

Description

Title of Invention:

LASER BEAM SHIELDING MEMBER, LASER PROCESSING DEVICE
AND LASER BEAM IRRADIATION METHOD

Technical Field

[0001]

The present invention relates to a laser beam shielding member for splitting a laser beam in a line beam shape to obtain a plurality of line beams, a laser processing device which splits a line beam to process a body to be processed, and a laser beam irradiation method.

Background Art

[0002]

There is known a method in which laser processing is performed on a workpiece to be used for a liquid crystal display and an organic EL display using a line beam.

In such laser processing, for example, a method is known in which a stable and high-quality semiconductor film (silicon film) formed only at a desired position is modified to a belt-like polycrystalline silicon film by being scanned with continuous oscillation laser beams focused in a linear or a rectangular (belt-like) shape and subjected to anneal processing while the continuous

oscillation laser beams are turned on/off (see Patent Literature 1).

Further, there is known a method in which upon application to a system-on-glass, or the like, transistor characteristics of a TFT are made homogeneous at a high level, and, particularly, to realize a TFT which excels in mobility in a peripheral circuit region and which can be driven at a high speed, a-Si film 2 is patterned on a glass substrate in a linear shape (ribbon shape) or an island shape, and a surface of the a-Si film or a reverse side of the glass substrate is irradiated and scanned with an energy beam temporally continuously outputted from a CW laser 3 in the direction of an arrow to crystalize the a-Si film (see Patent Literature 2, Figure 1(a) and Figure 1(b)).

Citation List

Patent Literature

[0003]

Patent Literature 1

Japanese Patent Laid-Open No. 2004-151668

Patent Literature 2

Japanese Patent Laid-Open No. 2005-354087

Summary of Invention

Technical Problem

[0004]

As described above, the conventional laser annealing device is directed to irradiate a laser workpiece with a laser beam, adjust a beam length of the laser beam in accordance with a size of the laser workpiece upon laser annealing processing, and remove a portion where energy density is not uniform, which is generated at an edge of a beam long axis, and uses a beam shielding member in a long axis direction.

Further, productivity is improved by increasing a beam size and reducing the number of times of scanning in accordance with increase in a size of the substrate.

However, some substrates include a portion where irradiation should not be performed, for example, there is a case where there is a portion which would be burned if irradiated with a laser beam. Further, some substrates can cause a problem of generating impurities or the like if irradiated with a laser beam. Therefore, there is a method in which a beam length of the laser beam is shortened to avoid the portion from being irradiated, which, however, reduces productivity.

[0005]

The present invention has been made to overcome the problems of the conventional device and method as described above, and one of the objects of the present invention is to provide a laser shielding member, a laser processing device and a laser beam irradiation method which are capable of splitting a line beam so as to

secure a portion where irradiation is avoided in a body to be processed and irradiating the body to be processed with the split line beams.

Solution to Problem

[0006]

That is, according to a first aspect of the invention, a laser beam shielding member is described, the laser beam shielding member shielding transmittance of full width of a short axis width of a laser beam in a line beam shape along a short axis direction in part of a long axis direction, and the laser beam is transmitted other than the shielding of full width of a short axis width within the range other than a long axis edge, to form a plurality of split line beams to be radiated on a body to be processed, wherein the shielding member is provided so that a shielding shape extends by a length which exceeding a short axis width of the laser beam, and the width shape of the shielding member changes stepwise or continuously in the length direction, part or the whole of the shielding member can perform sliding movement relatively in the line beam shape in a short axis width direction of the laser beam in the length direction with respect to a light path of the laser beam, and the shielding shape shielding the laser beam changes

in accordance with the movement, and adjustment of a shape of the split laser beams can be performed.

According to a second aspect of the invention, a laser beam shielding member is described, the laser beam shielding member shielding transmittance of full width of a short axis width of a laser beam in a line beam shape along a short axis direction in part of a long axis direction, and the laser beam is transmitted other than the shielding of full width of a short axis width, to form a plurality of split line beams to be radiated on a body to be processed, wherein the shielding member is provided so that part or the whole of the shielding member can perform a rotational movement relatively with respect to a light path of the laser beam in the line beam shape, and a shielding shape with respect to the laser beam changes in accordance with the movement, and adjustment of a shape of the split laser beams can be performed.

In embodiments, the shielding member has a shape such that a shielding shape changes in accordance with the movement.

