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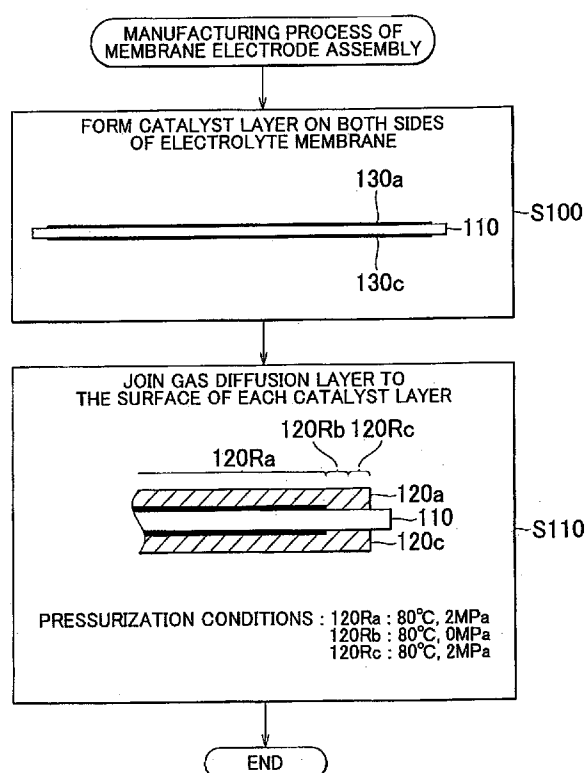
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FIG. 2



(57) Abstract: In manufacturing a membrane electrode assembly, an anode catalyst layer (130a) is formed on one side of an electrolyte membrane (110) and then a cathode catalyst layer (130c) is formed on the other side of the electrolyte membrane (110). Next, an anode gas diffusion layer (120a) is hot-press joined to the surface of the anode catalyst layer (130a) and a cathode gas diffusion layer (120c) is hot-press joined to the surface of the cathode catalyst layer (130c). The applied pressure during the hot-press joining at a region (120Rb), where the anode catalyst layer (130a) and the cathode catalyst layer (130c) are not formed on the electrolyte membrane (110), is less than the applied pressure at a region (120Ra), where the anode catalyst layer (130a) and the cathode catalyst layer (130c) are formed on the electrolyte membrane (110).

MANUFACTURING METHOD OF MEMBRANE ELECTRODE ASSEMBLY USED IN A FUEL CELL, AND MEMBRANE ELECTRODE ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a manufacturing method of a membrane electrode assembly used in a fuel cell, and a membrane electrode assembly.

2. Description of the Related Art

[0002] Fuel cells, which generate power through an electrochemical reaction between hydrogen and oxygen, are attracting attention as energy sources. Fuel cells are formed by sandwiching a membrane electrode assembly, in which gas diffusion electrodes (i.e., an anode and a cathode) are joined, one on each side, to a proton-conducting electrolyte membrane (such as a solid polymer membrane), in between separators. The anode and cathode each have a catalyst layer that promotes the electrochemical reaction, and a gas diffusion layer that diffuses reaction gas (i.e., a fuel gas on one side and an oxidant gas on the other side), supplied from to the fuel cell, across the catalyst layer.

[0003] Various technologies have been proposed for this kind of membrane electrode assembly. For example, Japanese Patent Application Publication No. 2006-164887 (JP-A-2006-164887) describes a technique to prevent wrinkling of the outer peripheral portion of a membrane electrode assembly by hot-pressing together, with even pressure, a central portion of the membrane electrode assembly, where the polymer electrolyte membrane overlaps an electrode sheet, and an outer peripheral portion of the membrane electrode assembly, that surrounds the central portion.

