

Description

Title of Invention:

APPARATUS AND METHOD FOR CONVEYING
POLYCRYSTALLINE SILICON

5

Technical Field

[0001]

The present invention relates to a polycrystalline
silicon conveyance device and a polycrystalline silicon
10 conveyance method.

Background Art

[0002]

Patent Literature 1 discloses a fruit feeding device
15 including a detection sensor that senses fruit through
contact of a fruit with a detection element, wherein an
amount by which the fruit is supplied is automatically
controlled according to a result of the sensing by the
detection sensor. Further, Patent Literature 2 discloses a
20 waste plastic sorting device provided with a passage
sensor for detecting the passage of waste plastic.

Citation List

[Patent Literature]

25 [0003]

[Patent Literature 1]

Japanese Patent Application Publication,
Tokukaisho, No. 59-127685

[Patent Literature 2]

5 Japanese Patent Application Publication *Tokukai* No.
2002-018364

Summary of Invention

Technical Problem

10 [0004]

Assuming that objects having irregular shapes are to be conveyed while being detected, there is a problem in that the fruit feeding device disclosed in Patent Literature 1 cannot detect small objects which do not come into
15 contact with the detection element. Further, in the waste plastic sorting device disclosed in Patent Literature 2, there is a problem in that use of the passage sensor configured to detect waste plastic from a single direction precludes sufficiently accurate detection of waste plastic.

20 [0005]

It is an object of an aspect of the present invention to accurately detect polycrystalline silicon with use of a sensor to reliably discharge the polycrystalline silicon, which is a discharge target, to the outside of a conveyance
25 section.

Solution to Problem

[0006]

In order to solve the foregoing problem, a polycrystalline silicon conveyance device in accordance with an aspect of the present invention includes: a conveyance section that has a discharge end portion from which polycrystalline silicon is discharged and that is configured to convey the polycrystalline silicon to discharge the polycrystalline silicon from the discharge end portion; a first sensor configured to detect the polycrystalline silicon from a plurality of directions above the conveyance section; and a control section configured to control driving of the conveyance section on the basis of a result of detection of the polycrystalline silicon by the first sensor.

[0007]

A polycrystalline silicon conveyance method in accordance with an aspect of the present invention includes: a conveyance step of, with use of a conveyance section that has a discharge end portion from which polycrystalline silicon is discharged, conveying the polycrystalline silicon to discharge the polycrystalline silicon from the discharge end portion; a detection step of detecting the polycrystalline silicon from a plurality of directions above the conveyance section; and a control

step of controlling driving of the conveyance section on the basis of a result of detection of the polycrystalline silicon in the detection step.

Advantageous Effects of Invention

5 [0008]

According to an aspect of the present invention, it is possible to accurately detect polycrystalline silicon with use of a sensor to reliably discharge the polycrystalline silicon, which is a discharge target, to the
10 outside of a conveyance section.

Brief Description of Drawings

[0009]

Fig. 1 is a view schematically illustrating one
15 example of the configuration of a polycrystalline silicon conveyance device in accordance with an embodiment of the present invention.

Fig. 2 is a functional block diagram illustrating one example of the configuration of the conveyance device
20 illustrated in Fig. 1.

Fig. 3 is a view for explaining a conveyance section and a first sensor included in the conveyance device illustrated in Fig. 1.

Fig. 4 is a view schematically illustrating operation
25 of the conveyance device illustrated in Fig. 1.

Fig. 5 is a flowchart illustrating one example of a supplying operation for polycrystalline silicon to the conveyance section included in the conveyance device illustrated in Fig. 1.

5 Fig. 6 is a flowchart illustrating one example of operation of the conveyance section included in the conveyance device illustrated in Fig. 1.

Fig. 7 is a flowchart illustrating one example of operation of a first retaining section included in the
10 conveyance device illustrated in Fig. 1.

Fig. 8 is a flowchart illustrating one example of operation of a second retaining section included in the conveyance device illustrated in Fig. 1.

Fig. 9 is a flowchart illustrating one example of
15 operation of a placement table included in the conveyance device illustrated in Fig. 1.

Description of Embodiments

[0010]

20 The following description will discuss an embodiment of the present invention in detail. It should be noted that the following description illustrates one example of a conveyance device 1 for polycrystalline silicon S in accordance with the present invention, and
25 that the technical scope of the present invention is not

limited to the following description or the illustrations of Figs. 1 to 9.

[0011]

[Overview of conveyance device]

5 Polycrystalline silicon S produced in rod form by, for example, the Siemens process is crushed so as to facilitate use as a raw material. In the form of lumps with a predetermined size thus formed, the polycrystalline silicon S is inspected to determine whether there are any
10 problems in quality. The predetermined size refers to a size such that a maximum side length is 10 mm to 150 mm. The maximum side length is a distance between two points located furthest from each other in the contour of the polycrystalline silicon S.

15 [0012]

The inspection of polycrystalline silicon S is carried out by capturing an image of the polycrystalline silicon S with use of an imaging section such as a camera and, for example, visually observing the captured image of the
20 polycrystalline silicon S. Alternatively, the inspection of the polycrystalline silicon S may be carried out by a combination of the captured image of the polycrystalline silicon S and AI (Artificial Intelligence). The conveyance device 1 is configured to supply the polycrystalline silicon

S to a position in which the imaging section can capture an image of the polycrystalline silicon S.

[0013]

[Conveyance device for polycrystalline silicon]

5 Fig. 1 is a view schematically illustrating one example of the configuration of a conveyance device 1 in accordance with an embodiment of the present invention. The dotted line in Fig. 1 indicates a detection range of each sensor. Fig. 2 is a functional block diagram
10 illustrating one example of the configuration of the conveyance device 1 illustrated in Fig. 1. As illustrated in Figs. 1 and 2, the conveyance device 1 includes a conveyance section 30, a first sensor 12, an upper sensor 13, a lower sensor 14, a third sensor 11, a fourth sensor
15 15, a control section 20, a first retaining section 40, a second retaining section 50, a placement table 60, and a wall section 70.

