DESCRIPTION

Title of Invention: EXTERIOR MATERIAL FOR POWER STORAGE DEVICE, POWER STORAGE DEVICE, AND METHOD FOR MANUFACTURING POWER STORAGE DEVICE

Technical Field

[0001] The present disclosure relates to an exterior material for an electricity storage device, an electricity storage device, and a method for manufacturing an electricity storage device.

Background Art

[0002] An electricity storage device element including an electrode and an electrolyte may be housed inside an exterior body formed by an exterior material including a barrier layer such as a metal foil (for example, Patent Literature 1). The exterior body may be formed by fusing heat-fusible resin layers to each other.

Citation List

Patent Literature

[0003] [Patent Literature 1] Japanese Patent No. 6882617

Summary of Invention

Technical Problem

[0004] In the case of an electricity storage device such as an all-solid-state battery, use at a higher temperature (for example, 200°C or higher) compared to a lithium-ion battery may be assumed. The present disclosure relates to an exterior material capable of appropriately holding an electricity storage device even at a higher temperature.

Solution to Problem

[0005] The present disclosure includes the following.

[1]

An exterior material for an electricity storage device, comprising:

a barrier layer; and

a thermocompression bonding layer provided on one surface side or both surface sides of the barrier layer,

wherein the thermocompression bonding layer comprises a resin layer that does not melt at 250°C or lower.

[2]

An exterior material for an electricity storage device, comprising:

a barrier layer; and

a thermocompression bonding layer provided on one surface side or both surface sides of the barrier layer,

wherein the thermocompression bonding layer comprises a resin layer comprising a polyamideimide resin, a polycarbonate resin, a polyethersulfone resin, or a polyarylate resin.

[3]

The exterior material for an electricity storage device according to [1] or [2], wherein the thermocompression bonding layer comprises a support film and the two resin layers respectively provided on both surface sides of the support film.

[4]

The exterior material for an electricity storage device according to any one of [1] to [3], wherein the single thermocompression bonding layer is provided on one surface side of the barrier layer, and

the exterior material further comprises a base material layer

provided on a side of the barrier layer opposite to the thermocompression bonding layer.

[5]

The exterior material for an electricity storage device according to any one of [1] to [3], wherein two thermocompression bonding layers are respectively provided on both surface sides of the barrier layer.

[6]

The exterior material for an electricity storage device according to [5], wherein the exterior material further comprises a base material layer, and

one of the two thermocompression bonding layers and the base material layer are provided in this order from the barrier layer side.

[7]

The exterior material for an electricity storage device according to [6], wherein the exterior material further comprises an additional barrier layer provided separately from the barrier layer, and

one of the two thermocompression bonding layers, the additional barrier layer, and the base material layer are provided in this order from the barrier layer side.

[8]

The exterior material for an electricity storage device according to [5], wherein the exterior material further comprises a base material layer, and

the base material layer and one of the two thermocompression bonding layers are provided in this order from the barrier layer side.

[9]

The exterior material for an electricity storage device according to any one of [1] to [8], used for housing an electricity storage device element comprising a solid electrolyte.

[10]

An electricity storage device, comprising:

an electricity storage device element; and

an exterior body housing the electricity storage device element,

wherein the exterior body comprises the exterior material for an electricity storage device according to any one of [1] to [8], and

at least a part of the thermocompression bonding layers of the exterior material for an electricity storage device is bonded to each other.

[11]

The electricity storage device according to [10], wherein the electricity storage device comprises a solid electrolyte.

[12]

A method for manufacturing an electricity storage device, comprising forming an exterior body so as to house an electricity storage device element,

wherein the exterior body is formed by bonding at least a part of the thermocompression bonding layers of the exterior material for an electricity storage device according to any one of [1] to [8] to each other by thermocompression bonding.

[13]

The method according to [12], wherein the electricity storage device element comprises a solid electrolyte.

Advantageous Effects of Invention

[0006] An exterior material capable of appropriately holding an electricity storage device even at a higher temperature (for example, 200°C or higher) can be provided.

Brief Description of Drawings

[0007] FIG. 1 is a cross-sectional view illustrating an example of an exterior material.

FIG. 2 is a cross-sectional view illustrating an example of a thermocompression bonding layer having a support film.

FIG. 3 is a cross-sectional view illustrating an example of an exterior material.

FIG. 4 is a cross-sectional view illustrating an example of an exterior material.

FIG. 5 is a cross-sectional view illustrating an example of an exterior material.

FIG. 6 is a cross-sectional view illustrating an example of an exterior material.

FIG. 7 is a plan view illustrating an example of an electricity storage device.

FIG. 8 is an end view taken along line VIII-VIII of FIG. 7.

Description of Embodiments

[0008] The present invention is not limited to the following examples.

[0009] FIG. 1 is a cross-sectional view illustrating an example of an exterior material. The exterior material 10 illustrated in FIG. 1 is a sheet-shaped laminate having a base material sheet 7 including a barrier

layer 1 and a thermocompression bonding layer 2 provided on one surface side of the base material sheet 7 or on one surface side of the barrier layer 1. The base material sheet 7 is a laminate further including an adhesive layer 3 and a base material layer 5. The base material layer 5 is provided on the side of the barrier layer 1 opposite to the thermocompression bonding layer 2. The barrier layer 1 and the base material layer 5 are bonded by the adhesive layer 3 interposed therebetween.

