A golf club head includes a golf club head body and a striking plate. A surface of the golf club head body and the striking plate has at least one surface-modified portion processed by a high-energy treating apparatus that has a luminous energy adjustment device. A defocused high-energy beam generated from the high-energy treating apparatus penetrates through the luminous energy adjustment device and projects on a predetermined portion of the golf club head that possesses different mechanical characteristics than other portions. A surface modifying method for the golf club head includes the steps of: providing a high-energy treating apparatus with a luminous energy adjustment device; and projecting a defocused high-energy beam transmitted from the luminous energy adjustment device on the predetermined portion of the golf club head to form at least one surface-modified portion.
BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a golf club head and a surface modifying method therefor. Particularly, the present invention relates to the golf club head having a surface-modified structure that possesses different mechanical characteristics. More particularly, the present invention relates to the surface-modified structure of the golf club head partially formed on a predetermined area in heat treatment by a high-energy apparatus. The golf club head has the same thickness but possesses different mechanical characteristics so as to prolong a striking distance (i.e. striking characteristic) in hitting a golf ball.

2. Description of the Related Art

In many golf club head designs, golf club heads are generally designed to reduce a thickness of a striking plate so as to enhance rebound abilities of the striking plate. Although it would be advantageous to enhance rebound abilities (i.e. elastic deformability), the thinner thickness of the striking plate is susceptible to weakness in hitting the golf ball. In this regard, there is a need for the golf club head having a high degree in both rebound and durable characteristics for long-term use. This is a major issue in golf club head design. To this end, various techniques in the known art have been used to enhance both rebound and durable characteristics of the golf club head in reducing the thickness of the striking plate but maintaining a sufficient strength of the structure.

For example, U.S. Pat. No. 6,652,391, entitled “GOLF CLUB HEAD WITH VARIABLE THICKNESS FRONT WALL,” discloses a front wall of a golf club head body varying its thickness. In particular, an inner wall of the front wall has a protruded region (i.e. bulging area) with a thicker thickness formed at a center portion. Furthermore, the inner wall of the front wall has a protruded region (generally ring shaped mass) surrounding the protruded region. The protruded region and ring are designed for having a certain degree in both rebound and durable characteristics of the front wall. However, the front wall of the golf club head body must be manufactured by casting or powder metallurgy that may increase difficulties in manufacturing and manufacture costs. Accordingly, this design is usually unsuitable for manufacture. Furthermore, U.S. Patent Application No. 2003/0063066 discloses a surface modifying method for a golf club head by a laser beam. Yet further, Taiwanese Patent Publication No. 448064, entitled “GOLF CLUB HEAD AND METHOD FOR TREATING A STRIKING PLATE”, discloses a method of employing a high-energy remelting apparatus such as a laser remelting apparatus or a plasma remelting apparatus in treating a partial area of a striking plate. This results in a good rigidity of a treated area of the striking plate in a laser treating or plasma treating process for example. Such a laser or plasma treatment is helpful in enhancing mechanical characteristics of the striking plate, resulting in an increase of rigidity and metal fatigue resistance for example. In general, the prior art is absent a high-energy remelting apparatus that employs a luminous energy adjustment device for uniform treatments. In this way, any high-energy treatment on a thicker thickness of the large-scale striking plate is susceptible to poor quality that cannot achieve a uniform treated area of the striking plate. Accordingly, this results in any possible inaccuracy of the high-energy treating and any possible deficiency in the treated area.

With regard to another heat-treating method, U.S. Pat. No. 6,776,726, entitled “GOLF CLUB HEAD”, discloses a heat-treating method for a striking plate. In general, the striking plate is made of a metal material, and has a central region and a peripheral region. In first step, the entire striking plate is successively processed by solution heat treatment and aging heat treatment. In second step, a surface of the peripheral region of the striking plate is subsequently processed by laser treatment such that the hardness of the peripheral region is reduced. The ratio of the surface hardness of the peripheral region to the central region may vary between 0.45 and 0.9. On the one hand the peripheral region of the striking plate achieves increases both in rebound characteristic and restitution coefficient, and on the other hand the central region of the striking plate ensures a certain degree of the hardness and durable characteristic.