[0014]

 The conveyance device 1 is capable of reliably
20 discharging polycrystalline silicon S having an irregular shape to the outside of the conveyance section 30 by controlling driving of the conveyance section 30 on the basis of a result of inspection by the first sensor 12 that detects the polycrystalline silicon S from a plurality of
25 directions above the conveyance section 30.

[0015]

[Conveyance device for polycrystalline silicon]

In the conveyance device 1, the conveyance section 30 is disposed in an upper position, and the first retaining section 40, the second retaining section 50, and the placement table 60 are disposed in this order from the conveyance section 30 downward. That is, the placement table 60 is disposed in the lowest position. The polycrystalline silicon S is discharged one by one from the conveyance section 30. The polycrystalline silicon S moves from an upper position to a lower position in the conveyance device 1 in order of the conveyance section 30, the first retaining section 40, the second retaining section 50, and the placement table 60.

15 [0016]

(Control section)

The control section 20 controls driving of the conveyance section 30, the first retaining section 40, the second retaining section 50, and the placement table 60 on the basis of results of detection by the first sensor 12, the upper sensor 13, the lower sensor 14, the third sensor 11, and the fourth sensor 15. The functions of the control section 20 may be implemented by a central processing unit (CPU) carrying out a program stored in an

unillustrated memory unit. The details of the control section 20 will be described later.

[0017]

(Conveyance section)

5 The polycrystalline silicon S formed into the form of lumps with a predetermined size is introduced to the conveyance section 30 from the outside of the conveyance device 1. The polycrystalline silicon S introduced into the conveyance section 30 is in the form of lumps with a
10 predetermined size formed by, so as to facilitate use as a raw material, crushing polycrystalline silicon produced in rod form by, for example, the Siemens process.

[0018]

 The conveyance section 30 has a discharge end
15 portion 31 from which the polycrystalline silicon S is discharged, and conveys the polycrystalline silicon S to discharge the polycrystalline silicon S to the outside from the discharge end portion 31. The conveyance section 30 includes a vibrating feeder 32 configured to vibrate to
20 convey the polycrystalline silicon S. The control section 20 controls the vibrating feeder 32.

[0019]

 The conveyance section 30 has conveyance surfaces 32a and 32b tilted with respect to the horizontal plane.
25 The conveyance surfaces 32a and 32b have a V shape when

the conveyance section 30 is seen from a discharge end
portion 31 side, and forms a valley portion 32c. Vibration
of the vibrating feeder 32 allows the polycrystalline silicon
S to be conveyed in a conveyance direction D1 along the
5 valley portion 32c.

[0020]

The vibrating feeder 32 vibrates in an obliquely
upward direction with respect to the conveyance direction
D1. Specifically, the vibration direction of the vibrating
10 feeder 32 is a direction between a direction from an
introduction end portion 33 included in the conveyance
section 30 to the discharge end portion 31 and a vertically
upward direction orthogonal to the horizontal plane. The
vibrating feeder 32 is, for example, a vibrating feeder that
15 vibrates with use of a vibrator, or an electromagnetic
feeder that vibrates with use of an electromagnet. Use of
the vibrating feeder 32 as the conveyance section 30 for
conveying the polycrystalline silicon S facilitates control
over the discharge of the polycrystalline silicon S to the
20 outside of the conveyance section 30.

[0021]

(Third sensor)

The third sensor 11 detects the presence of the
polycrystalline silicon S introduced to the vicinity of the
25 introduction end portion 33 located opposite from the

discharge end portion 31 in the conveyance section 30. The detection results from the third sensor 11 are outputted to the control section 20. As illustrated in Fig. 1, one third sensor 11 is preferably provided, but a plurality of third sensors 11 may be provided. The third
5 sensor 11 may be the same sensor as a laser sensor 12a described later. The control section 20 can determine, on the basis of the detection result from the third sensor 11, whether the polycrystalline silicon S has been introduced
10 to the conveyance section 30.

[0022]

The first sensor 12 detects the polycrystalline silicon S from a plurality of directions above the conveyance section 30. The detection results from the first
15 sensor 12 are outputted to the control section 20. The first sensor 12 is composed of a plurality of laser sensors 12a, 12b, and 12c provided so as to detect the polycrystalline silicon S from different directions.

[0023]

20 The first sensor 12 detects the polycrystalline silicon S from a plurality of directions in the vicinity of the discharge end portion 31 from which the polycrystalline silicon is discharged. Specifically, at least one of the laser sensors 12a to 12c detects the presence

of the polycrystalline silicon S in the vicinity of the discharge end portion 31.

[0024]

This enables the control section 20 to accurately
5 recognize the polycrystalline silicon S immediately prior to discharge to the outside of the conveyance section 30. The polycrystalline silicon S that has been detected by the first sensor 12 is thus immediately discharged to the outside of the conveyance section 30. Accordingly, after
10 the polycrystalline silicon S has been discharged to the outside of the conveyance section 30, the first sensor 12 can detect polycrystalline silicon S conveyed subsequently. Therefore, on the basis of the detection result from the first sensor 12 for the polycrystalline silicon S, the control
15 section 20 can control the driving of the conveyance section 30 so as to smoothly convey the polycrystalline silicon S.

[0025]

Fig. 3 is a view for explaining the conveyance section
20 30 and the first sensor 12 included in the conveyance device 1 illustrated in Fig. 1. Fig. 3 is a view illustrating the conveyance section 30 seen from a discharge end portion 31 side. The reference numeral 3001 in Fig. 3 indicates a view illustrating a case where one laser sensor
25 12a is provided, and the reference numeral 3002 in Fig. 3

indicates a view illustrating a case where a plurality of laser sensors 12a to 12c are provided.