[0010] The barrier layer 1 is a layer that suppresses permeation of moisture, oxygen, light, and the like. The barrier layer 1 may be a metal layer. The barrier layer 1 may be a metal layer including one or more metals selected from aluminum, stainless steel, copper, nickel, and titanium. The barrier layer 1 may be a metal layer including an alloy composed of two or more metals selected from these. The barrier layer 1 may be a metal foil, and particularly may be an aluminum foil. The thickness of the barrier layer 1 may be, for example, 5 μm or more and 200 μm or less.

[0011] The thermocompression bonding layer 2 includes a resin layer capable of thermocompression bonding. The resin layer of the thermocompression bonding layer 2 is generally insulating. The exterior material 10 can form an exterior body housing an electricity storage device element by thermocompression bonding of the thermocompression bonding layers 2 to each other, thermocompression bonding of the thermocompression bonding layer 2 to another member, or a combination thereof. In general, resin layers that melt at a relatively low temperature are often heat-fused to each other in order to form an

exterior body or a packaging body. In contrast, the exterior material 10 according to the present disclosure has the thermocompression bonding layer 2 including a resin layer capable of bonding by thermocompression bonding at a relatively high temperature.

[0012] When the thermocompression bonding layer is bonded to another member by thermocompression bonding, the resin layer of the thermocompression bonding layer, which has been heated to a rubbery state at or above the glass transition temperature, is pressed against the other member. Since the resin layer generally maintains its form as a "layer" without being completely crushed during thermocompression bonding, re-peeling and re-thermocompression bonding of the resin layer are possible depending on the use conditions. Since the thermocompression bonding layer acts as a cushioning material, stress on the electricity storage device can be relieved, and an effect of preventing damage such as tearing of the exterior material can also be obtained. On the other hand, when the resin layer is bonded to another member by heat fusion, the resin layer, which has been heated above its melting point to become liquid, is pressed against the other member. Therefore, after heat fusion, the original form of the resin layer as a "layer" is often not maintained. In this respect, the resin layer for heat fusion is distinguished from the thermocompression bonding layer.

[0013] The resin layer of the thermocompression bonding layer 2 according to one aspect of the present disclosure may include, for example, one or more resins selected from a polyamideimide resin, a polycarbonate resin, a polyethersulfone resin, and a polyarylate resin. The resin layer of the thermocompression bonding layer 2 may include

a polyamideimide resin (particularly a thermoplastic polyamideimide resin). The polyamideimide resin may be a polyetheramideimide.

[0014] An example of the polyamideimide resin may be a resin produced by a polycondensation reaction of a diamine compound having two amino groups or a diisocyanate compound having two isocyanate groups with a compound having an acidic functional group.

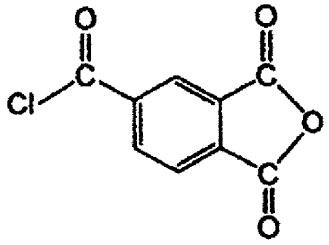
[0015] From the viewpoint of improving heat resistance and chemical resistance, the diamine compound and the diisocyanate compound may be compounds having an aromatic ring. Examples of the diamine compound having an aromatic ring include 1,3-bis(3-aminophenoxy)benzene and 2,2-bis[4-(4-aminophenoxy)phenyl]propane. From the viewpoint of improving flexibility of the thermocompression bonding layer and adjusting thermocompression bondability, the diamine compound may include a compound having an aromatic ring and 1,3-bis(3-aminopropyl)-1,1,3,3-tetramethyldisiloxane.

[0016] The compound having an acidic functional group may be one or more selected from a tricarboxylic acid anhydride, an acid halide of a tricarboxylic acid, and a tricarboxylic acid. These compounds may be used in combination with tetracarboxylic dianhydrides such as pyromellitic anhydride and biphenyltetracarboxylic dianhydride, an aromatic dicarboxylic acids such as terephthalic acid and isophthalic acid, an alicyclic dicarboxylic acids such as cyclohexanedicarboxylic acid, and an aliphatic dicarboxylic acids such as adipic acid and sebacic acid.

[0017] The compound having an acidic functional group may be

an acid halide of trimellitic anhydride, and examples thereof include trimellitic anhydride chloride represented by the following formula (I).

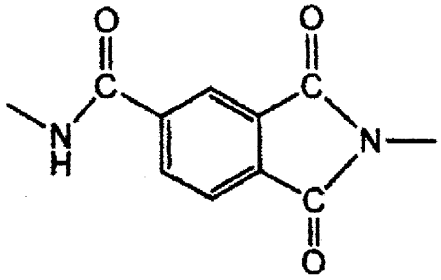
[Chem. 1]



(I)

[0018] The polyamideimide resin may include a structural unit represented by the following formula (Ia).

[Chem. 2]



(Ia)

[0019] The total amount of the diamine compound or the diisocyanate compound may be 0.90 to 1.10 mol, 0.95 to 1.05 mol, or 0.97 to 1.03 mol with respect to 1.00 mol of the total amount of the compound having an acidic functional group. The polyamideimide resin produced at an amount ratio within this range easily forms a uniform polymer structure, and as a result, the thermocompression bonding layer can have higher uniformity in terms of thermocompression bondability, heat resistance, chemical resistance, and the like.

