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COMPOSITE LAMINATE

Abstract

A composite laminate according to embodiments of the present disclosure includes a unidirectional tape layer including a thermoplastic resin and continuous fibers, and a first metal layer formed on the unidirectional tape layer. A content of the continuous fibers is 40 wt % or more based on the total weight of the unidirectional tape layer. The flame resistance and lightness of the composite laminate may be improved.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2024-0021165, filed on Feb. 14, 2024, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Invention

[0002] The embodiments of the present disclosure relate to a composite laminate such as a flame retardant laminate, and more specifically, to a composite laminate including a metal layer.

2. Description of the Related Art

[0003] A metal-plastic composite material is used in an automobile field. In the case of a metal material such as steel and aluminum, it has stability against heat but is highly corrosive. In addition, in the case of steel, it is heavy such that weight reduction for improving fuel efficiency is required.

[0004] Significant research and development efforts on a composite material such as a flame retardant material are being conducted to replace the metal, and the composite material known in the art includes a unidirectional (UD) tape, carbon fiber-reinforced plastic (CFRP), glass fiber-reinforced plastic (GFRP) and the like. The composite material (e.g., UD tape, CFRP, etc.) is light and corrosion resistant, but its shape may be limited due to low elongation.

[0005] Recently, significant research and developments are conducted on eco-friendly automobiles such as electric or hybrid vehicles, however, the above-described problems also exist in the electric vehicle. In the case of the electric vehicle, a battery pack including a plurality of secondary batteries accounts for a large proportion of the vehicle weight, such that weight reduction of the battery pack is required. In addition, when the plurality of secondary batteries is included in the vehicle, heat generation due to leakage of an electrolyte, gas generation, etc. occurs in series, thereby increasing the risk of explosion. Therefore, a material with reduced weight while having stability is highly desirable.

SUMMARY

[0006] Embodiments of the present disclosure provide a composite laminate having improved stability.

[0007] Another embodiment of the present disclosure provides a battery case having improved stability.

[0008] Further, another embodiment of the present disclosure provides a battery assembly having improved stability.

[0009] According to embodiments of the present disclosure, there is provided a composite laminate including a unidirectional tape layer which includes a thermoplastic resin and continuous fibers; and a first metal layer formed on the unidirectional tape layer. A content of the continuous fibers is 40% by weight or more based on a total weight of the unidirectional tape layer.

[0010] According to embodiments of the present disclosure, the composite laminate may further include a second metal layer formed on a lower surface of the unidirectional tape layer.

[0011] According to embodiments of the present disclosure, the content of the continuous fibers may be 60% by weight or more based on the total weight of the unidirectional tape layer.

[0012] According to embodiments of the present disclosure, the thermoplastic resin may further

include a flame retardant.

[0013] According to embodiments of the present disclosure, the continuous fibers may include one or more selected from the group consisting of carbon fibers, glass fibers and polypropylene fibers.

[0014] According to embodiments of the present disclosure, the unidirectional tape layer may include a plurality of continuous fiber layers including continuous fibers impregnated with the thermoplastic resin, and the unidirectional tape layer may include 2 layers or more of the continuous fiber layers.

[0015] According to embodiments of the present disclosure, the unidirectional tape layer may include 7 layers or less of the continuous fiber layers.

[0016] According to embodiments of the present disclosure, the unidirectional tape layer may have a thickness of 0.4 mm or more and 3.5 mm or less.

[0017] According to embodiments of the present disclosure, the first metal layer may be formed of one or more selected from the group consisting of aluminum, steel and an alloy thereof.

[0018] According to embodiments of the present disclosure, the second metal layer may be formed of the same metal as the first metal layer.

[0019] According to embodiments of the present disclosure, an adhesive layer may be formed between the unidirectional tape layer and the metal layer. The adhesive layer may include a polyolefin adhesive or a polypropylene adhesive.

[0020] According to embodiments of the present disclosure, a plurality of unidirectional tape layers and a plurality of metal layers may be sequentially and alternately formed on top of each other with optional adhesive layers included between the unidirectional tape layers and the metal layers. The metal layers may be included in an odd number within the composite laminate. The first main surface of the composite laminate may be formed by one of the metal layers and a second main surface of the composite laminate opposite to the first main surface may be formed by one of the unidirectional tape layers.

[0021] According to embodiments of the present disclosure, the second metal layer may have a thickness of 0.05 mm to 1.2 mm.

[0022] In addition, there is provided a battery case including the composite laminate according to the embodiments of the present disclosure.

[0023] Further, there is provided a battery assembly including a plurality of battery cells laminated on top of each other, and the battery case which is formed to surround at least a portion of the plurality of laminated battery cells, and includes the composite laminate according to the above-described embodiment.

[0024] Through the corrosion resistance and flame resistance of the composite laminate according to the above-described embodiments, the stability of the battery may be improved, and flame spread due to damage to the battery may be prevented.

[0025] According to embodiments of the present disclosure, the composite laminate may include continuous fibers in a predetermined content range. As the content of the continuous fibers is covered by the predetermined range, the flame resistance of the composite laminate may be improved.

[0026] According to embodiments of the present disclosure, a thickness of each layer included in the composite laminate may be adjusted, and thereby both the weight reduction and flame resistance of the composite laminate may be achieved simultaneously.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The above and other objectives, features and advantages of the present invention will be more clearly understood by those with ordinary skill in the art from the following detailed

description taken in conjunction with the accompanying drawings, in which:
[0028] FIGS. **1** to **5** are schematic cross-sectional views illustrating composite laminates according to embodiments of the present disclosure;
[0029] FIGS. **6A** and **6B** are schematic views illustrating unidirectional tape layers of the composite laminate according to embodiments of the present disclosure;
[0030] FIG. **7** is a schematic perspective view illustrating a battery assembly including the composite laminate according to embodiments of the present disclosure;
[0031] FIGS. **8A** to **8C** are schematic cross-sectional views illustrating a laminating sequence of the composite laminate according to embodiments of the present disclosure; and
[0032] FIG. **9** is a schematic view illustrating a method of manufacturing a composite laminate according to embodiments of the present disclosure.

DETAILED DESCRIPTION

[0033] Embodiments of the present disclosure are directed to a composite laminate including at least one unidirectional tape layer and at least one metal layer. Also embodiments of the present disclosure are directed to a battery case and a battery assembly including the composite laminate.
[0034] Embodiments of the present disclosure are described in more detail in conjunction with the accompanying drawings. However, it is noted that the drawings and the embodiments only serve as implementations which embody the technical spirit of the present disclosure, it, and, therefore, should not be construed as limiting the scope of the present disclosure. Many other embodiments and drawings of the invention may be envisioned by those having ordinary skill in the art from the disclosed embodiments and drawings.

[0035] The terms “upper portion,” “upper layer,” “lower portion,” “lower layer,” etc. used herein are not indicative of an absolute position, but are used in a relative sense to designate different areas in relation to a specific reference plane.

[0036] FIGS. **1** to **5** are schematic cross-sectional views illustrating composite laminates according to embodiments of the present disclosure.

