SPECIFICATION

GAS INJECTION MEAN FOR USE WITH LASER PROCESSING APPARATUS

Technical Field

【0001】 The present invention relates to a gas injection mean that may be included in the laser processing apparatus that provides the laser processing capabilities for an object such as an amorphous semiconductor thin film, including the manufacture of a polycrystalline semiconductor thin film by irradiating the amorphous semiconductor film with the laser beam.

Background

【0002】 In the conventional apparatus for crystallizing the amorphous silicon thin films by utilizing the laser beam, a method is known whereby only the laser irradiation atmosphere may be controlled by eliminating any possible effects of the atmosphere so that the atmosphere that is best suited for the crystallizing process can be obtained, instead of drawing the vacuum from the processing chamber and then introducing any suitable processing gas into the processing chamber. This method may be implemented by the apparatus that will be described below.

【0003】 (a) The apparatus known as the laser beam annealing apparatus (as disclosed in the below described patent document 1): this apparatus is characterized in that it includes the nitrogen gas injection mean for jetting the nitrogen gas in order to bring only the neighborhood of the region of the object being irradiated with the laser beam into the nitrogen gas-contained atmosphere, wherein the nitrogen gas injection mean includes a plate-like nozzle having a slit through which the laser beam is passed, a plurality of nitrogen gas injection outlets each arranged around the slit, and the labyrinth sealing portion arranged around the plurality of nitrnogen gas injection

outlets.

【0004】 (b)The apparatus known as the apparatus for manufacturing the polycrystalline semiconductor thin films formed on the insulating substrate (as disclosed in the below described patent document 2): this apparatus is characterized in that it uses the laser beam annealing method to crystallize the amorphous semiconductor thin films, and includes the local shield that is provided around the laser beam for controlling the atmosphere that exists on the surface of the substrate being irradiated with the laser beam.

The general arrangement of the apparatus mentioned in (b) above is shown in Fig. 8, and is now described below. A laser beam 6 may be emitted from the laser beam source 5, and the laser beam 6 may then be introduced through the optical system 7 into the gas injection tube 50. Then, the laser beam 6 may be applied to the amorphous semiconductor film 2 formed on the substrate 1 through the gas injection outlet 52 provided on the bottom end of the gas injection tube 50. The gas injection tube 50 is connected to the gas inlet pipe 51 through which the nitrogen gas may be introduced into the gas injection tube 50. Then, the nitrogen gas may be jetted onto the neighborhood of the region of the amorphous semiconductor thin film 2 through the gas injection outlet 52.

Patent document 1: Japanese patent application now opened for the public examination under No. 2000-349041

Patent document 2: Japanese patent application now opened for the public examination under No. 2002-93738

Disclosure of Invention

Problem to be solved by the Invention

【0005】 As the conventional laser beam annealing apparatus are constructed as described above, the nitrogen gas tends to flow irregularly in the longitudinal direction of the gas injection outlet, and the gas flow rate tends to be irregular. They raise the problem in that the polycrystalline film cannot be

formed uniformly after it is irradiated with the laser beam.

[0006] The present invention addresses the problems of the prior art that have been described above. Embodiments of the present invention provide a gas injection mean that may be used in conjunction with the laser processing apparatus, wherein the gas injection mean can improve the processing by the laser beam, by allowing the atmospheric gas to flow regularly, and allowing it to be jetted regularly through the gas injection outlet so that the atmosphere can be created uniformly in the neighborhood of the region of the object being irradiated with the laser beam.

Means for solving problem

[0007] The present invention provides several embodiments of the gas injection mean that may be mounted in the laser processing apparatus that is capable of processing an object by irradiating the object with the laser beam. Specifically, the gas injection mean in accordance with an aspect of the present invention may be used to jet the gas onto the neighborhood of the area of the object being irradiated with the laser beam for creating the laser irradiation atmosphere, wherein the gas injection mean is characterized in that it includes a gas inlet section, a gas injection outlet through which the gas may be jetted toward the object, and a gas flow path leading from the gas inlet section to the gas injection outlet. The gas flow path has a uniform flow surface to be formed to face opposite the direction of the gas flow for disturbing the gas flow and thereby making the gas flow uniform in the direction across the direction of the gas flow.