[0020] The content of these resins in the thermocompression bonding layer 2 may be 50% by mass or more and 100% by mass or less,

60% by mass or more and 100% by mass or less, 70% by mass or more and 100% by mass or less, 80% by mass or more and 100% by mass or less, 90% by mass or more and 100% by mass or less, or 95% by mass or more and 100% by mass or less, based on the mass of the thermocompression bonding layer 2 or the resin layer thereof.

[0021] The resin layer of the thermocompression bonding layer 2 may include additional components such as a colorant, a coupling agent, and a resin modifier, as necessary. The content of the additional components may be 50 parts by mass or less with respect to 100 parts by mass of the resin such as a polyamideimide resin, from the viewpoint of appropriate physical properties of the resin layer.

[0022] The coupling agent can contribute to improving heat resistance and improving adhesion to the support film or the barrier layer. The coupling agent can be, for example, a silane coupling agent, a titanium coupling agent, an aluminum coupling agent, or a combination thereof, and may be a silane coupling agent. Examples of the silane coupling agent include vinyltrichlorosilane, vinyltris(β-methoxyethoxy)silane, vinyltriethoxysilane, vinyltrimethoxysilane, γ-methacryloxypropyltrimethoxysilane, γ-methacryloxypropylmethyldimethoxysilane, β-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane, γ-glycidoxypropylmethyldimethoxysilane, γ-glycidoxypropylmethyldiethoxysilane, N-β(aminoethyl)γ-aminopropyltrimethoxysilane, N-β(aminoethyl)γ-aminopropylmethyldimethoxysilane, γ-aminopropyltriethoxysilane, N-

phenyl-γ-aminopropyltrimethoxysilane, γ-mercaptopropyltrimethoxysilane, γ-mercaptopropyltriethoxysilane, 3-aminopropylmethyldiethoxysilane, 3-ureidopropyltriethoxysilane, 3-ureidopropyltrimethoxysilane, 3-aminopropyltrimethoxysilane, 3-aminopropyl-tris[2-(2-methoxyethoxy)ethoxy]silane, N-methyl-3-aminopropyltrimethoxysilane, triaminopropyl-trimethoxysilane, 3-4,5-dihydroimidazol-1-yl-propyltrimethoxysilane, 3-methacryloxypropyl-trimethoxysilane, 3-mercaptopropyl-methyldimethoxysilane, 3-chloropropyl-methyldimethoxysilane, 3-chloropropyl-dimethoxysilane, 3-cyanopropyl-triethoxysilane, hexamethyldisilazane, N,O-bis(trimethylsilyl)acetamide, methyltrimethoxysilane, methyltriethoxysilane, ethyltrichlorosilane, n-propyltrimethoxysilane, isobutyltrimethoxysilane, amyltrichlorosilane, octyltriethoxysilane, phenyltrimethoxysilane, phenyltriethoxysilane, methyltri(methacryloyloxyethoxy)silane, methyltri(glycidyloxy)silane, N-β(N-vinylbenzylaminoethyl)-γ-aminopropyltrimethoxysilane, octadecyldimethyl[3-(trimethoxysilyl)propyl]ammonium chloride, γ-chloropropylmethyldichlorosilane, γ-chloropropylmethyldimethoxysilane, γ-chloropropylmethyldiethoxysilane, trimethylsilyl isocyanate, dimethylsilyl isocyanate, methylsilyl triisocyanate, vinylsilyl triisocyanate, phenylsilyl triisocyanate, tetraisocyanate silane, and ethoxysilane isocyanate. The silane coupling agent may be one or two or more selected from these.

[0023] The thermocompression bonding layer 2 according to one aspect of the present disclosure may include a resin layer that does not

melt at 250°C or lower. "Does not melt at 250°C or lower" means, in other words, that the resin layer does not become liquid at 250°C. For example, if the melting point observed in differential scanning calorimetry of the resin layer exceeds 250°C, the resin layer can be regarded as not melting at 250°C or lower. A resin layer including a resin selected from the already-exemplified polyamideimide resin, polycarbonate resin, polyethersulfone resin, and polyarylate resin often does not melt at 250°C or lower.

[0024] The thermocompression bonding layer 2 may include a resin layer exhibiting a glass transition temperature of 140°C or higher and 280°C or lower. The glass transition temperature of the resin layer of the thermocompression bonding layer 2 may be 150°C or higher, 160°C or higher, 170°C or higher, 180°C or higher, 190°C or higher, or 200°C or higher, and may be 270°C or lower, 260°C or lower, lower than 260°C, 250°C or lower, 240°C or lower, or 230°C or lower.

[0025] The thickness of the thermocompression bonding layer 2 or the resin layer thereof may be, for example, 1 μm or more and 2000 μm or less. The thickness of the thermocompression bonding layer 2 or the resin layer thereof may be 5 μm or more, or 10 μm or more, and may be 1000 μm or less, or 500 μm or less.

[0026] The thermocompression bonding layer 2 may be a single-layer resin layer capable of thermocompression bonding, or may be a laminate having a support film and a resin layer. FIG. 2 is a cross-sectional view illustrating an example of a thermocompression bonding layer having a support film. The thermocompression bonding layer 2 illustrated in FIG. 2 is a laminate composed of a support film 20 and two

resin layers 2A and 2B respectively provided on both surface sides of the support film 20. The support film 20 is provided between the two resin layers 2A and 2B. Each of the resin layers 2A and 2B can be a resin layer capable of the thermocompression bonding in the same manner as the thermocompression bonding layer 2 that is a single-layer resin layer. For example, in the exterior material 10 having the configuration of FIG. 1, the thermocompression bonding layer 2 that is a single-layer resin layer can be replaced with the thermocompression bonding layer 2 having the support film illustrated in FIG. 2.

