

DEVICE FOR PRODUCING CLEANED CRUSHED PRODUCT OF
POLYCRYSTALLINE SILICON BLOCKS, AND METHOD FOR PRODUCING
CLEANED CRUSHED PRODUCT OF POLYCRYSTALLINE SILICONE BLOCKS
USING SAME

5 TECHNICAL FIELD

[0001]

The present invention relates to the device for producing a cleaned crushed polycrystalline blocks, and relates to a method for producing a cleaned crushed polycrystalline blocks using said devices.

10 DESCRIPTION OF THE RELATED ART

[0002]

A silicon wafer used for the production of the semiconductor device and solar battery or so is generally produced by the method described in below using polycrystalline silicon blocks of rod shape by Siemens method. That is, after this silicon
15 blocks are crushed, these are classified into a piece having a size about a fist, the obtained crushed polycrystalline silicon blocks is used as the source material to generate a silicon ingot having a column shape by Czochralski method, then said silicon ingot is sliced and ground, thereby a wafer is obtained.

[0003]

20 The crushing of the polycrystalline silicon blocks mentioned in the above is generally carried out manually using hammer or so. Also, in order to obtain large amount of crushed silicon blocks efficiently, addition to the manual crushing by hammer, the crushing may be done using a crusher so called a jaw crusher which is generally used for crushing ores. Here, the material of the hammer, and the material of
25 two metal plates (jaw) having a projections which is the crushing parts of the jaw crusher is a high-hardness metal including tungsten carbide and titanium or so; however

fine powders of these metals cannot be avoided from being mixed in these obtained crushed products. When such metal fine powders as the impurities remain, this could be a main cause of metal contamination during the silicon ingot production by Czochralski method.

5 [0004]

Also, for the crushing of the polycrystalline silicon blocks using above mentioned hammer and jaw crusher or so, a large amount of the fine powders of the polycrystalline silicon having a small particle diameter (herein after, it may be referred as “silicon fine powders”) are also generated. The surface of the fine powders of such polycrystalline silicon has extensive metal contamination during the crushing, and also the fine powders scarcely dissolve when producing the silicon ingot by Czochralski method, thus the productivity of the silicon ingot is lowered. Therefore, for such crushed polycrystalline silicon blocks, the removal of the metal fine powders and the silicon fine powders which are mixed in during the crushing is highly demanded.

15 [0005]

On the other hand, as the classification after crushing said polycrystalline silicon blocks, a vibration sieving device which sieves by vibration (for example, see the Patent Article 1), a classifier which sieves by the rotation of the rotating cylinder (for example, see the Patent Article 2), and also a roller classifier (for example, see the Patent Article 3) wherein a belt for conveying the crushed product is made into mesh form, then passing the particles smaller than said mesh are passed through are known. However, the fine powders generated during the crushing is small and has large specific surface area, and it can enter to the complicated space of the crushed polycrystalline silicon blocks, then hooked to the surface of the crushed products, thus the fine powders cannot be removed by the selection using these conventional classifier. Thus, after this step, a complexed etching treatment or so using a special etching agent must be carried out to

sufficiently clean the obtained crushed product.

[0006]

Under such situation, in order to remove the fine powders mixed in the crushed polycrystalline silicon blocks, it has been proposed to apply a compressed air to the crushed products (see [claim 25], [0082] to [0088] of the Patent Article 4).

PRIOR ART

[0007]

[Patent Article 1] JP Patent Application Laid Open No.2009-532319

[Patent Article 2] JP Patent Application Laid Open No.2004-91321

[Patent Article 3] JP Patent Application Laid Open No.2012-62206

[Patent Article 4] JP Patent Application Laid Open No.2012-46412

DISCLOSURE OF INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0008]

In order to remove the fine powders by blowing the above mentioned compressed air, the Patent Article 4 only discloses to blow the compressed air immediately after the crushing and/or after the classification; and it does not describe what kind of the device structure is used within the classification and conveying line of after the crushing. Therefore, it was unable to carry out this process efficiently, thus the sufficient cleaning of the crushed product were not easily attained.

[0009]

In view of such situation, the object of the present invention is to provide the device which can efficiently remove the fine powders such as the metal fine powders or the silicon fine powders or so which are mixed after the crushing of the polycrystalline silicon blocks, using the air blowing or so, and also the method for production thereof.

MEANS FOR SOLVING THE PROBLEM

[0010]

The present inventors have carried out keen examination to attain the above mentioned object. As a result, the present inventors have found that the above object can
5 be attained by the structure of device provided with gas blowers at least on above the travel surface of the conveying belt when a conveying the crushed polycrystalline silicone blocks by conveyor, and also provided with a scattering prevention mesh for the crushed polycrystalline silicon blocks between the travel surface of the conveying belt and the gas blower provided above the travel surface; thereby the present invention was
10 attained.

[0011]

That is, the present is invention is a device for producing cleaned crushed polycrystalline silicon blocks comprising,

- a) a conveyor for crushed polycrystalline silicon blocks,
- 15 b) a gas blower placed above a travel surface of a conveying belt of said conveyor, and said gas blower is for blowing away fine powders mixed in the crushed polycrystalline silicon blocks, and
- c) a scattering prevention mesh for said crushed polycrystalline silicon blocks which is placed between said travel surface of said conveying belt and the gas blower
20 placed above the travel surface.

[0012]

Also, a device for producing cleaned crushed polycrystalline silicon blocks according another aspect of the present invention comprise,

- a conveyor for crushed polycrystalline silicon blocks,
- 25 a gas blower placed at least above or below a travel surface of a conveying belt of said conveyor for blowing away fine powders mixed in the crushed polycrystalline

silicon blocks, wherein

said conveying belt is a mesh form.