[0008] In the gas injection mean in accordance with the above aspect, the atmospheric gas that is introduced from the gas inlet section, and is made to flow along the gas flow path may also strike against the uniform flow surface provided on the gas flow path, disturbing the gas flow so that it can also flow in the direction across the direction of the gas flow. The gas flow in the direction across direction of the gas flow may thus become uniform,

enabling the gas to flow at a uniform rate. The uniform flow surface may be provided to occur at least two times in the direction of the gas flow so that the uniform gas flow can be promoted further. In the arrangement that allows the gas flow to change its direction just before the gas injection outlet, for example, it is difficult to cause the gas to flow at a uniform rate. When it is arranged such that the gas flow is finally to be jetted from the gas injection outlet, the uniform laser irradiation atmosphere can be obtained in the neighborhood of the part being irradiated with the laser beam, without causing any deflection in the gas flow. It is therefore desirable that the gas flow path having the uniform flow surface thereon should have the small cross-sectional area. In the conventional gas injection tube, however, it is difficult for the gas injection tube to provide the satisfactory action because its cross-sectional area is too large. It is therefore desirable that the uniform flow surface having the small cross-sectional area should be provided on the upstream side of the gas injection tube.

[0009] The gas injection mean according to an embodiment of the invention is characterized in that the laser beam has a line beam form, and the gas injection outlet has the elongated shape that allows the laser beam can be passed through.

[0010] The gas injection mean according to another embodiment of the invention is characterized in that the uniform flow surface may be formed by providing one or more baffle boards on the gas flow path.

[0011] The gas injection mean according to another embodiment of the invention is characterized in that the uniform flow surface may be formed by providing the curved or bent surface inside the gas flow path.

[0012] In accordance with the above embodiment, it is desirable that the curved surface should have the small curvature or the bent surface should have the small angle to ensure that the uniform flow surface can provide its proper action.

[0013] The gas injection mean according to a further embodiment of the invention is characterized in that the gas inlet section has a delimiting wall that delimits the gas flow path, and this delimiting wall has a plurality of gas passages formed at regular intervals along the direction across the gas flow within the gas flow path.

[0014] In accordance with the further embodiment, as the gas is introduced through the plurality of gas passages provided on the delimiting wall inside the gas flow path, a rate and a velocity of gas flow can be made uniform in the direction across the gas flow.

[0015] The gas injection mean according to another embodiment of the invention is characterized in that the gas inlet section includes a gas inlet chamber having chamber wall that a part of the chamber wall is formed on the delimiting wall.

[0016] In accordance with the above embodiment, as the gas may be made to flow into the gas inlet chamber from which the gas may then be introduced into the gas flow path through the plurality of gas passages, rate and the velocity of gas flow can be made uniform more effectively.

[0017] The gas injection mean according to another embodiment of the invention is characterized in that the gas inlet chamber includes a gas inlet pipe that is provided along the direction across the gas flow inside the gas flow path, and the gas flow pipe has a gas passage slit or a plurality of gas passage holes arranged at intervals along the longitudinal

direction through which the gas may be drawn into the gas inlet pipe from the outside.

[0018] In accordance with the above embodiment, as the gas can be introduced uniformly in the direction across the gas flow through the gas inlet pipe into the gas inlet chamber, the rate and the velocity of gas flow can be made to be uniform more effectively. Desirably, the direction in which the gas is jetted through the gas passage slit or the plurality of gas passage holes should not be directed toward the gas passages, and more desirably, the gas through the slit or holes should be jetted onto the side opposite the gas passages.

Effect of Invention

[0019] It may be appreciated from the foregoing description that the gas injection mean in accordance with any of the embodiments described above may be used with the laser processing apparatus for processing an object by irradiating the object with the laser beam, wherein the gas injection mean is capable of jetting the gas onto the neighborhood of the area of the object being irradiated with the laser beam so that the laser irradiation atmosphere can be created, and wherein the gas injection mean includes the gas inlet section, the gas injection outlet through which the gas may be directed to the object, and the gas flow path leading from the gas inlet section to the gas injection outlet, the gas flow path having the uniform flow surface for disturbing the gas flow in the direction opposite the direction of the gas flow and thereby making the gas flow uniform in the direction across the direction of the gas flow so that the rate and the velocity of gas flow can be made uniform in the direction across the direction of the gas flow. The uniform laser irradiation atmosphere can thus be created in the neighborhood of the area of the object being irradiated with the laser beam can be made uniform. Under this uniform laser irradiation atmosphere, the object can be processed uniformly and with the high quality by exposing it to the laser beam irradiation.

