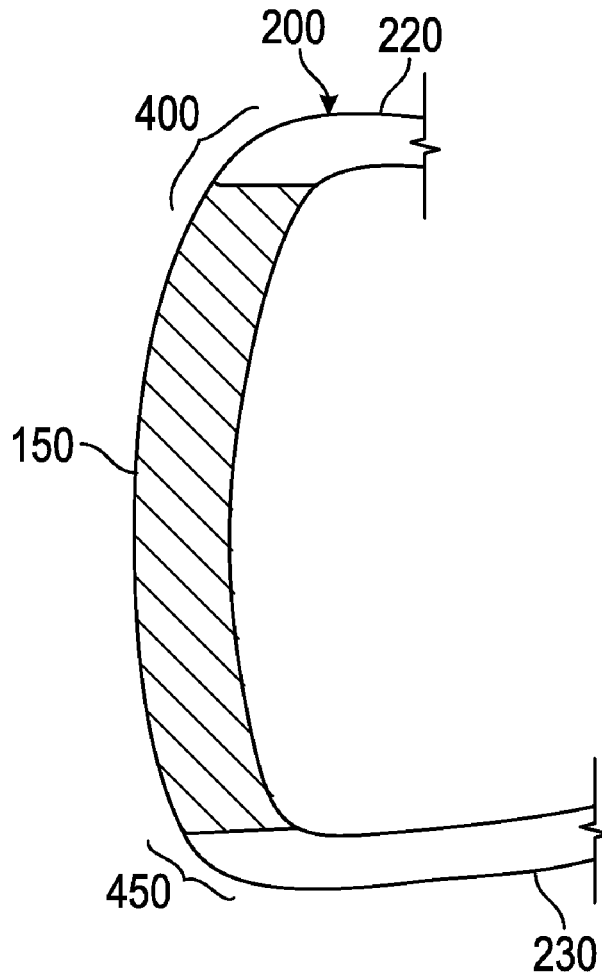




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(19) **United States**(12) **Patent Application Publication**
DeMille et al.(10) **Pub. No.: US 2018/0147458 A1**(43) **Pub. Date: May 31, 2018**(54) **GOLF CLUB HEAD WITH COMPOSITE
FACE**(60) Provisional application No. 61/881,159, filed on Sep.
23, 2013.(71) Applicant: **Callaway Golf Company**, Carlsbad,
CA (US)**Publication Classification**(72) Inventors: **Brandon D. DeMille**, Carlsbad, CA
(US); **Steven M. Ehlers**, Poway, CA
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2053/042 (2013.01); **A63B 2053/0425**
(2013.01); **A63B 2209/02** (2013.01)(21) Appl. No.: **15/878,165**(22) Filed: **Jan. 23, 2018****Related U.S. Application Data**(60) Continuation of application No. 15/014,415, filed on
Feb. 3, 2016, which is a division of application No.
14/158,963, filed on Jan. 20, 2014, now Pat. No.
9,283,447.(57) **ABSTRACT**A novel material comprising collections of prepreg plies and
a variable thickness core material such as sheet molding
compound or metal, methods of forming said material, and
golf clubs comprising said material are disclosed herein.

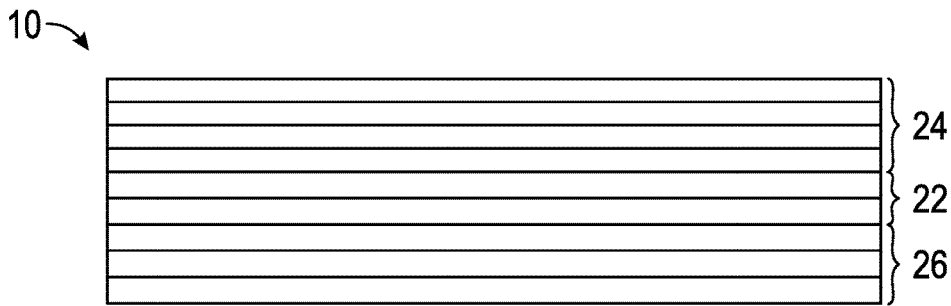


FIG. 1
(Prior Art)

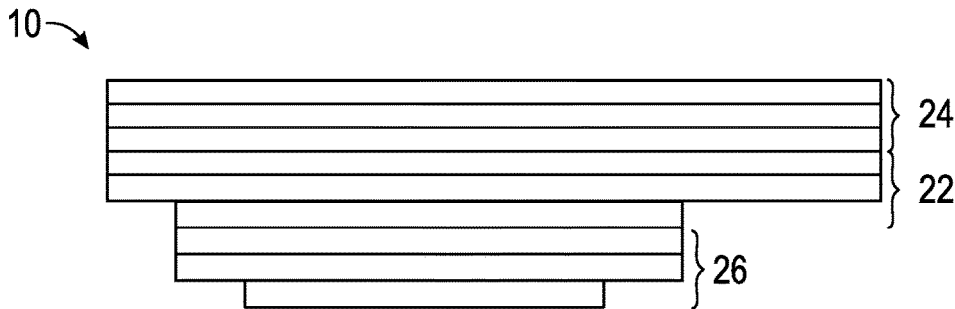


FIG. 2
(Prior Art)