[0037] Referring to FIGS. **1** and **2**, the composite laminate **100** may include a unidirectional tape layer **110** and a metal layer **120** formed on the unidirectional tape layer **110**. As shown in FIG. **2**, the composite laminate **100** may further include an adhesive layer **150** formed between the unidirectional tape layer **110** and the metal layer **120**.

[0038] Referring to FIGS. **3** and **4**, the composite laminate **100** may include the unidirectional tape layer **110**, a first metal layer **121** formed on an upper surface of the unidirectional tape layer and a second metal layer **122** formed on a lower surface of the unidirectional tape layer **110**. As shown in FIG. **4**, the composite laminate **100** may further include adhesive layers **150**. The adhesive layers **150** may include a first adhesive layer **151** disposed between the unidirectional tape layer **110** and the first metal layer **121** and a second adhesive layer **152** disposed between the unidirectional tape layer **110** and the second metal layer **122**.

[0039] Referring to FIG. **5**, the composite laminate **100** may include two or more unidirectional tape layers **110** and two or more metal layers **120**. For example, the first adhesive layer **151** and the first metal layer **121** may be formed on an upper surface of a first unidirectional tape layer **111**, and the second adhesive layer **152** and the second metal layer **122** may be formed on a lower surface of the first unidirectional tape layer **111**. A third adhesive layer **153** and a second unidirectional tape layer **112** may be formed on a lower surface of the second metal layer. For example, the unidirectional tape layers **110** and the metal layers **120** may be sequentially and alternately laminated, and the adhesive layers **150** may be included between the unidirectional tape layers **110** and the metal layers **120**.

[0040] For example, the composite laminate **100** may include two or more unidirectional tape layers **110** and two or more metal layers **120**, wherein the thickness of each layer may be adjusted. Accordingly, even if the composite laminate **100** is formed into a multilayer structure, the thickness or weight thereof may be included in a predetermined range.

[0041] FIGS. 6A and 6B are schematic views illustrating unidirectional tape layers of the composite laminate according to embodiments of the present disclosure.

[0042] Referring to FIGS. 6A and 6B, the unidirectional tape layer **110** may include two or more continuous fiber layers **105**.

[0043] According to embodiments of the present disclosure, the unidirectional tape layer **110** may include a thermoplastic resin and continuous fibers oriented in one direction. For example, the continuous fibers may be impregnated into a thermoplastic resin by determining orientations thereof to prepare the continuous fiber layers **105**, and the continuous fiber layers **105** may be sequentially laminated by determining the orientations thereof to prepare the unidirectional tape layer **110**.

[0044] According to embodiments of the present disclosure, the unidirectional tape layer **110** may include a thermoplastic resin. The unidirectional tape layer **110** including the thermoplastic resin may be bonded with the metal layer **120** under relatively low temperature and pressure conditions. In addition, physical properties of the unidirectional tape layer **110** may be adjusted depending on the content of the thermoplastic resin included in the unidirectional tape layer **110**.

[0045] For example, the thermoplastic resin may include polypropylene (PP), high density polyethylene (HDPE), polyethylene terephthalate (PET), polymethyl methacrylate (PMMA), thermoplastic polyurethane (TPU), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), polyphenylene sulfide (PPS), polyamide (PA), and the like.

[0046] In one embodiment, the thermoplastic resin may include polypropylene.

[0047] According to embodiments of the present disclosure, the thermoplastic resin may include polypropylene, and the polypropylene may be included in an amount of 60% by weight ("wt %") or less based on a total weight of the unidirectional tape layer **110**.

[0048] In one embodiment, the polypropylene may be included in an amount of 60 wt % or less, 50 wt % or less but 10 wt % or more, 50 wt % or less but 20 wt % or more, or 40 wt % or less but 20 wt % or more based on the total weight of the unidirectional tape layer **110**.

[0049] Within the above range, a composite laminate with reduced weight may be implemented.

[0050] According to embodiments of the present disclosure, the thermoplastic resin may further include a flame retardant. For example, the thermoplastic resin may include polypropylene and a flame retardant.

[0051] For example, the flame retardant may include a phosphorus-based flame retardant, a boron-based flame retardant, a magnesium-based flame retardant, an aluminum-based flame retardant, a nitrogen-based flame retardant, an antimony-based flame retardant, a halogen-based flame retardant, a non-halogen-based flame retardant, etc. In some embodiments, the flame retardant may include the phosphorus-based flame retardant.

[0052] According to embodiments of the present disclosure, the flame retardant may be included in an amount of 15 wt % to 45 wt % based on the total weight of the thermoplastic resin. In one embodiment, the flame retardant may be included in an amount of 20 wt % to 40 wt %, or 25 wt % to 35 wt % based on the total weight of the thermoplastic resin. Within the above range, the flame retardancy of the thermoplastic resin may be improved. Accordingly, the flame resistance of the composite laminate may be improved.

[0053] According to embodiments of the present disclosure, the unidirectional tape layer **110** may include two or more continuous fiber layers **105** which include continuous fibers oriented in one direction and are laminated on top of each other. Depending on the orientation of the continuous fiber layers **105**, the physical properties of the unidirectional tape layer **110** may be partially adjusted.

[0054] According to embodiments of the present disclosure, the unidirectional tape layer **110** may include continuous fibers oriented in one direction in an amount of 40 wt % or more, 50 wt % or more, 60 wt % or more, or 60 wt % or more and 90 wt % or less based on the total weight of the unidirectional tape layer **110**.

[0055] Within the above weight range, the flame resistance of the composite laminate may be improved and elongation characteristics and bending characteristics thereof may be improved. For example, if the content of the continuous fibers is less than the above content range, flame interruption performance of the composite laminate may be reduced, thereby resulting in the collapse of a structure or an occurrence of a hole due to the flame, and thus, the thermal runaway suppression of the secondary battery may not be implemented.

[0056] The content of the continuous fibers may be a sum total of the weights of the continuous fibers included in the continuous fiber layers **105**.

[0057] The content of the continuous fibers may be adjusted according to a design process of the unidirectional tape layer. For example, continuous fibers may be spread in an impregnation die in one direction or in multiple directions, then a thermoplastic resin may be supplied from an upper or lower portion of the die to impregnate the continuous fibers, and the unidirectional tape layer **110** may be formed through the impregnation. Alternatively, continuous fibers may be supplied to the thermoplastic resin in one direction or in multiple directions to impregnate the continuous fibers, and the unidirectional tape layer **110** may be formed via the impregnation. The content of the continuous fibers may be adjusted to the above range by controlling a supply speed of the continuous fibers or the thermoplastic resin, an impregnation speed, an impregnation temperature and the like.

[0058] According to embodiments of the present disclosure, the continuous fibers of the continuous fiber layers **105** may include one or more of carbon fibers, glass fibers and polypropylene fibers.

[0059] According to embodiments of the present disclosure, a single strand of the continuous fiber may have a cross-sectional diameter of 10 μm to 30 μm . For example, the single strand of the continuous fiber may have a cross-sectional diameter of 12 μm to 18 μm , 14 μm to 17 μm , or 15 μm to 17 μm .