[0004] In a membrane electrode assembly, the catalyst layer may be formed in a region having a smaller area than the area of the gas diffusion layer substrate that constitutes the gas diffusion layer in order to effectively utilize a comparatively expensive catalyst for power generation, i.e., in order to utilize almost the entire region of the catalyst layer that is formed on the electrolyte membrane. Also, the gas diffusion layer

substrate is typically made of carbon cloth or carbon paper that diffuses gas and conducts electricity. When manufacturing a membrane electrode assembly, the electrolyte membrane, the catalyst layer, and the gas diffusion layer (i.e., the gas diffusion layer substrate) are typically joined together by pressure-joining (e.g., hot-press joining).

[0005] Carbon fiber pile is typically present on the surface of carbon paper and carbon cloth used for the gas diffusion layer substrate. Therefore, with a membrane electrode assembly in which the catalyst layer is formed on a region having a smaller area than the area of the gas diffusion layer substrate that constitutes the gas diffusion layer as described above, the region of the surface of the electrolyte membrane on which the catalyst layer is not formed, i.e., the region where the electrolyte membrane and the gas diffusion layer substrate are directly joined, is more susceptible to damage from the carbon fiber pile during pressure-joining (hereinafter in this specification, the term "damage" refers to damage from carbon fiber pile during pressure-joining). A region of the electrolyte membrane that has been damaged is susceptible to short-circuiting between the anode and cathode, and cross-leaking through the electrolyte membrane. Such problems are particularly pronounced if the electrolyte membrane is made thinner to improve power generation efficiency, i.e., to reduce membrane resistance.

SUMMARY OF THE INVENTION

[0006] This invention provides a membrane electrode assembly that inhibits cross-leaking as well as short-circuiting between the anode and the cathode in a fuel cell as a result of damage sustained by the electrolyte membrane during the manufacture of the membrane electrode assembly.

[0007] A first aspect of the invention relates to a method of manufacturing a membrane electrode assembly. The membrane electrode assembly is used in a fuel cell and has a catalyst layer provided on both sides of an electrolyte membrane and a gas diffusion layer provided on at least one surface of the electrolyte membrane. The manufacturing method according to this aspect of the invention includes i) forming the catalyst layer in a region of at least one of the electrolyte membrane and a gas diffusion

layer substrate that constitutes the gas diffusion layer, the region excluding a peripheral edge portion of the at least one surface and having an area smaller than the area of the gas diffusion layer substrate; and ii) joining the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate together by pressure-joining such that the catalyst layer is arranged in a region between the electrolyte membrane and the gas diffusion layer substrate. The pressure-joining is performed in a catalyst layer non-forming region, where the catalyst layer is not formed, in the surface of the electrolyte membrane, under a plurality of pressurization conditions, which include pressurization pressure, pressurization temperature, and pressurization time during the pressure-joining, at least one of which is different from at least one of the pressurization conditions under which pressure-joining is performed in a catalyst layer forming region, where the catalyst layer is formed.

[0008] In the joining step, the pressure-joining is performed in a non-catalyst layer forming region where the catalyst layer is not formed in the surface of the electrolyte membrane, under a plurality of pressurization conditions which include pressurization pressure, pressurization temperature, and pressurization time during the pressure-joining, at least one of which is different from at least one of the pressurization conditions under which pressure-joining is performed in a catalyst layer forming region where the catalyst layer is formed. Accordingly, the adhesive force between the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate may be controlled as appropriate for each region. For example, in a region where the electrolyte membrane may be easily damaged, pressure-joining may be performed under pressurization conditions that do not easily damage the electrolyte membrane. Therefore, according to the manufacturing method of this aspect, cross-leaks and short-circuits between the anode and the cathode due to damage sustained by the electrolyte membrane during manufacture of the membrane electrode assembly may be suppressed. In particular, the manufacturing method according to this aspect is highly effective when applied to a membrane electrode assembly that uses a relatively weak solid polymer membrane as the electrolyte membrane. Also, hot-press joining, for

example, may be applied as pressure-joining.

[0009] In addition, the pressure-joining may be performed under pressurization conditions such that an adhesive force between the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate in the catalyst layer forming region is greater than the adhesive force between the electrolyte membrane and the gas diffusion layer substrate in at least a portion of the catalyst layer non-forming region.