[0013]

Also, the present invention provides a method of producing cleaned crushed
5 polycrystalline silicon blocks using the above mentioned device comprising a step of
blowing a gas to said crushed polycrystalline silicon blocks placed on running
conveying belt, and removing said fine powders mixed in the crushed polycrystalline
silicon blocks.

EFFECT OF THE INVENTION

10 [0014]

According to the device for producing the crushed polycrystalline silicon blocks
of the present invention, when conveying the crushed polycrystalline silicon blocks by
the conveyor, due to the gas blown from the gas blower provided at least above the
travel surface of the conveying belt, the fine powders mixed in the crushed products are
15 efficiently blown away; thereby the crushed product can be cleaned.

[0015]

Here, in case the gas blown from the above unevenly contacts the crushed
polycrystalline silicon blocks which are mounted on the conveying belt; then the
crushed products may scatter, and in case the crushed products scatters too much, the
20 crushed product may fall out of the conveying belt. However, in the device according to
the present invention, the scattering prevention mesh for such crushed polycrystalline
silicon blocks is provided between the travel surface of the conveying belt and the gas
blower for the fine powders provided above the travel surface. Thus, such scattering is
suppressed to appropriate level, and the above mentioned problems can be prevented.
25 Also, the device for producing the crushed polycrystalline silicon blocks wherein the
conveying belt of the conveyor is a mesh form, the mesh form conveying belt allows the

gas from the gas blowers to pass through, thereby the crushed polycrystalline silicon blocks can be prevented from scattering too much. Note that, by blowing the appropriate strength of gas to the crushed polycrystalline silicon products while suppressing the excessive scattering, the crushed polycrystalline silicon blocks on the conveying belt can make preferable movement and rotation. Thereby, the gas from the gas blowers can be applied to entire surface of the crushed polycrystalline silicon blocks, hence such device for producing the crushed polycrystalline silicon blocks can efficiently remove the fine powders.

[0016]

Further, in regards with the device for producing such polycrystalline silicon blocks, when the conveying belt of the conveyor is a mesh form, and the gas blowers for blowing the fine powders mixed with the crushed polycrystalline silicon blocks are also provided below the travel surface of the mesh form conveying belt, the movement and the rotation of the polycrystalline silicon blocks is activated due to the gas blown from below the travel surface of said mesh form conveying belt. Thereby, the gas is applied to the entire crushed product. As a result, the removal efficiency of the fine powders, particularly the removal efficiency of the fine powders attached to the lower surface of the crushed polycrystalline silicon blocks is enhanced thus it is preferable.

[0017]

In this embodiment, due to the gas blown from below, the scattering of the crushed polycrystalline silicon blocks will be even more prominent, thus the effect of the preventing the crushed product from falling out of the conveying belt by the scattering prevention mesh of the crushed polycrystalline silicon blocks is particularly effective, thus it is preferable. Furthermore, the crushed polycrystalline silicon blocks are prevented from coming up to the position too high from the travel surface of the conveying belt by the gas blown from below due to such scattering prevention mesh.

Therefore, the air from below is not weakened against the lower surface of the crushed product when contacting the lower surface of the crushed product, and the removal efficiency of the fine powders is not reduced as well.

[0018]

5 Therefore, according to the device of the present invention, the cleaned crushed polycrystalline silicon blocks can be easily produced wherein the mixing of the fine powders such as the metal fine powder impurities or the fine powders of the polycrystalline silicon when crushing the polycrystalline silicon blocks are greatly reduced.

10 BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

[Fig.1] Fig.1 is the vertical cross section in the running direction of the conveyor showing the representative schematic embodiment of the device for producing the cleaned crushed polycrystalline silicon blocks of the present invention.

15 [Fig.2] Fig.2 is the figure showing the vertical end plane of A-A line of the device for producing the cleaned crushed polycrystalline silicon blocks of Fig.1.

[Fig.3] Fig.3 is the vertical cross section in the running direction of the conveyor showing other embodiment of the device for producing the cleaned crushed polycrystalline silicon blocks.

20 [Fig.4] Fig.4 is the view of the vertical end plane of A-A line of the device for producing the cleaned crushed polycrystalline silicon blocks of Fig.3.

[Fig.5] Fig.5 is the enlarged plane view showing a part of the conveying belt 2 having a mesh form of the conveyor 1 of the device for producing the cleaned crushed polycrystalline silicon blocks of Fig.3.

25 [Fig.6] Fig.6 is the vertical cross section in the running direction of the conveyor showing other embodiment of the device for producing the cleaned crushed

polycrystalline silicon blocks of the present invention.

[Fig.7] Fig.7 is the vertical cross section showing the embodiment wherein the ionized gas discharger for removing the static electricity of the crushed polycrystalline silicon blocks is provided at further upstream than one gas blower for the fine powders which is provided at the most upstream of the travel surface of the conveying belt.

THE EMBODIMENTS TO CARRY OUT THE INVENTION

[0020]

According to the production device of the present invention, the crushed polycrystalline silicon blocks produced by Siemens method is subjected to a removal of the fine powders mixed in the crushed products, thereby carries out the cleaning. Here, Siemens method is the method of carrying out the vapor deposition by CVD (Chemical Vapor Deposition) method of the polycrystalline silicon to the surface of the silicon core wire by contacting the heated silicon core wire with the silane source gas such as trichlorosilane or monosilane or so.