[0060] Within the above range, the content of the continuous fibers in the unidirectional tape layer **110** may be increased.

[0061] For example, as shown in FIG. 6A, the unidirectional tape layer **110** may include continuous fiber layers arranged parallel to the continuous fiber arrangement of a first continuous fiber layer **105a**. For example, a second continuous fiber layer **105b** arranged parallel to the continuous fiber arrangement of the first continuous fiber layer **105a** may be laminated on the first continuous fiber layer **105a**. A third continuous fiber layer **105c** arranged parallel to the continuous fiber arrangement of the first continuous fiber layer **105a** may be laminated on the second continuous fiber layer **105b**. A fourth continuous fiber layer **105d** arranged parallel to the continuous fiber arrangement of the first continuous fiber layer **105a** may be laminated on the third continuous fiber layer **105c**.

[0062] For example, as shown in FIG. 6B, the unidirectional tape layer **110** may include continuous fiber layers arranged perpendicular to the continuous fiber arrangement of the first continuous fiber layer **105a**. For example, the second continuous fiber layer **105b** arranged perpendicular to the continuous fiber arrangement of the first continuous fiber layer **105a** may be laminated on the first continuous fiber layer **105a**. The third continuous fiber layer **105c** arranged parallel to the continuous fiber arrangement of the first continuous fiber layer **105a** may be laminated on the second continuous fiber layer **105b**. The fourth continuous fiber layer **105d** arranged perpendicular to the continuous fiber arrangement of the first continuous fiber layer **105a** may be laminated on the third continuous fiber layer **105c**.

[0063] The arrangement and lamination structure of the continuous fiber layers are not limited to the above descriptions, and continuous fiber layers which form predetermined angle, for example, 0°, 45°, 90°, 135°, 180°, etc., with the arrangement of the continuous fibers included in the first continuous fiber layer **105a** may be laminated.

[0064] According to embodiments of the present disclosure, the unidirectional tape layer **110** may include 10 layers or less of the continuous fiber layers **105**. In some embodiments, the

unidirectional tape layer **110** may include 7 layers or less of the continuous fiber layers **105**.

[0065] For example, the unidirectional tape layer **110** may include 3 to 7 layers of the continuous fiber layers **105**. However, the number of layers of the continuous fiber layers **105** is described as an example, and the number may be adjusted depending on the desired characteristics. For example, the thickness of the continuous fiber layers may be adjusted so that the unidirectional tape layer **110** may include 8 layers or more of the continuous fiber layers.

[0066] According to embodiments of the present disclosure, the unidirectional tape layer **110** may have a thickness of 0.4 mm to 3.5 mm.

[0067] According to embodiments of the present disclosure, the unidirectional tape layer **110** may have a thickness of 0.4 mm to 3.3 mm, 0.5 mm to 3.2 mm, 0.5 mm to 3.0 mm, 0.55 mm to 2.8 mm, or 0.55 mm to 2.4 mm.

[0068] Within the above range, the weight of the composite laminate **100** may be reduced while securing the flame resistance of the composite laminate **100**. For example, if the thickness of the unidirectional tape layer **110** exceeds the above range, the weight thereof is increased such that the weight reduction of the composite laminate **100** may not be implemented, and if the thickness of the unidirectional tape layer **110** is less than the above range, the flame resistance of the composite laminate **100** may not be secured.

[0069] The metal layer **120** may include aluminum, steel, magnesium, titanium and the like.

[0070] According to embodiments of the present disclosure, the metal layer **120** may include one or more of aluminum, steel and an alloy thereof.

[0071] According to embodiments of the present disclosure, the metal layer **120** may have a thickness of 0.05 mm to 1.2 mm.

[0072] According to embodiments of the present disclosure, the metal layer **120** may have a thickness of 0.08 mm to 1.1 mm, 0.1 mm to 1.1 mm, 0.1 mm to 1.05 mm, or 0.1 mm to 1.0 mm. In some embodiments, the metal layer **120** may have a thickness of 0.15 mm to 1.0 mm, 0.15 mm to 1.0 mm, or 0.2 mm to 1.0 mm.

[0073] Within the above thickness range, the weight of the composite laminate may be reduced. For example, if the thickness of the metal layer **120** exceeds the above range, the weight thereof is increased such that the weight reduction of the composite laminate **100** may not be implemented. For example, if the thickness of the metal layer **120** is less than the above range, the flame resistance may not be implemented even by repeatedly laminating the metal layers **120** and the unidirectional tape layers **110**.

[0074] The thickness of the unidirectional tape layer **110** and the thickness of the metal layer **120** may be adjusted to some extent depending on the structure of the composite laminate. For example, as shown in FIG. 5, when the composite laminate includes two or more unidirectional tape layers **110** or three or more metal layers **120**, the thickness of each unidirectional tape layer **110** and each metal layer **120** may be adjusted within a range that is small enough to reduce the weight of the composite laminate. The thickness of each unidirectional tape layer **110** and each metal layer **120** may be adjusted within the thickness range of each layer.

[0075] According to embodiments of the present disclosure, the composite laminate **100** may include the unidirectional tape layer **110**, the first metal layer **121** formed on an upper surface of the unidirectional tape layer **110**, and the second metal layer **122** formed on a lower surface of the unidirectional tape layer **110**.

[0076] According to embodiments of the present disclosure, the first metal layer **121** and the second metal layer **122** may include the same metal.

[0077] For example, when the first metal layer **121** includes steel, the second metal layer **122** may also include steel, and when the first metal layer **121** includes aluminum, the second metal layer **122** may also include aluminum.

[0078] According to embodiments of the present disclosure, the composite laminate **100** may include the unidirectional tape layer **110**, a first aluminum metal layer formed on the upper surface

of the unidirectional tape layer **110**, and a second aluminum metal layer formed on the lower surface of the unidirectional tape layer **110**.

[0079] For example, when the composite laminate **100** includes the first aluminum metal layer and the second aluminum metal layer, the thicknesses of the first aluminum metal layer and the second aluminum metal layer may be 0.2 mm to 0.4 mm, respectively. In this case, the thickness of the unidirectional tape layer **110** may be 0.8 mm to 1.6 mm.

[0080] According to embodiments of the present disclosure, when the metal layer **120** includes steel, the laminate may not include the second metal layer **122**. For example, when the composite laminate **100** includes the first steel metal layer, the thickness of the first steel metal layer may be 0.2 mm to 0.4 mm. In this case, the thickness of the unidirectional tape layer **110** may be 0.8 mm to 1.6 mm.

[0081] For example, a value according to Equation 1 below, of the composite laminate **100** may be 5% or more.

[00001] $B - A / B * 100$ Equation1

[0082] In Equation 1 above, B is a weight of steel with a thickness of 0.6 mm, and A is a weight of the composite laminate.

[0083] In Equation 1 above, the weights of the steel and the composite laminate are measured based on the same width and the same length.

[0084] For example, the value according to Equation 1 of the composite laminate **100** may be 10 wt % or more. The value according to Equation 1 may be included in the above range according to the weight reduction of the composite laminate **100**.