In embodiments, the shielding member has a shape such that the shielding

shape changes stepwise or continuously in accordance with the movement.

In embodiments, the movement includes sliding movement and/or rotational movement.

In embodiments, the adjustment of the shape of the line beam is adjustment of a length of the line beams in a long axis direction.

[0007]

According to a third aspect of the present invention, a laser processing device is described, the laser processing device includes a laser light source configured to output a laser beam, an optical system configured to form the laser beam into a line beam shape and guide the laser beam to a body to be processed, a processed body holding unit configured to hold the body to be processed in preparation for irradiation of the laser beam, and the laser beam shielding member according to any one of the above embodiments of the present invention, wherein the laser beam shielding member is disposed so that a plurality of split line beams can be formed by shielding transmittance of full width of a short axis width of a laser beam along a short

axis direction in part of a long axis direction on a light path leading to the body to be processed held by the processed body holding unit, with the laser beam formed in the line beam shape being guided, and the laser beam is transmitted other than the shielding of full width of a short axis width within the range other than a long axis edge.

In embodiments, the shielding member can slidably move and/or rotatingly move.

In embodiments, the body to be processed has a laminated structure and separation processing is performed on the body to be processed.

In embodiments, the body to be processed is a substrate having a semiconductor layer and the semiconductor layer is crystalized or a crystal of the semiconductor layer is activated.

In embodiments, the body to be processed is a plastic substrate.

According to a fourth aspect of the invention, a laser beam irradiation method is described, the laser beam irradiation method includes forming a laser beam into a line beam shape, disposing a shielding member part or the

whole of which can move on a light path of the line beam to shield transmittance of part of the line beam and form a plurality of split line beams having a shape determined according to a position where the shielding member is disposed through the movement, and

irradiating a body to be processed with the split line beams.

[0008]

According to embodiments of the present invention, the line beam is split by the shielding member, and the body to be processed is irradiated with the split line beams. The shielding member can change the shape of the line beams after being split according to the movement, so that it is possible to obtain a plurality of irradiation patterns for the body to be processed.

It should be noted that the body to be processed can include various kinds of bodies which are processed by being irradiated with a laser beam in a line beam shape, and can include various kinds of bodies aimed at separation, crystallization, activation, or the like. To achieve the aims, examples of the body to be processed include a glass substrate and a plastic substrate having a semiconductor layer.

[0009]

Further, the laser beam formed in a line beam shape is not limited to a pulse oscillation laser beam, a continuous oscillation laser beam, or the like, and types of the laser are not particularly limited and can include gas laser, solid laser, semiconductor laser, or the like.

The shielding shape of the shielding member changes according to the movement, and can change the shape of the split line beams. The shielding shape which changes

according to the movement can continuously change in accordance with the movement, or can change stepwise, or can change in a manner in which these are combined.

[0010]

It should be noted that shielding of the shielding member not only completely prevents transmittance of the laser beam, but also can include shielding which allows the laser beam to be transmitted in a level low enough to exclude influence on an irradiated face of the body to be processed by decreasing transmittance.

Further, movement of the shielding member can include sliding movement and rotational movement, and the rotational movement can include rotation using a plurality of rotational axes. The sliding movement can include movement along a plane direction of the shielding member, and movement in a direction intersecting with the plane direction of the shielding member. Further, these can be combined.

The movement of the shielding member can be performed manually or by being driven, or the shielding member can move automatically under control. It should be noted that the movement of the shielding member can be any movement if the shielding member can move relatively with respect to the light path of the line beam, and can be relative movement of the shielding member in accordance with movement of the line beam.

Advantageous Effects of Invention

[0011]

As described above, according to the present invention, it is possible to obtain split line beams in a shape determined according to a position where the shielding member moves and irradiate the body to be processed with the line beams, so that it is possible to irradiate the body to be processed with the line beams without irradiating a portion which has an obstacle to irradiation or a portion which is not desired to be irradiated, or the like, without the need of replacement of an optical system, an adjustment period, or the like, thereby realizing desired processing with favorable productivity and with favorable quality.

Brief Description of Drawings

[0012]

[Figure 1] Figure 1 is a diagram illustrating an outline of a laser processing device including a shielding member in one embodiment of the present invention.

[Figure 2] Figure 2 is a diagram illustrating a beam profile of a cross section in a long axis direction of a line beam before and after being split in one embodiment of the present invention.