[0010] Here, the pressurization conditions under which the adhesive force becomes great are equivalent to pressurization conditions under which the electrolyte membrane is easily damaged from heat and pressure, and the pressurization conditions under which the adhesive force becomes low are equivalent to pressurization conditions under which the electrolyte membrane is not easily damaged by heat and pressure. Generally, the adhesive force increases with increasing the pressurization pressure and pressurization temperature, and increasing the pressurization time. On the other hand, the adhesive force decreases with decreasing the pressurization pressure and pressurization temperature, and reducing the pressurization time.

[0011] According to the manufacturing method of this aspect, in the membrane electrode assembly, the catalyst layer also functions as a protective film that protects the electrolyte membrane from damage in the catalyst layer forming region. Accordingly, even if pressure-joining is performed under pressurization conditions that result in a relatively strong adhesive force in this region, damage to the electrolyte membrane will be relatively little. Thus, contact resistance may be decreased by increasing the adhesive force between the electrolyte membrane, the catalyst layer, and the gas diffusion layer. Also, in the catalyst layer non-forming region, pressure-joining is performed under pressurization conditions that result in an adhesive force that is weaker than the adhesive force in the catalyst layer forming region, so damage to the electrolyte membrane may be reduced.

[0012] In the manufacturing method of this aspect, the catalyst layer non-forming region may include a first catalyst layer non-forming region on an outer periphery closest to the catalyst layer, and a second catalyst layer non-forming region on an outer periphery

of the first catalyst layer non-forming region. Further, the pressure-joining may be performed under the pressurization conditions such that the adhesive force between the electrolyte membrane and the gas diffusion layer substrate in the second catalyst layer non-forming region is greater than the adhesive force between the electrolyte membrane and the gas diffusion layer substrate in the first catalyst layer non-forming region. Accordingly, the adhesive force between the gas diffusion layer substrate and the electrolyte membrane in the second catalyst layer non-forming region on the outer periphery of the first catalyst layer non-forming region may be made greater than the adhesive force between the gas diffusion layer substrate and the electrolyte membrane in the first catalyst layer non-forming region. As a result, peeling at the boundary between the gas diffusion layer substrate and the electrolyte membrane in the catalyst layer non-forming region of the membrane electrode assembly may be suppressed.

[0013] In the manufacturing method of this aspect, the membrane electrode assembly may be provided with a first gas diffusion layer substrate that is joined to one side of the electrolyte membrane and a second gas diffusion layer substrate that is joined to the other side of the electrolyte membrane, as the gas diffusion layer. Also, the area of the first gas diffusion layer substrate may be smaller than the area of the electrolyte membrane, and the area of the second gas diffusion layer substrate may be larger than the area of the first gas diffusion layer substrate. Further, the pressure-joining may be performed under the pressurization conditions such that the adhesive force between the electrolyte membrane and an outermost peripheral portion of the second gas diffusion layer substrate is greater than the adhesive force between the electrolyte membrane and the second gas diffusion layer substrate in the second catalyst layer non-forming region. Also, a frame member that functions as a gasket may be formed on an outer peripheral portion of the catalyst layer non-forming region.

[0014] In a membrane electrode assembly in which the gas diffusion layer substrate and the electrolyte membrane generally have the same outer shapes, a short-circuit may occur between portions of the anode and the cathode from an outer peripheral portion of the first gas diffusion layer substrate (such as the anode gas