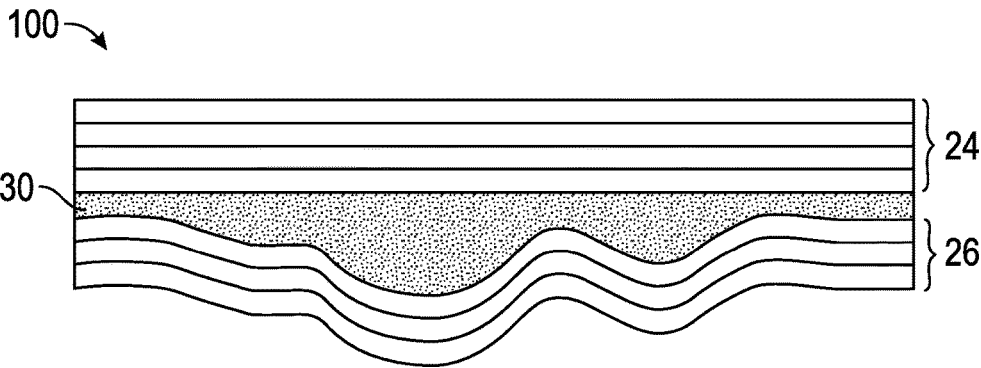


FIG. 3

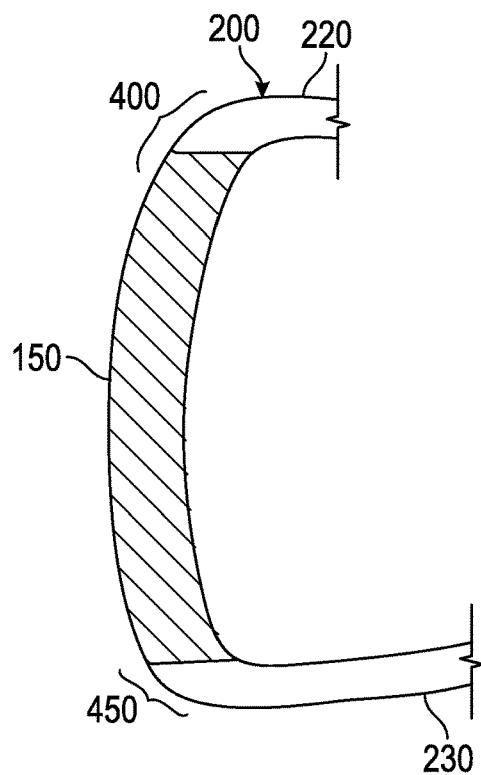


FIG. 4

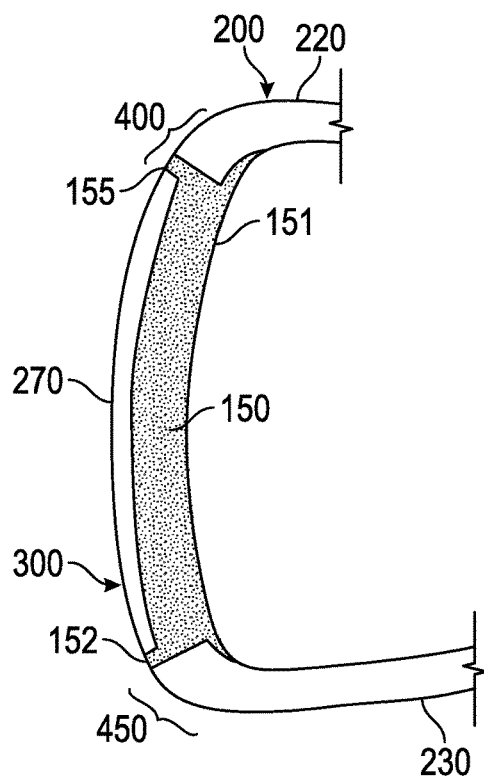


FIG. 5

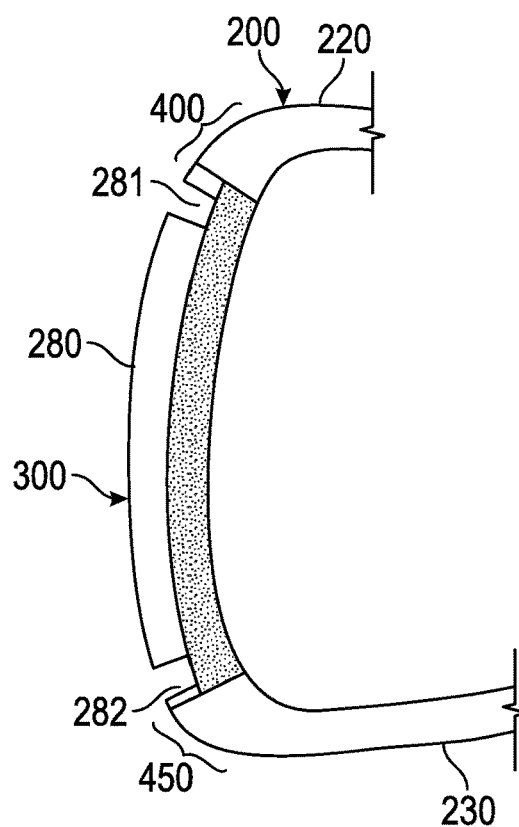


FIG. 6

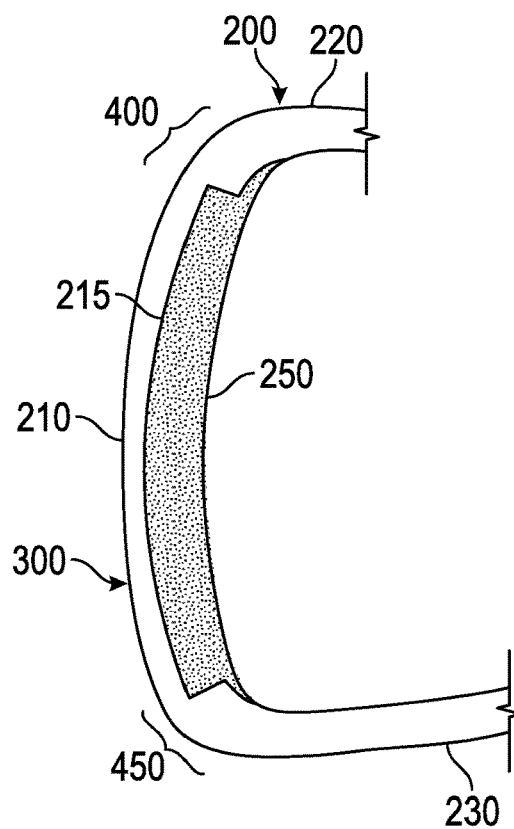


FIG. 7A

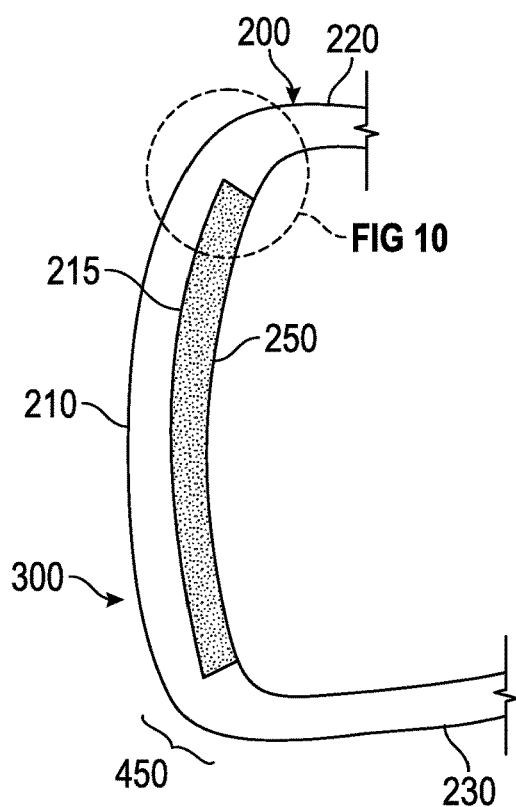


FIG. 7B

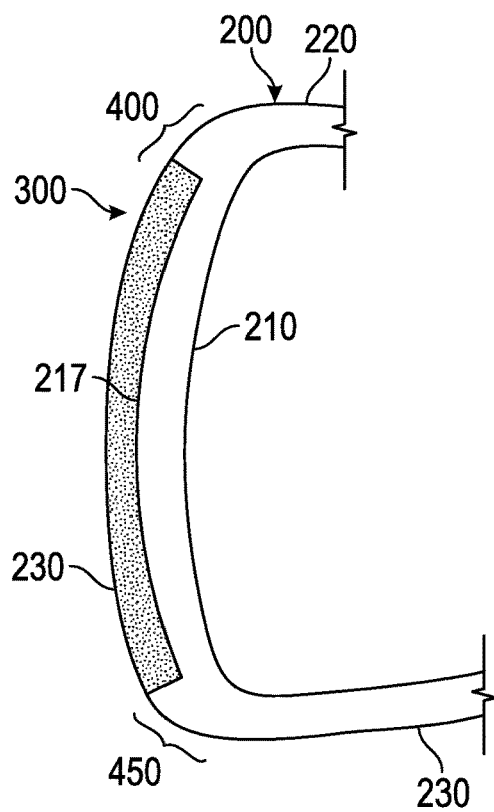


FIG. 8

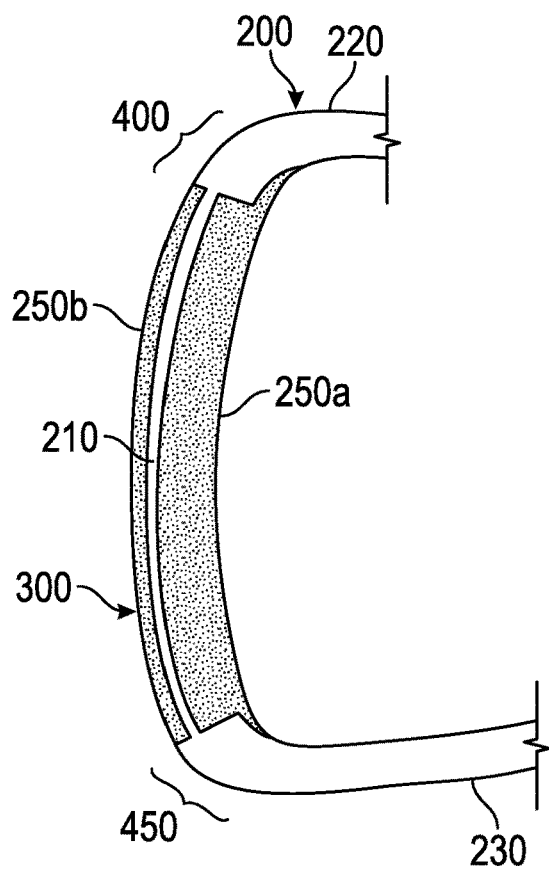


FIG. 9

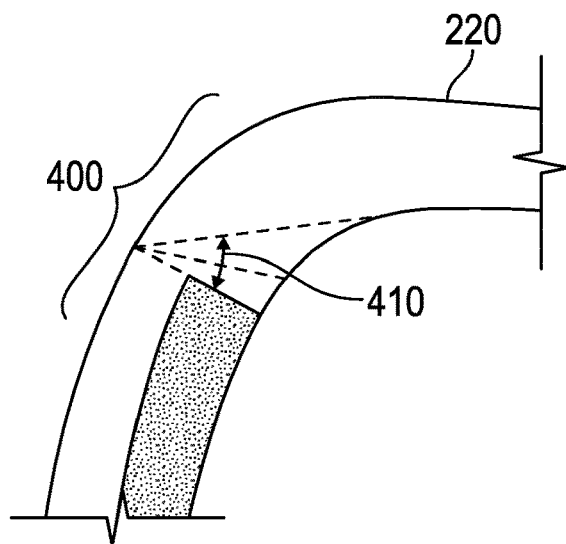


FIG. 10