[0026]

The laser sensor 12a, which is configured to emit
5 laser light toward the valley portion 32c (see Fig. 1),
measures a distance to a target with use of the laser light.
Further, the laser sensor 12a detects the presence of the
polycrystalline silicon S that has been conveyed to the
valley portion 32c by detecting that the measured distance
10 takes a value within a predetermined range.

[0027]

Here, as indicated by the reference numeral 3001 in
Fig. 3, if the polycrystalline silicon S in the vicinity of the
discharge end portion 31 is detected by only one laser
15 sensor 12a, there is a possibility that the presence of the
polycrystalline silicon S cannot be detected. This is
because the polycrystalline silicon S has an irregular
shape, and thus there is a possibility that, depending on
the location of the polycrystalline silicon S which is
20 irradiated with the laser light emitted from the laser
sensor 12a, the distance measured by the laser sensor 12a
falls outside a predetermined range, thus failing to detect
the presence of the polycrystalline silicon S.

[0028]

Therefore, as the first sensor 12 in the conveyance device 1, as indicated by the reference numeral 3002 in Fig. 3, a plurality of laser sensors 12a to 12c provided so as to detect the polycrystalline silicon S from different
5 directions are employed. Accordingly, the laser sensor, which is less expensive than, for example, an image sensor, is used, thus making it possible to reduce the manufacturing cost for the conveyance device 1.

[0029]

10 The conveyance section 30 is configured such that the polycrystalline silicon S having an irregular shape is conveyed while vibrating by the vibrating feeder 32, and thus the distance measured by laser light emitted from the laser sensor tends to vary due to the vibration.
15 Accordingly, there is thus a possibility that the accuracy of detecting the presence of the polycrystalline silicon S may be lowered. To address this, by providing the plurality of laser sensors 12a to 12c, it is possible to detect the polycrystalline silicon S with use of the plurality of laser
20 sensors, so that even if the distance measured by each laser sensor varies due to the vibration, the presence of the polycrystalline silicon S can be accurately detected. This makes it possible both to facilitate control over the discharge of the polycrystalline silicon S to the outside of
25 the conveyance section 30 and to accurately detect the

presence of the polycrystalline silicon S having an irregular shape.

[0030]

In a case where the first sensor 12 is composed of a plurality of laser sensors, the first sensor 12 is preferably composed of the three laser sensors 12a to 12c, as indicated by the reference numeral 3002 of Fig. 3. The laser sensor 12a is preferably disposed such that laser light emitted from the laser sensor 12a extends in a substantially vertical direction and is radiated to a bottom portion of the valley portion 32c between the conveyance surfaces 32a and 32b.

[0031]

The laser sensor 12b is preferably disposed such that the laser light from the laser sensor 12b is radiated to the bottom portion of the valley portion 32c along the conveyance surface 32a. The laser sensor 12c is preferably disposed such that the laser light from the laser sensor 12c is radiated to the bottom portion of the valley portion 32c along the conveyance surface 32b.

[0032]

The laser sensors 12b and 12c may be the same sensors as the laser sensor 12a. By disposing the laser sensors 12a to 12c in this manner, the distance to the polycrystalline silicon S can be measured from multiple

directions, and therefore, even when the conveyance
section 30 is configured to convey the polycrystalline
silicon S by vibration, it is possible to accurately detect
the polycrystalline silicon S at the discharge end portion
5 31.

[0033]

The first sensor 12 may be an image sensor
including a camera capable of three-dimensionally
capturing an image of the polycrystalline silicon S and
10 configured to detect the polycrystalline silicon S from a
plurality of directions with use of a 3D image obtained by
capturing an image of the polycrystalline silicon S with
use of the camera. In this case, the first sensor 12 may be
composed of one image sensor.

15 [0034]

(First retaining section)

The first retaining section 40 is capable of retaining
the polycrystalline silicon S discharged from the discharge
end portion 31. The first retaining section 40 causes the
20 polycrystalline silicon S to fall onto the second retaining
section 50 by releasing the retaining of the polycrystalline
silicon S. The driving of the first retaining section 40 is
controlled by the control section 20.

[0035]

Fig. 4 is a view schematically illustrating operation of the conveyance device 1 illustrated in Fig. 1. As illustrated in Figs. 1 and 4, the first retaining section 40 includes a movable section 41 and a support section 41a.

5 The movable section 41 moves in a substantially horizontal direction through control by the control section 20.

[0036]

The support section 41a is provided at an end part of the movable section 41 on a wall section 70 side. The support section 41a is provided to the movable section 41 so as to be tilted with respect to the horizontal direction to be able to support the polycrystalline silicon S discharged from the discharge end portion 31. By contact of the lower end portion of the support section 41a with the plate-shaped wall section 70 which is disposed along the vertical direction below the discharge end portion 31, a retaining space 42 is formed between the support section 41a and the wall section 70. The polycrystalline silicon S discharged from the discharge end portion 31 enters the retaining space 42 and is thereby retained by the support section 41a and the wall section 70.

[0037]

In Figs. 1 and 4, the support section 41a is illustrated as a single plate-shaped member; however, in

order to enable the polycrystalline silicon S to be more reliably retained, the support section 41a may be, for example, formed into a box shape that is opened at the top and that forms the retaining space 42 with the wall
5 section 70.

[0038]

Movement of the movable section 41 such that the support section 41a moves away from the wall section 70 causes the polycrystalline silicon S to fall from the
10 support section 41a onto the second retaining section 50. That is, the retaining of the polycrystalline silicon S by the first retaining section 40 is released, thus causing the polycrystalline silicon S to fall from the first retaining section 40 onto the second retaining section 50.