[0085] According to embodiments of the present disclosure, the composite laminate **100** may further include the adhesive layer **150** formed between the unidirectional tape layer **110** and the metal layer **120**.

[0086] For example, the adhesive layer **150** may include an epoxy adhesive, an acrylic adhesive, a silicone adhesive, a polyurethane adhesive, a rubber adhesive, a polyolefin adhesive, a silica adhesive, and the like.

[0087] According to embodiments of the present disclosure, the adhesive layer **150** may include a polyolefin adhesive. For example, the adhesive layer **150** may include maleic anhydride-graft polypropylene (MAPP).

[0088] For example, when the adhesive layer **150** includes a polypropylene adhesive, the unidirectional tape layer **110** may be securely adhered to the metal layer **120** while minimizing changes in the physical properties thereof.

[0089] For example, the adhesive layer **150** may have a thickness of 0.05 mm to 0.2 mm.

[0090] FIG. 7 is a schematic perspective view illustrating a battery assembly including the composite laminate according to embodiments of the present disclosure.

[0091] Referring now to FIG. 7, a battery assembly is provided that comprises the inventive composite laminate. The battery assembly may include: a plurality of stacked battery cells (not shown); and a battery case formed to surround at least a portion of the plurality of stacked battery cells. The plurality of battery cells may be stacked on top of each other or side to side.

[0092] The battery case is indicated generally by numeral **300** and may include top and bottom cover parts **310**, front and rear cover parts **320** (front cover part **320a**, rear cover part **320b**), and side cover parts **330**. The plurality of battery cells may be protected on all six sides by the cover parts **310**, **320** and **330** to prevent inflow of external foreign substances and maintain structural rigidity from an external impact.

[0093] At least one of the cover parts **310**, **320**, and **330** that make up the battery case **300** includes the above-described composite laminate **100**. In an embodiment, most or all of the cover parts **310**, **320**, and **330** that make up the battery case **300** include the above-described composite laminate **100**. As a result the battery case **300** exhibits an improved balance of weight, and structural strength. The battery case **300** has reduced weight and the same or improved strength capable to

withstand mechanical stress, impacts, and vibrations without deforming or breaking. It is noted, however, that embodiments of the battery case may also have different configurations.

[0094] FIGS. **8A** to **8C** are schematic views for describing a lamination structure of the composite laminate included in the cover parts of the battery case according to embodiments of the present disclosure.

[0095] Referring to FIGS. **8A** and **8B**, when the composite laminate **100** includes an odd number of metal layers **120**, the unidirectional tape layer **110** and the metal layer **120** may be arranged in different ways.

[0096] For example, when the metal layers **120** are included in an odd number, the directionality of the flame resistance of the composite laminate **100** may be defined. For example, the arrangement of the composite laminate **100** may vary depending on the metal type of the metal layer **120**.

[0097] For example, when the metal layers **120** including steel are included in an odd number within the composite laminate **100**, the unidirectional tape layer **110** may face toward the plurality of battery cells, and the metal layer **120** may face outward of the battery assembly.

[0098] For example, when the metal layers **120** including aluminum are included in an odd number within the composite laminate **100**, the unidirectional tape layer **110** may face outward of the battery assembly, and the metal layers **120** may face toward the plurality of battery cells.

[0099] For example, when the metal layer **120** includes aluminum, and if a high-temperature flame is applied in a direction toward the unidirectional tape layer **110** (in the direction indicated by an arrow in FIG. **8A**), only a part of the composite laminate **100** may burn or only a thickness change may occur. If the high-temperature flame is applied in a direction toward the metal layer **120** (in the direction indicated by an arrow in FIG. **8B**), a hole may occur in the composite laminate **100**.

[0100] For example, when the metal layer **120** includes steel, and if a high-temperature flame is applied in a direction toward the unidirectional tape layer **110** (in the direction indicated by the arrow in FIG. **8A**), the unidirectional tape layer **110** may melt, thereby resulting in the collapse of the structure of the composite laminate **100**. If the high-temperature flame is applied in a direction toward the metal layer **120** (in the direction indicated by the arrow in FIG. **8B**), only a part of the composite laminate **100** may burn or only a change in the thickness may occur.

[0101] Accordingly, the thermal stability of the battery assembly may be secured and thermal runaway may be suppressed.

[0102] Referring to FIG. **8C**, when the composite laminate **100** includes an even number of metal layers **120**, the first metal layer **121** on the upper surface of the unidirectional tape layer **110** and the second metal layer **122** on the lower surface may be arranged in any direction on the cover parts independent of the orientation.

[0103] For example, the unidirectional tape layer **110** is positioned between the metal layers **120**, such that if a high-temperature flame from the outside may be applied to the metal layers **120**, a hole does not occur in the composite laminate, thereby the plurality of battery cells may be protected from internal and external heats.

[0104] For example, the plurality of battery cells may include a cathode, an anode facing the cathode, and a separation membrane, respectively.

[0105] The cathode may include a cathode current collector and a cathode slurry layer disposed on at least one surface of the cathode current collector.

[0106] The cathode current collector may include stainless steel, nickel, aluminum, titanium, or an alloy thereof. The cathode current collector may also include aluminum or stainless steel subjected to surface treatment with carbon, nickel, titanium or silver.

[0107] The cathode slurry layer may include a cathode active material. The cathode active material may include a compound capable of reversibly intercalating and deintercalating lithium ions.

[0108] According to embodiments of the present disclosure, the cathode active material may include a lithium-nickel metal oxide. The lithium-nickel metal oxide may further include at least one of cobalt (Co), manganese (Mn) and aluminum (Al).

[0109] The cathode active material may further include a coating element or a doping element. For example, elements which are substantially the same as or similar to the above-described auxiliary elements may be used as the coating element or the doping element. For example, the above-described elements may be used alone or in combination of two or more thereof as the coating element or the doping element.

[0110] The anode may include an anode current collector and an anode slurry layer disposed on at least one surface of the anode current collector.

[0111] As a non-limiting embodiment, the anode current collector may include a copper foil, a nickel foil, a stainless steel foil, a titanium foil, nickel foam, copper foam, and a polymer substrate coated with a conductive metal.

[0112] The anode slurry layer may include an anode active material. As the anode active material, a material capable of intercalating and deintercalating lithium ions may be used. For example, as the anode active material, a carbon-based material such as crystalline carbon, amorphous carbon, a carbon composite, or carbon fibers; lithium metal; a lithium alloy; a silicon (Si)-containing material or tin (Sn)-containing material; and the like may be used.

[0113] Examples of the amorphous carbon may include hard carbon, cokes, mesocarbon microbead (MCMB), mesophase pitch-based carbon fiber (MPCF) or the like.

[0114] Examples of the crystalline carbon may include graphite-based carbon such as natural graphite, artificial graphite, graphite cokes, graphite MCMB, graphite MPCF or the like.

[0115] A separation membrane may be interposed between the cathode and the anode. The separation membrane may prevent electrical short-circuit between the cathode and the anode, and maintain flow of ions.

