

METHOD FOR CUTTING GLASS PROCESSED PRODUCT

TECHNICAL FIELD

[0001] The present inventive concept relates to a method of cutting a glass
workpiece, and more particularly, to a technology of cutting a glass workpiece by
using a laser beam and reinforcing a cut surface the glass workpiece.

BACKGROUND ART

[0002] A thin glass plate is processed and shaped widely throughout entire
industries, that is, from general products to panels protecting a screen of a display
apparatus that is an up-to-date precise product. The thin glass plate may be
commonly used as a cover glass in a smartphone or similar portable devices, and
needs to be cut according to products to which the thin glass plate is applied.

[0003] The thin glass plate may be cut by a mechanical method and a laser
processing method. According to the mechanical method, the thin glass plate is cut
by a cutting wheel, and in this case, it is difficult to make a cut surface of the glass
curved. Also, when the thin glass plate is cut by using laser, a roughness average of
a cut surface is large and the cut surface is likely to be broken.

DETAILED DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

[0004] To address the above problems, the present inventive concept provides a
method of cutting a glass workpiece.

TECHNICAL SOLUTION

[0005] According to an aspect of the present invention, there is provided
[0006] a method of cutting a glass workpiece by using a laser beam, the method
including:

[0007] cutting the glass workpiece by irradiating a first laser beam to the glass
workpiece; and

[0008] processing a cut surface of the glass workpiece by irradiating a second
laser beam to the cut surface of the glass workpiece,

[0009] wherein the first laser beam and the second laser beam have different
wavelengths from each other.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0010] According to example embodiments of the present inventive concept, a laser beam irradiated from a light source is changed to a line beam having a nearly even intensity distribution, and thus, quality of laser processing may be improved.

DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a flowchart illustrating a method of cutting a glass workpiece, according to an example embodiment;

[0012] FIG. 2 is a schematic diagram of a glass workpiece cutting apparatus for executing the method of cutting the glass workpiece illustrated in FIG. 1;

[0013] FIG. 3 is an example diagram showing a cut surface of a glass workpiece that was cut in a cutting operation of the glass workpiece;

[0014] FIG. 4 is another example diagram showing a cut surface of a glass workpiece that was cut in a cutting operation of the glass workpiece;

[0015] FIG. 5 is a diagram illustrating a surface roughness of the cut surface of the glass workpiece illustrated in FIG. 4;

[0016] FIG. 6 is a diagram showing a variation in a cut surface shape, when a second laser beam is irradiated to the cut surface of the glass workpiece illustrated in FIG. 5; and

[0017] FIGS. 7 and 8 are diagrams showing examples of changes in the cut surface of the glass workpiece illustrated in FIG. 6 due to the second laser beam.

BEST MODE

[0018] According to an aspect of the present inventive concept,

[0019] there is provided a method of cutting a glass workpiece by using a laser beam, the method including:

[0020] cutting the glass workpiece by irradiating a first laser beam to the glass workpiece; and

[0021] processing a cut surface of the glass workpiece by irradiating a second laser beam to the cut surface of the glass workpiece,

[0022] wherein the first laser beam and the second laser beam have different wavelengths from each other.

[0023] The first laser beam may have a wavelength of 1030 nm to 1080 nm.

[0024] The second laser beam may have a wavelength of 9.4 μm to 10.6 μm .

[0025] The processing of the cut surface of the glass workpiece may include irradiating the second laser beam to the cut surface of the glass workpiece for 2 seconds to 3 seconds.

5 [0026] The cutting of the glass workpiece may include irradiating the first laser beam along a curved line to make the cut surface of the glass workpiece curved.

[0027] The first laser beam may be a pulse laser beam having a pulse width of 100 ps to 1 fs.

[0028] According to another aspect of the present inventive concept,

10 [0029] there is provided an apparatus for cutting a glass workpiece by using a laser beam, the apparatus including:

[0030] a first light source configured to cut the glass workpiece by irradiating a first laser beam to the glass workpiece; and

15 [0031] a second light source configured to process a cut surface of the glass workpiece by irradiating a second laser beam to the cut surface of the glass workpiece.

[0032] The first laser beam may have a wavelength of 1030 nm to 1080 nm.

[0033] The second laser beam may have a wavelength of 9.4 μm to 10.6 μm .

[0034] The second light source may be a CO₂ laser light source.

20 [0035] The first laser beam may be a pulse laser beam having a pulse width of 100 ps to 1 fs.