15 [0039]

(Upper sensor)

The upper sensor 13, which is one example of the second sensor, detects the polycrystalline silicon S falling from the discharge end portion 31 onto the first retaining
20 section 40. The detection results from the upper sensor 13 are outputted to the control section 20. The upper sensor 13 is disposed between the conveyance section 30 and the lower sensor 14. The detection range of the upper sensor 13 is preferably defined as a part of a horizontal
25 plane located between the conveyance section 30 and the

support section 41a which part, in the vertical direction, overlaps the support section 41a that is in a state of forming the retaining space 42.

[0040]

5 The upper sensor 13 may be, for example, a photoelectric sensor including an unillustrated light emitting section that emits planar light, and a light receiving section that receives light resulting from reflection, on the polycrystalline silicon S, of the light
10 emitted from the light emitting section. As illustrated in Figs. 1 and 4, one upper sensor 13 is preferably provided, but a plurality of upper sensors 13 may be provided.

[0041]

(Second retaining section)

15 The second retaining section 50 can retain the polycrystalline silicon S falling downward from the first retaining section 40, that is, can retain the polycrystalline silicon S discharged from the discharge end portion 31. The second retaining section 50 causes the polycrystalline
20 silicon S to fall onto the placement table 60 by releasing the retaining of the polycrystalline silicon S. The driving of the second retaining section 50 is controlled by the control section 20. As illustrated in Figs. 1 and 4, the second retaining section 50 includes a movable section 51
25 and a support section 51a. The movable section 51 is

movable in a substantially horizontal direction through control by the control section 20.

[0042]

The support section 51a is provided at an end part
5 of the movable section 51 on a wall section 70 side. The support section 51a is provided to the movable section 51 so as to be tilted with respect to the horizontal direction to be able to support the polycrystalline silicon S falling from the first retaining section 40. By contact of the lower
10 end portion of the support section 51a with the wall section 70, a retaining space 52 is formed between the support section 51a and the wall section 70. The polycrystalline silicon S falling from the first retaining section 40 enters the retaining space 52 and is thereby
15 retained by the support section 51a and the wall section 70.

[0043]

In Figs. 1 and 4, the support section 51a is illustrated as a single plate-shaped one; however, in order
20 to enable the polycrystalline silicon S to be reliably retained, the support section 51a may be, for example, formed into a box shape that is opened at the top and that forms the retaining space 52 with the wall section 70.

[0044]

Movement of the movable section 51 such that the support section 51a moves away from the wall section 70 causes the polycrystalline silicon S to fall from the support section 51a onto the placement table 60. That is, the retaining of the polycrystalline silicon S by the second retaining section 50 is released, thus causing the polycrystalline silicon S to fall from the second retaining section 50 to the placement table 60.

[0045]

10 (Lower sensor)

The lower sensor 14, which is an example of a second sensor, detects the polycrystalline silicon S falling from the discharge end portion 31 onto the second retaining section 50 through the first retaining section 40. The detection results from the lower sensor 14 are outputted to the control section 20. The lower sensor 14 is disposed below the upper sensor 13. The detection range of the lower sensor 14 is preferably defined as a part of a horizontal plane located between the support section 41a and the support section 51a which part, in the vertical direction, overlaps the support section 51a that is in a state of forming the retaining space 52.

[0046]

The lower sensor 14 may be the same sensor as the upper sensor 13. As illustrated in Figs. 1 and 4, one lower

sensor 14 is preferably provided, but a plurality of lower sensors 14 may be provided.

[0047]

(Placement table)

5 The placement table 60 supplies the polycrystalline silicon S one by one from a first position P1 to a second position P2. The placement table 60 is movable between the first position P1 and the second position P2. The first position P1 is a position in which the polycrystalline
10 silicon S falling downward from the second retaining section 50 can be placed. The second position P2 is separated from the first position P1 and is, for example, a position to which the polycrystalline silicon S is supplied. Further, the second position P2 is, for example, a position
15 in which the above-described imaging section can capture an image of the polycrystalline silicon S.

[0048]

 The placement table 60 is driven through control by the control section 20. The polycrystalline silicon S that
20 has fallen from the second retaining section 50 is placed onto the placement table 60 in the first position P1, and the placement table 60 supplies the polycrystalline silicon S to the second position P2. In the second position P2, after the above-described imaging section has captured an
25 image of the polycrystalline silicon S, the polycrystalline

silicon S may be removed from the placement table 60. After the polycrystalline silicon S has been removed, the placement table 60 returns from the second position P2 to the first position P1.

5 [0049]

In a case where the placement table 60 is located in the first position P1, the first retaining section 40 and the second retaining section 50 are disposed above the placement table 60. This enables the first retaining
10 section 40 and the second retaining section 50 to temporarily retain the polycrystalline silicon S.

[0050]

The conveyance device 1 may include only the first retaining section 40 among the first retaining section 40
15 and the second retaining section 50, and include only the upper sensor 13 among the upper sensor 13 and the lower sensor 14. In this case, when the first retaining section 40 releases the retaining of the polycrystalline silicon S, the polycrystalline silicon S falls from the first retaining
20 section 40 onto the placement table 60.

[0051]

(Fourth sensor)

The fourth sensor 15 detects whether or not the placement table 60 is present in the first position P1. The
25 detection results from the fourth sensor 15 are outputted

to the control section 20. The fourth sensor 15 may be the same sensor as the laser sensor 12a.

[0052]

(Flow of operation of conveyance section)

5 Fig. 5 is a flowchart illustrating one example of a supplying operation for the polycrystalline silicon S to the conveyance section 30 included in the conveyance device 1 illustrated in Fig. 1. Fig. 6 is a flowchart illustrating one example of operation of the conveyance section 30
10 included in the conveyance device 1 illustrated in Fig. 1. With reference to Figs. 5 and 6, the following will describe the flow of operation of the conveyance section 30.