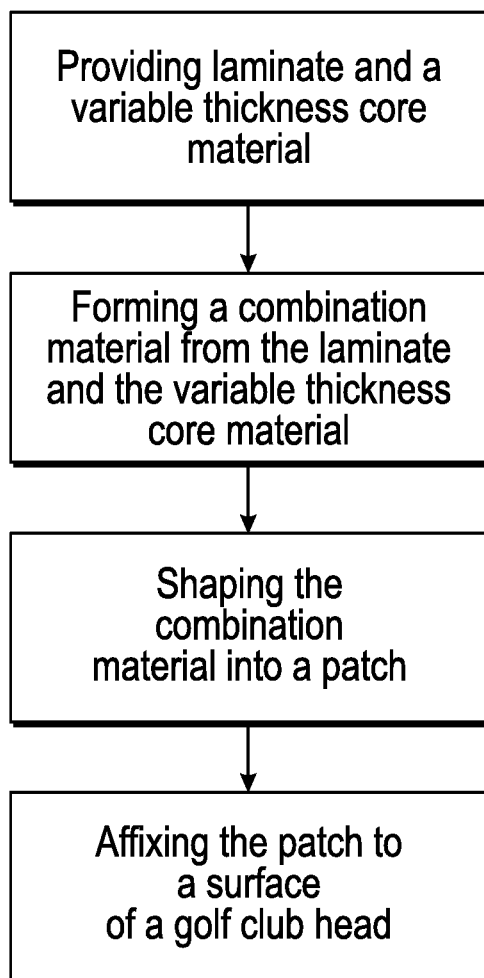


FIG. 11

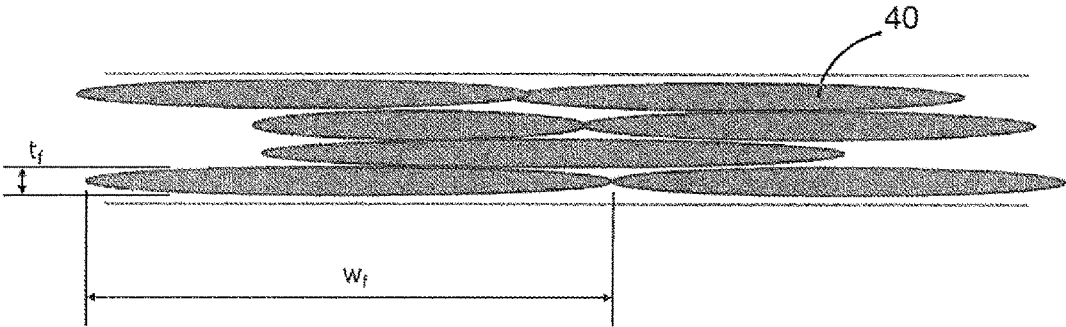


FIG. 12

GOLF CLUB HEAD WITH COMPOSITE FACE

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] The present application is a continuation of U.S. patent application Ser. No. 15/014,415, filed on Feb. 3, 2016, which is a division of U.S. patent application Ser. No. 14/158,963, filed on Jan. 20, 2014, and issued on Mar. 15, 2016, as U.S. Pat. No. 9,283,447, which claims priority to U.S. Provisional Patent Application No. 61/881,159, filed on Sep. 23, 2013, the disclosure of each of which is hereby incorporated by reference in its entirety herein.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

BACKGROUND OF THE INVENTION

Field of the Invention

[0003] The present invention relates to a multiple material golf club head. More specifically, the present invention relates to a golf club head with a face comprising a composite material.