MODE OF THE INVENTION

25 [0036] In the accompanying drawings, like reference numerals denote like elements, and sizes of components in the drawings may be exaggerated for clarity and convenience of the description. Embodiments are example embodiments, and various modifications may be allowed from the embodiments.

[0037] It will be understood that although the terms "first" and "second" are used herein to describe various elements, these elements should not be limited by these terms. Terms are only used to distinguish one element from other elements.

30 [0038] An expression used in the singular encompasses the expression of the plural, unless it has a clearly different meaning in the context. Throughout the specification, when a portion "includes" an element, another element may be further

included, rather than excluding the existence of the other element, unless otherwise described.

[0039] In addition, the term such as "...unit", "module", etc. provided herein indicates a unit performing at least one function or operation.

5 [0040] FIG. 1 is a flowchart illustrating a method of cutting a glass workpiece 10, according to an example embodiment. Also, FIG. 2 is a schematic diagram of a glass workpiece cutting apparatus for executing the method of cutting the glass workpiece 10 illustrated in FIG. 1.

10 [0041] Referring to FIGS. 1 and 2, the method of cutting the glass workpiece according to the example embodiment may include an operation of cutting the glass workpiece 10 by irradiating a first laser beam to the glass workpiece 10 (S110). The glass workpiece 10 may include a thin glass plate, a glass plate, etc. A cut shape and size of the glass workpiece 10 may vary depending on kinds of products in which the glass workpiece 10 is used. The glass workpiece 10 that is cut and
15 processed may be used as a cover glass of a mobile phone or a panel of a display apparatus.

[0042] In the operation of cutting the glass workpiece 10 (S110), a first light source 110a of the glass workpiece cutting apparatus may be used. The first light source 110a may emit a first laser beam having a wavelength of 1030 nm to 1080
20 nm. The first light source 110a may include Nd:YAG (neodymium-doped yttrium aluminum garnet; $\text{Nd:Y}_3\text{Al}_5\text{O}_{12}$) laser as an example, but is not limited thereto. The first light source 110a irradiates the first laser beam to the glass workpiece 10 to cut the glass workpiece 10. As shown in FIG. 2, a first beam transferring optical system may be provided between the first light source 110a and the glass workpiece 10. The
25 first beam transferring optical system may adjust a beam size of the first laser beam emitted from the first light source 110a, and a location on the glass workpiece 10, to which the first laser beam is irradiated. Also, the first beam transferring optical system may include a first focusing unit 120a for focusing the first laser beam onto the glass workpiece 10. The configuration of the first beam transferring optical
30 system shown in FIG. 2 is an example, and configuration and the number of optical devices that may be included in the first beam transferring optical system may vary.

[0043] Also, the first laser beam emitted from the first light source 110a may be short or ultra short pulse laser. That is, a pulse width of the pulse laser may be pico second (ps, 10^{-12} second, short pulse) to femto second (fs, 10^{-15} second, ultra short

pulse). Also, the first laser beam may be selected to have a pulse width ranging from hundreds of ps to fs, according to a thickness and characteristics of the glass workpiece that is a processing target. More preferably, the pulse width may be selected to be 1 ps to 1 fs. The pulse laser having the short or ultra short pulse width transfers energy of high efficiency so that the cut surface may be smoothly processed. Also, when the glass workpiece is processed by a laser beam having short or ultra short pulse width, a processed region and a region adjacent to the processed region are only affected by the laser, and thus, durability may be guaranteed in an additional processing that may be performed later. The glass workpiece 10 may be cut in various shapes in the process of cutting the glass workpiece 10 (S110). Since the glass workpiece 10 is cut by the first laser beam in the process of cutting the glass workpiece (S110), the cut shape of the glass workpiece 10 may not be restricted.

[0044] FIG. 3 is an example diagram showing a cut surface S1 of the glass workpiece 10 that was cut in the cutting operation S110 of the glass workpiece 10 .

[0045] Referring to FIG. 3, the cut surface S2 of the glass workpiece 10 may be a curved surface in an operation of cutting the glass workpiece (S110). To do this, the first light source 110a may irradiate the first laser beam to the glass workpiece 10 along a curved line on the glass workpiece 10.

[0046] FIG. 4 is another example diagram showing the cut surface S1 of the glass workpiece 10 that is cut in cutting operation S110, FIG. 3 is an example diagram showing a cut surface S1 of the glass workpiece 10 that was cut in the cutting operation S110 of the glass workpiece 10.