[0053]

As illustrated in Fig. 5, first, the control section 20
15 starts supplying the polycrystalline silicon S to the conveyance section 30 with use of an unillustrated supplying section (S1). The control section 20 then determines whether or not the polycrystalline silicon S has been detected by the third sensor 11 (S2). In a case
20 where the polycrystalline silicon S has been detected by the third sensor 11 (YES in S2), the control section 20 stops the supply of the polycrystalline silicon S to the conveyance section 30 using the above-described supplying section (S3).

25 [0054]

After the supply of the polycrystalline silicon S is stopped, the control section 20 then determines whether or not the detection of the polycrystalline silicon S by the third sensor 11 has been canceled (S4). In a case where
5 the detection of the polycrystalline silicon S by the third sensor 11 has been canceled (YES in S4), the control section 20 advances to the process of the step S1 and resumes the supply of the polycrystalline silicon S to the conveyance section 30. In a case where the detection of
10 the polycrystalline silicon S by the third sensor 11 has not been canceled (NO in S4), the control section 20 continues to stop the supply of the polycrystalline silicon S to the conveyance section 30 until the detection of the polycrystalline silicon S by the third sensor 11 is canceled.
15 [0055]

In contrast, in a case where the polycrystalline silicon S has not been detected by the third sensor 11 (NO in S2), the control section 20 continues the supply of the polycrystalline silicon S to the conveyance section 30
20 until the polycrystalline silicon S is detected by the third sensor 11.
[0056]

In the step S1, after starting the supply of the polycrystalline silicon S to the conveyance section 30, the
25 control section 20, as illustrated in Fig. 6, drives the

conveyance section 30 to convey the polycrystalline silicon S toward the discharge end portion 31 (S11). The step S11 is one example of a conveyance step and a control step.

5 [0057]

After the control section 20 has driven the conveyance section 30, the control section 20 determines whether or not the polycrystalline silicon S has been detected by the first sensor 12 (S12). Specifically, the
10 control section 20 determines whether or not the polycrystalline silicon S has been detected by at least one of the laser sensors 12a to 12c. The step S12 is one example of a detection step.

[0058]

15 In a case where the polycrystalline silicon S has been detected by the first sensor 12 (YES in S12), the control section 20 temporarily stops the driving of the conveyance section 30 (S13). Therefore, in a case where additional polycrystalline silicon S is conveyed following
20 the polycrystalline silicon S that has been discharged to the outside of the conveyance section 30, the conveyance of the following polycrystalline silicon S is, on detection of the following polycrystalline silicon S by the first sensor 12, stopped temporarily. The step S13 is one
25 example of a control step.

[0059]

When the conveyance of the polycrystalline silicon S is resumed in the step S15 described later, the polycrystalline silicon S is discharged to the outside of the conveyance section 30. Thus, the conveyance section 30 can discharge the polycrystalline silicon S one by one to the outside from the discharge end portion 31, on the basis of the detection results from the first sensor 12. In a case where the first sensor 12 has not detected the polycrystalline silicon S (No in S12), the control section 20 drives the conveyance section 30 until the first sensor 12 detects the polycrystalline silicon S.

[0060]

After temporarily stopping the conveyance section 30 in the step S13, the control section 20 determines whether or not the polycrystalline silicon S is retained by the first retaining section 40 (S14). In a case where, after the polycrystalline silicon S has been detected by the upper sensor 13, the retaining of the polycrystalline silicon S by the first retaining section 40 is not released, the control section 20 determines that the polycrystalline silicon S is retained by the first retaining section 40.

[0061]

In a case where, after the control section 20 has caused the first retaining section 40 to release the

retaining of the polycrystalline silicon S, the polycrystalline silicon S is not detected by the upper sensor 13, the control section 20 determines that the polycrystalline silicon S is not retained by the first
5 retaining section 40. In a case where the control section 20 determines that the polycrystalline silicon S is not retained by the first retaining section 40 (NO in S14), the control section 20 resumes the driving of the conveyance section 30 to discharge the polycrystalline silicon S from
10 the discharge end portion 31 (S15). The step S15 is one example of a conveyance step and a control step.

[0062]

In a case where the control section 20 determines that the polycrystalline silicon S is retained by the first
15 retaining section 40 (YES in S14), the control section 20 maintains the stopped state of the conveyance section 30. After resuming the driving of the conveyance section 30, the control section 20 determines whether or not the polycrystalline silicon S has been detected by the upper
20 sensor 13 (S16).

[0063]

The following will consider a case where it is determined that the polycrystalline silicon S has been detected by the upper sensor 13 (YES in S16). In this case,
25 the control section 20 determines whether or not the

polycrystalline silicon S conveyed following the polycrystalline silicon S that has been discharged from the discharge end portion 31 has been detected by the first sensor 12 (S17). In a case where the control section 20
5 determines that the following polycrystalline silicon S has been detected by the first sensor 12 (YES in S17), the control section 20 advances to the process of the step S13.
[0064]

In a case where the polycrystalline silicon S has not
10 been detected by the upper sensor 13 (NO in S16), the control section 20 drives the conveyance section 30 until the polycrystalline silicon S is detected by the upper sensor 13. In a case where the control section 20 determines that the following polycrystalline silicon S has
15 not been detected by the first sensor 12 (NO in S17), the control section 20 drives the conveyance section 30 until the following polycrystalline silicon S is detected by the first sensor 12.

[0065]

20 As such, use of the first sensor 12 that detects the polycrystalline silicon S from a plurality of directions above the conveyance section 30 enables the first sensor 12 to accurately detect the polycrystalline silicon S having an irregular shape. Therefore, the control section 20
25 controls the driving of the conveyance section 30 on the

basis of a result of detection of the polycrystalline silicon S by the first sensor 12, so that it is possible to reliably discharge the polycrystalline silicon S, which is a discharge target, to the outside of the conveyance section 30.