diffusion layer substrate) and an outer peripheral portion of the second gas diffusion layer substrate (such as the cathode gas diffusion layer substrate) that wrap around the outermost peripheral portion of the electrolyte membrane at the outermost peripheral portion of the membrane electrode assembly and come into contact with one another. In order to prevent this kind of short-circuiting from occurring, the outer shapes of the anode gas diffusion layer substrate and the cathode gas diffusion layer substrate are sometimes made different from one another. Also, when the membrane electrode assembly is applied to a fuel cell, a gasket, such as a resin or rubber frame member, may be integrally formed on the outer peripheral portion of the membrane electrode assembly. In this case, the frame member is often formed through injection molding. During injection molding of the frame member, material for forming the frame member is often injected from an outer peripheral portion of the mold. Accordingly, at this time, the inflow of the material may cause peeling to occur at the boundary between the electrolyte membrane and the gas diffusion layer substrate. With the membrane electrode assembly of this aspect of the invention, however, the pressure-joining may be performed under pressurization conditions such that the adhesive force between the electrolyte membrane and the outermost peripheral portion of the second gas diffusion layer substrate is greater than the adhesive force between the electrolyte membrane and the second gas diffusion layer substrate in the second catalyst layer non-forming region, which suppresses peeling at the boundary between the gas diffusion layer substrate and the electrolyte membrane during injection molding. Thus, if the outermost peripheral portion of the membrane electrode assembly is embedded in the frame member, cross leaking will not occur through the electrolyte membrane even if the electrolyte membrane sustains a relatively large amount of damage in the region.

[0015] A second aspect of the invention relates to a membrane electrode assembly. The membrane electrode assembly is used in a fuel cell and has a catalyst layer provided on both sides of an electrolyte membrane and a gas diffusion layer provided on at least one surface. In the membrane electrode assembly, the catalyst layer is formed between the electrolyte membrane and the gas diffusion layer, in a region which excludes a

peripheral edge portion of a surface of a gas diffusion layer substrate that constitutes the gas diffusion layer, and has an area smaller than the area of the gas diffusion layer substrate. Also, i) the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate, or ii) the electrolyte membrane and the gas diffusion layer substrate are joined together by pressure-joining in a catalyst layer non-forming region, where the catalyst layer is not formed in the surface of the electrolyte membrane, under a plurality of pressurization conditions, which include pressurization pressure, pressurization temperature, and pressurization time, at least one of which is different from at least one of the pressurization conditions under which pressure-joining is performed in a catalyst layer forming region where the catalyst layer is formed.

[0016] A third aspect of the invention relates to a membrane electrode assembly. The membrane electrode assembly is used in a fuel cell and has a catalyst layer provided on both sides of an electrolyte membrane and a gas diffusion layer provided on at least one surface. The catalyst layer is formed between the electrolyte membrane and the gas diffusion layer, in a region which excludes a peripheral edge portion of a surface of a gas diffusion layer substrate that constitutes the gas diffusion layer, and has an area smaller than the area of the gas diffusion layer substrate. Also, adhesive force between the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate in a catalyst layer forming region, where the catalyst layer is formed, is greater than the adhesive force between the electrolyte membrane and the gas diffusion layer substrate in a catalyst layer non-forming region, where the catalyst layer is not formed, in the surface of the membrane electrode assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The foregoing and further features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIGS. 1A and 1B are views schematically showing the structure of a membrane

electrode assembly 100 according to a first embodiment of the invention;

FIG. 2 is a view illustrating a manufacturing process of the membrane electrode assembly 100 according to the first embodiment;

FIGS. 3A and 3B are views schematically showing the structure of a membrane electrode assembly 100A according to a second embodiment of the invention; and

FIG. 4 is a view illustrating a manufacturing process of the membrane electrode assembly 100A according to the second embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0018] In the following description and the accompanying drawings, the present invention will be described in greater detail with reference to embodiments. FIG. 1 is a view schematically showing the structure of a membrane electrode assembly 100 according to a first embodiment of the invention. This membrane electrode assembly 100 is used in a fuel cell. FIG. 1A is a plan view of the membrane electrode assembly 100 as viewed from the anode, and FIG. 1B is a sectional view of the membrane electrode assembly 100 taken along line I-I in FIG. 1A.

[0019] As shown in FIG. 1B, the membrane electrode assembly 100 is formed by laminating an anode catalyst layer 130a and an anode gas diffusion layer 120a, in the stated order, to one side of a proton-conducting electrolyte membrane 110, and laminating a cathode catalyst layer 130c and a cathode gas diffusion layer 120c, in the stated order, to the other side of the proton-conducting electrolyte membrane 110.