[0027] The support film 20 can be a film having high heat resistance and sufficiently high adhesion in order to suppress peeling or blistering at the interface between the support film 20 and the resin layers 2A and 2B at a high temperature (for example, 200°C). The glass transition temperature of the support film may be higher than the glass transition temperature of the resin layers capable of thermocompression bonding (resin layers 2A and 2B). The glass transition temperature of the support film 20 need not be detected. When the glass transition temperature of the support film 20 is detected, the glass transition temperature of the support film 20 may be, for example, 200°C or higher, 250°C or higher, 260°C or higher, or 300°C or higher, and may be 400°C or lower, or 350°C or lower. The support film 20 may be, for example, a film including at least one polymer selected from the group consisting of an aromatic polyimide, an aromatic polyamide, an aromatic polyamideimide, an aromatic polysulfone, an aromatic polyethersulfone, a polyphenylene sulfide, an aromatic polyetherketone, a polyarylate, an aromatic polyether ether ketone, polyethylene naphthalate, and

polyethylene terephthalate. From the viewpoint of heat resistance, adhesion to the resin layer at high temperature, and the like, the support film 20 may be a polyimide film including an aromatic polyimide.

[0028] The glass transition temperatures of the resin layer of the thermocompression bonding layer 2 and the support film can be glass transition temperatures measured by a thermomechanical analyzer under the conditions of a tensile mode with a chuck distance of 10 mm, a temperature range of 30°C to 400°C, a heating rate of 10°C/min, and a tensile load of 98 mN, using a strip-shaped test piece having a size of 2 mm in width × 25 mm in length cut out from the resin layer or the support film.

[0029] The support film 20 may be surface-treated in order to sufficiently enhance the adhesion of the support film 20. Examples of the surface treatment methods for the support film 20 include chemical treatment (alkali treatment, silane coupling treatment, and the like), physical treatment (sand mat treatment and the like), plasma treatment, and corona treatment.

[0030] The thickness of the support film 20 is not particularly limited, but may be 100 μm or less, 50 μm or less, or 25 μm or less from the viewpoint of conformability to the shape of the electricity storage device element and the like. The thickness of the support film 20 may be 5 μm or more, or 10 μm or more. The thickness of the support film 20 may be 5 μm or more and 100 μm or less.

[0031] An adhesive layer need not be provided between the thermocompression bonding layer 2 and the barrier layer 1, and in that case, the thermocompression bonding layer 2 and the barrier layer 1 (for

example, a metal foil) may be in direct contact with each other. For example, a resin layer including a polyamideimide resin tends to adhere sufficiently to other layers such as the barrier layer even without an adhesive layer being provided.

[0032] The base material layer 5 can be a resin film commonly used as a base material layer of an exterior material for an electricity storage device, and is a resin film including a resin (particularly a thermoplastic resin) different from the resin constituting the thermocompression bonding layer 2. The base material layer 5 may be a single-layer or multilayer resin film. For example, the base material layer 5 may be a resin film including polyamideimide, polyamide, polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, polyethylene, polypropylene, or a combination thereof. The thickness of the base material layer 5 may be, for example, 5 μm or more and 50 μm or less.

[0033] The adhesive layer 3 is formed by any adhesive capable of bonding the barrier layer 1 and the base material layer 5. For example, the adhesive layer 3 is formed by a curable adhesive such as an energy ray (UV, X-ray, and the like) curable type. The adhesive layer forming the adhesive layer 3 may be a urethane-based adhesive, an olefin-based adhesive, an acrylic-based adhesive, or an epoxy-based adhesive. The thickness of the adhesive layer 3 may be, for example, 2 μm or more and 50 μm or less. The adhesive layer 3 need not be provided.

[0034] FIG. 3 is a cross-sectional view illustrating another example of an exterior material. The exterior material 10 illustrated in FIG. 3 has the barrier layer 1 and two thermocompression bonding layers 2 and 2'

respectively provided on both surface sides of the barrier layer 1. The barrier layer 1 is provided between the two thermocompression bonding layers 2 and 2'. Each of the thermocompression bonding layers 2 and 2' in this case can be a layer similar to the thermocompression bonding layer 2 constituting the exterior material 10 of FIG. 1. The two thermocompression bonding layers 2 and 2' constituting one exterior material 10 can include resin layers including the same or different resins from each other. The thicknesses of the two thermocompression bonding layers 2 and 2' may be the same or different. When one or both of the thermocompression bonding layers 2 and 2' substantially function as a base material layer, a base material layer need not be provided separately from the thermocompression bonding layer.

[0035] FIG. 4 is a cross-sectional view illustrating yet another example of an exterior material. The exterior material 10 illustrated in FIG. 4 differs from the exterior material 10 of FIG. 3 in that it further includes the adhesive layer 3 and the base material layer 5. Each of the adhesive layer 3 and the base material layer 5 of FIG. 4 can be a layer similar to the adhesive layer 3 and the base material layer 5 constituting the exterior material 10 of FIG. 1. One thermocompression bonding layer 2' of the two thermocompression bonding layers 2 and 2' and the base material layer 5 are provided in this order from the barrier layer 1 side. The thermocompression bonding layer 2' and the base material layer 5 are bonded by the adhesive layer 3 interposed therebetween. The adhesive layer 3 need not be provided.