[0021]

The crushing of the polycrystalline silicon blocks produced by such Siemens method is carried out by manual crushing using hammer or so, or by mechanical crushing using crusher such as jaw crusher or so. Of course, said two means can be combined, that is the coarse crushing of the polycrystalline silicon blocks by hammer is carried out first, and then a fine crushing of the obtained coarsely crushed products by crusher such as the jaw crusher or so is carried out.

[0022]

In the crushed products of these polycrystalline silicon blocks, the fine powders of the polycrystalline silicon are mixed in, and in some cases the metal fine powders may be mixed in as well. The material of the above mentioned hammer, and the crushing part of the jaw crusher are, for example, a high hardness metal such as super

hard alloy wherein tungsten carbide and cobalt as the binder are mix sintered. However, in the above mentioned crushed product of the polycrystalline silicon blocks, the metal fine powders as the impurities such as tungsten and cobalt, titanium, iron, nickel, chromium and copper or so which are derived from the metal material tends to be easily
5 mixed in together with the silicon fine powders. These fine powders refer to the powder form having fine particle diameter which can pass through 500 μm mesh filter.

[0023]

The crushed polycrystalline silicon blocks obtained as such may be cleaned directly by the device of the present invention, however the crushed polycrystalline
10 silicon blocks are classified in various particle sizes depending on the purpose of use, hence it is preferable to first classify and then clean. Specifically the cleaned crushed polycrystalline silicon blocks is classified so that a group whose long diameter of 90 mass% accumulation at least satisfies the range of 2 to 160 mm. Particularly, it is preferably classified so that a group whose long diameter of 90 mass% accumulation at
15 least satisfies the range of 90 to 160 mm, a group whose long diameter of 90 mass% accumulation at least satisfies the range of 10 to 120 mm, a group whose long diameter of 90 mass% accumulation at least satisfies the range of 10 to 60 mm, or a group whose long diameter of 90 mass% at least satisfies 2 to 10 mm or so.

[0024]

Said classification can be carried out by using the conventional classifiers alone
20 or by combining those, such as a vibration sieving device which sieves using a vibration, a classifier which sieves by the rotation of the rotating cylinder, and also a roller classifier or so. The aforementioned classification cannot carry out sufficient removal of the metal fine powders or the silicon fine powders which are generated during the
25 crushing of the polycrystalline silicon blocks. The device of the present invention efficiently removes fine powders mixed in the crushed products of the polycrystalline

silicon blocks. Hereinafter, the device for producing the cleaned crushed polycrystalline silicon blocks according to the present invention will be described using Fig.1 and 2 which are the vertical cross section showing the schematic view of the representative embodiment.

5 [0025]

That is, in the device shown in Fig.1 and Fig.2, “1” is the conveyor of the polycrystalline silicon blocks, and the conveying belt 2 runs substantially horizontally in the main device. On the upper surface of this conveying belt 2, the crushed polycrystalline silicon blocks 4 are mounted.

10 [0026]

The material of the conveying belt 2 is not particularly limited, and it may be made of metal or resin; however the conveying belt 2 is preferably made of resin due to low contamination, and particularly preferably the conveying belt 2 is made of the mixed resin of fluorocarbon resin with glass fiber, aramid fiber, polyurethane, polyethylene, polypropylene or so from the point of the mechanical strength and durability. Also, these resins may be coated with fluorocarbon resin.

[0027]

The gas blowers 5 for the fine powders are provided above the travel surface of the conveying belt 2. The gas blowers 5 may be provided at least one position above the travel surface of the conveying belt 2 with respect to the running direction of the conveying belt 2; however from the point of improving the removal efficiency of the fine powders 6, preferably these are provided at 2 positions or more. Preferably, the gas blowers 5 blows the gas to entire area in the width direction of the belt at the position placed along the running direction of the conveying belt 2. Such is difficult to accomplish just by a single injection nozzle, thus preferably plurality of injection nozzles are provided in the width direction of the conveying belt 2. Also, from this point

of view, the gas blowers 5 preferably comprises a nozzle header installed with plurality of the blower nozzles along the longitudinal direction of the header which supplies the gas, or the slit nozzle headers of which plurality of the slits for the gas blowers are opened.

5 [0028]

Further, when only one or just few gas blowers 5 are provided with respect to the width direction of the belt, and thus the gas can only be blown from such positions to certain parts along the width direction of the belt; then the gas blowers 5 may have a structure which moves along the width direction of the conveying belt 2 while blowing
10 the gas, thereby allowing the gas to be blown on entire area in the width direction of the belt. That is, Fig.2 is the figure showing the vertical end plane along A-A line of the device for producing the cleaned crushed polycrystalline silicon blocks of Fig.1, and the gas blowers 5 are placed at three different positions along the running direction of the conveying belt 2; but all of them are placed at the left end with respect to the running
15 direction of the belt along the width direction of the belt. However, in this device, each gas blowers 5 are provided at the tip of the extendible supporting axis 13 which extends in the horizontal direction from the movable unit 12 of the gas blower 5 which is provided with the conveyor, and by extending this extendible supporting axis 13 in the horizontal direction, the gas of the gas blower can reach to the right end with respect to
20 the width direction of the belt.

[0029]

The movement of this gas blower in the width direction of the conveying belt 2 is preferably done at sufficiently fast speed so that the crushed polycrystalline silicon blocks do not move away from the gas blowing area before the gas blowers 5 reaches
25 thereto in running conveying belt 2. Also, the gas blowers 5 preferably make back and forth movement in the width direction of the conveying belt 2, and in such case, the

back and forth movement is preferably done at the speed so that when one back and forth movement is made, the gas blowing area of the starting point and the finishing point has overlapping area.

[0030]

5 Note that, as the gas blown from the gas blower 5 for the crushed fine powders, inactive gas such as helium and nitrogen or so may be mentioned other than the clean air.

