in element manufacturing processes is decreased. For example, contamination with heavy metals such as Cu or Fe reduces life time of minority carriers, thus changing characteristics of a transistor, or increasing a leakage current. In addition, by contamination with sodium (Na), mobile ions are generated in an oxide film, thereby degrading stability of an operation of the elements.

So-called gettering is well-known as such a method of cleaning contamination of a semiconductor substrate generated in a manufacturing process. This gettering includes hydrochloric acid oxidation, phosphorus gettering, and the like which are performed during manufacturing processes. In another technique, a silicon wafer serving as a starting material has a gettering ability. In addition, gettering of a substrate includes intrinsic gettering which utilizes oxygen precipitate in the substrate, back side damage (to be referred to as a BSD hereinafter) which causes the back-side surface of the wafer (an opposite side surface to a major surface on which semiconductor elements are formed in the later steps) to be mechanically damaged or distorted, and the like.

Sandblasting is known as a conventional method of forming the above BSD. In this method, a solution obtained by dispersing fine particles of alumina is sprayed to a back-side surface of the silicon wafer to form a mechanical damage. Although this method is effective to form a mechanical damage, the method cannot provide high purity of the silicon wafer required in the manufacture of the semiconductor element. More specifically, the solution obtained by dispersing fine particles of alumina contains very small amounts of metal impurities such as Fe, Cr, Ni, and Cu. Surface analysis using an ion microanalyzer frequently demonstrated that these impurities are strongly attached to and remain on a wafer material as a surface contamination after the treatment. In addition, the back-side surface of the wafer is a roughened surface, and three-dimensional micropatterns are present therein. However, since a solution containing an alumina is sprayed to this uneven surface, the fine particles of alumina fill the recessed patterns in the back-side surface of the wafer. For this reason, process defects are undesirably caused in manufacturing processes of the semiconductor element, as in the case of surface contamination due to metal impurities.

In a conventional case, treatment processes of the semiconductor wafer are performed in a clean room to manage cleanliness. However, in the sandblasting treatment process, fine particle of alumina solution is sprayed with high pressure. Therefore, the cleanliness in operation environment can be hardly maintained.

As described above, formation of BSD using the conventional sandblasting undesirably has low cleanliness.

Prior art document Patent Abstracts of Japan, vol. 5, no. 121, (E-68) [793], 5 August 1981; & JP-A-5 660 022, discloses a semiconductor wafer processing method in which a wafer is sticked to a wafer supporting disk with the reverse side facing outside, and soaked into an abrasive solution filled in an abrasive solution vessel. Vibrations are given by an ultrasonic vibration generator and a damaged layer is formed with an excellent reproducibility on the reverse side on the wafer. As a uniform back-distortion processed layer is formed hereby, a large quantity of wafers having an increased gettering effect can be manufactured simultaneously.

Further, prior art document Patent Abstracts of Japan, vol. 9, no. 240, (E-245) [1963], 26 September 1985; & JP-A-6 091 648, discloses a semiconductor wafer treatment method in which a semiconductor wafer, whose mirror ground surface has been faced downwards, is containing abrasive particles dipped in water and applied with supersonic oscillation. The wafer is moved vertically to pass through a position, where a standing wave of high energy is generated so as to give mechanical damages. After prescribed damages were given to the wafer, stuck abrasive material is washed off from the wafer. The wafer is then cleaned in a solution of $NH_4OH + H_2O_2 + H_2O$, and moreover in pure water and made to dry. According to this method, a gettering treatment can be favourably performed on the water by a simple device and the degree of mechanical damages to give to the water can be easily controlled by changing the kind of abrasive material to be used and the abrasive particle diameter, and, by adjusting the supersonic energy applied to the wafer.

It is an object of the present invention to provide a method of treating a surface of a semiconductor substrate which can form a clean mechanical damage on a back-side surface of the substrate.

To solve this object the present invention provides a method as specified in claim 1.

In such a method, the surface (back-side surface) of the semiconductor wafer is irradiated with ultrasonic waves propagating in pure water, so that

mechanical damages may be formed on the surface. This damage serves as a back side damage. In addition, only pure water is brought into contact with the substrate, and impurities such as heavy metals or Na may not be attached to and remain on a wafer material as surface contamination after the treatment, as in the conventional case.

There is, therefore, provided a method of treating a surface of a semiconductor substrate which can form clean mechanical damage, on the back-side surface of the wafer.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which

Fig. 1 is a front view for explaining an arrangement of a treatment device used when a treatment method of the present invention is performed; and

Fig. 2 is a side view of the treatment device shown in Fig. 1.

Fig. 1 is a front view showing an arrangement of a treatment device used when a method of the present invention is performed, and Fig. 2 is a side view thereof. However, in Figs. 1 and 2, in order to explain a state in treatment bath 10, this treatment bath 10 is cut away to show its inner portion. Treatment bath 10 is filled with a treatment solution, e.g., ultra-pure water 11 or pure water. Ultrasonic generator 12 consisting of an ultrasonic wave oscillator and an ultrasonic wane diaphagm is arranged at a bottom portion of treatment bath 10. Ultrasonic waves generated by this ultrasonic generator 12 propagate in ultrapure water 11 in treatment bath 10. Wafer carrier 14 vertically containing a plurality of silicon wafers 13 each having mirror-finished surfaces is dipped in treatment bath 10. Partition plates 15 are disposed between adjoining wafers 13 in wafer carrier 14, respectively.