[Figure 3] Figure 3 is a schematic diagram illustrating a light path near the shielding member, a schematic diagram illustrating split beam profiles and a plan view of a

semiconductor substrate in one embodiment of the present invention.

[Figure 4] Figure 4 is a plan view and a front view illustrating a detailed shape of the shielding member in one embodiment of the present invention.

[Figure 5] Figure 5 is a plan view and a front view for explaining change of a shielding shape in accordance with movement of the shielding member in one embodiment of the present invention.

[Figure 6] Figure 6 is a plan view illustrating a modified example of the shielding member in one embodiment of the present invention.

[Figure 7] Figure 7 is a plan view illustrating another modified example of the shielding member in one embodiment of the present invention.

[Figure 8] Figure 8 is a plan view illustrating yet another modified example of the shielding member in one embodiment of the present invention.

[Figure 9] Figure 9 is a plan view illustrating yet another modified example of the shielding member in one embodiment of the present invention.

[Figure 10] Figure 10 is a front view illustrating yet another modified example of the shielding member in one embodiment of the present invention.

[Figure 11] Figure 11 is a front view illustrating yet another modified example of the shielding member in one embodiment of the present invention.

[Figure 12] Figure 12 is a plan view illustrating yet another modified example of the shielding member in one embodiment of the present invention.

[Figure 13] Figure 13 is a schematic diagram illustrating vicinity of a long axis edge shielding unit and a diagram illustrating outline of a beam profile in the conventional laser processing device.

Description of Embodiments

[0013]

A laser processing device including a shielding member according to one embodiment of the present invention will be described below based on Figure 1.

The laser processing device 1 includes a processing chamber 2, and a scanning device 3 is provided inside the processing chamber 2. A base 4 is provided on the scanning device 3 so that the base 4 can move in an X direction (scanning direction) by the scanning device 3, and the base 4 can also move in a Y direction.

Further, an introduction window 6 for introducing a line beam from outside is provided at the processing chamber 2.

[0014]

Upon laser processing, a semiconductor substrate 100 in which an amorphous silicon film 100b, or the like, is formed on a glass substrate 100a, or the like, is provided on the base 4. The semiconductor substrate 100

corresponds to a body to be processed. Further, the body to be processed is not limited to the semiconductor substrate 100, and, for example, a plastic substrate on which a semiconductor film is formed can be used as the body to be processed.

It should be noted that while description will be provided assuming that the laser processing device of the present embodiment involves laser annealing processing for crystalizing an amorphous film through laser processing, the laser processing in the present invention is not limited to this, and, for example, can be processing of single-crystalizing a non-single crystal semiconductor film or processing of modifying a crystal semiconductor film. Further, the processing can be processing of performing separation of the body to be processed.

[0015]

A laser light source 10 is provided outside the processing chamber 2. The laser light source 10 can output any of a pulse oscillation laser beam and a continuous oscillation laser beam, and is not limited to any of them in the present invention.

In the present embodiment, a pulse laser beam 15 is outputted from the laser light source 10. Energy density of the laser beam 15 is adjusted as necessary at an attenuator 11, and the laser beam 15 is formed into a line beam shape, or the like, or polarized at the optical

system 12 including a reflection mirror 12a, a homogenizer 12b, a reflection mirror 12c, a condenser lens 12d, or the like. It should be noted that optical members constituting the optical system 12 are not limited to those described above, and can include various kinds of lenses, mirrors, a waveguide unit, or the like. A line beam 150 whose beam cross-section shape is made a line shape can be obtained by the optical system 12. The size of the line beam 150 is not particularly limited, but, for example, can have a short axis width of 0.155 to 0.450 mm and have a long axis width of 370 to 1300 mm as a shape on a surface of the body to be processed.

[0016]

Further, a shielding member 13 which is located on a light path of the line beam 150 and which splits the line beam 150 to form a plurality of line beams, and a long axis edge shielding unit 20 which shields a long axis edge of the line beam 150 are disposed between the condenser lens 12d and the introduction window 6. The shielding member 13 and the long axis edge shielding unit 20 can be integrated or can be separately configured.

The shielding member 13 can move with respect to the light path of the line beam 150, and the position where the shielding member 13 moves can be adjusted manually and/or by a driving unit. The shielding member 13 can slidably move or rotatably move with respect to the light path, or can move in a manner in which these are

combined. The shielding member 13 can be one which can evacuate to outside of the light path of the line beam 150 and move within the light path of the line beam 150 upon shielding of the line beam 150, or can be one which moves only within the light path. In the present embodiment, while the shielding member 13 is disposed between the optical system 12 and the introduction window 6, the shielding member 13 can be located in the course from the introduction window to the body to be processed.