[0031]

As the preferable embodiment of the present invention, the production device of
10 the crushed polycrystalline silicon blocks has a mesh form conveying belt 2 of the conveyor, and further the gas blower 5 for the fine powders mixed in the crushed polycrystalline silicon blocks are provided not only above but also below the travel surface of the conveying belt; thereby the removal efficiency of the fine powders, particularly the removal efficiency of the fine powders adhered to the lower surface of
15 the crushed polycrystalline silicon blocks is enhanced, thus it is preferable. This embodiment will be described by referring to Fig.3 to 6 showing the schematic diagram thereof. The conveying belt 2 is a mesh form as shown in enlarged plane view of Fig.5, and at the cross section thereof, numerous opening parts 3 in vertical direction are formed as the mesh.

20 [0032]

The size of this opening part 3 is required to be smaller than the particle size of the crushed polycrystalline silicon blocks mounted on the upper surface of the opening part 3. In case the condition that the long diameter of 90 mass% accumulation of the crushed polycrystalline silicon blocks 4 mounted on the upper surface of the conveying
25 belt 2 being within the range of 90 to 160 mm is at least satisfied, the size of the opening part of the conveying belt 2 is preferably 10 to 80 mm. When the condition that

the long diameter of 90 mass% accumulation of the crushed polycrystalline silicon blocks being within the range of 10 to 120 mm is at least satisfied, the preferable size of the opening part of the conveying belt 2 is 2 to 8 mm. When the condition that the long diameter of 90 mass% accumulation of the crushed polycrystalline silicon blocks being
5 within the range of 10 to 60 mm is at least satisfied, the preferable size of the opening part of the conveying belt 2 is 2 to 8 mm. Further, when the condition that the long diameter of 90 mass% accumulation of the crushed polycrystalline silicon blocks being within the range of 2 to 10 mm is at least satisfied, the preferable size of the opening part of the conveying belt 2 is 0.5 to 1.5 mm.

10 [0033]

Not only the gas blowers 5 for the fine powders provided above the travel surface of the conveying belt 2, but also the gas blowers 5 provided below the travel surface is not limited to one and two or more may be provided.

[0034]

15 As the vertical cross section of the device in Fig.6 shows, the gas blowers 5 according to the present invention are preferably provided above and below of the travel surface of the mesh from conveying belt at the same positions along the running direction thereof. In such case, the travelling distance of the cleaning device can be shortened and the device can be made compact; and also because the gas pushes from
20 top, the crushed polycrystalline silicon blocks can be suppressed from floating, thus the cleaning can be done efficiently. In case of providing the gas blowers 5 of above and below the travel surface of the conveying belt 2 at two or more positions along the running direction of the conveying belt, at least one gas blowers 5 may be provided at the same position at above and below the travel surface, and rest of these may be
25 provided at different positions.

[0035]

Further according to the present invention, for the particularly preferable embodiment of mounting the gas blowers 5 for the fine powders, which is shown in the vertical cross section of the device of Fig.3, first it is provided above the travel surface at the upstream of the running direction of the conveying belt 2, then it is provided
5 below the travel surface at the downstream therefrom, and at further downstream therefrom, it is provided above the travel surface again. That is, for the removal of the fine powders 6 by blowing the gas to each crushed polycrystalline silicon blocks 4 on the conveying belt 2, the removal efficiency of the gas blowing from below which is against the gravity is lower than that of gas blowing from above. Therefore, first the gas
10 is blown from above to remove the fine powders 6 adhered on the upper surface of the crushed products 4, then the gas is blown from below to remove the fine powders 6 adhered on the lower surface of the crushed products 4; and due to this gas from below, the crushed products 4 on the conveying belt 2 is turned over to change the surface contacting the conveying belt 2. Then, the air is again blown from above to remove the
15 fine powders 6 remained on the new upper surface of the crushed products 4 by strong gas from above; thereby the entire surface of the crushed products can be highly cleaned.

[0036]

Furthermore, addition to this embodiment, in case appropriate distance is taken
20 for the space between each of the gas blowers 5 provided above, below and above of the travel surface along the running direction of the conveying belt 2, depending on the particle size of the cleaned crushed polycrystalline silicon blocks 6, while the crushed polycrystalline silicon blocks 6 mounted on the conveying belt 2, the crushed polycrystalline silicon blocks are blown with the gas from the opposite direction from
25 both above and below respectively. Thereby, the crushed products 6 rotates on the surface of the conveying belt, and even more excellent removal efficiency of the fine

powders can be attained, hence it is most preferable. Since such rotational force is applied to the crushed polycrystalline silicon blocks 6, the space between near the gas blowers at above and below may be adjusted depending on the particle size of the crushed polycrystalline silicon blocks to be cleaned. The lower limit of preferable length of space is the longer length of either of 10 mm or the length of 0.3 times (particularly preferably 0.5 times) with respect to average long diameter of said crushed polycrystalline silicon blocks 6. On the other hand, the upper limit of the preferable length of space is the longer length of either of 50 mm or the length of 2.0 times (particularly preferably 1.8 times) with respect to average long diameter of said crushed polycrystalline silicon blocks 6. Note that, the above mentioned average long diameter of the crushed polycrystalline silicon blocks refers to the average value obtained by first selecting arbitrary 300 crushed polycrystalline silicon blocks and then measuring the long diameter thereof using the caliper.