Gas supply tube 16 for supplying a gas such as air or nitrogen is disposed at a lower portion in treatment bath 10. Spray nozzle 17 is arranged midway along gas supply tube 16 so as to oppose a major surface side (a surface side on which semiconductor elements are formed in the following steps) of each silicon wafer 13 contained in wafer carrier 14, respectively. The gas is sprayed to the front surface of each substrate 13 from corresponding nozzle 17. Gas filter 18 is disposed midway along gas supply tube 16 outside treatment bath 10, thereby removing fine particles contained in the supplied gas.

As shown in Fig. 2, two rotating shafts 19 respectively rotated along the directions indicated by arrows 100 in Fig. 2 are arranged so as to be in contact with the outer surface of each silicon wafer 13 contained in wafer carrier 14. With rotations of rotating shafts 19, wafers 13 are rotated along the direction indicated by arrow 101 in Fig. 2.

In the treatment device having the above arrangement, treatment bath 10 is filled with ultra-pure water 11, and wafer carrier 14 containing a plurality of silicon wafers 13 is dipped therein. Ultrasonic generator 12 is operated to generate ultrasonic waves. In addition, the predetermined gas is supplied to gas supply tube 16 to perform a treatment. Therefore, by ultrasonic waves propagating in the ultra-pure water, three-dimensional mechanical damage or distortion is formed on the back-side surface of each silicon wafer 13 contained in wafer carrier 14. In this case, ultrasonic output is selected within the range of 50 W to 500 W. Its frequency is selected within the range of 10 kHz to 100 kHz. If the frequency is not selected within the above range, the wafers tend not to be damaged. In addition, if the output is 500 W or more, the damage is increased, thus leaving a large scratch on the surface of the wafer.

On the other hand, by spraying the gas from nozzles 17, bubbles are generated on the major surfaces of silicon wafers 13. These bubbles cause the ultrasonic waves on the wafer major surface sides to disappear. Partition plates 15 are arranged between adjoining wafers 13, respectively, so that ultrasonic waves do not propagate from an adjacent section. Therefore, mechanical damages are not formed on the major surface side of each wafer 13. Since wafers 13 are rotated by two rotating shafts 19, formation of mechanical damages on the back-side surface and step coverage of bubbles on the major surface of wafer 13 are uniform.

The present inventors caused ultrasonic waves of 38 kHz to propagate in ultra-pure water using the above treatment device to perform a treatment for 15 minutes. As a result, it is confirmed that mechanical damages of about 1×10^5 (atoms/cm^2) are formed on the back-side surface of each silicon wafer 13. Since ultra-pure water is used, the number of impurity fine particles attached to the back-side surface is five pieces or less per wafer having a diameter of 12,7 cm (5 inches). Metal contamination due to Cu, Fe, Ni, Al, and the like is 2×10^{10} - (atoms/cm^2) or less. A subsequent analysis revealed that wafers 13 are extremely clean.

Thus, with the above treating method, ultrasonic waves propagating in ultra-pure water are caused to propagate along the back-side surface of the semiconductor wafer, so that mechanical damages are formed. Therefore, cleanliness in this method can be greatly improved as compared to that in formation of mechanical damages by the conventional sandblasting.

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Claims

1. A method of treating the back-side surface of semiconductor wafers, to form mechanical damages for gettering on said back-side surface, wherein ultrasonic waves are caused to propagate along said back-side surface of said semiconductor wafers (13), through a treatment solution (11), to form the mechanical damages on said back-side surface of said semiconductor wafers (13), wherein said treatment solution is pure water,

   the step of forming said mechanical damages comprises placing said semiconductor wafers (13) vertically in a treatment bath (10) filled with said treatment solution, disposing an ultrasonic generator (12) in a bottom portion of this treatment bath (10), to cause the ultrasonic waves having a power in the range 50 W to 500 W and a frequency in the range of 10 kHz to 100 kHz to propagate in said treatment solution, thereby forming mechanical damages on said back-side surface of each of said semiconductor wafers (13), and spraying a gas from said bottom portion, to generate bubbles in said treatment solution on the major surface of the semiconductor wafers (13), thereby preventing formation of mechanical damages on said major surfaces of each of said semiconductor wafers (13).

2. A method according to claim 1, characterized in that said treatment solution (11) is selected from a group consisting of pure water and ultra-pure water.

3. A method according to claim 1 or 2, characterized in that the said gas is supplied after fine particles are removed in a gas filter (18).

4. A method according to claim 3, characterized in that the gas is selected from a group consisting of air and nitrogen.

5. A method according to claim 1 or 2 characterized in that partition walls (15) are arranged between said semiconductor wafers (13).