BRIEF DESCRIPTION OF DRAWINGS

【0020】 Fig. 1 is a schematic diagram illustrating the laser beam annealing apparatus that includes the gas injection mean according to a first embodiment of the present invention;

Fig. 2 is a perspective view showing the cross section of part of the gas injection mean according to the first embodiment;

Fig. 3 is a schematic diagram illustrating the laser beam annealing apparatus that includes the gas injection mean according to a second embodiment of the present invention;

Fig. 4 is a schematic diagram illustrating the laser beam annealing apparatus that includes the gas injection mean according to a third embodiment of the present invention;

Fig. 5 is a plane sectional view illustrating the gas injection mean according to a fourth embodiment of the present invention;

Fig. 6 is a plane sectional view illustrating the gas injection mean according to a fifth embodiment of the present invention;

Fig. 7 is a plane sectional view and a perspective view illustrating the gas injection mean according to a sixth embodiment of the present invention; and

Fig. 8 is a schematic diagram illustrating the laser beam annealing apparatus that includes the conventional gas injection mean according to the prior art.

【0021】 In the drawings,

1: Substrate

2: Amorphous semiconductor thin film

3: Sample stage

5: Laser beam source

6: Laser beam

10: Gas injection tube

12: Gas supply pipe

13: Gas flow path

14a, 14b, 14c: Baffle boards

15: Gas injection outlet

20: Delimiting wall

20a: Gas passage hole

21: Gas inlet chamber

22a... 22f: Flow rate control valve

23a...23f: Gas passage hole

24: Gas supply pipe

24a: Gas passage hole

100, 110, 120, 130, 140: Gas injection tube

102, 112: Gas supply pipe

103, 113: Gas flow path

103a, 103b, 103c, 103d: Bent section

105, 115, 125, 135, 145: Gas injection outlet

113a, 113b, 113c, 113d: Curved section

BEST MODE OF EMBODYING THE INVENTION

【0022】 (Embodiment 1)

Referring now to Figs. 1 and 2, the laser beam annealing apparatus that includes the gas injection mean according to one embodiment of the present invention is described below.

As shown in Fig. 1, the sample stage 3 having the directional axis in plane (X axis and Y axis) is provided so that it can be moving transversely in the right and left directions in Fig. 1, and an elongated gas injection tube 10 is disposed above the sample stage 3. A laser beam inlet window 11 which is made of glass, for example, is disposed above the gas injection tube 10 and is sealed. A laser beam 6 emitted from a laser beam source 5 may be passed through an optical system 7 into the laser beam inlet window 11, through

which the laser beam 6 may be jetted downwardly through an elongated gas injection outlet 15 formed on the bottom end of the gas injection tube 10.

【0023】 The gas injection tube 10 is connected to a gas supply pipe 12 that extends from the lateral side thereof, and a gas flow path 13 is provided inside the lateral side. In the gas flow path 13, there are three baffle boards 14a, 14b, 14c, for example, which are arranged in the longitudinal (such as vertical) direction such that they are spaced away from each other. Specifically, one baffle board such as 14a is mounted such that it has its bottom end fixed and its top end free, another baffle board such as 14b is mounted such that it has its top end fixed and its bottom end free, and the other baffle board such as 14c is mounted such that it has its bottom end fixed and its top end free, and gaps are provided between the free ends of the baffle boards and the top or bottom side of the laser beam irradiation tube 10. Furthermore, a space is provided between the baffle board 14c located on the most downstream side and the inner side of the gas injecting tube located on the opposite end of the baffle board 14c. The laser beam 6 can be passed through this space, and the gas on the gas flow path 13 can enter this space through which the gas can be led to the gas injection outlet 15 beneath it.