[0037]

The height of mounting the above mentioned gas blowers 5 with respect to the travel surface of the conveying belt 2 may be set depending on the strength of the blowing gas and the removal efficiency of the fine powders. Generally, the lower limit of the height from the travel surface is chosen from either higher one of the position which is 0.3 times (particularly preferably 0.5 times) longer than the long diameter of 90 mass% accumulation of the crushed polycrystalline silicon blocks or the position which is 10 mm longer than the length of the long diameter of 90 mass% accumulation of the crushed polycrystalline silicon blocks. On the other hand, the upper limit of the suitable height is chosen from either higher one of the position which is 2.0 times (particularly preferably 1.5 times) longer the long diameter of 90 wt% accumulation of the crushed polycrystalline silicon blocks or the position which is 50 mm longer than the length of the long diameter of 90 mass% accumulation of the crushed polycrystalline silicon

blocks. Note that, the above mentioned long diameter of 90 mass% accumulation of the crushed polycrystalline silicon blocks refers to a value wherein mass accumulation obtained by first selecting arbitrary 300 crushed polycrystalline silicon blocks then measuring the weight by electronic scale and the long diameter by a caliper is 90%.

5 [0038]

As mentioned in above, the removal efficiency of the fine powders is lower at the gas blowing from below than the gas blowing from above, thus the gas blowers provided at below is preferably provided closer to the conveying belt 2 than the gas blowers provided above.

10 [0039]

Further, in the device of Fig.1 to 7, the scattering prevention mesh 7 is provided between the travel surface of said conveying belt 2 and the gas blowers 5 provided above the conveying belt 2. This scattering prevention mesh 7 prevents the crushed products 4 from falling out of the conveying belt which is caused by excessive scattering of the crushed products 4 due to the gas blown from the gas blowers 5. Further, if the crushed products reaches to a high position, the gas from the gas blowers 5 at below may not be able to reach to the crushed products 4, thus the removal efficiency of the fine powders 6 adhered on the lower surface of the crushed products 4 may decline; however such problems can be prevented by providing the scattering prevention mesh 7. The scattering of the crushed products 4 becomes even more prominent due the gas blowing from the gas blowers 5 provided below the conveying belt 2. However, as mentioned in above, in case that the gas blowers 5 are only provided above the conveying belt 2, if the air is blown unevenly to the crushed products 4, the scattering occurs to certain degree. Therefore, to prevent the scattering of the crushed products 4 by providing the scattering prevention mesh 7 is very important from the point of preventing the crushed products 4 from falling out of said conveying belt.

[0040]

The size of the opening part and the opening ratio of the mesh property of this scattering prevention mesh 7 is the same as the mesh form conveying belt 2. For example, the opening ratio of the mesh form conveying belt 2 and the scattering
5 prevention mesh 7 can be 30 to 85%. Also, the material thereof may be metal or resin, and specifically the resin made of fluorocarbon resin is particularly preferable.

[0041]

The scattering prevention mesh 7 is appropriately provided at the position between the travel surface 2a of the conveying belt 2 and the height where the gas
10 blowers are provided above the conveying belt 2. The scattering prevention mesh 7 may be provided so that the excessive scattering of the crushed polycrystalline silicon blocks can be prevented, and also provided at the position which can attain the object of providing the scattering prevention mesh 7 that is at the position which can maintain the high removal efficiency of the fine powders 6 adhered to the lower surface of the
15 crushed products 4. When the gas blowers 5 are provided at the lowest height of the limit, the scattering prevention mesh is to be provided below and close to the gas blowers 5, which is substantially at the same height. When the gas blower 5 is provided at the position, with respect to the travel surface 2a of the conveying belt 2, higher than either of higher point of 1.5 times longer than the long diameter of 90 mass%
20 accumulation of the crushed polycrystalline silicon blocks 6, or 50 mm longer than the length of the long diameter of 90 mass% accumulation of the crushed polycrystalline silicon blocks 6; then the scattering prevention mesh is preferably provided within this higher height.

[0042]

25 Note that, in the device of the present invention, besides the scattering prevention mesh 7 provided between the above mentioned travel surface 2a of the

conveying belt 2 and the gas blowers 5 provided above the travel surface, in order to prevent the crushed polycrystalline silicon blocks 4 from scattering and falling out of the conveying belt, the vertical plate 8 for preventing the scattering is preferably placed near the both side parts of the belt, and along sides thereof.

5 [0043]

Also, as shown in Fig.7, at the device for producing the cleaned crushed polycrystalline silicon blocks according to the present invention, the ionized gas discharger 11 for removing the static electricity of the crushed polycrystalline silicon blocks is preferably provided at further upstream along the travel surface of the conveying belt than the gas blower 5 provided at the most upstream among all of the gas blowers 5 provided above and below the conveying belt 2. That is, the fine powders mixed with the crushed polycrystalline silicon blocks are usually charged with static electricity, hence in such case the fine powders are difficult to remove by blowing the gas to said crushed products. Therefore, it is effective to remove the static electricity by exposing to the ionized gas in advance. As for the ionized gas discharger, a corona discharger and a plasma discharger or so can be applied without particular limitation.

[0044]

Such ionized gas discharger 11 may be provided above or below the conveying belt 2, and preferably it is provided above. Further, these ionized gas dischargers 11 are preferably provided so that the ionized gas is discharged across the entire width of the running conveying belt 2.

[0045]

As discussed in above, in the production device of the present invention, the position where the gas blowers 5 is provided and the part where the gas blown from the blower contacts with the conveying belt 2 are preferably housed in a case 10 comprising the outlet 9 at the wall part. That is, the fine powders 6 blown and removed from the

crushed polycrystalline silicon blocks 5 by the blowing gas is sucked from the outlet 9 of the case 10, this is preferable since the room having the device will not be messed with the powders. The outlet 9 may be provided at any wall part of the case 10, however it is preferably provided at the top wall or the bottom wall.