In laser-treating operation, the prior art is absent a laser-treating apparatus that employs a luminous energy adjustment device for uniform treatments. In this way, any laser treatment on a thicker thickness of the large-scale striking plate is susceptible to poor quality that cannot achieve a uniform treated area of the striking plate. Accordingly, this may result in excess melting portions and deficiencies in the laser-treated peripheral region. To avoid resulting in excess melting occurrence, the operational time and intensity of laser must be limited. In this circumstance, the laser-treating quality of the striking plate is uneven and imperfect.

As is described in greater detail below, the present invention intends to provide a golf club head having a uniform surface-modified structure in such a way as to mitigate and overcome the above problem. In heat-treating operation, the golf club head has a heat-treated thin portion processed by high energy. The uniform surface-modified structure possesses a high degree of the hardness, tensile strength and wear resisting.

SUMMARY OF THE INVENTION

The primary objective of this invention is to provide a golf club head having a predetermined portion with a thinner thickness on which to provide a surface-modified portion. Accordingly, the surface-modified portion possesses different mechanical characteristics than other portions.

The secondary objective of this invention is to provide a surface modifying method for the golf club head. A high-energy treating apparatus generates a defocused high-energy beam to penetrate through a luminous energy adjustment device on a predetermined portion (i.e. predetermined area) of a golf club head body or a striking plate. Accordingly, the surface modifying method can enhance a degree of uniformity of the high-energy treated area.

The golf club head in accordance with an aspect of the present invention includes a golf club head body and a striking plate. A surface of the golf club head body and the striking plate has at least one surface-modified portion.
processed by a high-energy treating apparatus that has a luminous energy adjustment device. A defocused high-energy beam generated from the high-energy treating apparatus penetrates through the luminous energy adjustment device and projects on a predetermined portion (i.e. predetermined area) of the golf club head that possesses different mechanical characteristics than other portions.

[0012] The surface modifying method for the golf club head in accordance with an aspect of the present invention comprises the steps of: providing a high-energy treating apparatus with a luminous energy adjustment device; and projecting a defocused high-energy beam transmitted from the luminous energy adjustment device on the predetermined portion of the golf club head to form at least one surface-modified portion.

[0013] In a separate aspect of the present invention, the surface-modified portion is formed on a portion of the golf club head body selected from a group consisting of a crown portion, a sole portion, a skirt portion, a rear portion and a neck portion.

[0014] In a further separate aspect of the present invention, the surface-modified portion is formed on a portion of the striking plate selected from the group consisting of a sweet spot region and a peripheral region.

[0015] In a yet further separate aspect of the present invention, the surface-modified portion is formed on a thin wall of the golf club head.

[0016] In a yet further separate aspect of the present invention, the surface-modified portion is formed on an outer or inner surface of the golf club head body or the striking plate.

[0017] In a yet further separate aspect of the present invention, the high-energy treating apparatus is selected from a plasma or laser device.

[0018] In a yet further separate aspect of the present invention, the luminous energy adjustment device is selected from an integral lens.

[0019] In a yet further separate aspect of the present invention, the high-energy treating apparatus can produce a high-energy beam by means of positive or negative defocus.

[0020] Further scope of the applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The present invention will become more fully understood from the detailed description given hereinafter and the accompanying drawings which are given by way of illustration only, and thus are not limiting of the present invention, and wherein:

[0022] FIG. 1 is a perspective view of a golf club head having a surface-modified structure in accordance with a first embodiment of the present invention, which is processed by a high-energy treating apparatus;

[0023] FIG. 2 is a cross-sectional view, taken along line 2-2 in FIG. 1, of the surface-modified structure of the golf club head in accordance with the first embodiment of the present invention;