[0020] In the membrane electrode assembly 100 according to the first embodiment, the area of the anode gas diffusion layer 120a is substantially equal to the area of the cathode gas diffusion layer 120c. Further, the areas of the anode gas diffusion layer 120a and the cathode gas diffusion layer 120c are both smaller than the area of the electrolyte membrane 110. As a result, a short circuit resulting from the contact between an outer peripheral portion of the anode gas diffusion layer 120a and an outer peripheral portion of the cathode gas diffusion layer 120c wrapping around the outermost peripheral portion of the electrolyte membrane 110 may be prevented.

[0021] Although a solid polymer electrolyte membrane is used as the electrolyte membrane 110 in this embodiment, other suitable types of electrolyte membranes may also be used. In addition, while carbon paper is used as the gas diffusion layer substrate that constitutes the anode gas diffusion layer 120a and the cathode gas diffusion layer 120c in this embodiment, other materials that suitably diffuse gas and conduct electricity, such as carbon cloth, may also be used as the gas diffusion layer substrate.

[0022] The membrane-electrode assembly 100 of this embodiment is—manufactured using a hot-press, which will be described later, but it may also be manufactured using other suitable pressure-joining methods. The anode catalyst layer 130a and the cathode catalyst layer 130c have the same area and are formed on opposing regions sandwiching the electrolyte membrane 110. In FIG. 1A, the region 120Ra enclosed by the alternate long and short dash line indicates the region in which the anode catalyst layer 130a is formed between the electrolyte membrane 110 and the anode gas diffusion layer 120a, as well as the region in which the cathode catalyst layer 130c is formed between the electrolyte membrane 110 and the cathode diffusion catalyst layer 120c. Thus the region 120Ra may be regarded as a catalyst layer region of the invention.

[0023] Also, the region 120Rb, which is enclosed by the broken line on the outer periphery nearest the region 120Ra, represents the region in which the anode catalyst layer 130a is not formed between the electrolyte membrane 110 and the anode gas diffusion layer 120a. Also, the region 120Rc, which is enclosed by the outer peripheral solid line on the outer periphery of the region 120Rb, represents the region where the cathode catalyst layer 130c is not formed between the electrolyte membrane 110 and the cathode gas diffusion layer 120c. That is, the anode catalyst layer 130a is formed in a region having a smaller area than the area of the anode gas diffusion layer 120a, and the cathode catalyst layer 130c is formed in a region having a smaller area than the area of the cathode gas diffusion layer 120c so that almost the entire region of the anode catalyst layer 130a and almost the entire region of the cathode catalyst layer 130c, which are formed on the electrolyte membrane 110, are effectively used to generate electricity.

The boundaries of the region 120Rb and the region 120Rc may be set as appropriate. However, the width of the region 120Rc is preferably as small as possible to minimize damage to the electrolyte membrane 110 by hot pressing in the region 120Rc, as will be described later. The difference between the region 120Rc and the region 120Rb will be described later. The region 120Rb and the region 120Rc may be regarded as catalyst layer non-forming regions of the invention. Also, the region 120Rb may be regarded as a first catalyst layer non-forming region of the invention, and the region 120Rc may be regarded as a second catalyst layer non-forming region.

[0024] Also in this embodiment, hot-press joining is performed under different pressurization conditions for each of the regions described above during the manufacturing of the membrane electrode assembly 100, as will be described later. Hereinafter, the manufacturing process of the membrane electrode assembly 100 will be described.

[0025] FIG. 2 is a view illustrating a manufacturing process of the membrane electrode assembly 100 according to the first embodiment. First, the anode catalyst layer 130a is formed on one side of the electrolyte membrane 110 and the cathode catalyst layer 130c is formed on the other side of the electrolyte membrane 110 (step S100).