[0047] Referring to FIG. 4, the cut surface S1 of the glass workpiece 10 may be a flat surface in operation of cutting the glass workpiece (S110). To do this, the first light source 110a may irradiate the first laser beam to the glass workpiece 10 along a straight line on the glass workpiece 10.

[0048] As shown in FIGS. 3 and 4, when the glass workpiece 10 is cut by using the first laser beam of the first light source 110a, the shape of the cut surface of the glass workpiece 10 may be variously modified. That is, unlike the mechanical cutting method using a cutting wheel, there may be no limitation in modifying the cut surface of the glass workpiece 10. As such, a processed shape of the glass workpiece 10 may be easily changed according to products to which the glass workpiece 10 is applied.

[0049] When the glass workpiece 10 is cut by using the first light source 110a, a roughness average (Ra) of the cut surface S1 or S2 of the glass workpiece may be large. FIG. 5 is a diagram illustrating a surface roughness of the cut surface S1 of the glass workpiece 10 illustrated in FIG. 4.

5 [0050] Referring to FIG. 5, when the glass workpiece 10 is cut by using the first laser beam, the cut surface of the glass workpiece 10 is not smooth. When the roughness average of the cut surface of the glass workpiece 10 is large, there is a concern about damage in other processes and it may not be easy for the glass workpiece to couple to other components. Therefore, it is necessary to process the
10 cut surface S1 or S2 of the glass workpiece 10 that is cut by using the first laser beam.

[0051] As an example of processing the cut surface S1 or S2 of the glass workpiece 10, there may be provided a method of performing a chamfering process on the cut surface of the glass workpiece 10 by using a chamfering device. However,
15 in order to perform the chamfering process, additional time and expenses are necessary to set the chamfering device and a setting space for the chamfering device may be also necessary. Also, working environment may be contaminated due to dust generated during the chamfering process, and an additional cleaning process has to be performed in order to remove a machining fluid applied to the glass
20 workpiece 10 for the chamfering process. In addition, the glass workpiece 10 may be broken during the chamfering process, and thus, production yield may degrade.

[0052] In order to process the cut surface of the glass workpiece 10 without performing the chamfering process, the method of cutting the glass workpiece according to the example embodiment may process the cut surface of the glass
25 workpiece 10 by using a second laser beam.

[0053] Referring back to FIGS. 1 and 2, the method of cutting the glass workpiece according to the example embodiment may include an operation of processing the cut surface of the glass workpiece 10 by irradiating the second laser beam to the cut surface of the glass workpiece 10 (S120). In the operation of processing the cut
30 surface of the glass workpiece 10 (S120), a thermal reaction occurs on the glass workpiece 10 due to the second laser beam, and then, the cut surface of the glass workpiece 10 may be smoothened. Also, a tensile strength of the cut surface in the glass workpiece 10 may be improved.

[0054] A second light source 110b of the glass workpiece cutting apparatus may be used in the operation of processing the cut surface of the glass workpiece 10 (S120). The second laser beam emitted from the second light source 110b may have a different wavelength from that of the first laser beam emitted from the first light source 110a. The first laser beam may have a wavelength that disconnects bonding relations of a compound included in the glass workpiece 10 to be suitable for cutting the glass workpiece 10. Meanwhile, the second laser beam may have a wavelength that may cause a thermal reaction on the cut surface of the glass workpiece 10. Therefore, the second laser beam may have different wavelength from the first laser beam.

[0055] As an example, the wavelength of the second laser beam emitted from the second light source 110b may be about 9.4 μm to about 10.6 μm . When the wavelength of the second laser beam has a value within the above wavelength range, thermal reaction may occur on the cut surface of the glass workpiece 10 due to the second laser beam. In addition, the cut surface of the glass workpiece may be smoothened and the tensile strength of the cut surface may be improved through the thermal reaction.

[0056] In order to satisfy the wavelength range of the second laser beam, the second light source 110b may be a CO₂ laser light source, as an example. The second light source 110b and the first light source 110a emit the laser beams through different media from each other, and thus, wavelengths of the first and second laser beams may be different from each other.

[0057] As shown in FIG. 2, a second beam transferring optical system may be provided between the second light source 110b and the glass workpiece 10. The second beam transferring optical system may adjust a beam size of the second laser beam emitted from the second light source 110b, and a location on the glass workpiece 10, to which the second laser beam is irradiated. Also, the second beam transferring optical system may include a second focusing unit 120b for focusing the second laser beam onto the glass workpiece 10. The configuration of the second beam transferring optical system shown in FIG. 2 is an example, and configuration and the number of optical devices that may be included in the second beam transferring optical system may vary.