[0017]

Further, the laser processing device 1 includes a scanning device 3, a driving unit of the shielding member 13 (not illustrated), and a control unit 7 which controls the laser light source 10, or the like. The control unit 7 is configured with a CPU, a program for causing the CPU to operate, a storage unit, or the like.

[0018]

Operation of the laser processing device 1 will be described next.

The laser light source 10 performs pulse oscillation at a predetermined repetition frequency under control of the control unit 7 and outputs the laser beam 15 at predetermined output. Examples of the laser beam 15 include, for example, a laser beam having a wavelength of 400 nm or less and a pulse half width of 200 nanoseconds or less. However, the laser beam is not limited to these in the present invention.

Pulse energy density of the laser beam 15 is adjusted at the attenuator 11 which is controlled by the control unit 7. A predetermined attenuation rate is set at the attenuator 11, and the attenuation rate is adjusted so that irradiation pulse energy density most appropriate for crystallization can be obtained on an irradiation face of the silicon film 100b. For example, when an amorphous silicon film 100b is crystalized, the attenuation rate can be adjusted so that the energy density becomes 250 to 500 mJ/cm² on the substrates surface.

[0019]

The laser beam 15 which passes through the attenuator 11 is formed into a line beam shape and a short axis width is condensed so as to form a line beam 150 at the optical system 12. The line beam 150 is formed so that, for example, a length at a long axis side on the silicon film 100b becomes 370 to 1300 mm, and a length at a short axis side becomes 100 μ m to 500 μ m.

[0020]

As illustrated in the beam profile of the cross section in the long axis direction in Figure 2, the line beam 150 has a flat portion 150a at which energy intensity is 96% or higher with respect to maximum energy intensity and a steepness portion 150b which is located at both ends in the long axis direction and at which energy intensity is lower than that of the flat portion

150a and gradually decreases toward outside. The steepness portion 150b can be a region at which energy intensity falls within a range of 10% to 90% of the maximum intensity.

[0021]

Figure 13 illustrates outline of a light path in the conventional laser annealing processing device. This laser processing device also includes an optical system such as a reflection mirror 12c and a condenser lens 12d as with the laser processing device 1 of the above-described embodiment, and a long axis edge shielding unit 20 which shields a long axis edge of the line beam 150 is disposed on a light path between the condenser lens 12d and an introduction window which is not illustrated. By cutting the long axis edge of the line beam by the long axis edge shielding unit 20, a slant of the steepness portion 150b of the line beam 150 can be made small. Figure 13 also illustrates a beam profile of the line beam 150 whose long axis edge is cut.

[0022]

In the present embodiment, the control unit 7 controls movement of the shielding member 13, shields part of the line beam 150 and obtains split line beams.

An example thereof is illustrated in Figure 3. While passing through the shielding member 13 and the long axis edge shielding unit 20, an edge in the long axis direction of the line beam 150 is shielded at the

long axis edge shielding unit 20 and part of the flat portion is shielded at shielding units 130 of the shielding member 13 located at intervals in the long axis direction of the line beam 150, so that a plurality of split line beams 151 whose long axis length is shortened can be obtained, and the line beams 151 are radiated on the semiconductor substrate 100.

Figure 3(a) also illustrates a beam profile of the split line beams 151. The more detailed beam profile is illustrated in Figure 2(b). The line beams 151 have flat portions 151a and steepness portions 151b at both sides in the long axis direction for each of the line beams 151, and an interval corresponding to the interval of the shielding units 130 are provided between adjacent flat portions 151a.

[0023]

Further, Figure 3(b) illustrates a plan view of the semiconductor substrate 100 to which processed portions 110 are assigned in a matrix at intervals. The line beam 151 is split so as to have a long axis length corresponding to the width of the processed portion 110 (horizontal direction in the figure). Therefore, the shielding units 130 are arranged at the shielding member 13 so as to correspond to arrangement of the processed portions 110.

[0024]

The laser processing device 1 can perform overlapped irradiation of the line beams 151 in accordance with the arrangement of the processed portions 110 by radiating the line beams 151 while moving the silicon film 100b at a predetermined scanning speed. After irradiation for a predetermined time period, by turning off irradiation of the laser beam for a short period and radiating the laser beam again, it is possible to secure an unirradiated region 110a in a scanning direction. By repeating this, it is possible to obtain processing portions 111 distributed in an island shape by performing processing on the semiconductor substrate 100 while preventing the laser beam from radiating on portions other than the processed portions 110.