5 [0046]

Next, the method of producing the cleaned crushed polycrystalline silicon blocks using the device of the present invention will be described. That is, using the device of the present invention, the gas is blown from the gas blower 5 provided above the conveying belt 2 and if necessary, the gas is blown from below the conveying belt 2 to the crushed polycrystalline silicon blocks 4 mounted on the conveying belt 2 of the conveyor 1. Thereby, the fine powders 6 are efficiently removed, and the cleaned crushed polycrystalline silicon blocks are easily produced.

[0047]

In this production method, the running speed of the conveying belt 2 of the conveyor 1 is preferably 1 to 15 m/min, and more preferably 2 to 9 m/min. The bulk density of the crushed polycrystalline silicon blocks mounted on the upper surface of the conveying belt 2 may be different depending on the particle size distribution, however generally it is 0.5 to 1.5 g/cm³, and more preferably 0.7 to 1.2 g/cm³.

[0048]

The gas blown from the gas blower 5 preferably has blowing amount of 8 to 82 L/min per blower opening unit area (mm²), and more preferably of 16 to 60 L/min. The temperature of gas being blown is generally 20 to 25°C. When the condition for blowing the gas is within such preferable range, an excellent removal of the fine powders 6 can be done.

25 [0049]

Also, when said ionized gas discharger 11 is provided to the device of the

present invention used for this method, the discharging method of this ionized gas is not particularly limited, however in order to sufficiently remove the static electricity from the crushed polycrystalline silicon blocks, it may be carried out accordingly by combining the pulse method with DC type or AC type.

5 [0050]

The crushed polycrystalline silicon blocks cleaned as such is significantly reduced of the content of the metal fine powder impurities and the fine powders of the polycrystalline silicon blocks, hence this may be directly used as the source material of the ingot used for Czochralski method. In case the silicon wafer is produced which is
10 used for the semiconductor device by slicing the obtained silicon ingot, and in case high purity is required, the crushed polycrystalline silicon blocks may be used by further carrying out the etching treatment.

[0051]

Note that, in the production device of the cleaned crushed polycrystalline silicon
15 blocks shown in Fig.1 to Fig.7, each embodiment such as the number and the arrangement of the gas blowers 5, whether or not to make the conveying belt 2 to a mesh form, whether or not to provide the scattering prevention mesh 7 or so can be selected accordingly depending on the size of the crushed polycrystalline silicon blocks subjected to the cleaning, or depending on the level of the cleanness required for the
20 crushed polycrystalline silicon blocks. For example, in case the mesh form is used for the conveying belt 2, the gas blowers 5 may only be provided above the conveying belt 2. Also, if the mesh form conveying belt 2 can appropriately prevent the excessive scattering of the crushed polycrystalline silicon blocks caused by the blowing of the gas, the scattering prevention mesh 7 may not be provided.

25 [0052]

Further, the shape of the mesh form conveying belt 2 and the scattering

prevention mesh 7 are not particularly limited as long as at least part of the gas by the gas blowers 5 can pass through. The device of the present invention may for example be an embodiment wherein the scattering prevention mesh 7 and the conveying belt 2 are combined to form the conveying pathway of a basket form which extends to the conveying direction, and the gas is blown to the crushed polycrystalline silicon blocks conveyed in the basket. Also, the device of the present invention may have an embedment wherein the scattering prevention mesh moves in the conveying direction together with the conveying belt. Also, the embodiment wherein the gas blowers 5 are provided above or below the travel surface 2a of the conveying belt 2 includes the embodiment wherein the gas blowers 5 are provided diagonally above and below the travel surface 2a. Further, in the embodiment wherein the gas blowers 5 are provided above the travel surface 2a includes the embodiment wherein the gas is blown to the crushed polycrystalline silicon blocks on the conveying belt 2 from the sides.

EXAMPLE

[0053]

Hereinafter, the present invention will be described further in detail using the examples and the comparative examples; however the present invention is not to be limited thereto. Various physical properties of the present invention were evaluated by the methods described in below.

[0054]

(1) Surface metal concentration analysis

For the surface metal concentration analysis, the decomposition and removal of the surface of the crushed polycrystalline silicon blocks was carried out, then a quantitative analysis of each metal element in the sample was carried out by an inductively coupled plasma mass spectrometry (ICP-MS).

[0055]

(2) Surface fine powder concentration analysis

About 1 kg of crushed polycrystalline silicon blocks were introduced into 2L beaker, and 1L of ultrapure water was introduced so that said crushed polycrystalline silicon blocks was completely immersed. Then, the beaker was slowly shaken to left and right, thereby the surface of the crushed polycrystalline silicon blocks were completely contacted with the ultrapure water to float the fine powders on the surface in the ultrapure water. The obtained suspension of the fine powders were passed through 500 μm mesh filter, then said fine powders were collected by a filter paper of 1 μm mesh. The collected filter paper was dried in the dry warehouse of 100°C for 12 hours or more, then the weight of the fine powders were calculated from the difference of the weight of the filter paper before and after collecting the fine powders. Then, the concentration of the fine powders was calculated from the weight of the crushed polycrystalline silicon blocks used for this analysis.

[0056]

Example 1

Using the device shown in Fig.3 and Fig.4, the crushed polycrystalline silicon blocks were cleaned. The crushed polycrystalline silicon blocks subjected to the treatment were obtained by crushing the polycrystalline silicon blocks of the rod shape having the diameter of 120 to 140 mm produced by Siemens method to have the particle diameter (long diameter) of 110 mm or less using the crusher comprising the ultrahard alloy blade; then these are classified to pieces having the average particle diameter of 30 mm and the long diameter range of 8 to 50 mm using the classifier. Also, the long diameter of 90 mass% accumulation of the classified product was 38 mm.