[0116] The separation membrane may include a porous polymer film or a porous nonwoven fabric. The porous polymer film may include a polyolefin polymer such as an ethylene polymer, a propylene polymer, an ethylene/butene copolymer, an ethylene/hexene copolymer, an ethylene/methacrylate copolymer, etc. The porous nonwoven fabric may include glass fibers having a high melting point, polyethylene terephthalate fibers and the like.

[0117] The separation membrane may also include a ceramic-based material. For example, inorganic particles may be applied to the polymer film or dispersed within the polymer film to improve heat resistance.

[0118] The separation membrane may have a single-layer or multi-layer structure including the above-described polymer film and/or non-woven fabric.

[0119] FIG. 9 is a schematic view for describing a method for manufacturing a composite laminate according to embodiments of the present disclosure.

[0120] Referring to FIG. 9, a preliminary composite laminate including a preliminary unidirectional tape layer **115** and a preliminary metal layer **125** formed on the preliminary unidirectional tape layer **115** may be prepared. The preliminary composite laminate may be placed in a mold (e.g., process S10). Heat and pressure may be applied to the preliminary composite laminate through molding parts **215** and **215'** (e.g., process S20). The formed preliminary composite laminate may be cooled (e.g., process S30).

[0121] According to embodiments of the present disclosure, a preliminary first metal layer **125** may be formed on an upper surface of the preliminary unidirectional tape layer **115** and a preliminary second metal layer may be formed on a lower surface of the preliminary unidirectional tape layer **115** to form a preliminary composite laminate.

[0122] The preliminary unidirectional tape layer **115** and the preliminary metal layer **125** may be the same as the above-described unidirectional tape layer **110** and the metal layer **120** except for the thickness. For example, the preliminary unidirectional tape layer **115** may include a thermoplastic resin and continuous fibers oriented in one direction.

[0123] The thickness of the preliminary unidirectional tape layer **115** may be adjusted to about 10% within the thickness range of the above-described unidirectional tape layer **110**. In addition, the

thickness of the preliminary metal layer **125** may be adjusted to about 10% within the thickness range of the above-described metal layer **120**.

[0124] According to embodiments of the present disclosure, the laminate may further include a preliminary adhesive layer between the preliminary unidirectional tape layer **115** and the preliminary metal layer **125**. The preliminary adhesive layer may be the same as the above-described adhesive layer.

[0125] According to embodiments of the present disclosure, the preliminary composite laminate may be formed at a temperature of 130° C. to 170° C. in the molding parts **215** and **215'**.

[0126] According to embodiments of the present disclosure, the preliminary composite laminate may be formed at a pressure of 10 kPa to 300 kPa in the molding parts **215** and **215'**.

[0127] For example, the preliminary unidirectional tape layer **115** may include a thermoplastic resin, such that the composite laminate may be manufactured under the relatively mild conditions of the above-described temperature and pressure ranges. Suitable examples of thermoplastic resins may include polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), acrylonitrile butadiene styrene (ABS), polyethylene terephthalate (PET), nylon, polycarbonate (PC) and the like, and any combinations thereof. In some embodiments, the thermoplastic resin may be PE, PP, or combinations thereof.

[0128] The molding parts **215** and **215'** may use a device for applying heat and pressure. For example, a hand press, a roller press, etc. may be used as a molding part device. For example, the preliminary composite laminate may be formed through a calendaring process.

[0129] The preliminary unidirectional tape layer **115** and the preliminary metal layer **125** may be laminated to stack integrally through the molding part.

[0130] According to embodiments of the present disclosure, the formed preliminary composite laminate may be cooled in a range of 0° C. to 30° C. The formed preliminary composite laminate may be quickly cooled in the above range of temperatures to maintain the continuous fiber arrangement of the unidirectional tape layer.

[0131] Hereinafter, specific experimental examples are proposed to facilitate understanding of the embodiments of the present disclosure. However, the following examples are only given for illustrating the embodiments and those skilled in the art will understand that various alterations and modifications are possible within the scope and spirit of the present disclosure. Such alterations and modifications are duly included in the appended claims.

EXAMPLES AND COMPARATIVE EXAMPLES

Preparative Example. Preparation of Unidirectional (UD) Tape Layer

Preparative Example 1-1. Preparation of Flame Retardant-Treated Unidirectional Tape Layer

[0132] A flame retardant-treated polypropylene resin was prepared by adding a flame retardant (ADEKA, FR-2500S) to a polypropylene resin so that the amount of the flame retardant in the flame-retardant-treated polypropylene resin was 25 wt % to 35 wt %. The flame retardant-treated polypropylene resin was impregnated with glass fiber so that the content of the glass fiber was 60 wt % based on the total weight of the flame retardant-treated polypropylene resin with the impregnated glass fiber. The polypropylene resin impregnated with the glass fiber was laminated in 4 layers (plies) to prepare a unidirectional tape layer having a thickness of 1.1 mm.

Preparative Example 1-2. Preparation of Flame Retardant-Treated Unidirectional Tape Layer

[0133] A unidirectional tape layer was prepared by the same method as Preparative Example 1-1, except that the polypropylene resin impregnated with the glass fiber was laminated in 6 layers (plies) to change the thickness to 1.6 mm.

Preparative Example 1-3. Preparation of Flame Retardant-Treated Unidirectional Tape Layer

[0134] A unidirectional tape layer was prepared by the same method as Preparative Example 1-1, except that the glass fiber-impregnated polypropylene resin was laminated in 8 layers (plies) to change the thickness to 2.2 mm.

Preparative Example 2. Preparation of Flame Retardant-Treated Unidirectional Tape Layer

[0135] A unidirectional tape layer was prepared by the same method as Preparative Example 1-1, except that the content of the glass fiber was changed to 50 wt %.

Preparative Example 3. Preparation of Flame Retardant-Treated Unidirectional Tape Layer

[0136] A unidirectional tape layer was prepared by the same method as Preparative Example 1-1, except that the content of the glass fiber was changed to 70 wt %.

Preparative Example 4. Preparation of Non-Flame Retardant-Treated Unidirectional Tape Layer

[0137] A unidirectional tape layer was prepared by the same method as Preparative Example 1-1, except that a polypropylene resin which does not include the flame retardant was used.

Preparative Example 5. Preparation of Flame Retardant-Treated Unidirectional Tape Layer

[0138] A unidirectional tape layer was prepared by the same method as Preparative Example 1-1, except that the content of the glass fiber was changed to 30 wt %.

Example 1. Manufacture of Composite Laminate (1)

[0139] A maleic anhydride-grafted polypropylene (MAPP) film having a thickness of 0.05 mm was laminated on a first metal layer including aluminum or steel, and the unidirectional tape layer according to one of Preparative Examples 1-1, 1-2, 1-3, 2, 3 or 4 was laminated on the MAPP film to form a first preliminary laminate. Thereafter, the first preliminary laminate was placed in a mold, then the layers were bonded by passing through a heating zone of 130° C. to 170° C. depending on the type of the unidirectional tape, and the layers were rapidly cooled by passing through a cooling zone of 30° C. to manufacture a first composite laminate.

[0140] The types and thicknesses of each layer included in the first composite laminate are as shown in Table 1 below.