[0066]

Furthermore, the control section 20 controls the driving of the conveyance section 30 on the basis of the detection of the polycrystalline silicon S by at least one of the plurality of laser sensors 12a to 12c. This enables the conveyance device 1 to reliably discharge the polycrystalline silicon S, which is a discharge target, to the outside of the conveyance section 30.

[0067]

(Flow of operation of first retaining section)

Fig. 7 is a flowchart illustrating one example of operation of the first retaining section 40 included in the conveyance device 1 illustrated in Fig. 1. In a case of YES in the step S16 illustrated in Fig. 6, the control section 20 determines whether or not the polycrystalline silicon S is retained by the second retaining section 50 (S21). In a case where, after the polycrystalline silicon S has been detected by the lower sensor 14, the retaining of the polycrystalline silicon S by the second retaining section 50 is not released, the control section 20 determines that

the polycrystalline silicon S is retained by the second retaining section 50.

[0068]

In a case where, after the control section 20 has
5 caused the second retaining section 50 to release the retaining of the polycrystalline silicon S, the polycrystalline silicon S is not detected by the lower sensor 14, the control section 20 determines that the polycrystalline silicon S is not retained by the second
10 retaining section 50.

[0069]

In a case where the control section 20 has determined that the polycrystalline silicon S is not retained by the second retaining section 50 (NO in S21),
15 the control section 20 causes the first retaining section 40 to release the retaining of the polycrystalline silicon S (S22). This causes the polycrystalline silicon S to fall from the first retaining section 40 onto the second retaining section 50.

20 [0070]

After the control section 20 has caused the first retaining section 40 to release the retaining of the polycrystalline silicon S, the control section 20 determines whether or not the polycrystalline silicon S
25 has been detected by the lower sensor 14 (S23). In a case

where the control section 20 has determined that the polycrystalline silicon S has been detected by the lower sensor 14 (YES in S23), the control section 20 closes the first retaining section 40 (S24). The closed state of the
5 first retaining section 40 refers to a state where the lower end portion of the support section 41a is in contact with the wall section 70.

[0071]

In contrast, in a case where the control section 20
10 has determined that the polycrystalline silicon S is retained by the second retaining section 50 (YES in S21), the control section 20 stands by until causing the second retaining section 50 to release the retaining of the polycrystalline silicon S.

15 [0072]

In a case where the control section 20 has determined that the polycrystalline silicon S has not been detected by the lower sensor 14 (NO in S23), the control section 20 maintains the first retaining section 40 in an
20 opened state until the polycrystalline silicon S is detected by the lower sensor 14. The opened state of the first retaining section 40 refers to a state in which the support section 41a and the wall section 70 are separated from each other. In a case where the first sensor 12 detects the
25 polycrystalline silicon S during the process illustrated in

Fig. 7, the control section 20 carries out the processes of the step S13 and subsequent steps illustrated in Fig. 6.

[0073]

(Flow of operation of second retaining section)

5 Fig. 8 is a flowchart illustrating one example of operation of the second retaining section 50 included in the conveyance device 1 illustrated in Fig. 1. After the step S24 illustrated in Fig. 7, the control section 20 determines whether or not it is detected by the fourth
10 sensor 15 that the placement table 60 is present in the first position P1 (S31). In a case where the control section 20 has determined that the placement table 60 is detected by the fourth sensor 15 (YES in step S31), the control section 20 causes the second retaining section 50 to
15 release the retaining of the polycrystalline silicon S (S32). This causes the polycrystalline silicon S to fall from the second retaining section 50 onto the placement table 60. In the step S32, the second retaining section 50 is in an opened state. This state refers to a state in which the
20 support section 51a and the wall section 70 are separated from each other.

[0074]

 Thus, on the basis of the detection results from the upper sensor 13 and the lower sensor 14 for the
25 polycrystalline silicon S, the control section 20 places the

polycrystalline silicon S onto the placement table 60 by causing the first retaining section 40 and the second retaining section 50 to release the retaining of the polycrystalline silicon S.

5 [0075]

After causing the second retaining section 50 to release the retaining of the polycrystalline silicon S, the control section 20 determines whether retraction of the placement table 60 is detected by the fourth sensor 15 (S33). In the step S33, in a case where the placement table 60 is not present in the first position P1, the fourth sensor 15 detects that the placement table 60 has been retracted. In this case, the control section 20 determines that the placement table 60 has moved from the first position P1 to the second position P2. Further, the control section 20 determines that the stock of the polycrystalline silicon S is absent. The stock is that of polycrystalline silicon S to be supplied to the conveyance section 30.

[0076]

20 Further, in a case where the placement table 60 is present in the first position P1, the fourth sensor 15 detects that the placement table 60 has not retracted. In this case, the control section 20 determines that the placement table 60 stands by in the first position P1.

25 [0077]

In a case where the fourth sensor 15 has detected that the placement table 60 has retracted (YES in S33), the control section 20 closes the second retaining section 50 (S34). The closed state of the second retaining section 50 refers to a state where the lower end portion of the support section 51a is in contact with the wall section 70. In contrast, in a case where the fourth sensor 15 detects that the placement table 60 has not retracted (NO in S33), the control section 20 maintains the second retaining section 50 in an opened state.

[0078]

On the other hand, in a case where the control section 20 determines that the placement table 60 is not detected by the fourth sensor 15 (NO in S31), the control section 20 stands by until the placement table 60 is detected by the fourth sensor 15.

[0079]

(Flow of operation of placement table)

Fig. 9 is a flowchart illustrating one example of operation of the placement table 60 included in the conveyance device 1 illustrated in Fig. 1. After the step S32 illustrated in Fig. 8, the control section 20 causes the placement table 60 on which the polycrystalline silicon S is placed to move from the first position P1 to the second position P2 (S41).