[0058] FIG. 6 is a diagram showing a variation in a cut surface shape, when a second laser beam is irradiated to the cut surface of the glass workpiece 10 illustrated in FIG. 5.

[0059] Referring to FIG. 6, as the second laser beam from the second light source 110b is irradiated to the cut surface S1 of the glass workpiece 10, the cut surface S1 of the glass workpiece 10 may be changed. The cut surface S1 of the glass workpiece 10 may be changed according to an irradiation direction and an irradiation time period of the second laser beam. However, if the second laser beam is irradiated to the glass workpiece 10 for an excessively long time period, a physical property of the glass workpiece may be changed or the shape of the cut surface of the glass workpiece 10 may be changed not to be controllable. Therefore, a time period during which the second laser beam is irradiated to the glass workpiece 10 may be adjusted to be about 2 seconds to 3 seconds. Also, an output power of the second laser beam may be maintained about 500 W or greater.

[0060] As shown in FIG. 6, the cut surface S1 of the glass workpiece 10 may be changed to a curved surface, that is, a first cut surface S3 or a flat surface, that is, a second cut surface S4, according to an irradiation amount and an irradiation direction of the second laser beam. The variation in the shape of the cut surface shown in FIG. 6 is an example, and the example embodiments are not limited thereto.

[0061] FIGS. 7 and 8 are diagrams showing examples of changes in the cut surface of the glass workpiece 10 illustrated in FIG. 6 due to the second laser beam.

[0062] Referring to FIG. 7, the cut surface S3 of the glass workpiece 10 may be a curved surface. In addition, the roughness average of the cut surface S3 of the glass workpiece 10 may be reduced. In addition, referring to FIG. 8, the cut surface S4 of the glass workpiece 10 may be a flat surface. Also, the roughness average of the cut surface S4 of the glass workpiece 10 may be reduced. As shown in FIGS. 7 and 8, when the second light source 110b including CO₂ laser irradiates the second laser beam to the cut surface of the glass workpiece 10, the roughness average of the cut surface S3 or S4 of the glass workpiece 10 may be reduced. Moreover, the tensile strength of the cut surface S3 or S4 of the glass workpiece 10 may be improved.

[0063] As described above, the glass workpiece cutting method and apparatus according to the example embodiments have been described with reference to FIGS. 1 to 8. According to the embodiment, the glass workpiece 10 is cut by using the first

laser beam, and after that, the cut surface of the glass workpiece 10 may be processed by using the second laser beam having different wavelength from that of the first laser beam. As such, the roughness average and the tensile strength of the cut surface of the glass workpiece 10 may be improved.

5 [0064] While the present inventive concept has been particularly shown and described with reference to example embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present inventive concept as defined by the following claims.

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CLAIMS

1. A method of cutting a glass workpiece by using a laser beam, the method comprising:

cutting the glass workpiece by irradiating a first laser beam to the glass workpiece; and

processing a cut surface of the glass workpiece by irradiating a second laser beam to the cut surface of the glass workpiece,

wherein the first laser beam and the second laser beam have different wavelengths from each other.

2. The method of claim 1, wherein the first laser beam has a wavelength of 1030 nm to 1080 nm.

3. The method of claim 1, wherein the second laser beam has a wavelength of 9.4 μm to 10.6 μm .

4. The method of claim 3, wherein the processing of the cut surface of the glass workpiece comprises irradiating the second laser beam to the cut surface of the glass workpiece for 2 seconds to 3 seconds.

5. The method of claim 1, wherein the cutting of the glass workpiece comprises irradiating the first laser beam along a curved line to make the cut surface of the glass workpiece curved.

6. The method of claim 1, wherein the first laser beam is a pulse laser beam having a pulse width of 100 ps to 1 fs.

7. An apparatus for cutting a glass workpiece by using a laser beam, the apparatus comprising:

a first light source configured to cut the glass workpiece by irradiating a first laser beam to the glass workpiece; and

a second light source configured to process a cut surface of the glass workpiece by irradiating a second laser beam to the cut surface of the glass workpiece.

8. The apparatus of claim 7, wherein the first laser beam has a wavelength of 1030 nm to 1080 nm.

5 9. The apparatus of claim 7, wherein the second laser beam has a wavelength of 9.4 μm to 10.6 μm .

10. The apparatus of claim 7, wherein the second light source is a CO₂ laser light source.

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11. The apparatus of claim 7, wherein the first laser beam is a pulse laser beam having a pulse width of 100 ps to 1 fs.