【0024】 Now, the operation of the laser beam annealing apparatus described above is described below.

An object being processed such as the amorphous semiconductor thin film 2 formed on the substrate 1 is placed on the sample stage 3. The laser beam source 5 may emit a laser beam 6 (for example, an excimer laser beam having the wavelength of 308 nm and the pulse width of 30 ns), which may be passed in its pulse forms through the optical system 7 through which it may be formed into a streak of beam (line beam). Then, this line form laser beam may be applied onto the surface of the amorphous semiconductor thin film 2 through the laser beam inlet window 11 and then through the gas injection outlet 15.

【0025】 In the meantime, a nitrogen gas may be introduced as the atmospheric gas into the gas injection tube 10 through the gas supply pipe 12, flowing on the gas flow path 13. Then, the gas flow that occurs transversely from the lateral side may face the outer side of the baffle board 14a, striking against the baffle board 14a. This may disturb the gas flow, part of which may flow in the longitudinal direction of the gas injection tube 10. The gas flow may be made uniform in this way. This means that the outer side of the baffle board 14a may act as the uniform flow surface. As the gas flow strikes against the baffle board 14a, it will be rising along the outer side of the baffle board 14a until it strikes against the upper inner side of the gas injection tube 10. Upon striking against the upper inner side of the gas injection tube 10, the gas flow will be disturbed again. Then, some of the gas will flow in the longitudinal direction of the gas injection tube 10, making the gas flow become uniform. This means that the upper inner side of the gas injection tube 10 may act as the uniform flow surface. Upon striking against the upper inner side of the gas injection tube 10, the gas flow will be moving along the upper inner side until it strikes against the outer side of the baffle board 14b. Upon striking the outer side of the baffle board 14b, the gas flow will change its direction and strike against the lower inner side of the gas injection tube 10. Upon striking against the lower inner side of the gas injection tube 10, the gas flow will change its direction and strike against the outer side of the baffle board 14c. Upon striking against outer side of the baffle board 14c, the gas flow will change its direction and strike against the upper inner side of the gas injection tube 10. Then, the gas flow will change its direction, flowing into the space inside the baffle board 14c. Upon striking against the baffle boards 14b, 14c and upper and lower inner sides of the gas injection tube 10, the gas flow will also be disturbed, and some of the gas will flow in the longitudinal direction of the gas injection tube 10, making the gas flow become uniform. It may be understood, therefore, that the baffle boards 14b, 14c and the upper

and lower inner sides of the gas injection tube 10 may also act as the uniform flow surface.

【0026】 After the gas flow has become uniform by repeating the steps described above, the gas flow will go downwardly in the space inside the baffle board 14c, and then will be applied upon the neighborhood of the area of the amorphous semiconductor thin film 2 being irradiated with the laser beam through the gas injection outlet 15.

It may be appreciated that the rate and the velocity of the gas flow has been made to be uniform by the uniform gas flow in the longitudinal direction, and therefore the laser irradiation atmosphere that has thus been made uniform will be created near the area of the object being irradiated with the laser beam.

【0027】 The amorphous semiconductor thin film 2 may reaches the initial position set by the sample stage 3 where the object begins to be irradiated with the laser beam 6. The sample stage 3 can be moved at the speed paced by the pulses of the laser beam 6 (20 pulses per one area being irradiated with the laser beam). Upon reaching the initial position, the sample stage 3 may be moved at a constant speed. Then, the surface of the object being irradiated with the laser beam 6 may be moved with the movement of the sample stage 3 while the laser beam 6 is being scanned. Any area of the amorphous semiconductor thin film 2 may be crystallized by this moving surface. During this process, the gas may be jetted onto the neighborhood of the surface of the amorphous semiconductor thin film 2 being irradiated with the laser beam, and the good and uniform gaseous atmosphere from which the oxygen has been removed effectively will be created. The laser beam annealing process can be performed properly under this gaseous atmosphere from which the oxygen has thus been removed sufficiently.

【0028】 (Embodiment 2)

In the first embodiment described above, the uniform flow surface may

be provided by providing the baffle boards in the gas flow path. It should be noted that the present invention is not restricted to any particular method of providing such uniform flow surface.