Description of the Related Art

[0004] The prior art discloses several different composite golf club face concepts. For example, U.S. Pat. Nos. 5,310,185, 6,607,623, 6,612,938, 7,267,620, 7,628,712, 7,850,546, 7,862,452, 7,871,340, 8,096,897, and 8,163,119, disclose face inserts or face components formed of multiple prepreg plies, while U.S. Pat. Nos. 7,874,936, 7,874,937, 7,874,938, and 8,303,435, disclose face plates composed of multiple composite prepreg plies and prepreg strips to achieve variable face thickness.

[0005] Prepreg plies are not the ideal materials to use for golf club face construction, however, because using these materials to create the variable face thickness patterns that are demanded by consumers can be time consuming (the plies must be oriented by hand in a mold), expensive (the cost of plies can be high), and wasteful (scrap parts of the plies cannot easily be reused). Therefore, there is a need for improved materials and methods to create composite golf club faces.

BRIEF SUMMARY OF THE INVENTION

[0006] One aspect of the present invention is a composition comprising a first plurality of prepreg plies (collectively known as a laminate), a second plurality of prepreg plies, and a variable thickness core material, wherein the variable thickness core material is permanently sandwiched between the first plurality of prepreg plies and the second plurality of prepreg plies, and wherein the composition comprises a variable thickness pattern. The variable thickness core material may be selected from a group consisting of sheet molding compound, metal, and polymeric material, and in some embodiments may be sheet molding compound. In some embodiments, the thickness of the composition may be continuously variable. In a further embodiment, a golf club head may comprise a component composed of this compo-

sition, and the component may be selected from the group consisting of a face cup, a face insert, a face plate, a sole, and a crown.

[0007] Another aspect of the present invention is a golf club head comprising a body comprising a top portion, a bottom portion, and a face portion, and a first patch composed of the composition described above, wherein the first patch is affixed to the face portion. In some embodiments, the first patch may be custom molded onto the face portion, while in other embodiments, the first patch may be affixed to the face portion with an adhesive material. In some embodiments, the face portion may be composed of a metal material. In other embodiments, at least one of the face portion and the first patch may comprise a variable thickness pattern. In some embodiments, the first patch may be affixed to one of an inner surface and an outer surface of the face portion. In a further embodiment, the first patch may be affixed to an inner surface of the face portion and a second patch composed of the composition described above may be affixed to an outer surface of the face portion. In another embodiment, the face portion may comprise a recess sized to receive the first patch.

[0008] Yet another aspect of the present invention is a method comprising providing first and second pluralities of prepreg materials, providing a sheet molding compound, forming a combination material from the first and second pluralities of prepreg materials and the sheet molding compound, shaping the combination material into a patch, and affixing the patch to a surface of a golf club head. In some embodiments, the step of forming a combination material may be selected from the group consisting of co-molding the first and second pluralities of prepreg materials with the sheet molding compound or bonding the first and second pluralities of prepreg materials to the sheet molding compound. In one embodiment, the step of affixing the patch to a surface of the golf club head may comprise custom-molding the patch onto the surface of the golf club head. In another embodiment, the step of affixing the patch to a surface of the golf club head may comprise bonding the patch onto the surface of the golf club head with an adhesive material.

[0009] Another aspect of the present invention is a method comprising providing first and second pluralities of prepreg plies, providing a variable thickness core compound, sandwiching the variable thickness core compound between the first and second pluralities of prepreg plies to form a combination material, shaping the combination material into a patch, and co-molding the patch to a surface of a golf club head. In some embodiments, the step of sandwiching the variable thickness core compound between the first and second pluralities of prepreg plies may further comprise the step of co-molding the variable thickness core compound with the first and second pluralities of prepreg plies.

[0010] Having briefly described the present invention, the above and further objects, features and advantages thereof will be recognized by those skilled in the pertinent art from the following detailed description of the invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0011] FIG. 1 is a line drawing of a prior art laminate material with constant thickness.

[0012] FIG. 2 is a line drawing of a prior art laminate material with discrete thicknesses.

[0013] FIG. 3 is a line drawing of the combination composite material of the present invention.

[0014] FIG. 4 is a cross-sectional view of a first embodiment of a golf club head of the present invention.

[0015] FIG. 5 is a cross-sectional view of a second embodiment of a golf club head of the present invention.

[0016] FIG. 6 is a cross-sectional view of a third embodiment of a golf club head of the present invention.

[0017] FIG. 7A is a cross-sectional view of a fourth embodiment of a golf club head of the present invention.

[0018] FIG. 7B is a cross-sectional view of a fifth embodiment of a golf club head of the present invention.

[0019] FIG. 8 is a cross-sectional view of a sixth embodiment of a golf club head of the present invention.

[0020] FIG. 9 is a cross-sectional view of a seventh embodiment of a golf club head of the present invention.

[0021] FIG. 10 is an enlarged view of the circled portion of FIG. 7B.

[0022] FIG. 11 is a flow chart showing a preferred method of the present invention.

[0023] FIG. 12 is a cross-sectional view of pre-spread carbon fiber bundles, also known as "spread-tows."

