**Title:** LASER PROCESSING APPARATUS USING LASER BEAM SPLITTING

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**Abstract:** The present invention relates to a laser processing apparatus using laser beam splitting, which divides an incident laser beam into at least two beams and processes a workpiece using at least two beams, thereby improving processing quality and increasing processing efficiency. The laser processing apparatus includes a beam splitting means for dividing the laser beam emitted from the laser generation means into at least two beams and causing the resultant beams to be incident on the mirror. The beam splitting means comprises a prism, beam splitter or a combination of a prism and a beam splitter.
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LASER PROCESSING APPARATUS USING LASER BEAM SPLITTING

Technical Field

The present invention relates generally to a laser processing apparatus and, more particularly, to a laser processing apparatus using laser beam splitting, which divides an incident laser beam into at least two beams and processes a workpiece using at least two beams, thereby improving processing quality and increasing processing efficiency.

Background Art

Generally, in order to manufacture products using various materials, such as wafers, metals, and plastics, processing procedures, such as cutting and grooving, are required. These processing procedures are very important because they greatly affect the quality and yield in the subsequent procedures.

For these processing procedures, lasers have been used recently. A processing method using a laser causes a target portion to be eliminated by focusing a laser beam having a high ultraviolet ray range of 250 to 360 run on the surface of a workpiece and, therefore, generating heating and chemical reactions.

Recently, in the manufacturing of semiconductors, the number of chips per wafer is sometimes increased by reducing the intervals between chips on a wafer so as to increase the yield of manufactured chips. Accordingly, the industry demands a very narrow wafer processing line width of about 15 μm. In order to meet the demand for such a very narrow line width, it is necessary to increase the degree of overlapping of laser beam processing, that is, the frequency of incidence of a
laser on a workpiece, and to keep the intensity of a laser beam relatively low, so as to reduce breakage around processing lines. However, the power of a currently used laser is inversely proportional to the frequency of a laser beam due to its characteristics, so that processing quality can be improved, but processing time cannot be guaranteed. Furthermore, if a low-frequency laser beam is used to improve processing speed, the laser beam is excessively incident on a workpiece, so that the line width is increased, therefore it is impossible to perform fine processing.

Disclosure of the Invention

Accordingly, the present invention has been made keeping in mind the above problems occurring in the prior art, and an object of the present invention is to provide a laser processing apparatus using laser beam splitting, which is capable of improving processing speed while maintaining the intensities of the laser beams.

Another object of the present invention is to provide a laser processing apparatus using laser beam splitting, which divides a laser beam into at least two beams prior to incidence onto a workpiece and, therefore, increases the power a number of times equal to the number of divided beams while keeping the intensities of the divided beams identical to that of an original beam, thereby improving processing efficiency.

In order to achieve the above-described objects, an embodiment of the present invention provides a laser processing apparatus that includes a beam splitting means for dividing a laser beam emitted from a laser generation means into at least two beams and causing at least two beams to be incident on a mirror.

In this case, the beam splitting means may be constructed using a prism, a beam splitter or a combination of a prism and a beam splitter.
The present invention was devised with an eye on the fact that, when a laser beam incident on a laser processing apparatus is divided into a plurality of laser beams, the divided beams can be increased in power a number of times equal to the number of divided beams while maintaining the intensity of the original laser beam, and the frequency of the laser beams is increased. For example, a workpiece processed using a 200 kHz, 4 W laser beam has an intensity identical to that of a 100 kHz, 2 W laser beam. Accordingly, when a 100 kHz, 6 W laser beam is divided into three beams and a workpiece is processed using the three beams, a narrower line width can be guaranteed, processing speed can be increased (because the power is 6 W), and a triple beam overlapping effect can be achieved. In the same manner, when a 100 kHz, 8 W laser beam is divided into four beams and a workpiece is processed using the four beams, advantages can be achieved in that the workpiece can be processed using an even narrower line width at a higher speed.