As shown in Fig. 3, the gas flow path 103 in the gas injection tube 100 may have the flat cross-sectional shape along the longitudinal direction of the gas injection outlet 105, and may also include several bent sections extending above the gas injection outlet 105. In Fig. 3, reference numeral 101 denotes the laser beam inlet window, and numeral 102 denotes the gas supply pipe.

The gas may be introduced from the gas supply pipe 102 into the gas flow path 103, and may flow through the bent sections 103a to 103d. Through each bent section, the gas may strike against the bent surface of the bent section, producing the turbulent gas flow and thereby making the gas flow uniform. That is, the inner surface of the gas flow path that is located near the downstream side of the bent sections 103a to 103d in the gas flow path 103 may act as the uniform flow surface.

【0029】 (Embodiment 3)

The gas flow path that includes the curved sections may also be designed to have the winding construction. The gas flow can thus be made to be uniform because each of the inner surfaces of the curved sections can act as the uniform flow surfaces.

As shown in Fig. 4, the gas flow path 113 in the gas injection tube 110 may have the flat cross-sectional shape along the longitudinal direction of the gas injection outlet 115, and may have the winding construction that includes several curved sections 113a to 113d each having the small curvature. In Fig. 4, reference numeral 111 denotes the laser beam inlet window, and numeral 112 denotes the gas supply pipe.

As the gas flow along the gas flow path 113 flows through the curved sections 113a to 113d, it will strike against the inner surface of each curved section, thereby making the gas flow uniform. This means that the inner

surface of each of the curved sections 113a to 113d in the gas flow path 113 can act as the uniform flow surface.

【0030】 (Embodiment 4)

Although the uniform flow surface has been described in detail with reference to each of the preceding embodiments, the uniform flow action may be increased further by designing the gas inlet section as described below. In the embodiments that will be described below, the gas flow path including the uniform flow surfaces will not be described any further in order to avoid the duplicate explanation. Instead, the gas inlet section will be described in detail.

As shown in Fig. 5, the gas injection tube 120 having the gas injection outlet 125 includes the delimiting wall 20 that delimits the gas flow path on the side of the gas inlet section, and the delimiting wall 20 has a plurality of gas passage holes 20a...20a arranged at regular intervals as gas passage sections. The delimiting wall 20 may form a part of the chamber wall of the gas inlet chamber 21 on the gas entry side.

【0031】 In this fourth embodiment, the gas introduced into the gas inlet chamber 21 may be diffused there, and may be delivered through each of the gas passage holes 20a,...20a into the gas flow path. The rate and the velocity of gas flow can become uniform in the longitudinal direction of the gas injection outlet 125 while the gas flow is thus being delivered into the gas flow path. The gas flow that has thus become uniform can become further uniform by the action of the uniform flow surface described in connection with the preceding embodiments.

【0032】 (Embodiment 5)

In the embodiment 4 described above, the gas inlet chamber is provided on the upstream side of the delimiting wall so that the gas flow can be made uniform. In the embodiment 5 shown in Fig. 6, the delimiting wall 23 is provided on the gas injection tube 130 having the gas injection outlet 135,

and has the gas passage holes 23a to 23f as the gas passage sections, each of which is connected to each respective gas supply pipe. Each gas supply pipe is connected to each respective flow control valve 22a to 22f through which the gas flow in each gas supply pipe can be controlled to be uniform. Through each of the flow control valves 22a to 22f, the gas will be delivered uniformly into the gas flow path in the longitudinal direction. Any deviations that might occur in the gas flow in the longitudinal direction when the gas flow is delivered into the gas flow path may be avoided by ensuring that such deviations should not occur in the gas flow path so that the gas flow can be made uniform, but not by regulating the gas flow rate through each gas supply pipe in the same manner by controlling the flow control valves 22a to 22f individually.

【0033】 (Embodiment 6)

In the sixth embodiment shown in Fig. 7, the gas inlet chamber 21 described above in connection with the fifth embodiment may be provided in the gas injection tube 140 having the gas injection outlet 145, and the gas supply pipe 24 may be disposed in the gas inlet chamber 21, wherein the gas supply pipe 24 may have the gas passage holes 24a...24a at regular interval through which the gas may be delivered along the longitudinal direction. It should be noted that those gas passage holes might be replaced by a slit extending along the longitudinal direction.