[0036] FIG. 5 is also a cross-sectional view illustrating yet another example of an exterior material. The exterior material 10 illustrated in

FIG. 5 differs from the exterior material 10 of FIG. 4 in that it further has an additional barrier layer 1' provided separately from the barrier layer 1. The additional barrier layer 1' is provided between one thermocompression bonding layer 2' of the two thermocompression bonding layers 2 and 2' and the base material layer 5 (or the adhesive layer 3). In other words, one thermocompression bonding layer 2' of the two thermocompression bonding layers 2 and 2', the additional barrier layer 1', and the base material layer 5 are provided in this order from the barrier layer 1 side. The additional barrier layer 1' can be a layer similar to the barrier layer 1. The two barrier layers 1 and 1' may be the same as or different from each other. The additional barrier layer 1' and the base material layer 5 are bonded by the adhesive layer 3 interposed therebetween. The adhesive layer 3 need not be provided.

[0037] FIG. 6 is also a cross-sectional view illustrating yet another example of an exterior material. The exterior material 10 illustrated in FIG. 6 has the barrier layer 1, two thermocompression bonding layers 2 and 2', the adhesive layer 3, and the base material layer 5. The two thermocompression bonding layers 2 and 2' are respectively provided on both surface sides of the barrier layer 1. In other words, the barrier layer 1 is provided between the two thermocompression bonding layers 2 and 2'. The base material layer 5 and one thermocompression bonding layer 2' of the two thermocompression bonding layers 2 and 2' are provided in this order from the barrier layer 1 side. The barrier layer 1 and the base material layer 5 are bonded by the adhesive layer 3 interposed therebetween. The adhesive layer 3 need not be provided. Each of the barrier layer 1, the two thermocompression bonding layers 2 and 2', the

adhesive layer 3, and the base material layer 5 can be a layer similar to the barrier layer 1, the thermocompression bonding layers 2 and 2', the adhesive layer 3, and the base material layer 5 constituting the exterior material of FIG. 1 or FIGS. 3 to 5. The thermocompression bonding layer 2' of the exterior material 10 of FIG. 6 can also reinforce the function of the base material layer 5 as a base material layer. From such a viewpoint, the glass transition temperature of the thermocompression bonding layer 2' may be higher than the glass transition temperature of the thermocompression bonding layer 2. The difference between the glass transition temperatures of the two may be 10°C or more, or 20°C or more.

[0038] The method for forming the thermocompression bonding layer constituting the exterior material is not particularly limited. For example, a resin layer as the thermocompression bonding layer can be formed by a method including applying a resin varnish for forming a thermocompression bonding layer, which includes a resin for forming the thermocompression bonding layer or a precursor thereof and a solvent, onto the barrier layer 1, and removing the solvent from the coating film. The coating film may be heated to remove the solvent. When manufacturing an exterior material having two thermocompression bonding layers, the resin varnish may be applied onto both surfaces of the barrier layer to form thermocompression bonding layers on both surfaces of the barrier layer. When manufacturing an exterior material having a thermocompression bonding layer provided on a base material layer, the resin varnish may be applied onto the base material layer. A thermocompression bonding

layer including a polyamideimide resin may be formed by a method of removing the solvent from a coating film of a resin varnish including a precursor of a polyamideimide resin (for example, polyamic acid) and a solvent, and further generating a polyamideimide resin by imidization of the precursor.

[0039] Examples of the method for applying the resin varnish include roll coating, reverse roll coating, gravure coating, bar coating, comma coating, die coating, and reduced-pressure die coating.

[0040] The solvent of the resin varnish for forming the thermocompression bonding layer 2 or the resin layer thereof may be, for example, N-methyl-2-pyrrolidone, dimethylacetamide, diethylene glycol dimethyl ether, tetrahydrofuran, cyclohexanone, methyl ethyl ketone, dimethylformamide, or a combination thereof. The resin varnish may further include the above-described additional components as necessary.

[0041] A thermocompression bonding layer formed in advance on any base film can also be used. In that case, the thermocompression bonding layer formed on the base film may be laminated on one surface or both surfaces of the barrier layer. The thermocompression bonding layer can be formed on the base film using the above-described resin varnish. The base film may have a surface subjected to a release treatment (for example, a silicone release treatment), and the above-described resin varnish may be applied onto the surface. A protective film may be provided on the surface of the thermocompression bonding layer on the side opposite to the base film.

[0042] FIG. 7 is a plan view illustrating an example of an

electricity storage device having an exterior body formed by an exterior material. FIG. 8 is an end view taken along line VIII-VIII of FIG. 7. The electricity storage device 100 illustrated in FIGS. 7 and 8 has an electricity storage device element 30, a connection terminal 31 connected to the electricity storage device element 30, and an exterior body 40 housing the electricity storage device element 30. The exterior body 40 seals the electricity storage device element 30. The connection terminal 31 extends to the outside of the exterior body 40.

[0043] The exterior body 40 is formed by, for example, an exterior material 10 having a base material sheet 7 including a barrier layer 1, and a thermocompression bonding layer 2, as illustrated in FIG. 1. At the peripheral portion 40A of the exterior body 40, the thermocompression bonding layers 2 of the exterior material 10 are bonded to each other. The connection terminal 31 may be sandwiched between the two thermocompression bonding layers 2.