[0024] FIG. 3 is a perspective view of a golf club head having a surface-modified structure in accordance with a second embodiment of the present invention, which is processed by a high-energy treating apparatus;

[0025] FIG. 4 is a cross-sectional view, taken along line 4-4 in FIG. 3, of the surface-modified structure of the golf club head in accordance with the second embodiment of the present invention;

[0026] FIG. 5 is a perspective view of a golf club head having a surface-modified structure in accordance with a third embodiment of the present invention;

[0027] FIG. 6 is a cross-sectional view, taken along line 6-6 in FIG. 5, of the surface-modified structure of the golf club head in accordance with the third embodiment of the present invention;

[0028] FIG. 7 is a perspective view of a golf club head having a surface-modified structure in accordance with a fourth embodiment of the present invention; and

[0029] FIG. 8 is a cross-sectional view, taken along line 8-8 in FIG. 7, of the surface-modified structure of the golf club head in accordance with the fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0030] Referring now to FIGS. 1 and 2, views of a golf club head having a surface-modified structure in accordance with the first embodiment of the present invention are illustrated. In the first embodiment, the construction of the golf club head 1 is of wood types, and includes a golf club head body 11 having a crown portion, a sole portion, a skirt portion, a rear portion and a neck portion. Preferably, the golf club head 1 further includes a striking plate 12 and a hosel 13 integrally formed on the golf club head body 11. With particular reference to FIG. 2, the golf club head body 11 has at least one thin wall identified as “a”. The thin wall “a” is formed on the crown portion of the golf club head body 11 having a thickness less than those of other portions. In the illustrated first embodiment, the thickness of the thin wall “a” is generally less than 1.5 mm. In another preferred embodiment, the thickness of the thin wall “a” is preferably less than 1.2 mm, more preferably less than 1.0 mm, and most preferably less than 0.8 mm. Furthermore, the thin wall “a” has two surface-modified portions 111 and 112 each of which is circular in shape. The surface-modified portions 111 and 112 of the thin wall “a” are functioned to possess different mechanical characteristics than other portions.

[0031] In the illustrated first embodiment, the golf club head 1 is integrally formed, or is combined by separate body pieces in precision casting, forging, mechanically processing, welding, inter-fit snapping, adhesive-adhering, braze welding or screw-connecting. If the golf club head 1 is a one-piece monolithic member, it is preferably made of a metal selected from isotropic materials. If the golf club head 1 is formed from a hybrid design, the material may be selected from either metal materials or nonmetal materials.
Preferably, the above-mentioned metal material may be selected from a group consisting of stainless steel (e.g. 17-4PH stainless steel), carbon steel, low-carbon steel, alloy steel, low-alloy steel, Fe—Mn—Al alloy, cast iron, nickel-based ferroalloy, structural steel, super alloy steel and titanium alloy (titanium 6Al—4V alloy). Preferably, the above-mentioned nonmetal material may be selected from a group consisting of various macromolecular compounds (i.e. polymers) or fiber reinforced composites thereof, carbon fiber prepreg or PPTA (p-phenylene terephthalamide) available from Kevlar® for example.

[0032] Still referring to FIGS. 1 and 2, a high-energy beam generated from a high-energy treating apparatus 2 penetrates through a luminous energy adjustment device (e.g. integral lens) 3 for the surface treatment. In surface heat-treating operation, the high-energy beam projects on an outer surface of the thin wall “a” of the golf club head body 11 so as to process a remelting treatment on the metal material of the golf club head body 11. Once finished, there provide the surface-modified portions 111 and 112 that constitute the surface-modified structure. In a preferred embodiment, the high-energy treating apparatus 2 can be selected from a plasma device or the like. Other possible high-energy treating apparatuses 2 are YAG (Yttrium Aluminum Garnet) laser device and carbon dioxide laser device. When the high-energy treating apparatus 2 is selected from the laser device, the luminous energy adjustment device 3 can ensure the intensity of a laser beam projecting on the outer surface of the thin wall “a”, thereby enhancing the surface-modified quality. In high-energy treating operation, the laser beam (not shown) applied in the illustrated embodiment may be positively or negatively defocused in the laser device so as to avoid high power density resulting from a focused point of the laser beam. Consequently, any deficiency of the surface-modified portions 111 and 112 resulted from the excess intensity the high-energy beam can thus be avoided.