[0080]

After the control section 20 has caused the placement table 60 to move from the first position P1 to the second position P2, the above-described imaging
5 section captures an image of the polycrystalline silicon S, and the polycrystalline silicon S is then removed from the placement table 60. The control section 20 then causes the placement table 60 to move from the second position P2 to the first position P1 (S42). While carrying out the
10 process of the step S41 or S42, the control section 20 continues the processes of the steps illustrated in Figs. 5 to 7 and the process of the step S31 illustrated in Fig. 8.

[0081]

As such, the conveyance device 1 can temporarily
15 retain the polycrystalline silicon S by including the first retaining section 40 and the second retaining section 50 that can retain the polycrystalline silicon S. Further, on the basis of the detection results from the upper sensor 13 and the lower sensor 14 for the polycrystalline silicon
20 S, the control section 20 causes the first retaining section 40 and the second retaining section 50 to release the retaining of the polycrystalline silicon S.

[0082]

Thus, from the detection results from the upper
25 sensor 13 and the lower sensor 14, the control section 20

recognizes that the polycrystalline silicon S is in a state of being retained by at least one of the first retaining section 40 and the second retaining section 50, and causes the polycrystalline silicon S to fall from the second
5 retaining section 50. The control section 20 can thus place the polycrystalline silicon S onto the placement table 60.
[0083]

In a case where the placement table 60 has returned from the second position P2 to the first position P1, the
10 polycrystalline silicon S can be immediately placed onto the placement table 60 from the first retaining section 40 and the second retaining section 50 by releasing the retaining of the polycrystalline silicon S by the first retaining section 40 and the second retaining section 50.
15 Therefore, it is possible to smoothly supply the polycrystalline silicon S from the first position P1 to the second position P2.
[0084]

Aspects of the present invention can also be
20 expressed as follows:

A polycrystalline silicon conveyance device in accordance with Aspect 1 of the present invention includes: a conveyance section that has a discharge end portion from which polycrystalline silicon is discharged
25 and that is configured to convey the polycrystalline silicon

to discharge the polycrystalline silicon from the discharge
end portion; a first sensor configured to detect the
polycrystalline silicon from a plurality of directions above
the conveyance section; and a control section configured
5 to control driving of the conveyance section on the basis
of a result of detection of the polycrystalline silicon by the
first sensor.

[0085]

Use of the first sensor that detects the
10 polycrystalline silicon from a plurality of directions above
the conveyance section enables accurate detection of
polycrystalline silicon having an irregular shape using the
first sensor. Therefore, by controlling the driving of the
conveyance section on the basis of a result of detection of
15 the polycrystalline silicon by the first sensor, the control
section can reliably discharge the polycrystalline silicon,
which is a discharge target, to the outside of the
conveyance section.

[0086]

20 A polycrystalline silicon conveyance device in
accordance with Aspect 2 of the present invention may be
configured, in Aspect 1 above, such that the first sensor
is composed of a plurality of laser sensors configured to
detect the polycrystalline silicon from different directions,
25 and the control section controls the driving of the

conveyance section on the basis of detection of the polycrystalline silicon by at least one of the plurality of laser sensors.

[0087]

5 A plurality of laser sensors are provided so as to detect the polycrystalline silicon from different directions. Accordingly, the laser sensor, which is less expensive than, for example, an image sensor, is used, thus making it possible to reduce the manufacturing cost for the
10 polycrystalline silicon conveyance device. Furthermore, the control section controls the driving of the conveyance section on the basis of the detection of the polycrystalline silicon by at least one of the plurality of laser sensors. This enables the polycrystalline silicon conveyance device
15 to reliably discharge the polycrystalline silicon, which is a discharge target, to the outside of the conveyance section.

[0088]

 A polycrystalline silicon conveyance device in
20 accordance with Aspect 3 of the present invention may be configured, in Aspect 1 or 2 above, such that the conveyance section includes a vibrating feeder configured to vibrate to convey the polycrystalline silicon.

[0089]

Use of the vibrating feeder as the conveyance section that conveys the polycrystalline silicon facilitates control over the discharge of the polycrystalline silicon to the outside of the conveyance section. Further, the plurality
5 of laser sensors can accurately detect the polycrystalline silicon with an irregular shape that vibrates by the vibrating feeder. This makes it possible both to facilitate control over the discharge of the polycrystalline silicon to the outside of the conveyance section and to accurately
10 detect the polycrystalline silicon having an irregular shape.

[0090]

A polycrystalline silicon conveyance device in accordance with Aspect 4 of the present invention may be
15 configured, in any one of Aspects 1 to 3 above, such that in a case where the first sensor has detected the polycrystalline silicon, the control section temporarily stops the driving of the conveyance section.

[0091]

20 Therefore, in a case where additional polycrystalline silicon is conveyed following the polycrystalline silicon that has been discharged to the outside of the conveyance section, the conveyance of the following polycrystalline silicon is, on detection of the following polycrystalline
25 silicon by the first sensor, stopped temporarily. When the

conveyance of the polycrystalline silicon is then resumed,
the polycrystalline silicon is discharged to the outside of
the conveyance section. Thus, the conveyance section can
discharge the polycrystalline silicon one by one to the
5 outside from the discharge end portion, on the basis of
the detection results from the first sensor for the
polycrystalline silicon.

[0092]

A polycrystalline silicon conveyance device in
10 accordance with Aspect 5 of the present invention may be
configured, in any one of Aspects 1 to 4 above, such that
the first sensor detects the polycrystalline silicon from a
plurality of directions in a vicinity of the discharge end
portion.