[0044] The electricity storage device element 30 can be any structure having a function of storing electricity. For example, the electricity storage device element 30 may have a positive electrode, a negative electrode, and an electrolyte provided between the positive electrode and the negative electrode. The electrolyte may be a solid electrolyte, and in that case, the electricity storage device 100 can be an all-solid-state battery. An all-solid-state battery may be required to have high durability even in a high-temperature environment (for example, 200°C or higher), and if the exterior body 40 is deformed at a high temperature, there is a possibility that the electricity storage device element 30 is not appropriately fixed. However, the exterior body 40

formed by the exterior material having the specific thermocompression bonding layer according to the present disclosure can appropriately hold the electricity storage device element 30 even in a high-temperature environment.

[0045] The exterior body 40 may be formed by combining two or more exterior materials 10, or may be formed by folding one exterior material 10. For example, the exterior body 40 can be formed by a method including bonding, by thermocompression bonding, two thermocompression bonding layers 2 that are arranged to face each other when the exterior materials 10 are overlapped in a state in which the electricity storage device element 30 is housed. The heating temperature for thermocompression bonding may be, for example, 180°C or higher and 400°C or lower. For thermocompression bonding, the overlapping exterior materials 10 may be heated while being pressurized. In that case, the pressure applied to the pressurized surface of the exterior material may be 0.2 MPa or more and 10 MPa or less. The heating time may be, for example, 1 second or more and 60 seconds or less. The thermocompression bonding layers 2 may be bonded to each other by thermocompression bonding performed a plurality of times (for example, three times). The thermocompression bonding layers 2 need not be bonded to each other over the entire peripheral portion of the exterior body 40. The thermocompression bonding layers 2 may be bonded to each other at a part of the peripheral portion of the exterior body 40 so that the electricity storage device element 30 can be housed.

Examples

[0046] The present invention is not limited to the following

examples.

1. Production of exterior materials of Examples A to E

(1) Production of resin varnish for film formation

Resin Varnish A

In a 5-liter four-necked flask equipped with a thermometer, a stirrer, a nitrogen inlet tube, and a fractionating column, 270.9 g (0.66 mol) of 2,2-bis[4-(4-aminophenoxy)phenyl]propane and 8.7 g (0.035 mol) of 1,3-bis(3-aminopropyl)tetramethyldisiloxane were dissolved in 1950 g of N-methyl-2-pyrrolidone under a nitrogen atmosphere. The resulting solution was cooled to -10°C, and 149.5 g (0.71 mol) of trimellitic anhydride chloride was added while maintaining the temperature. After the trimellitic anhydride chloride was dissolved, 100 g of triethylamine was added so as not to exceed 10°C. A reaction at room temperature for 3 hours produced a polyamic acid. Imidization was allowed to proceed by heating the solution at 180°C for 5 hours to produce a polyetheramideimide from the polyamic acid. The solution containing the polyetheramideimide was poured into methanol. The precipitated solid content was collected and dried. The dried solid content was dissolved in N-methyl-2-pyrrolidone, and the solution was poured into methanol to precipitate the solid content again. The solid content was dried under reduced pressure to obtain purified powdery polyetheramideimide A (thermoplastic polyamideimide resin). 120 g of this polyetheramideimide A and 3.6 g of a silane coupling agent (manufactured by Dow Toray Co., Ltd., trade name: XIAMETER (registered trademark) OFS-6040 Silane) were dissolved in 280 g of N-methyl-2-pyrrolidone to obtain a resin varnish A for forming a

thermocompression bonding layer.

[0047] Resin Varnish B

In a 5-liter four-necked flask equipped with a thermometer, a stirrer, a nitrogen inlet tube, and a fractionating column, 258.6 g (0.63 mol) of 2,2-bis[4-(4-aminophenoxy)phenyl]propane and 67.0 g (0.27 mol) of 1,3-bis(3-aminopropyl)tetramethyldisiloxane were dissolved in 1550 g of N-methyl-2-pyrrolidone under a nitrogen atmosphere. The resulting solution was cooled to -10°C, and 187.3 g (0.89 mol) of trimellitic anhydride chloride was added while maintaining the temperature. After the trimellitic anhydride chloride was dissolved, 100 g of triethylamine was added so as not to exceed 10°C. A reaction at room temperature for 3 hours produced a polyamic acid. Imidization was allowed to proceed by heating the solution at 180°C for 5 hours to produce a polyetheramideimide from the polyamic acid. The solution containing the polyetheramideimide was poured into methanol. The precipitated solid content was collected and dried. The dried solid content was dissolved in N-methyl-2-pyrrolidone, and the solution was poured into methanol to precipitate the solid content again. The solid content was dried under reduced pressure to obtain purified powdery polyetheramideimide B (thermoplastic polyamideimide resin). 120 g of this polyetheramideimide B and 3.6 g of a silane coupling agent (manufactured by Dow Toray Co., Ltd., trade name: XIAMETER (registered trademark) OFS-6040 Silane) were dissolved in 280 g of N-methyl-2-pyrrolidone to obtain a resin varnish B for forming a thermocompression bonding layer.

[0048] Resin Varnish C

18 g of polyetheramideimide A synthesized in the production of resin varnish A, 102 g of polyetheramideimide B synthesized for the production of resin varnish B, and 3.6 g of a silane coupling agent (manufactured by Dow Toray Co., Ltd., trade name: XIAMETER (registered trademark) OFS-6040 Silane) were dissolved in 280 g of N-methyl-2-pyrrolidone to obtain a resin varnish C for forming a thermocompression bonding layer.