**Brief Description of the Drawings**

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

- FIG. 1 is a diagram illustrating the construction of a laser processing apparatus according to the present invention;
- FIGS. 2A and 2B are diagrams respectively illustrating the construction of a beam splitting means and the cross section of split beams according to a first embodiment of the present invention;
- FIGS. 3A and 3B are diagrams respectively illustrating the construction of a beam splitting means and the cross section of split beams according to a second embodiment of the present invention;
FIGS. 4A and 4B are diagrams respectively illustrating the construction of a beam splitting means and the cross section of split beams according to a third embodiment of the present invention; and

FIGS. 5A and 5B are diagrams respectively illustrating the construction of a beam splitting means and the cross section of split beams according to a fourth embodiment of the present invention.

**Best Mode for Carrying Out the Invention**

Preferred embodiments of the present invention are described in detail with reference to the accompanying drawings below.

FIG. 1 is a diagram illustrating the construction of a laser processing apparatus according to the present invention.

As illustrated in FIG. 1, the laser processing apparatus of the present invention includes a control unit 110 for controlling the overall operation of the apparatus, a laser generation means 120 for outputting a laser beam of a designated diameter, a beam splitting means 130 for splitting the laser beam emitted from the laser generation means 120 into at least two beams, a mirror actuation unit 140 for actuating a mirror, an input unit 150 for inputting control parameters and control commands, an output unit 160 for displaying information such as operational status, a storage unit 170 for storing data, a mirror 10 for reflecting the laser beams emitted from the beam splitting means 130 onto a workpiece 14, and an optical system 12 for condensing laser beams reflected by the mirror 10 or changing the shapes of the condensed laser beams.

Furthermore, the workpiece 14 is seated on a stage 16, and the stage 16 is moved in a designated direction by a stage transfer means 18.

The mirror 10 may be implemented using a reflecting mirror or a polygon mirror. When
the mirror 10 is implemented using the polygon mirror, it is preferable that, the number of the reflecting surfaces of the mirror such that the diameter of the laser beam can cover the plural reflecting surfaces. A laser processing apparatus using a polygon mirror was filed with the Korean Industrial Property Office on March 31, 2004 by the present applicant (Korean Patent Application No. 10-2004-0022270), and a laser processing apparatus using a polygon mirror having a controlled number of reflecting surfaces was filed with the Korean Industrial Property Office on August 18, 2004 by the present applicant (Korean Patent Application No. 10-2004-0065066).

The optical system 12 may be implemented using a condenser lens, or a condenser lens and a cylindrical lens. When the optical system 12 includes the cylindrical lens, the sectional shape of a laser beam is elliptical. If the major axis of an ellipse is controlled to coincide with a processing direction, superior processing efficiency can be achieved.

When the workpiece 14 is processed using the laser processing apparatus, control parameters are set by the input unit 150 first. This setting process may be easily performed in such a way as to register and store a menu preset based on workpiece types and processing types in the storage unit 170 and call the menu.

After the setting of the control parameters is completed, the position of the mirror 10 is adjusted by the mirror actuation unit 140. When the mirror 10 is a polygon mirror, the mirror 10 constantly rotates at a preset rotation speed. The control unit 110 operates the stage transfer means 18 so that the stage transfer means 18 transfers the workpiece 14 in a designated direction, and controls the laser generation means 120 to generate a laser beam. When the laser beam is generated and emitted, the emitted laser beam is split into at least two beams by the beam splitting means 130 and is incident on the mirror 10.

Thereafter, at least two laser beams reflected by the mirror 10 are vertically radiated onto the workpiece 14 through the optical system 12. In this case, the beams passed through the optical
system 12 are plural, so that results identical to those obtained when a laser beam is radiated onto the workpiece 14 a plurality of times can be achieved. Since a plurality of laser beams is simultaneously incident on the workpiece 14, narrow line width processing can be accomplished while processing speed is kept the same as that prior to the splitting of a laser beam. Moreover, post-processing quality can be also guaranteed.