[0057]

Here, in the device shown in Fig.3 and Fig.4, the conveying belt 2 was made of fluorocarbon resin coating of the aramid resin fiber, and it was also a mesh form having

the size of the opening part of 4 mm. Also, the gas blowers 5 of the fine powders 6 are provided above the conveying belt at the upstream of the running direction of the conveying belt, and provided below at the downstream therefrom, then it was provided above once again at further downstream. The space in the running direction of the conveying belt of each gas blowers 5 were 50 mm. Also, the height of each gas blowers 5 which were provided above with respect to the travel surface 2a of the conveying belt 2 were 55 mm above the conveying belt 2. Similarly, the height of each gas blowers 5 which were provided below with respect to the travel surface 2a of the conveying belt 2 was 10 mm below the conveying belt 2. Also, at the inside of both ends of the conveying belt 2, the vertical plates 8 for preventing the crushed polycrystalline silicon blocks from jumping out were provided, and the space between these two opposing vertical plates 8 were 100 mm. This space was used as the mounting part of the polycrystalline silicon blocks.

[0058]

Further, in the device shown in Fig.3 and Fig.4, the scattering prevention mesh 7 was made of fluorocarbon resin; and the scattering prevention mesh 7 had a width which encompass the entire width direction of the running conveying belt, and also had the length which encompass almost the entire length of the running pathway. The scattering prevention mesh 7 had the mesh of the opening size of 3 mm, and the opening ratio was 72%. The position placed therewith was between the travel surface 2a of the conveying belt 2 and the gas blowers 5 provided above, and at the position 50 mm above the travel surface 2a of the conveying belt 2.

[0059]

Next, the gas blowing amount from all of the gas blowers 5 were adjusted so that the amount was 16.4 L/min per blower opening unit area (mm^2), then 1.5 kg of the above mentioned polycrystalline silicon blocks was placed at the bulk density of 0.8

g/cm³ on the upper surface of the conveying belt 2 of the conveyor 1 of the device shown in Fig.3. After the aforementioned, the conveying belt 2 was driven at the speed of 3 m/min, and the fine powders removal process was done. The obtained polycrystalline silicon blocks were subjected to the surface metal concentration analysis and the surface fine powders concentration analysis; thereby the level of the cleanness was evaluated. The results are shown in Table 1.

[0060]

Example 2

The procedures as same as Example 1 were carried out except that the gas blowing amount from all of the gas blowers 5 were adjusted so that the amount was 32.3 L/min per blower opening unit area (mm²). The obtained polycrystalline silicon blocks were subjected to the surface metal concentration analysis and the surface fine powders concentration analysis; thereby the level of the cleanness was evaluated. The results are shown in Table 1.

[0061]

Example 3

The procedures as same as Example 1 were carried out except that the gas blowing amount from all of the gas blowers 5 were adjusted so that the amount was 58.6 L/min per blower opening unit area (mm²). The obtained polycrystalline silicon blocks were subjected to the surface metal concentration analysis and the surface fine powders concentration analysis; thereby the level of the cleanness was evaluated. The results are shown in Table 1.

[0062]

Example 4

The procedures as same as Example 1 were carried out except that ionized gas was released by DC type using the device shown in Fig.7 which is the embodiment

providing the corona discharger type ionizer as the ionized gas discharger at further upstream than the gas blower provided at the most upstream of the travel surface of the conveying belt 2 of the device shown in Fig.3 and Fig.4. The obtained polycrystalline silicon blocks were subjected to the surface metal concentration analysis and the surface fine powders concentration analysis; thereby the level of the cleanness was evaluated. The results are shown in Table 1.

[0063]

Example 5

The procedures as same as Example 1 were carried out except that the gas blower provided above the travel surface of the mesh form conveying belt 2 at the most downstream was removed, and the gas blowers were provided one above and one below at different positions. The obtained polycrystalline silicon blocks were subjected to the surface metal concentration analysis and the surface fine powders concentration analysis; thereby the level of the cleanness was evaluated. The results are shown in Table 1.

[0064]

Example 6

The same procedures as Example 1 were carried out except that instead of using the device shown in Fig.3 and Fig.4, the device of Fig.6 was used as the production device of the cleaned crushed polycrystalline silicon blocks, that is the device wherein the gas blowers provided below and above are placed at the same position with respect to the running direction of the mesh form conveying belt was used. The obtained polycrystalline silicon blocks were subjected to the surface metal concentration analysis and the surface fine powders concentration analysis; thereby the level of the cleanness was evaluated. The results are shown in Table 1.

[0065]

Example 7

The procedures as same as Example 1 were carried out except that conveying belt 2 of the device shown in Fig.3 and Fig.4 was not a mesh form but was flat belt without opening parts; and also the gas blower provided above the travel surface of the conveying belt 2 at the most downstream and the gas blower 5 provided below at the upstream therefrom were removed; thus the gas blower 5 at the most upstream was only provided. The obtained polycrystalline silicon blocks were subjected to the surface metal concentration analysis and the surface fine powders concentration analysis; thereby the level of the cleanness was evaluated. The results are shown in Table 1.