[0033] With regard to positions of the surface-modified area, the surface-modified portion 111 occupies a greatest elastically deformable area of the golf club head body 11 as well as a central area of the crown portion. On the other hand, the surface-modified portion 112 is adjacent to a greatest stress-concentrated region of the golf club head body 11 as well as a peripheral area of the hosel 13. With regard to sizes of the surface-modified area, preferred outer radii of the surface-modified portions 111 and 112 are 30 mm and 10 mm respectively. In a preferred embodiment, the difference between an outer radius of the surface-modified portion 111 and an inner radius of the surface-modified portion 112 may vary between 4 mm and 8 mm according to the design need.

[0034] In comparison with an untreated area, the surface-modified portions 111 and 112 possess a high degree of the hardness, tensile strength and wear resisting, thereby reinforcing the thin wall “a” of the golf club head body 11. Accordingly, the surface-modified portions 111 and 112 intensify the entire structure of the golf club head body 11. In the illustrated first embodiment, the preferred hardness of the surface-modified portions 111 and 112 is greater than 38 HRC.

[0035] In the surface-treating process, a high-energy beam of the high-energy treating apparatus 2 is only applied to treat the outer surface of the thin wall “a” of the golf club head body 11. A penetrating depth of the high-energy beam on the surface-modified portions 111 and 112 is substantially not greater than 1.5 mm. In a preferred embodiment, the high-energy beam of the high-energy treating apparatus 2 can be applied to treat one of an inner surface and an outer surface of the thin wall “a” of the golf club head body 11 or both. The high-energy beam of the high-energy treating apparatus 2 is applied to treat both of the inner and outer surfaces of the thin wall “a” of the golf club head body 11. Preferably, the penetrating depth of the high-energy beam on the surface-modified portions 111 and 112 is substantially not greater than 1.0 mm. As best shown in FIG. 2, the surface-modified portions 111 and 112 are exposed on the inner and outer surface of the crown portion of the golf club head body 11.

[0036] Table 1 gives a set of striking characteristics of the surface-modified and non-surface-modified golf club heads obtained from a ball-striking test. The striking characteristics shall be determined by ball launch angle, speed ratio, flying distance, flying height and spin speed. The speed ratio is a ratio of a ball launch speed to a swinging speed.

<table>
<thead>
<tr>
<th>Type of Golf Club Heads</th>
<th>Ball Launch Angle (°)</th>
<th>Speed Ratio</th>
<th>Flying Distance (yard)</th>
<th>Flying Height (meter)</th>
<th>Spin Speed (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface-modified</td>
<td>11.9</td>
<td>1.40</td>
<td>233.8</td>
<td>90</td>
<td>3708</td>
</tr>
<tr>
<td>Non-surface-modified</td>
<td>12.0</td>
<td>1.39</td>
<td>229.2</td>
<td>85</td>
<td>3400</td>
</tr>
</tbody>
</table>

[0037] Turning now to FIGS. 3 and 4, views of a golf club head having a surface-modified structure in accordance with the second embodiment of the present invention are illustrated. In the second embodiment, the golf club head 1 is of wood types, and includes a golf club head body 11, a striking plate 12 and a hosel 13. Preferably, each of the golf club head body 11 and the striking plate 12 is selected from a “hybrid” multi-piece design. A boundary line is identified as “b” and is located between connecting portions of the golf club head body 11 and the striking plate 12. The boundary line “b” is adjacent to a thin wall “a” of the golf club head body 11. Formed on a joining area along the boundary line “b” is a surface-modified portion 113 that possesses different mechanical characteristics than other portions.