Further, the shielding member 13 can change a shape or a position of the shielding units 130 according to movement, so that it is possible to change a shape of the split line beams. This will be described below.

[0025]

Figure 4 illustrates a detailed shape of the shielding member 13.

The shielding member 13 has shielding units 130 having widths different stepwise along a short axis direction of the line beam 150, and widths of the respective shielding units 130 are the same in the long axis direction of the line beam 150. Each shielding unit 130 is connected at a base and the respective shielding

units 130 can move in an integrated manner. When the shielding member 13 moves in the short axis direction of the line beam 150 and the shielding units 130 are positioned at the line beam 150 at a predetermined shielding width, it is possible to adjust a shape of the split line beams according to the shielding width.

It should be noted that the shielding unit has preferably a shape such that an edge direction of a shielding edge is perpendicular or at a predetermined angle with respect to the long axis direction of the line beam, and a cross section in an irradiation direction of the line beam becomes preferably smaller toward the shielding edge, and, more preferably, the shielding edge is sharp. By this means, it is possible to prevent or suppress adverse effect on the semiconductor substrate 100 due to occurrence of diffraction of the line beam 150 by the shielding edge of the shielding unit.

[0026]

Figures 5(a) to 5(d) illustrate states where the shielding member 13 moves with respect to the light path, thereby the width of the shielding unit 130 located on the light path is changed, and schematic shapes of the beam profile of the split line beams. In this shielding member 13, it is possible to adjust a length in the long axis direction and an interval of each of the split line beams stepwise.

[0027]

Figure 6 illustrates a shielding member 13a in another example.

The shielding member 13a has shielding units 130a at intervals, the shielding units 130a having a shape of an isosceles triangle, and a width of the shielding units 130a continuously changing along the short axis direction of the line beam 150. It should be noted that each shielding unit 130a can move independently from each other, and by moving the shielding units 130a in the short axis direction of the line beam 150, it is possible to adjust a long axis length of the split line beams by changing the shielding width. Further, by positioning part of the shielding units 130a on a light path and positioning other shielding units 130a outside the light path, it is possible to change the number of split line beams.

Further, in the present embodiment, the long axis edge shielding unit 20 can move in the long axis direction of the line beam 150, and it is possible to change a size between both side edges of the split line beams by moving the long axis edge shielding unit 20 in accordance with adjustment at the optical system 12.

[0028]

Figure 7 illustrates a shielding member 13b in yet another example.

The shielding member 13b has a shape in which widths in the long axis direction are different stepwise along

the short axis direction of the line beam 150 as with the shielding member 13. However, the shielding member 13b is different from the shielding member 13 in that each shielding unit 130b can independently move in the short axis direction, and by moving each shielding unit 130b in the short axis direction of the line beam 150, it is possible to adjust a long axis length of the split line beams by changing the shielding width. Further, by disposing part of the shielding units 130b on the light path while disposing other part of the shielding units 130b outside the light path, it is possible to change the number of split line beams.

[0029]

While description has been provided above where in the above-described each shielding member, the width in the long axis direction changes with a similar tendency (increases or decreases) stepwise or continuously along the short axis direction of the line beam 150, the width in the long axis direction can be different depending on the position where the shielding units move without having a tendency to increase or decrease.

Figure 8 illustrates a shielding member 13c in yet another example.

The shielding member 13c has a plurality of shielding units 130c at intervals in the long axis direction of the line beam, and each shielding unit 130c can move independently in the short axis direction. The

shielding units 130c have different widths in the long axis direction without having a fixed tendency to increase or decrease at a position in the short axis direction, and by moving each shielding unit 130c in the short axis direction of the line beam 150, it is possible to adjust a long axis length of the split line beams by changing the shielding width. It should be noted that the width in the long axis direction of each shielding unit 130c does not have a tendency to be large or small in the short axis direction, and has an appropriate width according to the position where the shielding unit moves in the short axis direction.

[0030]

Further, while description has been provided above where in the above-described each shielding member, the shielding units have the same shape, the shielding units can have different shapes.