FIGS. 2A and 2B are diagrams respectively illustrating the construction of a beam splitting means and the cross section of split beams according to a first embodiment of the present invention.

FIGS. 2A and 2B illustrate a case where a laser beam is divided into two beams using a prism. For this purpose, a beam splitting means 130 includes a first mirror 1311 for reflecting an incident laser beam, a prism 1312 for splitting the laser beam reflected by the first mirror 1311, and a second mirror 1313 for reflecting the two beams obtained through the prism 1312.

In that case, the first mirror 1311 functions to cause the laser beam to be incident on the prism 1312, and the prism 1312 causes the two beams to be symmetrical to each other based on the placement thereof. The second mirror 1313 controls the light axes of the laser beams so that the light axes of the beams incident from the prism 1312 are parallel to the light axis of the laser beam incident on the first mirror 1311. The laser beams reflected by the second mirror 1313 are incident on the mirror 10, and are radiated onto a workpiece. For this purpose, the light axes of the laser beams reflected by the mirror 10 must be controlled to be perpendicular to the workpiece.

An example of a sectional view of the laser beams that are radiated onto the workpiece by the beam splitting means is illustrated in FIG. 2B. The interval between two laser beams having a semicircular shape may be changed by the refraction of the beams by the prism 1312. Furthermore, two laser beams can be radiated onto an area identical to that onto which a laser beam is radiated according to the prior art, that is, the number of laser beams radiated onto a unit area can be increased, so that processing efficiency can be increased.
FIGS. 3A and 3B are diagrams respectively illustrating the construction of a beam splitting means and the cross section of split beams according to a second embodiment of the present invention.

FIGS. 3A and 3B illustrate a case where a laser beam is divided into two beams using a beam splitter. For this purpose, a beam splitting means 130 includes a beam splitter 1321 for splitting an incident laser beam into two beams, a polarizer 1322 for changing the polarization characteristics of a first laser beam reflected by the beam splitter 1321, a first mirror 1324 for reflecting a second laser beam having passed through the beam splitter 1321, a second mirror 1325 for reflecting the second laser beam reflected by the first mirror 1324, and a polarized beam splitter 1323 for reflecting the first laser beam, the polarization characteristics of which are converted by the polarizer 1322, and passing the second laser beam reflected by the second mirror 1325 therethrough. The first and second laser beams respectively reflected by and passed through the polarized beam splitter 1323 are vertically radiated onto a workpiece by the mirror 10.

An example of a sectional view of the first and second laser beams in the beam splitting means is illustrated in FIG. 3B. The interval between the two laser beams can be freely controlled by changing the location of the second mirror 1325.

The light axis of the laser beam departing from the polarized beam splitter 1323 must be controlled to be parallel to the light axis of the laser beam incident on the beam splitter 1321, and the light axis of the laser beam reflected by the mirror 10 must be controlled to be perpendicular to a workpiece.

Furthermore, a polarizer for converting horizontal linearly polarized light (p-polarized light) into vertical linearly polarized light (s-polarized light) may be used as the polarizer 1322, and a polarized beam splitter for passing p-polarized light therethrough and reflecting s-polarized light may be used as the polarized beam splitter 1323.
FIGS. 4A and 4B are diagrams respectively illustrating the construction of a beam splitting means and the cross section of split beams according to a third embodiment of the present invention.

The present embodiment illustrates the beam splitting means that splits a laser beam into two beams through a beam splitter and divides any one of the two laser beams into two beams, thus renting in division into three beams.