[0049] Resin Varnish D

In a 5-liter four-necked flask equipped with a thermometer, a stirrer, a nitrogen inlet tube, and a fractionating column, 235.3 g (0.80 mol) of 1,3-bis(3-aminophenoxy)benzene and 85.6 g (0.34 mol) of 1,3-bis(3-aminopropyl)tetramethyldisiloxane were dissolved in 1500 g of N-methyl-2-pyrrolidone under a nitrogen atmosphere. The resulting solution was cooled to -10°C, and 239.7 g (1.14 mol) of trimellitic anhydride chloride was added while maintaining the temperature. After the trimellitic anhydride chloride was dissolved, 138.0 g (1.36 mol) of triethylamine was added so as not to exceed 10°C. A reaction at room temperature for 3 hours produced a polyamic acid. Imidization was allowed to proceed by heating the solution at 180°C for 5 hours to produce a polyetheramideimide from the polyamic acid. The solution containing the polyetheramideimide was poured into methanol. The precipitated solid content was collected and dried. The dried solid content was dissolved in N-methyl-2-pyrrolidone, and the solution was poured into methanol to precipitate the solid content again. The solid content was dried under reduced pressure to obtain purified powdery polyetheramideimide D (thermoplastic polyamideimide resin). 120 g of

this polyetheramideimide D and 6.0 g of a silane coupling agent (manufactured by Dow Toray Co., Ltd., trade name: XIAMETERTM (registered trademark) OFS-6040 Silane) were dissolved in 280 g of N-methyl-2-pyrrolidone to obtain a resin varnish D for forming a thermocompression bonding layer.

[0050] Resin Varnish E

In a 5-liter four-necked flask equipped with a thermometer, a stirrer, a nitrogen inlet tube, and a fractionating column, 172.4 g (0.42 mol) of 2,2-bis[4-(4-aminophenoxy)phenyl]propane and 153.7 g (0.42 mol) of 4,4'-methylenebis(2,6-diisopropylaniline) were dissolved in 1550 g of N-methyl-2-pyrrolidone under a nitrogen atmosphere. The resulting solution was cooled to -10°C, and 174.7 g (0.83 mol) of trimellitic anhydride chloride was added while maintaining the temperature. After the trimellitic anhydride chloride was dissolved, 130 g of triethylamine was added so as not to exceed 10°C. A reaction at room temperature for 3 hours produced a polyamic acid. Imidization was allowed to proceed by heating the solution at 180°C for 5 hours to produce a polyetheramideimide from the polyamic acid. The solution containing the polyetheramideimide was poured into methanol. The precipitated solid content was collected and dried. The dried solid content was dissolved in N-methyl-2-pyrrolidone, and the solution was poured into methanol to precipitate the solid content again. The solid content was dried under reduced pressure to obtain purified powdery polyetheramideimide E (thermoplastic polyamideimide resin). 120 g of this polyetheramideimide E and 6.0 g of a silane coupling agent (manufactured by Dow Toray Co., Ltd., trade name: XIAMETER

(registered trademark) OFS-6040 Silane) were dissolved in 280 g of N-methyl-2-pyrrolidone to obtain a resin varnish E for forming a thermocompression bonding layer.

[0051] (2) Production of exterior materials

Examples A to E

Resin varnish A was applied onto a rough, non-glossy surface of an aluminum foil (manufactured by Toyo Aluminium K.K., TY-X2, material 8079). The coating film was dried by heating at 100°C for 10 minutes and at 300°C for 10 minutes to form a thermocompression bonding layer having a thickness of approximately 40 μm on the aluminum foil. By the above method, an exterior material for evaluation of Example A, which is a sheet-shaped laminate having an aluminum foil (barrier layer) and a thermocompression bonding layer, was produced. Exterior materials for evaluation of Examples B, C, D, and E were produced in the same manner except that resin varnishes B, C, D, and E were used, respectively.

[0052] 2. Evaluation

(1) Change in appearance of exterior material at high temperature

A plurality of strip-shaped test pieces having a width of 10 mm and a length of 50 mm were cut out from each exterior material for evaluation. Two test pieces were superposed with the thermocompression bonding layers facing each other. The resulting laminate was thermocompression bonded under the conditions shown in Table 1 to bond the thermocompression bonding layers to each other, thereby producing a bonded body for evaluating appearance change. The pressure of the thermocompression bonding conditions shown in

Table 1 (1 MPa) is the pressure applied to the laminate. This bonded body was placed on a hot plate heated to 200°C, 220°C, or 250°C for 10 seconds. At that point, the bonded body was observed to confirm the presence or absence of appearance changes such as blistering and wrinkling. As shown in Table 1, it was confirmed that none of the bonded bodies showed appearance changes such as blistering and wrinkling at high temperature, and all had excellent heat resistance.

[0053] (2) Glass transition temperature of thermocompression bonding layer

Each of resin varnishes A, B, C, D, and E was applied onto a support film that could be peeled off after drying. The coating film was dried by heating at 100°C for 10 minutes and at 300°C for 10 minutes to form a thermocompression bonding layer having a thickness of approximately 40 μm on the support film. A strip-shaped test piece having a size of 2 mm in width × 25 mm in length was cut out from the thermocompression bonding layer peeled off from the support film. This test piece was attached to a chuck for tensile mode measurement of a thermomechanical analyzer (manufactured by Hitachi High-Tech Corporation, TMA/SS7100 type). The chuck distance was set to 10 mm. Measurement was performed under the conditions of a temperature range of 30°C to 300°C, a heating rate of 10°C/min, and a tensile load of 98 mN. From the measurement results, the glass transition temperatures of the thermocompression bonding layers formed from resin varnishes A, B, C, D, and E were determined. The measured glass transition temperatures are shown in Table 1.