Figure 9 illustrates a shielding member 13d in yet another example. In this example, shielding units 130d and shielding units 131d are alternately arranged in the long axis direction and have shapes different from each other. The shielding units 130d are configured so that the width in the long axis direction changes stepwise along the short axis direction. Therefore, by moving the shielding units in the same direction, it is possible to sequentially increase or decrease the width in the long axis direction. Change of the width in the long axis

direction of the shielding units 131d does not have a fixed tendency to increase or decrease, and the shielding units 131d have an appropriate width in the long axis direction according to the position in the short axis direction.

By moving the shielding units 130d and the shielding units 131d as appropriate, it is possible to obtain split line beams with various lengths. It should be noted that in this embodiment, while description has been provided where the shielding members having different shapes are alternately arranged, the arrangement method is not particularly limited and types of the shielding members having different shapes are not particularly limited in the present invention.

[0031]

It should be noted that while description has been provided above where in the above-described shielding units, the shielding units move along the short axis direction, the shielding units can move on the same plane as the short axis direction so as to form an angle with the short axis direction, or can move along the long axis direction on the same plane as the short axis direction. Further, the shielding units can move in a plane having an angle with the short axis direction. The movement direction is not limited to one direction, and the shielding units can move in a plurality of directions.

[0032]

While description has been provided in the above-described embodiments where the shielding units slidably move, the shielding units can rotatably move. This will be described below.

Figure 10 illustrates another shielding member 13e, in which a plurality of shielding units 130e are arranged at intervals along the long axis direction. The shielding units 130e have a flat plate-like shape, have a rotational axis along the short axis direction of the line beam 150, and can be rotatably driven according to the rotational axis. This rotation can change a shielding effective width in the long axis direction in an irradiation direction of the line beam 150. Each shielding unit 130e can rotate in conjunction with each other, or part or the whole of the shielding units 130e can rotate independently. If the shielding units can rotate independently, it is possible to change a shielding shape by making rotation angles between part or the whole of the shielding units 130e different from each other.

Figure 11 illustrates a shielding member 13f in yet another example, in which a plurality of shielding units 130f are arranged at intervals along the long axis direction. The shielding units 130f have a rotational axis along the short axis direction of the line beam 150, and can be rotatably driven according to the rotational axis. The respective shielding units 130f have different

shapes of an outer periphery at a position in a circumferential direction, and the rotation can change a shielding effective width in the long axis direction with respect to the line beam 150 according to the rotation position. Further, each shielding unit 130f can rotate in conjunction with each other as with the above-described example, or part or the whole of the shielding units 130f can rotate independently from each other. If the shielding units 130f can rotate independently, it is possible to change a shielding shape by making rotation angles between part or the whole of the shielding units 130f different from each other.

It should be noted that while description has been provided in the above-described embodiment where the rotational axis is along the short axis direction, a direction of the rotational axis is not particularly limited, and a plurality of rotational axes can be provided.

[0033]

Further, while description has been mainly described above where each shielding member has a symmetric shape in the long axis direction, the right shape and the left shape can be different.

Figure 12 illustrates a shielding member 13g in another example.

A slant of an exterior piece of the shielding member 130g continuously changes along the short axis direction

of the line beam 150 at the right side in the long axis direction, and the exterior piece has a shape of a rectangular triangle along the short axis direction at the left side in the long axis direction, and the width in the long axis direction continuously changes according to the position where the shielding units move in the short axis direction. By moving the shielding units 13g in the short axis direction, it is possible to adjust a length in the long axis direction of the split line beams, and it is possible to adjust a position of an edge of the long axis direction of the split line beams at one side. Each shielding unit 130g can move in conjunction with each other or part or the whole of the shielding units can move independently.

[0034]

The shape of each shielding member described above is merely an example, the shape of the shielding member is not particularly limited in the present invention, and any shape can be used if the shielding shape can be changed according to movement.

[0035]

It should be noted that a surface of each shielding member as described above at least at a side irradiated with a laser beam is preferably made a rough face to prevent reflection of the laser beam. Alternatively, an upper face of each shielding member can be made so as not to form 90 degrees with respect to an angle of incidence

of the laser beam by forming an angle. These measures can prevent a reflected beam from returning to the optical system due to vertical reflection of the laser beam.

Alternatively, it is also possible to make a reflected beam reflect in a direction different from the optical system by allowing the surface of the shielding member to reflect the line beam and forming an angle at an upper face. By providing measurement equipment for measuring intensity (power, energy density, or the like) of this reflected beam and adjusting energy output of the laser beam by utilizing the measurement result, or adjusting an attenuation rate of the attenuator, it is possible to make fixed power reach a laser workpiece.