DETAILED DESCRIPTION OF THE INVENTION

[0024] The present invention provides a solution to the problems set forth above by providing a preferred, combination composite material that can be used to more efficiently make structurally sound golf club parts, including face cups, face inserts, face plates, face patches, soles, crowns, and other parts that require specific and/or continuously variable thicknesses. The present invention also provides face structures that incorporate the novel composite material. The present invention may also be used to make parts for products and devices other than golf clubs.

[0025] As shown in FIGS. 1 and 2, the composite material 10 used to create prior art composite golf club faces typically is made up of multiple prepreg plies 20. Collections of prepreg plies are also referred to as laminates herein. These plies include collections of core-level plies 22, exterior plies 24, and interior plies 26. As noted above, it is both time consuming and expensive to create thickness changes in composite parts when using layers of prepreg plies. The inventive material 100 of the present invention is novel because, as shown in FIG. 3, the core-level plies 22 are replaced with a core 30 comprising sheet molding compound (also referred to herein as SMC), which may be one of the sheet molding compounds disclosed in U.S. patent application Ser. No. 13/912,994, the disclosure of which is hereby incorporated by reference in its entirety herein, or a titanium alloy. For example, the sheet molding compound may comprise bundles 40 of thousands of aligned carbon fibers that are pre-spread ("spread-tows") to have narrow, elongated oval, rather than circular, cross-sections (as shown in FIG. 12), and then are randomly assorted and combined with a matrix material. Starting out with spread-tows 40 allows for the inclusion of a greater number of fiber bundles 40 through the thickness, reduces the size of the resin rich areas, and increases the minimum expected values for tensile strength and elastic modulus in the final part. The sheet molding compound may also include carbon nanotubes, nanoclays, and other micro- and nano-fillers to increase the

material properties of the compound, and can be reinforced with fibers such as carbon, fiberglass, aramid, and combinations of the three. Other materials that can be manufactured easily into desired shapes with variable thicknesses may also be combined with or used instead of SMC or titanium. Polymers, other metals, foams, honeycomb structures, wood, and fiber reinforced polymers may all be used as variable thickness core 30 materials. Manufacturing methods for variable thickness cores 30 include casting, forging, injection molding, metal injection molding, die casting and machining.

[0026] Once the variable thickness core 30 is formed, the pluralities of prepreg plies 24, 26 (collectively laminates) and the core 30 can be combined in several ways. In a first process, the inventive material 100 can be co-molded, in which case the pluralities of prepreg plies 24, 26 are pressed together around the core 30 during their cure cycle. A second process involves curing the core 30 piece separately, then pressing the collections of prepreg plies 24, 26 onto the core 30 in a separate cure cycle. An adhesive layer may also be added between the core 30 and the collections of prepreg plies 24, 26. A third process is to mold the core 30 and the outer collections of prepreg plies 24, 26 completely separately, and then bond them together afterwards. Similar options exist for titanium variable thickness cores 30. The collections of prepreg plies 24, 26 can be molded directly onto the titanium with or without an adhesive layer. This method is preferable for titanium variable thickness cores 30 because it allows for custom molding of the collections of prepreg plies 24, 26 onto each golf club head casting, which ensures a perfect fit between the parts, even if the casting has some dimensional variation. The collections of prepreg plies 24, 26 can also be molded separately and then bonded to the titanium. A flow chart showing a high-level process of creating and using the inventive material 100 is shown in FIG. 11.

[0027] Variable thickness cores 30 are preferable to prepreg plies because the thicknesses of the materials used to make these cores 30, including but not limited to SMC and metals (including titanium), are easier to manipulate than that of laminate or layers of prepreg plies. SMC also is cheaper than prepreg plies. When a prior art composite material comprising only laminate or multiple layers of prepreg plies is subject to bending forces, the deformation of the material is influenced the most by the stiffness of the collections of exterior and interior prepreg plies 24, 26, while the properties of the core-level prepreg plies 22 are not nearly as important to the structural integrity of the material. In other words, the prepreg plies at the center of a part composed entirely of prepreg plies have much less of an influence on bending stiffness and strength of the part than do its outer layers. Replacing the core-level plies 22 with a core 30 made of a more easily/cheaply made variable thickness material thus allows a manufacture to fine-tune a golf club part's thicknesses without adding additional plies or layers (which must be hand-placed in a mold), while at the same time using collections of prepreg plies 24, 26 on the inside and outside surfaces of the part where they can have the most influence on the structure of that part. The inventive material 100 thus allows a golf club manufacturer to make more complicated and/or continuously variable thickness patterns, an example of which is shown in FIG. 3, especially in golf club faces, without sacrificing structural integrity of

the face and without wasting the time, material, and money that is required when working only with laminates or collections of prepreg plies.

[0028] The bending stiffness (D) of the inventive material **100** can be altered using variable thickness patterns and by changing the orientation of its collections of prepreg plies **24**, **26**. If the prepreg plies are oriented properly, the inventive material **100** can be stiff in one direction and compliant in another, thus positively affecting launch angle robustness, backspin robustness, and off-center ball speed when the inventive material **100** is used to form a golf club face. In an A-B-D matrix that satisfies the force/moment to strain/curvature relationship:

$$\begin{bmatrix} N \\ M \end{bmatrix} = \begin{bmatrix} A & B \\ B & D \end{bmatrix} \begin{bmatrix} \epsilon^o \\ \kappa \end{bmatrix}$$

where $[D] = \begin{bmatrix} D_{xx} & D_{xy} & D_{xs} \\ D_{yx} & D_{yy} & D_{ys} \\ D_{sx} & D_{sy} & D_{ss} \end{bmatrix}$

prepreg plies, variable thickness patterns, and combinations of the two can be chosen such that D_{xx} is significantly different from D_{yy} .