TABLE-US-00001									
TABLE 1 First metal layer Unidirectional tape layer Thickness Thickness Item									
Type (mm)	Type (mm)	Example 1-1	Steel	0.25	Preparative 1.1	Example 1-2	Steel	0.30	Example 1-1
Example 1-3	Steel	0.40 (4 plies)	Example 1-4	Aluminum	0.30	Example 1-5	Aluminum	0.50	
Example 1-6	Steel	0.25	Preparative 1.6	Example 1-7	Steel	0.30	Example 1-2	Example 1-8	Steel
0.40 (6 plies)	Example 1-9	Aluminum	0.30	Example 1-10	Aluminum	0.50	Example 1-11	Steel	0.25
Preparative 2.2	Example 1-12	Steel	0.30	Example 1-3	Example 1-13	Steel	0.40 (8 plies)	Example	
1-14	Aluminum	0.30	Example 1-15	Aluminum	0.50	Example 1-16	Steel	0.25	Preparative 1.1
Example 1-17	Aluminum	0.30	Example 2 (4 plies)	Example 1-18	Steel	0.25	Preparative 1.1		
Example 1-19	Aluminum	0.30	Example 3 (4 plies)	Example 1-20	Steel	0.25	Preparative 1.1		
Example 1-21	Aluminum	0.30	Example 4 (4 plies)						

Example 2. Manufacture of Composite Laminate (2)

[0141] A first preliminary laminate was formed by the same method as Example 1, and a MAPP film with a thickness of 0.05 mm and a second metal layer were sequentially laminated on the unidirectional tape layer of the first preliminary laminate to form a second preliminary laminate. Thereafter, the second preliminary laminate was placed in a mold, then the layers were bonded by passing through a heating zone of 130° C. to 170° C. depending on the type of the unidirectional tape, and the layers were rapidly cooled by passing through a cooling zone of 30° C. to manufacture a second composite laminate.

[0142] The types and thicknesses of each layer included in the second composite laminate are as shown in Table 2 below.

TABLE-US-00002									
TABLE 2		First metal layer		Unidirectional tape layer		Second metal layer			
Thickness	Thickness	Thickness	Item	Type (mm)	Type (mm)	Type (mm)	Example	2-1	Steel 0.25
Preparative 1.1	Steel 0.25	Example 2-2	Steel 0.30	Example 1-1	Steel 0.30	Example 2-3	Steel 0.40		
(4 plies)	Steel 0.40	Example 2-4	Aluminum 0.30	Aluminum 0.30	Example 2-5	Aluminum 0.5			
Aluminum 0.5	Example 2-6	Steel 0.25	Preparative 1.1	Steel 0.25	Example 2-7	Aluminum 0.30			
Example 2	Aluminum 0.30 (4 plies)	Example 2-8	Steel 0.25	Preparative 1.1	Steel 0.25	Example 2-9	Aluminum 0.30		
Aluminum 0.30	Example 3	Aluminum 0.30 (4 plies)	Example 2-10	Steel 0.25	Preparative 1.1	Steel 0.25	Example 2-11		
Steel 0.25	Example 2-11	Aluminum 0.30	Example 4	Aluminum 0.30 (4 plies)					

Comparative Example 1. Single Metal Layer

[0143] Aluminum single metal layers having thicknesses of 0.3 mm, 1.0 mm, 2.0 mm, 2.5 mm, and 3.0 mm, respectively, were manufactured.

Comparative Example 2. Single Unidirectional Tape Layer

[0144] A single unidirectional tape layer having a thickness of 1.1 mm was manufactured according to Preparative Examples 1-1, 2, 3 and 4.

Comparative Example 3. Manufacture of Composite Laminate

[0145] A composite laminate was manufactured by the same method as Example 1, except that polytetrafluoroethylene (PTFE) was used instead of the first metal layer including the aluminum or steel.

Comparative Example 4. Manufacture of Composite Laminate

[0146] A composite laminate was manufactured by the same method as Example 1, except that a unidirectional tape layer according to Preparative Example 5 was used instead of the unidirectional tape layer according to one of Preparative Examples 1-1, 1-2, 1-3, 2, 3 and 4.

[0147] The types and thicknesses of each layer included in the single metal layer, the single unidirectional tape layer or the composite laminate according to Comparative Examples 1 to 4 are as shown in Table 3 below.

TABLE-US-00003 TABLE 3 Metal layer or polymer layer Unidirectional tape layer Thickness

Thickness	Item	Type (mm)	Type (mm)	Comparative	Aluminum	0.3	—	—	Example	1-1				
Comparative	1.0	Example	1-2	Comparative	2.0	Example	1-3	Comparative	2.5	Example	1-4			
Comparative	3.0	Example	1-5	Comparative	—	—	Preparative	1.1	Example	2-1	Example	1-1	(4	
				plies)	Comparative	—	—	Preparative	1.1	Example	2-2	Example	2	(4
				plies)	Comparative	—	—	Preparative	1.1	Example	2-4	Example	4	(4
				plies)	Comparative	PTFE	0.1	Preparative	1.1	Example	3-1	Example	1-1	Comparative
				PTFE	0.2	(4	plies)	Example	3-2	Comparative	PTFE	1.0	Example	3-3
				Comparative	PTFE	1.0	Example	3-3	Comparative	Steel	0.25	Preparative	1.1	Example
				Example	4-1	Example	5	Comparative	Aluminum	0.30	(4	plies)	Example	4-2
				Experimental	Example									

(1) Evaluation of Flame Resistance

[0148] The flame resistance of the single-layers or composite laminates according to the examples and comparative examples was evaluated.

[0149] A torch was positioned at a distance 10 cm away from the single-layer or composite laminate in a thickness direction thereof. The distance of the torch to the single layer or the composite laminate was adjusted so that the temperature of the torch flame on the surface of the single-layer or the composite laminate could reach 1,100° C. Thereafter, heat was applied to the single-layer or to the composite laminate with the torch to evaluate whether or not a hole would form and record an occurrence time of the hole formation if the hole actually formed.

[0150] In the cases of the first composite laminate according to Example 1, the composite laminate according to Comparative Example 3, and the composite laminate according to Comparative Example 4, the flame resistance evaluation was performed for each state where the metal layer faced the torch and the unidirectional tape layer faced the torch.

[0151] As experimental results, flame resistance evaluation results according to the examples are shown in Table 4 below, and flame resistance evaluation results according to the comparative examples are shown in Table 5 below.