[0036]

Further, while description has been described in the above-described embodiment where the whole of the shielding member moves, it is also possible to adjust the shape of the split line beams by changing the shielding shape, for example, with a combination of a fixed shielding unit and a movable shielding unit.

[0037]

While the present invention has been described above based on the above-described embodiment, the present invention is not limited to the above-described embodiment, and can be modified as appropriate without departing from the scope of the present invention.

Reference Signs List

[0038]

- 1 Laser processing device
- 2 Processing chamber
- 3 Scanning device
- 4 Base
- 6 Introduction window
- 7 Control unit
- 10 Laser light source
- 12 Optical system
- 12a Reflection mirror
- 12b Homogenizer
- 12c Reflection mirror
- 12d Condenser lens
- 13, 13a, 13b, 13c, 13d, 13e, 13f, 13g Shielding member
- 130, 130a, 130b, 130c, 130d, 131d, 130e, 130f, 130g
Shielding unit
- 20 Long axis edge shielding unit
- 100 Semiconductor substrate

Claims

[Claim 1]

A laser beam shielding member shielding transmittance of full width of a short axis width of a laser beam in a line beam shape along a short axis direction in part of a long axis direction, and the laser beam is transmitted other than the shielding of full width of a short axis width within the range other than a long axis edge, to form a plurality of split line beams to be radiated on a body to be processed,

wherein the shielding member is provided so that a shielding shape extends by a length which exceeding a short axis width of the laser beam, and the width shape of the shielding member changes stepwise or continuously in the length direction, part or the whole of the shielding member can perform sliding movement relatively in the line beam shape in a short axis width direction of the laser beam in the length direction with respect to a light path of the laser beam, and the shielding shape shielding the laser beam changes in accordance with the movement, and adjustment of a shape of the split laser beams can be performed.

[Claim 2]

A laser beam shielding member shielding transmittance of full width of a short axis width of a laser beam in a line beam shape along a short axis direction in part of a long axis direction, and the laser beam is transmitted other than the shielding of full width of a short axis width, to form a plurality of split line beams to be radiated on a body to be processed,

wherein the shielding member is provided so that part or the whole of the shielding member can perform a rotational movement

relatively with respect to a light path of the laser beam in the line beam shape, and a shielding shape with respect to the laser beam changes in accordance with the movement, and adjustment of a shape of the split laser beams can be performed.

[Claim 3]

The laser beam shielding member according to claim 2, wherein the shielding member is provided so that a shielding shape extends by a length which exceeding a short axis width of the laser beam, and the width shape of the shielding member changes stepwise or continuously in the length direction, and part or the whole of the shielding member can perform a sliding movement relatively in a short axis width direction of the laser beam in the length direction with respect to a light path of the laser beam in the line beam shape, and the shielding shape with respect to the laser beam changes in accordance with the rotational movement and/or the sliding movement, and adjustment of a shape of the split laser beams can be performed.

[Claim 4]

The laser beam shielding member according to any one of claims 1 to 3, wherein the adjustment of the shape of the line beam is adjustment of a length of the line beam in a long axis direction.

[Claim 5]

A laser processing device comprising:

a laser light source configured to output a laser beam;

an optical system configured to form the laser beam into a line beam shape and guide the laser beam to a body to be processed;

a processed body holding unit configured to hold the body to be processed in preparation for irradiation of the laser beam; and

the laser beam shielding member according to any one of claims 1 to 4,

wherein the laser beam shielding member is disposed so that a plurality of split line beams can be formed by shielding transmittance of full width of a short axis width of a laser beam along a short axis direction in part of a long axis direction on a light path leading to the body to be processed held by the processed body holding unit, with the laser beam formed in the line beam shape being guided, and the laser beam is transmitted other than the shielding of full width of a short axis width within the range other than a long axis edge.

[Claim 6]

The laser processing device according to claim 5, wherein the body to be processed has a laminated structure, and separation processing is performed on the body to be processed.

[Claim 7]

The laser processing device according to claim 5 or 6, wherein the body to be processed is a substrate having a semiconductor layer, and the semiconductor layer is crystalized or a crystal of the semiconductor layer is activated.

[Claim 8]

The laser processing device according to any one of claims 5 to 7, wherein the body to be processed is a plastic substrate.