[0029] The A-B-D matrix represents the relationship between loads and bending moments to strains and curvatures. N represents forces, M represents bending moments, ϵ^o represents strains, and κ represents curvatures. The x-direction typically is defined as the projection of the heel-toe direction onto the face. The y-direction also is on the surface of the face and perpendicular to the x-direction. The z-direction is the direction through the thickness of the collections of prepreg plies and face. Golf club faces are not perfectly circular, so an optimal face does not have the same bending stiffness in every direction. Launch conditions and launch condition robustness (launch angle, back spin, side spin, ball speed) can be improved by creating faces with the appropriate bending stiffness in each direction and each location on the face. In some embodiments, a face formed from or including the inventive material **100** may satisfy one or both of the following equations:

$$\frac{D_{xx}}{D_{yy}} > C$$

$$\frac{D_{yy}}{D_{xx}} > C$$

wherein C can range from 1.00 to 1.50, and more preferably from 1.05 to 1.10.

[0030] An exemplary golf club face insert **150** made from the inventive material **100** is shown in FIG. 4 in combination with a golf club head **200**, which may be a driver, fairway wood, iron, hybrid, or putter head, but preferably is a driver. In a further embodiment, shown in FIG. 5, the face insert **150** includes a recess **155** in its inner or outer surfaces **151**, **152** to receive a reinforcement plate **270**. This embodiment may be particularly attractive to a golfer who wishes to continue using a golf club head **200** with a metallic face but wants a golf club head **200** with lower overall weight. Golfers who like visible technology in their golf clubs will also appreciate the fact that the inventive material **100** is

visible in this embodiment. In an alternative embodiment, shown in FIG. 6, a metal plate or cap **280** covers the entire outer surface **152** of the face insert **150**, and holes or slots **281**, **282** are drilled into or otherwise formed in the cap **280** so that the inventive material **100** is visible to a consumer. These holes or slots **281**, **282** can be filled with another material, such as the inventive material **100** or another lightweight material known to a person skilled in the art.

[0031] The inventive material **100** can also be used to make other face components, such as face plates, face cups, face patches, and other golf club head parts. For example, a patch **250** of the inventive material **100** can be affixed to an inside surface **215** of a face **210** as shown in FIGS. 7A and 7B or on an outside surface **217** of a face **210** as shown in FIG. 8. In another embodiment, multiple patches **250a**, **250b** are fixed to both the inside and outside surfaces **215**, **217** of a face **210** as shown in FIG. 9. The patch **250** may be affixed to the face **210** by any means known to a person skilled in the art, including via adhesives and mechanical fasteners, but it is most preferable to custom mold the patch **250** onto the face **210**. When a patch **250** of the inventive material **100** is custom molded onto a golf club face **210**, it reduces or eliminates the need for a separate adhesive layer between the face **210** and the patch **250** and guarantees a perfect fit between the patch **250** and any part with which it is molded. In each of these embodiments, the face **210** preferably is composed of a metal material, such as stainless steel or titanium alloy.

[0032] In each of the embodiments shown in FIGS. 5-9, the overall thickness of the resulting golf club striking face **300** is controlled by varying the thickness of the metal face **210**, the variable thickness core (e.g., SMC or metal) material included in the inventive material **100**, or both. In each of the embodiments shown in these Figures, the patch **250** can be smoothly blended with the surface of the golf club head **200** to which it is attached, as shown in FIGS. 5, 7A, and 9 (with respect to the rear patch **250a**), or disposed entirely within a recess or cavity, as shown in FIGS. 7B, 8, and 9 (with respect to the front patch **250b**).

[0033] In each of the embodiments disclosed herein, the joint angles **410** and configurations in the hinge regions **400**, **450**, defined as the regions where the face transitions into the crown **220** and sole **230**, an example of which is shown in FIG. 10, preferably are custom tailored to allow for efficient stress transfer and a more gradual transition from the fully metallic composition of crown **220** and sole **230** portions of the club head **200** to the metallic and composite composition of the face.

[0034] In any of the embodiments disclosed herein, holes and/or slots may be drilled into or otherwise included in the metal face **210** portion of the club head **200**, and can be filled with something less dense than the original material in order to reduce the overall weight of the golf club head **200**. The filler material may be a lightweight metal such as aluminum or magnesium, or a thermoset or thermoplastic material. The holes and slots may go part of the way through the thickness of the metal face **210**, or may extend all the way through the face **210** before the patch **250** disclosed herein is added.