Referring to FIG. 4A, the beam splitting means of the present embodiment includes a beam splitter 1331 for dividing an incident laser beam into two beams, a polarizer 1332 for changing the polarization characteristics of the laser beam reflected by the beam splitter 1331, a prism 1333 for dividing the laser beam polarized by the polarizer 1332 into first and second laser beams, a first mirror 1335 for reflecting a third laser beam having passed through the beam splitter 1331, a second mirror 1336 for reflecting the third laser beam reflected by the first mirror 1335, and a polarized beam splitter 1334 for reflecting the first and second laser beams departing from the prism 1333 and passing the third laser beam incident on the second mirror 1336 therethrough. The first to third laser beams reflected by or passed through the polarized beam splitter 1334 are vertically radiated onto a workpiece by the mirror 10.

An example of a sectional view of the laser beams obtained through the beam splitting means of the present embodiment is illustrated in FIG. 4B. The interval between the first and second laser beams can be adjusted by controlling the refractive index of the prism 1333, the two laser beams can be caused to be symmetrical to each other by controlling the placement of the prism 1333, and the location of the third laser beam can be adjusted by controlling the location of the second mirror 1336.

In the present embodiment, a polarizer for converting horizontal linearly polarized light (p-polarized light) into vertical linearly polarized light (s-polarized light) may be used as the polarizer 1332, and a polarized beam splitter for passing p-polarized light therethrough and reflecting s-
polarized light may be used as the polarized beam splitter 1334.

FIGS. 5A and 5B are diagrams respectively illustrating the construction of a beam splitting means and the cross section of split beams according to a fourth embodiment of the present invention.

The present embodiment illustrates the beam splitting means that splits a laser beam into two beams through a prism and divides each of the two laser beams into two beams through a beam splitter, thus resulting in division into four beams.

Referring to FIG. 5A, the beam splitting means of the present embodiment includes a prism 1341 for dividing an incident laser beam into two beams, a beam splitter 1342 for dividing each of the two beams obtained by the prism 1341 into two beams and reflecting the beams or passing the beams therethrough, a polarizer 1343 for changing the polarization characteristics of the first and second laser beams reflected by the beam splitter 1342, a first mirror 1345 for reflecting the third and fourth laser beams having passed through the beam splitter 1342, a second mirror 1346 for reflecting the laser beams reflected by the first mirror 1345, and a polarized beam splitter 1344 for reflecting the first and second laser beams whose polarization characteristics have been changed by the polarizer 1343 and passing the third and fourth laser beams incident through the second mirror 1346 therethrough. The first to fourth laser beams reflected by or passed through the polarized beam splitter 1344 are vertically radiated onto a workpiece by the mirror 10.

An example of a sectional view of the laser beams obtained through the beam splitting means of the present embodiment is illustrated in FIG. 5B. The intervals between the first to fourth laser beams can be adjusted by controlling the refractive index of the prism 1341 or the placement of the second mirror 1346. In this case, the light axis of the laser beam reflected by the second mirror 1346 must be controlled to be parallel to the light axis of the laser beam incident on the prism 1341, and the light axis of the laser beam reflected by the mirror 10 must be controlled to be perpendicular to the workpiece.
In the above-described present invention, a laser beam is divided into two or more beams using the prism, the beam splitter or a combination of the prism and the beam splitter and a workpiece is processed using the resultant beams. A total sum of the energy of the divided laser beams is the same as that of an original laser beam, so that processing speed can be maintained, and the intensity of each of the divided laser beams is lower than that of the original laser beam, so that a narrow line width can be guaranteed. The intervals between the divided laser beams can be easily changed using the placement of the optical elements that constitute the beam splitting means.

Industrial Applicability

According to the present invention, since a laser beam is divided into two or more beams and a workpiece is processed using the divided beams, an effect similar to that of a case where a workpiece is processed using a laser beam having low energy a plurality of times can be achieved, so that a narrow line width can be guaranteed. Furthermore, a plurality of laser beams is simultaneously radiated onto a workpiece, so that high processing speed can be guaranteed.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.
Claims

1. A laser processing apparatus for processing a workpiece by reflecting a laser beam emitted from a laser generation means using a mirror, comprising:
   a beam splitting means for dividing the laser beam emitted from the laser generation means into at least two beams and causing the resultant beams to be incident on the mirror.