TABLE-US-00004 TABLE 4 Structure Hole occurrence Thickness Occurred Occurrence Example

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80																				

layer Aluminum 0.30 X — unidirectional Second Flame retardant UD 1.1 tape layer layer tape (4 plies) Example Heat applied to First layer Steel 0.25 X — 1-17 metal layer Second Flame retardant UD 1.1 layer tape (4 plies) Heat applied to First layer Aluminum 0.30 X — unidirectional Second Flame retardant UD 1.1 tape layer layer tape (4 plies) Example Heat applied to First layer Steel 0.25 X — 1-20 metal layer Second Non-flame retardant 1.1 layer UD tape (4 plies) Heat applied to First layer Steel 0.25 O 1 minute unidirectional Second Non-flame retardant 1.1 18 seconds tape layer layer UD tape (4 plies) Example Heat applied to First layer Aluminum 0.30 O 20 seconds 1-21 metal layer Second Non-flame retardant 1.1 layer UD tape (4 plies) Heat applied to First layer Aluminum 0.30 O 40 seconds unidirectional Second Non-flame retardant 1.1 tape layer layer UD tape (4 plies) Example Heat applied to First layer Steel 0.25 X — 2-1 metal layer Second Flame retardant UD 1.1 layer tape (4 plies) Third layer Steel 0.25 Example Heat applied to First layer Aluminum 0.3 X — 2-4 metal layer Second Flame retardant UD 1.1 layer tape (4 plies) Third layer Aluminum 0.3 Example Heat applied to First layer Steel 0.25 X — 2-10 metal layer Second Non-flame retardant 1.1 layer UD tape (4 plies) Third layer Steel 0.25 Example Heat applied to First layer Aluminum 0.3 X — 2-11 metal layer Second Non-flame retardant 1.1 layer UD tape (4 plies) Third layer Aluminum 0.3

[0152] As shown in Table 4 above, in the composite laminate according to Example 1, the flame retardant evaluation results were different for the case of applying heat to the surface of the metal layer and the case of applying heat to the surface of the unidirectional (UD) tape layer. In the case of Example 1-1 including a steel metal layer and a flame retardant-treated unidirectional tape layer, no hole occurred regardless of the type of the surface to which heat was applied.

[0153] In the case of Example 1-4 including an aluminum metal layer and a flame retardant-treated unidirectional tape layer, it was confirmed that a hole occurred within 5 minutes when heat was directly applied to the metal layer. However, when heat was directly applied to the flame retardant-treated unidirectional tape layer, no hole occurred even after 10 minutes.

[0154] In the case of Example 1-20 including a steel metal layer and a non-flame retardant-treated unidirectional tape layer, a hole occurred when heat was directly applied to the non-flame retardant-treated unidirectional tape layer, but no hole occurred when heat was directly applied to the metal layer. In the case of Example 1-21 including an aluminum metal layer and a non-flame retardant-treated unidirectional tape layer, a hole occurred regardless of the type of the surface to which heat was applied.

[0155] It was confirmed that the composite laminate including the first metal layer, the unidirectional tape layer, and the second metal layer had significantly improved flame resistance, since no hole occurred regardless of the flame retardant treatment of the unidirectional tape layer.

TABLE-US-00005 TABLE 5 Structure Hole occurrence Thickness Occurred Occurrence Comparative Example Item Type (mm) or not time Comparative Example 1-1 First layer Aluminum 0.3 O 5 seconds Comparative Example 1-2 First layer Aluminum 1.0 O 18 seconds Comparative Example 1-3 First layer Aluminum 2.0 O 1 minute 20 seconds Comparative Example 1-4 First layer Aluminum 2.5 O 3 minutes 40 seconds Comparative Example 1-5 First layer Aluminum 3.0 O 4 minutes Comparative Example 2-1 First layer Flame retardant UD 1.1 O 1 minute tape (4plies) 30 seconds Comparative Example 2-4 First layer Non-flame retardant 1.1 O 15 seconds UD tape (4plies) Compara- Heat applied to First layer PTFE 0.1 O 30 seconds tive metal layer Second layer Flame retardant UD 1.1 Example tape (4 plies) 3-1 Heat applied to First layer PTFE 0.1 O 1 minute unidirectional Second layer Flame retardant UD 1.1 tape layer tape (4 plies) Compara- Heat applied to First layer PTFE 0.2 O 1 minute tive metal layer Second layer Flame retardant UD 1.1 30 seconds Example tape (4 plies) 3-2 Heat applied to First layer PTFE 0.1 O 2 minutes unidirectional Second layer Flame retardant UD 1.1 30 seconds tape layer tape (4 plies) Compara- Heat applied to First layer PTFE 1.0 O 3 minutes tive metal layer Second layer Flame retardant UD 1.1 Example tape (4 plies) 3-3 Heat applied to First layer PTFE 0.1 O 5 minutes unidirectional Second layer Flame retardant UD 1.1 tape layer tape (4 plies) Compara- Heat

applied to First layer Steel 0.25 O 4 minutes tive metal layer Second layer Flame retardant UD 1.1 30 seconds Example tape (4 plies) 4-1 Heat applied to First layer Steel 0.25 O 1 minute unidirectional Second layer Flame retardant UD 1.1 20 seconds tape layer tape (4 plies) Compara- Heat applied to First layer Aluminum 0.30 O 50 seconds tive metal layer Second layer Flame retardant UD 1.1 Example tape (4 plies) 4-2 Heat applied to First layer Aluminum 0.30 O 30 seconds metal layer Second layer Flame retardant UD 1.1 tape (4 plies)

[0156] As shown in Table 5 above, in the cases of Comparative Examples 1-1 to 1-5 corresponding to the single metal layer, the occurrence time of a hole was delayed as the thickness of the metal layer was increased, but a hole occurred even when the thickness of the metal layer corresponded to 3.0 mm or more.

[0157] In the cases of Comparative Examples 2-1 and 2-4 corresponding to the single unidirectional tape layer, the occurrence time of hole was delayed due to flame retardant treatment, but a hole occurred within a short period of time even after flame retardant treatment.

[0158] In the cases of Comparative Examples 3-1 to 3-3 using polytetrafluoroethylene (PTFE) instead of the metal layer, the occurrence time of hole was delayed as the thickness of PTFE was increased, but a hole occurred within 5 minutes in all cases.

[0159] In the cases of Comparative Examples 4-1 and 4-2 using the unidirectional tape layer with a low content of glass fiber, it was confirmed that the occurrence of hole was not delayed even when they corresponded to the same metal and the same thickness as the examples.

(2) Evaluation of Weight Reduction Rate

[0160] The weight reduction rate of the composite laminates according to the above examples was evaluated. Based on the weight of steel of 100 mm×100 mm×0.6 mm, the weight reduction rate was evaluated after setting the same length and width, and the weight reduction rate was calculated according to Equation 1 below. Evaluation results are as shown in Tables 6 and 7 below.

[00002] $B - A / B \times 100$ Equation1

[0161] In Equation 1 above, B is a weight of the reference steel, and A is a weight of the composite laminate.