[0038] In surface heat-treating operation, a high-energy beam penetrates through the luminous energy adjustment device 3 and projects on outer connecting surfaces of the golf club head body 11 and the striking plate 12 such that the surface-modified structure extends along the boundary line “b”. In addition, the surface-modified portion 113 occupies peripheries of the outer connecting surfaces of the golf club head body 11 and the striking plate 12 located at opposite sides of the boundary line “b”. In the second embodiment, the high-energy treating apparatus 2 can be applied to treat one of an inner surface and an outer surface of the golf club head body 11 and the striking plate 12 or both. The surface modifying method used in the second embodiment is the same as that used in the first embodiment and detailed descriptions may be omitted. Advantageously, the surface-modified structure may intensify the structural strength of
the welding portion located between the golf club head body 11 and the striking plate 12 and enhance mechanical characteristics thereof.

[0039] Turning now to FIGS. 5 and 6, views of a golf club head having a surface-modified structure in accordance with the third embodiment of the present invention are illustrated. In the third embodiment, the golf club head 1 is of wood types, and includes a golf club head body 11, a striking plate 12 and a hosel 13. Preferably, each of the golf club head body 11 and the striking plate 12 is selected from a one-piece design. The striking plate 12 generally has a central flat portion identified as “c” at a sweet spot region. Surrounding the central flat portion “c” is an annular surface-modified portion 121.

[0040] In surface heat-treating operation, a high-energy beam penetrates through the luminous energy adjustment device (not shown in FIGS. 5 and 6) and projects on an outer peripheral surface of the striking plate 12. In the third embodiment, the high-energy treating apparatus (not shown in FIGS. 5 and 6) can be applied to treat the outer peripheral surface of the striking plate 12 or both. The surface modifying method used in the third embodiment is the same as that used in the first embodiment and detailed descriptions may be omitted. Advantageously, the surface-modified structure may enhance an elastically deformability of the striking plate 12 and increase the striking characteristics thereof.

[0041] Turning now to FIGS. 7 and 8, views of a golf club head having a surface-modified structure in accordance with the fourth embodiment of the present invention are illustrated. In the fourth embodiment, the golf club head 1 is of wood types, and includes a golf club head body 11, a striking plate 12 and a hosel 13. Preferably, each of the golf club head body 11 and the striking plate 12 is selected from a one-piece design. The striking plate 12 generally has a thin wall identified as “d1” at a sweet spot region, and a thick wall identified as “d2” at a peripheral region. Preferably, the striking plate 12 includes a first surface-modified portion 122 located at the sweet spot region, and a second surface-modified portion 123 located at the peripheral region.

[0042] In surface heat-treating operation, a high-energy beam penetrates through the luminous energy adjustment device (not shown in FIGS. 7 and 8) and projects on an outer surface of the striking plate 12. In the fourth embodiment, the high-energy treating apparatus (not shown in FIGS. 7 and 8) can be applied to treat the outer peripheral surface of the striking plate 12 or both. The surface modifying method used in the fourth embodiment is the same as that used in the first embodiment and detailed descriptions may be omitted.

[0043] Still referring to FIG. 8, in this illustrated embodiment, the sweet spot region of the striking plate 12 has a relatively thin thickness while the peripheral region has a relatively thick thickness. A higher energy beam is used to treat the thin wall of the sweet spot region of the striking plate 12 so that the first surface-modified portion 122 performs a higher degree of the hardness and wear resisting. But, conversely, a lower energy beam is used to treat the thick wall of the peripheral region of the striking plate 12 so that the first surface-modified portion 122 performs a higher degree of the elastically deformability. Advantageously, the surface-modified structure may increase the striking characteristics of the striking plate 12.

[0044] As has been discussed above, the surface-modified structure of the present invention is not limited to located at the thin wall “a” of the crown portion of the golf club head body 11 or the thin wall “c” of the sweet spot region of the striking plate 12, but may be changed to one of the sole portion, the skirt portion, the rear portion, the neck portion of the golf club head body 11 and any region of the striking plate 12.