[0054] [Table 1]

		Examples				
Thermocompression bonding layer	Resin varnish	A	B	C	D	E
	Glass transition temperature [°C]	230	180	190	150	260
Bonded body	Thermocompression bonding conditions	250°C 1MPa 5 sec	230°C 1MPa 5 sec	230°C 1MPa 5 sec	200°C 1MPa 5 sec	280°C 1MPa 5 sec
Appearance change	200°C/10 sec	None	None	None	None	None
	220°C/10 sec	None	None	None	None	None
	250°C/10 sec	None	None	None	None	None

[0055] (3) Exterior materials having a heat-fusion layer (Comparative Examples A and B)

For comparison, exterior materials of Comparative Examples A and B, which are sheet-shaped laminates of an aluminum foil and a heat-fusion layer (thickness: approximately 40 μm) including polyethylene or polyethylene terephthalate, were prepared. A plurality of strip-shaped test pieces having a width of 10 mm and a length of 50 mm were cut out from these exterior materials. Two test pieces were superposed with the heat-fusion layers facing each other. The resulting laminate was heat-fused under the conditions shown in Table 2 to bond the heat-fusion layers to each other, thereby producing a bonded body for evaluating appearance change. The pressure of the heat-fusion conditions shown in Table 2 (1 MPa) is the pressure applied to the laminate. The heat-fusion layer including polyethylene melts at approximately 100°C. The heat-fusion layer including polyethylene terephthalate resin melts at 250°C or lower. The change in appearance at high temperature of the bonded

bodies formed by the exterior materials of Comparative Examples A and B was evaluated by the same method as described above. As shown in the results in Table 2, blistering or wrinkling was observed at a high temperature of 200°C or higher.

[0056] [Table 2]

		Comparative Examples	
		A	B
Heat-fusion layer	Resin	Polyethylene	Polyethylene terephthalate
	Glass transition temperature [°C]	-125°C	70 to 80°C
Bonded body	Heat-fusion conditions	130°C 1MPa 5 sec	250°C 1MPa 5 sec
Appearance change	200°C/10 sec	Blistering present	None
	220°C/10 sec	-	None
	250°C/10 sec	-	Wrinkling/blistering present

Reference Signs List

[0057] 1: barrier layer, 1': additional barrier layer, 2, 2': thermocompression bonding layer, 3: adhesive layer, 5: base material layer, 7: base material sheet, 10: exterior material, 20: support film, 30: electricity storage device element, 31: connection terminal, 40: exterior body, 100: electricity storage device.

CLAIMS

[Claim 1]

An exterior material for an electricity storage device, comprising:

a barrier layer; and

a thermocompression bonding layer provided on one surface side or both surface sides of the barrier layer,

wherein the thermocompression bonding layer comprises a resin layer comprising one or more resins selected from a polyamideimide resin, and a polyethersulfone resin.

[Claim 2]

The exterior material for an electricity storage device according to claim 1, wherein the thermocompression bonding layer comprises a support film and the two resin layers respectively provided on both surface sides of the support film.

[Claim 3]

The exterior material for an electricity storage device according to claim 1, wherein the single thermocompression bonding layer is provided on one surface side of the barrier layer, and

the exterior material further comprises a base material layer provided on a side of the barrier layer opposite to the thermocompression bonding layer.

[Claim 4]

The exterior material for an electricity storage device according to claim 1, wherein two thermocompression bonding layers are respectively provided on both surface sides of the barrier layer.

[Claim 5]

The exterior material for an electricity storage device according to claim 4, wherein the exterior material further comprises a base material layer, and

one of the two thermocompression bonding layers and the base material layer are provided in this order from the barrier layer side.

[Claim 6]

The exterior material for an electricity storage device according to claim 5, wherein the exterior material further comprises an additional barrier layer provided separately from the barrier layer, and

one of the two thermocompression bonding layers, the additional barrier layer, and the base material layer are provided in this order from the barrier layer side.

[Claim 7]

The exterior material for an electricity storage device according to claim 4, wherein the exterior material further comprises a base material layer, and

the base material layer and one of the two thermocompression bonding layers are provided in this order from the barrier layer side.

[Claim 8]

The exterior material for an electricity storage device according to claim 1, used for housing an electricity storage device element comprising a solid electrolyte.

[Claim 9]

An electricity storage device, comprising:

an electricity storage device element; and

an exterior body housing the electricity storage device element,

wherein the exterior body comprises the exterior material for an electricity storage device according to claim 1, and at least a part of the thermocompression bonding layers of the exterior material for an electricity storage device is bonded to each other.

[Claim 10]

The electricity storage device according to claim 9, wherein the electricity storage device comprises a solid electrolyte.

[Claim 11]

A method for manufacturing an electricity storage device, comprising forming an exterior body so as to house an electricity storage device element,

wherein the exterior body is formed by bonding at least a part of the thermocompression bonding layers of the exterior material for an electricity storage device according to claim 1 to each other by thermocompression bonding.

[Claim 12]

The method according to claim 11, wherein the electricity storage device element comprises a solid electrolyte.