TABLE-US-00006 TABLE 6 Lamination structure Thickness (mm) Actually Weight Structure measured Weight reduction Item Type thickness thickness (g) rate (%) Example First Steel 0.25 1.38 37.1 20.7 1-1 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Steel 0.30 1.44 41.0 12.4 1-2 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Steel 0.40 1.55 48.8 -4.3 1-3 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Aluminum 0.30 1.40 25.7 45.1 1-4 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Aluminum 0.50 1.60 31.1 33.5 1-5 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Steel 0.25 1.90 45.1 3.6 1-6 layer Second Flame retardant UD 1.6 layer tape (6 plies) Example First Steel 0.30 1.96 49.0 -4.7 1-7 layer Second Flame retardant UD 1.6 layer tape (6 plies) Example First Steel 0.40 2.08 56.8 -21.4 1-8 layer Second Flame retardant UD 1.6 layer tape (6 plies) Example First Aluminum 0.30 1.89 33.7 28.0 1-9 layer Second Flame retardant UD 1.6 layer tape (6 plies) Example First Aluminum 0.50 2.09 39.1 16.5 1-10 layer Second Flame retardant UD 1.6 layer tape (6 plies) Example First Steel 0.25 2.51 54.7 -16.9 1-11 layer Second Flame retardant UD 2.2 layer tape (8 plies) Example First Steel 0.30 2.58 58.6 -25.2 1-12 layer Second Flame retardant UD 2.2 layer tape (8 plies) Example First Steel 0.40 2.67 66.4 -41.9 1-13 layer Second Flame retardant UD 2.2 layer tape (8 plies) Example First Aluminum 0.30 2.46 44.3 7.5 1-14 layer Second Flame retardant UD 2.2 layer tape (8 plies) Example First Aluminum 0.50 2.65 48.7 -4.1 1-15 layer Second Flame retardant UD 2.2 layer tape (8 plies) Example First Steel 0.25 1.38 36.9 21.1 1-16 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Aluminum 0.30 1.40 25.4 45.7 1-17 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Steel 0.25 1.38 37.3 20.3 1-18 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Aluminum 0.30 1.40 26.0 44.4 1-19 layer Second Flame retardant UD 1.1 layer tape (4 plies) Example First Steel 0.25 1.38 36.8 21.3 1-20 layer Second Flame retardant UD

1.1 layer tape (4 plies) Example First Aluminum 0.30 1.40 25.8 44.8 1-21 layer Second Flame retardant UD 1.1 layer tape (4 plies)

[0162] As shown in Table 6 above, it was confirmed that as the thickness of the metal layer or the unidirectional tape layer was increased, the weight was increased and the weight reduction rate was decreased compared to the reference steel.

[0163] In the cases of the composite laminates of Examples 1-16 to 1-19 manufactured including the unidirectional tape layer with different contents of the glass fiber, there was no significant difference in the thickness and weight of the composite laminates. In addition, in the cases of the composite laminates of Examples 1-20 and 1-21 manufactured including the unidirectional tape layer which does not include the flame retardant, there was no significant difference in the thickness and weight of the composite laminates.

TABLE-US-00007 TABLE 7 Lamination structure Thickness (mm) Actually Weight Structure measured Weight reduction Item Type thickness thickness (g) rate (%) Example First Steel 0.25 1.65 56.60 -20.94 2-1 layer Second Flame retardant UD 1.1 layer tape (4 plies) Third Steel 0.25 layer Example First Steel 0.30 1.73 64.40 -37.61 2-2 layer Second Flame retardant UD 1.1 layer tape (4 plies) Third Steel 0.30 layer Example First Aluminum 0.30 1.71 33.8 27.8 2-3 layer Second Flame retardant UD 1.1 layer tape (4 plies) Third Aluminum 0.30 layer Example First Aluminum 0.30 1.88 39.2 16.2 2-4 layer Second Flame retardant UD 1.1 layer tape (4 plies) Third Aluminum 0.50 layer Example First Aluminum 0.50 2.03 44.6 4.70 2-5 layer Second Flame retardant UD 1.1 layer tape (4 plies) Third Aluminum 0.50 layer

[0164] As shown in Table 7 above, the weight reduction was not possible when steel was used as the metal layer.

DESCRIPTION OF REFERENCE NUMERALS

[0165] **100**: Composite laminate [0166] **105**: Continuous fiber layer [0167] **110**: Unidirectional tape layer [0168] **115**: Preliminary unidirectional tape layer [0169] **120**: Metal layer [0170] **125**: Preliminary metal layer [0171] **150**: Adhesive layer [0172] **210**: Mold [0173] **215**: Molding part [0174] **300**: Battery case

Claims

1. A composite laminate comprising: a unidirectional tape layer which comprises a thermoplastic resin and continuous fibers; and a first metal layer formed on an upper surface of the unidirectional tape layer, wherein a content of the continuous fibers is 40% by weight or more based on a total weight of the unidirectional tape layer.
2. The composite laminate according to claim 1, further comprising a second metal layer formed on a lower surface opposite to the upper surface of the unidirectional tape layer.
3. The composite laminate according to claim 1, wherein the content of the continuous fibers is 60% by weight or more is based on the total weight of the unidirectional tape layer.
4. The composite laminate according to claim 1, wherein the thermoplastic resin further comprises a flame retardant.
5. The composite laminate according to claim 1, wherein the continuous fibers comprise one or more selected from the group consisting of carbon fibers, glass fibers and polypropylene fibers.
6. The composite laminate according to claim 1, wherein the unidirectional tape layer comprises a plurality of continuous fiber layers including continuous fibers impregnated with the thermoplastic resin, and the unidirectional tape layer comprises 2 layers or more of the continuous fiber layers.
7. The composite laminate according to claim 6, wherein the unidirectional tape layer comprises 7 layers or less of the continuous fiber layers.
8. The composite laminate according to claim 1, wherein the unidirectional tape layer has a thickness of 0.4 mm or more and 3.5 mm or less.
9. The composite laminate according to claim 1, wherein the first metal layer is formed of one or

more selected from the group consisting of aluminum, steel and an alloy thereof.

- 10.** The composite laminate according to claim 2, wherein the second metal layer is formed of the same metal as the first metal layer.
 - 11.** The composite laminate according to claim 1, wherein an adhesive layer is formed between the unidirectional tape layer and the metal layer, wherein the adhesive layer includes a polyolefin adhesive or a polypropylene adhesive.
 - 12.** The composite laminate according to claim 1, wherein a plurality of unidirectional tape layers and a plurality of metal layers are sequentially and alternately formed on top of each other with optional adhesive layers included between the unidirectional tape layers and the metal layers, wherein the metal layers are included in an odd number within the composite laminate, wherein a first main surface of the composite laminate is formed by one of the metal layers and a second main surface of the composite laminate opposite to the first main surface is formed by one of the unidirectional tape layers.
 - 13.** The composite laminate according to claim 2, wherein the second metal layer has a thickness of 0.05 mm to 1.2 mm.
 - 14.** A battery case comprising the composite laminate according to claim 1.
 - 15.** A battery assembly comprising: a plurality of battery cells stacked within a battery case; and the battery case according to claim **14** formed to surround at least a portion of the plurality of laminated battery cells.
 - 16.** A battery case comprising: a plurality of cover parts comprising a composite laminate, wherein the composite laminate comprises, at least one unidirectional tape layer comprising a thermoplastic resin and a plurality of unidirectional continuous fibers; at least one metal layer formed over the at least one unidirectional tape layer, an adhesive layer disposed between the at least one metal layer and the at least one unidirectional tape layer, wherein the at least one unidirectional tape layer is made of a thermoplastic resin including a flame retardant, and wherein the unidirectional continuous fibers are glass fibers.
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