It should also be noted that the gas passage holes 24a...24a or slit may be formed without facing to the gas passage holes 20a...20a so that the gas delivered from the gas passage holes 24a...24a or slit would not be moving directly toward the gas passage holes 20a...20a. It is more desirable for the same reason that the gas passage holes 24a...24a or slit be formed turning to the other side of the gas passage holes 20a...20a. In this way, the gas that has been delivered from the gas supply pipe 24 may flow into the gas inlet chamber 21 in which the gas may be made to diffuse in the longitudinal

direction, and then may be delivered into the gas flow path through the gas passage holes 20a...20a. Thus, the gas flow can be made to be more uniform in the longitudinal direction.

【0034】 The present invention has been described with particular reference to the embodiments. However it should be understood that the present invention is not restricted to those embodiments, but those embodiments may be modified or changed in numerous ways without departing from the spirit and scope of the present invention.

CLAIMS

What is claimed is:

1. A gas injection mean adapted to be included in the laser processing apparatus for processing an object by irradiating the object with the laser beam, the gas injection mean being provided for jetting a gas toward the neighborhood of the area of the object being irradiated with the laser beam for creating a laser irradiation atmosphere, wherein the gas injection mean includes a gas inlet section, a gas injection outlet through which the gas is jetted toward the object, and a gas flow path leading from the gas inlet section to the gas injection outlet, the gas flow path having a uniform flow surface to be formed to face opposite the direction of the gas flow for disturbing the gas flow and thereby making the gas flow uniform in the direction across the direction of the gas flow.

2. The gas injection mean as defined in Claim 1, wherein the laser beam has the shape of a line beam and wherein the gas injection outlet has the elongated shape that allows the laser beam to pass through the gas injection outlet.

3. The gas injection mean as defined in Claim 1, wherein the uniform flow surface is formed by providing one or more baffle boards in the gas flow path.

4. The gas injection mean as defined in Claim 1, wherein the uniform flow surface is formed by providing the bent or curved surface in the gas flow path.

5. The gas injection mean as defined in Claim 3, wherein the uniform flow surface is formed by providing the bent or curved surface in the gas flow path.

6. The gas injection mean as defined in any one of Claims 1 through 5, wherein the gas inlet section includes a delimiting wall for delimiting the gas flow path, the delimiting wall including a plurality of gas passage sections

along the direction across the direction the gas flow in the gas flow path and spaced away from each other.

7. The gas injection mean as defined in Claim 6, wherein the gas inlet section includes a gas inlet chamber having chamber wall that a part of the chamber wall is formed on the delimiting wall.

8. The gas injection mean as defined in Claim 7, wherein the gas inlet chamber has a gas inlet pipe disposed to extend along the direction across the direction of the gas flow in the gas flow path, the gas inlet pipe having a gas passage slit along the longitudinal direction or a plurality of gas passage holes spaced away from each other for allowing the gas to enter the gas inlet pipe from the outside through the slit or holes.

ABSTRACT

An adequately-controlled gaseous atmosphere is provided, and the area of an object being irradiated with the laser beam by the laser processing apparatus may be placed under such gaseous atmosphere.

A gas injection mean adapted to be included in the laser processing apparatus for processing an object (such as the amorphous semiconductor thin film 2) by irradiating the object with the laser beam 6 is provided, wherein the gas injection mean jets a gas toward the neighborhood of the area of the object being irradiated with the laser beam for creating the laser irradiation atmosphere, and wherein the gas injection mean includes a gas inlet section (such as the gas supply pipe 12), a gas injection outlet 15 through which the gas is jetted toward the object, and a gas flow path 13 leading from the gas inlet section to the gas injection outlet, the gas flow path having a uniform flow surface to be formed to face opposite the direction of the gas flow for disturbing the gas flow and thereby making the gas flow uniform in the direction across the direction of the gas flow. Thus, the uniform laser irradiation atmosphere may be created in the neighborhood of the area of the object being irradiated with the laser beam, and the process of irradiating the object with the laser beam can be performed uniformly and efficiently under such laser irradiation atmosphere.