2. The laser processing apparatus as set forth in claim 1, wherein the beam splitting means comprises a prism for dividing the emitted laser beam into two beams.

3. The laser processing apparatus as set forth in claim 1, wherein the beam splitting means comprises a beam splitter for dividing the emitted laser beam into two beams.

4. The laser processing apparatus as set forth in claim 1, wherein the beam splitting means comprises a beam splitter for dividing the emitted laser beam into two beams and a prism for dividing any one of the two beams obtained by the beam splitter into two beams.

5. The laser processing apparatus as set forth in claim 1, wherein the beam splitting means comprises a prism for dividing the emitted laser beam into two beams and a beam splitter for dividing each of the two beams obtained by the prism into two beams.

6. The laser processing apparatus as set forth in claim 1, wherein the beam splitting means comprises:
   a first mirror for reflecting the emitted laser beam;
a prism for dividing the laser beam reflected by the first mirror into two beams; and

a second mirror for reflecting the two beams obtained by the prism.

7. The laser processing apparatus as set forth in claim 1, wherein the beam splitting means comprises:

a beam splitter for dividing the emitted laser beam into two beams;

a polarizer for changing polarization characteristics of a first laser beam reflected by the beamsplitter;

a first mirror for reflecting a second laser beam having passed through the beam splitter,

a second mirror for reflecting the second laser beam reflected by the first mirror, and

a polarized beam splitter for reflecting the first laser beam, the polarization characteristics of which have been changed by the polarizer, and passing the second laser beam reflected by the second mirror therethrough.

8. The laser processing apparatus as set forth in claim 1, wherein the beam splitting means comprises:

a beam splitter for dividing the emitted laser beam into two beams;

a polarizer for changing polarization characteristics of a laser beam reflected by the beam splitter;

a prism for dividing the laser beam, the polarization characteristics of which have been changed by the polarizer, into first and second beams;

a first mirror for reflecting a third laser beam having passed through the beam splitter;

a second mirror for reflecting the third laser beam reflected by the first mirror, and

a polarized beam splitter for reflecting the first and second laser beams departing from the
prism, and passing the third laser beam reflected by the second mirror therethrough.

9. The laser processing apparatus as set forth in claim 1, wherein the beam splitting means comprises:

- a prism for dividing the emitted laser beam into two beams;
- a beam splitter for dividing each of the two beams obtained by the prism into two beams, and reflecting some of them or passing some of them therethrough;
- a polarizer for changing polarization characteristics of first and second laser beams reflected by the beam splitter;
- a first mirror for reflecting third and fourth laser beams having passed through the beam splitter;
- a second mirror for reflecting the laser beams reflected by the first mirror, and
- a polarized beam splitter for reflecting the first and second laser beams, the polarization characteristics of which have been changed by the polarizer, and passing the third and fourth laser beams incident through the second mirror therethrough.

10. The laser processing apparatus as set forth in claim 1, wherein the mirror is a polygon mirror.

11. The laser processing apparatus as set forth in claim 1, wherein the mirror is a polygon mirror, the number of reflecting surfaces of which is determined such that the diameter of a laser beam can cover the plural reflecting surfaces.
A. CLASSIFICATION OF SUBJECT MATTER

B23K 26/067(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC8  B23K 26/00, B23K 26/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions since 1975
Korean Utility models and applications for Utility models since 1975
Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
e KIPASS (KIPO internal) & Key words  laser, split, prism, miror

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>JP 01-316415 A (NIPPON STEEL CORP ) 21 December 1989 See claim 1, and figure 1</td>
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<td>Y</td>
<td>JP 2000-288765 A (MURATA MFG CO , LTD ) 17 October 2000 See the abstract, and figure 1</td>
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<td>JP 01-186293 A (NEC CORP ) 25 July 1989 See claim 1 and figure 1</td>
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Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents
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Date of the actual completion of the international search
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