6. A method according to claim 1 or 2, characterized in that said semiconductor wafers (13) are rotated (cf. 100) when said mechanical damages are formed.

Patentansprüche

1. Verfahren zur Behandlung der rückseitigen Oberfläche von Halbleiterscheiben bzw. -wafern zur Ausbildung mechanischer Schäden auf dieser rückseitigen Oberfläche zum Zwekke der Getterung, bei dem Ultraschallwellen veranlaßt werden, sich entlang der rückseitigen Oberfläche der Halbleiterwafer (13) in einer Behandlungslösung (11) auszubreiten, um die mechanischen Schäden auf der rückseitigen Oberfläche der Halbleiterwafer (13) hervorzurufen, und bei dem die Behandlungslösung (11) reines Wasser ist,
   wobei der Schritt zur Ausbildung der mechanischen Schäden folgendes umfaßt:
   - senkrechte Anordnung der Halbleiterwafer (13) in einem mit der Behandlungslösung (11) gefüllten Behandlungsbad (10),
   - Anordnung eines Ultraschallgenerators (12) in einem unteren Abschnitt dieses Behandlungsbades (10) zur Veranlassung der Ultraschallwellen mit einer Leistung im Bereich von 50 W bis 500 W und einer Frequenz im Bereich von 10 kHz bis 100 kHz sich in der Behandlungslösung (11) auszubreiten, wodurch sie mechanische Schäden auf der rückseitigen Oberfläche jedes der Halbleiterwafer (13) hervorrufen, und
   - Sprühen von Gas aus dem unteren Abschnitt zur Erzeugung von Blasen in der Behandlungslösung (11) auf der Hauptoberfläche der Halbleiterwafer (13, um dadurch die Entstehung mechanischer Schäden auf der Hauptoberfläche jedes der Halbleiterwafer (13) zu verhindern.

2. Verfahren gemäß Anspruch 1, dadurch gekennzeichnet, daß die Behandlungslösung (11) aus einer Gruppe gewählt wird, die reines Wasser und ultrareines Wasser umfaßt.

3. Verfahren gemäß Anspruch 1 oder 2, dadurch gekennzeichnet, daß das Gas zugeführt wird, nachdem feine Partikel in einem Gasfilter (18) zurückgehalten sind.

4. Verfahren gemäß Anspruch 3, dadurch gekennzeichnet, daß das Gas aus einer Gruppe gewählt wird, die Luft und Stickstoff umfaßt.

5. Verfahren gemäß Anspruch 1 oder 2, dadurch gekennzeichnet, daß Trennwände (15) zwischen den Halbleiterwafern (13) angeordnet sind.

6. Verfahren gemäß Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Halbleiterwafer (13) gedreht werden (siehe 100), wenn die mechanischen Schäden ausgebildet werden.

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Revendications

1. Méthode de traitement de la surface arrière des plaquettes semi-conductrices, pour effectuer des décapages mécaniques pour décontaminer ladite surface arrière, dans laquelle des ondes ultrasonores sont contraintes de se propager sur ladite surface arrière desdites plaquettes semi-conductrices (13), via une solution de traitement (11), pour effectuer des décapages mécaniques de ladite surface arrière desdites plaquettes semi-conductrices (13), dans laquelle ladite solution de traitement est de l'eau pure, l'étape de formation desdits décapages mécaniques comprend le placement desdites plaquettes semi-conductrices (13) verticalement dans une cuve de traitement (10) remplie avec ladite solution de traitement, l'utilisation d'un générateur d'ultra-sons (12) dans une partie du fond de cette cuve de traitement 10, pour générer des ondes ultrasonores ayant une puissance comprise dans une gamme de 50W à 500W et une fréquence dans la gamme de 10 kHz à 100 kHz pour se propager dans ladite solution de traitement, effectuant ainsi des décapages mécaniques de ladite face arrière de chacune desdites plaquettes semi-conductrices (13), et diffusion d'un gaz à partir de ladite partie du fond, pour générer des bulles dans ladite solution de traitement sur la surface principale des plaquettes semi-conductrices (13), empêchant ainsi la formation du décapage mécanique sur lesdites surfaces principales de chacune desdites plaquettes semi-conductrices (13).

2. Méthode selon la revendication 1, caractérisée en ce que ladite solution de traitement (11) est sélectionnée à partir d'un groupe se composant d'eau pure et d'eau ultra-pure.

3. Méthode selon la revendication 1 ou 2, caractérisée en ce que ledit gaz est fourni après avoir enlevé de fines particules grâce à un filtre pour gaz (18).

4. Méthode selon la revendication 3, caractérisée en ce que le gaz est sélectionné à partir d'un groupe se composant de l'air et de l'azote.

5. Méthode selon la revendication 1 ou 2 caractérisée en ce que des parois de séparation (15) sont placées entre lesdites plaquettes semi-conductrices (13).

6. Méthode selon la revendication 1 ou 2 caractérisée en ce que lesdites plaquettes semi-conductrices (13) sont mises en rotation (cf 100) lorsqu'on effectue lesdits décapages mécaniques.