15 [0093]

The first sensor detects the polycrystalline silicon
in the vicinity of the discharge end portion from which the
polycrystalline silicon is discharged, so that the control
section can accurately recognize the polycrystalline
20 silicon immediately prior to discharge to the outside of the
conveyance section. The polycrystalline silicon that has
been detected by the first sensor is thus immediately
discharged to the outside of the conveyance section.
Accordingly, after the polycrystalline silicon has been
25 discharged to the outside of the conveyance section, the

first sensor can detect polycrystalline silicon conveyed subsequently. Therefore, on the basis of the detection result from the first sensor, the control section can control the driving of the conveyance section so as to
5 smoothly convey the polycrystalline silicon.

[0094]

A polycrystalline silicon conveyance device in accordance with Aspect 6 of the present invention may be configured, in any one of Aspects 1 to 5 above, to further
10 include: a retaining section capable of retaining the polycrystalline silicon that has been discharged from the discharge end portion; and a second sensor configured to detect the polycrystalline silicon falling from the discharge end portion onto the retaining section, and the
15 control section may cause, on the basis of a result of detection of the polycrystalline silicon by the second sensor, the retaining section to release retaining of the polycrystalline silicon to place the polycrystalline silicon onto a placement table movable between a first position in
20 which the polycrystalline silicon falling downward from the retaining section is able to be placed and a second position separated from the first position.

[0095]

The polycrystalline silicon conveyance device can
25 temporarily retain the polycrystalline silicon by including

the retaining section that can retain the polycrystalline silicon. Further, the control section causes the retaining section to release the retaining of the polycrystalline silicon on the basis of the detection result from the second
5 sensor for the polycrystalline silicon. Thus, the control section can recognize, from the detection result from the second sensor, that the polycrystalline silicon is in a state of being retained by the retaining section, and cause the polycrystalline silicon to fall from the retaining section to
10 place the polycrystalline silicon onto the placement table.
[0096]

Further, in a case where the placement table has returned from the second position to the first position, the retaining of the polycrystalline silicon by the retaining
15 section is released, thereby making it possible to immediately place the polycrystalline silicon from the retaining section onto the placement table. Therefore, it is possible to smoothly supply the polycrystalline silicon from the first position to the second position.

20 [0097]

A polycrystalline silicon conveyance method in accordance with Aspect 7 of the present invention includes: a conveyance step of, with use of a conveyance section that has a discharge end portion from which
25 polycrystalline silicon is discharged, conveying the

polycrystalline silicon to discharge the polycrystalline silicon from the discharge end portion; a detection step of detecting the polycrystalline silicon from a plurality of directions above the conveyance section; and a control
5 step of controlling driving of the conveyance section on the basis of a result of detection of the polycrystalline silicon in the detection step.

[0098]

The present invention is not limited to the above
10 embodiments, but can be altered within the scope of the claims. The present invention also encompasses, in its technical scope, any embodiment derived by combining technical means disclosed in the embodiment as appropriate.

15

Reference Signs List

[0099]

- 1 Conveyance device
- 12 First sensor
- 20 13 Upper sensor (second sensor)
- 14 Lower sensor (second sensor)
- 20 Control section
- 30 Conveyance section
- 31 Discharge end portion
- 25 40 First retaining section (retaining section)

50	Second retaining section (retaining section)
60	Placement table
P1	First position
P2	Second position
5 S	Polycrystalline silicon

Claims

[Claim 1]

A polycrystalline silicon conveyance device comprising:

5 a conveyance section that has a discharge end portion from which polycrystalline silicon is discharged and that is configured to convey the polycrystalline silicon to discharge the polycrystalline silicon from the discharge end portion;

10 a first sensor configured to detect the polycrystalline silicon from a plurality of directions above the conveyance section; and

 a control section configured to control driving of the conveyance section on the basis of a result of detection of
15 the polycrystalline silicon by the first sensor.

[Claim 2]

The polycrystalline silicon conveyance device according to claim 1, wherein

20 the first sensor is composed of a plurality of laser sensors configured to detect the polycrystalline silicon from different directions, and

 the control section controls the driving of the conveyance section on the basis of detection of the

polycrystalline silicon by at least one of the plurality of laser sensors.

[Claim 3]

5 The polycrystalline silicon conveyance device according to claim 2, wherein the conveyance section includes a vibrating feeder configured to vibrate to convey the polycrystalline silicon.

10 [Claim 4]

 The polycrystalline silicon conveyance device according to any one of claims 1 to 3, wherein in a case where the first sensor has detected the polycrystalline silicon, the control section temporarily stops the driving
15 of the conveyance section.

[Claim 5]

 The polycrystalline silicon conveyance device according to any one of claims 1 to 3, wherein the first
20 sensor detects the polycrystalline silicon from a plurality of directions in a vicinity of the discharge end portion.

[Claim 6]

 The polycrystalline silicon conveyance device
25 according to any one of claims 1 to 3, further comprising:

a retaining section capable of retaining the polycrystalline silicon that has been discharged from the discharge end portion; and

5 a second sensor configured to detect the polycrystalline silicon falling from the discharge end portion onto the retaining section,

the control section causing, on the basis of a result of detection of the polycrystalline silicon by the second sensor, the retaining section to release retaining of the
10 polycrystalline silicon to place the polycrystalline silicon onto a placement table movable between a first position in which the polycrystalline silicon falling downward from the retaining section is able to be placed and a second position separated from the first position.

15

[Claim 7]

A polycrystalline silicon conveyance method comprising:

a conveyance step of, with use of a conveyance
20 section that has a discharge end portion from which polycrystalline silicon is discharged, conveying the polycrystalline silicon to discharge the polycrystalline silicon from the discharge end portion;

a detection step of detecting the polycrystalline silicon from a plurality of directions above the conveyance section; and

a control step of controlling driving of the
5 conveyance section on the basis of a result of detection of the polycrystalline silicon in the detection step.