[0066]

Example 8

As the production device of the cleaned crushed polycrystalline silicon blocks, the device comprising the conveying belt 2 which was a flat belt without the opening parts, and comprising the gas blowers 5 only provided above the conveying belt 2 was used, as shown in Fig.1 and Fig.2. The gas blowers 5 in this device were provided above the conveying belt 2 in different positions with respect to the running direction. As shown in Fig.2, regarding the each position with respect to the running direction, each of these are provided at the left end with respect to the width direction of the conveying belt (inner side than the vertical plate 8 provided at the left side for preventing the scattering of the crushed polycrystalline silicon blocks). Note that, the gas blowers 5 were connected to the movable unit 12 of the gas blower provided with the conveyor; and during the cleaning when the conveying belt 2 is running, the gas blowers 5 were moving reciprocally from left end to right end (inner side than the vertical plate 8 provided at the right side for preventing the scattering of the crushed polycrystalline silicon blocks) with respect to the width direction of the conveying belt by extending and shortening the extendible supporting axis 13 at the speed of 30 round trip/ min.

[0067]

The obtained polycrystalline silicon blocks were subjected to the surface metal concentration analysis and the surface fine powders concentration analysis; thereby the level of the cleanness was evaluated. The results are shown in Table 1.

5 [0068]

Comparative example 1

The crushed polycrystalline silicon blocks were not cleaned and the surface metal concentration analysis and the surface fine powders concentration analysis were carried out, then the level of the cleanness was evaluated. The results are shown in

10 Table 1.

[0069]

[Table 1]

	Surface metal concentration (pptw)															Surface fine powders concentration (ppmw)
	Na	Mg	Al	K	Ca	Cr	Fe	Ni	Co	Cu	Zn	W	Ti	Mo	Entire metal	
Example 1	25	7	15	12	181	5	49	3	60	1	91	107	12	1	569	14
Example 2	40	9	17	16	152	5	50	3	45	2	78	80	9	1	507	11
Example 3	35	6	11	11	122	3	48	2	18	1	65	36	6	1	365	10
Example 4	22	7	15	10	181	5	44	3	55	1	86	97	11	1	538	14
Example 5	18	5	10	8	179	4	61	3	93	2	175	400	7	1	966	16
Example 6	31	9	18	15	140	7	32	4	67	2	116	225	13	1	680	15
Example 7	33	11	20	16	193	5	55	3	57	2	137	265	24	1	822	17
Example 8	37	9	21	15	184	4	52	3	77	1	144	281	12	1	841	17
Comparative example 1	119	19	27	21	356	5	110	3	202	2	329	941	27	1	2162	24

15 REFERENCES OF NUMERALS

[0070]

1 Conveyor

2 Conveying belt

3 Opening part

20 4 Crushed polycrystalline silicon blocks

5 Gas blower for the fine powders

6 Fine powders

7 Scattering prevention mesh for the crushed polycrystalline silicon blocks

- 8 Vertical plate for the preventing the scattering of crushed polycrystalline silicon blocks
- 9 Outlet
- 10 Case
- 5 11 Ionized gas discharger
- 12 Movable unit of gas blower
- 13 Extendible supporting axis

CLAIMS

1. A device for producing cleaned crushed polycrystalline silicon blocks comprising,
- a) a conveyor for crushed polycrystalline silicon blocks,
- b) a gas blower placed above a travel surface of a conveying belt of said conveyor,
- 5 and said gas blower is for blowing away fine powders mixed in the crushed polycrystalline silicon blocks, and
- c) a scattering prevention mesh for said crushed polycrystalline silicon blocks which is placed between said travel surface of said conveying belt and the gas blower placed above the travel surface.

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2. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in claim 1, wherein said conveying belt is a mesh form.

3. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in
- 15 claim 2, wherein said gas blower is also placed below said travel surface of said conveying belt of mesh form.

4. A device for producing cleaned crushed polycrystalline silicon blocks comprising,
- a conveyor for crushed polycrystalline silicon blocks,
- 20 a gas blower placed at least above or below a travel surface of a conveying belt of said conveyor for blowing away fine powders mixed in the crushed polycrystalline silicon blocks, wherein
- said conveying belt is a mesh form.

5. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in any one of claims 2 to 4, wherein said gas blowers are placed at least at three positions as first one of them is placed above said travel surface at upstream of running direction of said conveying belt, and second one of them is placed below said travel surface at downstream therefrom, and third one of them is placed above said travel surface at further downstream therefrom.

6. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in any one of claims 2 to 5, wherein at least one gas blower is respectively placed above and below of said travel surface of said conveying belt at the same positions with respect to the running direction of said conveying belt.

7. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in any one of claims 1 to 6 comprising a mechanism to move said gas blower in the width direction of said conveying belt while blowing the gas.

8. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in any one of claims 1 to 7, wherein the long diameter of 90 mass% accumulation of said cleaned crushed polycrystalline silicon blocks at least satisfies a range of 2 to 160 mm.

9. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in any one of claims 1 to 8, wherein said gas blowers have the blowing amount per blower opening unit area (mm^2) of 8 to 82 L/min.

10. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in any one of claims 1 to 9, wherein an ionized gas discharger for removing the static electricity of the crushed polycrystalline silicon blocks is placed at further upstream than any said gas blowers in the running direction of said conveying belt.

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11. The device for producing cleaned crushed polycrystalline silicon blocks as set forth in as set forth in any one of claims 1 to 10, wherein a position where said gas blowers are placed, and a part where a gas from said gas blowers contacts to said conveying belt are housed in a case having an outlet at a wall part.

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12. A method of producing cleaned crushed polycrystalline silicon blocks using the device for producing cleaned crushed polycrystalline silicon blocks as set forth in any one of claims 1 to 11 comprising a step of blowing a gas to said crushed polycrystalline silicon blocks placed on running conveying belt, and removing said fine powders mixed in the
15 crushed polycrystalline silicon blocks.