[0045] In the illustrated embodiments, the luminous energy adjustment device 3 of the high-energy treating apparatus 2 generates the high-energy beam by means of positive or negative defocus. The defocused high-energy beam of the high-energy treating apparatus 2 can eliminate the uneven laser-treating problem with the deficiencies of the golf club head which is resulted by the conventional high-energy treating apparatus in remelting operation.

[0046] Although the invention has been described in detail with reference to its presently preferred embodiment, it will be understood by one of ordinary skill in the art that various modifications can be made without departing from the spirit and the scope of the invention, as set forth in the appended claims.

What is claimed is:

1. A golf club head having a surface-modified structure comprising:

   a golf club head body at least including a crown portion, a sole portion, a skirt portion, a rear portion and a neck portion, the golf club head body having an inner surface and an outer surface;

   a striking plate having an inner surface and an outer surface; and

   at least one surface-modified portion provided on one of the golf club head body and the striking plate;

   wherein the surface-modified portion is treated by a defocused high-energy beam which penetrates through a luminous energy adjustment device of a high-energy treating apparatus such that the surface-modified portion possesses a higher degree of the hardness than other portions.

2. The golf club head as defined in claim 1, wherein the surface-modified portion is provided on a greater elastically deformable region of the striking plate.

3. The golf club head as defined in claim 1, wherein the surface-modified portion is in circular form.

4. The golf club head as defined in claim 1, wherein the surface-modified portion is in ring form.

5. The golf club head as defined in claim 1, wherein the defocused high-energy beam has a penetrating depth not greater than 1.5 mm while the defocused high-energy beam only treating one of the outer surfaces of the golf club head body and the striking plate.

6. The golf club head as defined in claim 1, wherein the surface-modified portion is provided on one of the inner surfaces of the golf club head body and the striking plate by the defocused high-energy beam treating the selected inner surface.

7. The golf club head as defined in claim 6, wherein the defocused high-energy beam has a penetrating depth substantially not greater than 1.0 mm.
8. The golf club head as defined in claim 1, wherein the high-energy treating apparatus is selected from a plasma device or a laser device.

9. The golf club head as defined in claim 1, wherein the luminous energy adjustment device is selected from an integral lens.

10. The golf club head as defined in claim 1, wherein the surface-modified portion is provided on a stress-concentrated region of the golf club head.

11. The golf club head as defined in claim 1, wherein the golf club head body and the striking plate are integrally formed.

12. The golf club head as defined in claim 1, wherein the surface-modified portion is provided on a thin wall of one of the golf club head body and the striking plate.

13. A surface modifying method for a golf club head, comprising the steps of:

- providing a high-energy treating apparatus with a luminous energy adjustment device;
- preparing a defocused high-energy beam of the high-energy treating apparatus; and
- projecting the defocused high-energy beam transmitted from the luminous energy adjustment device on a predetermined portion of the golf club head to form at least one surface-modified portion.

14. The surface modifying method as defined in claim 13, wherein the surface-modified portion is provided on a thin wall of one of a golf club head body and a striking plate.

15. The surface modifying method as defined in claim 13, wherein the defocused high-energy beam is used to treat an outer surface of the golf club head.

16. The surface modifying method as defined in claim 13, wherein the defocused high-energy beam has a penetrating depth not greater than 1.5 mm while the defocused high-energy beam treating an outer surface of the golf club head.

17. The surface modifying method as defined in claim 13, wherein the surface-modified portion is provided on an inner surface of the golf club head by the defocused high-energy beam treating the inner surface.

18. The surface modifying method as defined in claim 17, wherein the defocused high-energy beam has a penetrating depth substantially not greater than 1.0 mm.

19. The surface modifying method as defined in claim 13, wherein the high-energy treating apparatus is selected from a plasma device or a laser device.

20. The surface modifying method as defined in claim 13, wherein the luminous energy adjustment device is selected from an integral lens.

21. The surface modifying method as defined in claim 13, wherein the high-energy beam is defocused by means of positive or negative defocus.