[0035] The golf club parts, and particularly the faces, disclosed herein preferably have a variable thickness pattern, which may be any of the patterns disclosed in U.S. Pat. Nos., 5,163,682, 5,318,300, 5,474,296, 5,830,084, 5,971,868, 6,007,432, 6,338,683, 6,354,962, 6,368,234, 6,398,666, 6,413,169, 6,428,426, 6,435,977, 6,623,377, 6,997,821,

7,014,570, 7,101,289, 7,137,907, 7,144,334, 7,258,626, 7,422,528, 7,448,960, 7,713,140, 8,012,041, and 8,376,876, the disclosure of each of which is incorporated in its entirety herein. The golf club parts disclosed herein may also have the variable face thickness patterns disclosed in U.S. Patent Application Publication No. 20120021849, the disclosure of which is incorporated in its entirety herein.

[0036] From the foregoing it is believed that those skilled in the pertinent art will recognize the meritorious advancement of this invention and will readily understand that while the present invention has been described in association with a preferred embodiment thereof, and other embodiments illustrated in the accompanying drawings, numerous changes, modifications and substitutions of equivalents may be made therein without departing from the spirit and scope of this invention which is intended to be unlimited by the foregoing except as may appear in the following appended claims. Therefore, the embodiments of the invention in which an exclusive property or privilege is claimed are defined in the following appended claims.

We claim:

1. A method comprising:

providing first and second pluralities of prepreg materials; providing a variable thickness sheet molding compound comprising a plurality of bundles of pre-spread carbon fibers having elongated oval cross-sections and a matrix material;

providing a cap;

forming one or more holes in the cap;

forming a combination material from the first and second pluralities of prepreg materials and the sheet molding compound;

shaping the combination material into a patch;

affixing the patch to a surface of a golf club head;

affixing the cap to the patch; and

filling the one or more holes with a thermoplastic material wherein the combination material satisfies at least one equation selected from the group consisting of

$$\frac{D_{xx}}{D_{yy}} > C \text{ and}$$

$$\frac{D_{yy}}{D_{xx}} > C,$$

wherein D is the bending stiffness of the combination material,

wherein the plurality of bundles of pre-spread carbon fibers are randomly assorted within the matrix material, and

wherein C is at least 1.05 and is no more than 1.10.

2. The method of claim 1, wherein the step of forming a combination material comprises co-molding the first and second pluralities of prepreg materials with the sheet molding compound.

3. The method of claim 1, wherein the step of forming a combination material comprises bonding the first and second pluralities of prepreg materials to the sheet molding compound.

4. The method of claim 1, wherein the step of forming a combination material comprises sandwiching the sheet molding compound between the first and second pluralities of prepreg materials.

5. The method of claim 1, wherein the step of affixing the patch to a surface of the golf club head comprises custom-molding the patch onto the surface of the golf club head.

6. The method of claim 1, wherein the step of affixing the patch to a surface of the golf club head comprises bonding the patch onto the surface of the golf club head with an adhesive material.

7. A method comprising

providing first and second pluralities of prepreg plies;

providing a variable thickness core compound comprising a plurality of bundles of pre-spread carbon fibers having elongated oval cross-sections, a matrix material, and a filler material selected from the group consisting of carbon nanotubes and nanoclays;

sandwiching the variable thickness core compound between the first and second pluralities of prepreg plies to form a combination material;

shaping the combination material into a patch; and

co-molding the patch to a surface of a golf club head, wherein the combination material satisfies at least one equation selected from the group consisting of

$$\frac{D_{xx}}{D_{yy}} > C \text{ and}$$

$$\frac{D_{yy}}{D_{xx}} > C,$$

wherein D is the bending stiffness of the combination material,

wherein the bundles of pre-spread carbon fibers are randomly assorted within the matrix material, and

wherein C is at least 1 and is no more than 1.5.

8. The method of claim 7, wherein the step of sandwiching the variable thickness core compound between the first and second pluralities of prepreg plies further comprises the step of co-molding the variable thickness core compound with the first and second pluralities of prepreg plies.

9. The method of claim 7, wherein the step of sandwiching the variable thickness core compound between the first and second pluralities of prepreg plies further comprises the step of bonding the variable thickness core compound to the first and second pluralities of prepreg plies with an adhesive material.

10. The method of claim 7, wherein the variable thickness core compound comprises a honeycomb structure.

11. The method of claim 7, further comprising the step of affixing a cap to the patch after the patch is co-molded to the surface of the golf club head, wherein the cap does not completely cover the patch.

12. The method of claim 7, wherein the cap comprises at least one hole.

13. The method of claim 12, further comprising the step of filling the at least one hole with a thermoset or thermoplastic material.

14. A method comprising

providing first and second pluralities of prepreg plies;

providing a variable thickness core compound comprising a plurality of bundles of pre-spread carbon fibers having elongated oval cross-sections, a matrix material, and a nanoclay filler material;

co-molding the variable thickness core compound with the first and second pluralities of prepreg plies to form a combination material;
 shaping the combination material into a patch;
 co-molding the patch to a surface of a golf club head; and
 affixing a cap to the patch so that the cap does not completely cover the patch,
 wherein the combination material satisfies at least one equation selected from the group consisting of

$$\frac{D_{xx}}{D_{yy}} > C \text{ and}$$

$$\frac{D_{yy}}{D_{xx}} > C,$$

wherein D is the bending stiffness of the combination material,
 wherein the bundles of pre-spread carbon fibers are randomly assorted within the matrix material, and
 wherein C is at least 1 and is no more than 1.5.

* * * * *