[0026] In this embodiment, the anode catalyst layer 130a is formed by applying a catalyst ink to a region on one side of the electrolyte membrane 110, which excludes the peripheral edge portion of the surface of the electrolyte membrane 110 and has a smaller area than the area of the anode gas diffusion layer 120a, and then drying the catalyst ink. Similarly, the cathode catalyst layer 130c is formed by applying the catalyst ink to a region on the other side of the electrolyte membrane 110, excluding the peripheral edge portion of the surface of the electrolyte membrane 110, that has a smaller area than the area of the cathode gas diffusion layer 120c, and then drying the catalyst ink. The catalyst ink is a mixture of i) carbon that carries a catalyst metal such as platinum (Pt), for example, which promotes the electrochemical reaction between hydrogen and oxygen, ii) a Nafion dispersing solution (Nafion is a registered trademark) as the electrolyte solution,

and iii) a medium (such as water, ethanol, or polyethylene glycol). The mixture fraction may be set as appropriate.

[0027] Next, the anode gas diffusion layer 120a is hot-press joined to the surface of the anode catalyst layer 130a and the cathode gas diffusion layer 120c is hot-press joined to the surface of the cathode gas catalyst layer 130c (step S110).

[0028] In step S110, the region 120Ra is hot-press joined under pressurization conditions in which the pressurization temperature is 80 °C and the pressurization pressure Pa is 2 MPa, the region 120Rb is hot-press joined under pressurization conditions in which the pressurization temperature is 80 °C and the pressurization pressure Pb is 0 MPa, and the region 120Rc is hot-press joined under pressurization conditions in which the pressurization temperature is 80 °C and the pressurization pressure Pc is 2 MPa. These values may be set as appropriate taking into account the required adhesive force and the potential for damaging the electrolyte membrane 110. In this embodiment, the pressurization pressures Pa, Pb, and Pc in the regions 120Ra, 120Rb, and 120Rc, respectively, are set such that $Pa \geq Pc > Pb$ ($Pa > Pb$ at the very least). Also, the pressurization times for the regions 120Ra, 120Rb, and 120Rc are the same in this embodiment. Generally, a higher pressurization temperature, a higher pressurization pressure, and a longer pressurization time during hot-pressing result in greater adhesive force, while a lower pressurization temperature, a lower pressurization pressure, and a shorter pressurization time during hot-pressing result in less damage to the electrolyte membrane 110 from heat and pressure. Therefore, the damage done to the electrolyte membrane 110 in the region 120Rb is less than the damage done to the electrolyte membrane 110 in the region 120Ra or the region 120Rc.

[0029] Incidentally, in this embodiment, the pressurization temperature, pressurization time, and pressurization pressure are the same for the regions 120Ra and 120Rc, while the pressurization pressure for the region 120Rb is 0 MPa, so the hot-press joining is performed by hot-pressing only once. Alternatively, however, it may also be performed broken down into a plurality of times for the regions 120Ra, 120Rb, and 120Rc.

[0030] The membrane electrode assembly 100 may be manufactured according to the manufacturing process described above. Also, in addition, a fuel cell may be manufactured by sandwiching the membrane electrode assembly 100 between an anode separator and a cathode separator.

[0031] As described above, carbon fiber pile is present on the surface of the carbon paper, which is used for the anode gas diffusion layer 120a and the cathode gas diffusion layer 120c. Therefore, if hot-press joining with the same pressurization conditions is performed over the entire surface of the membrane electrode assembly 100 when manufacturing the membrane electrode assembly 100, the electrolyte membrane 110 is susceptible to being damaged by the carbon fiber pile from the pressure during the hot-press joining in the regions where the anode catalyst layer 130a and the cathode catalyst layer 130c are not formed on the surfaces of the electrolyte membrane 110, i.e., in the regions where the anode gas diffusion layer 120a and the cathode gas diffusion layer 120c are directly joined to the electrolyte membrane 110. Regions of the electrolyte membrane 110 that have been damaged are susceptible to short-circuiting between the anode and cathode, as well as cross-leaking through the electrolyte membrane 110.

[0032] With the membrane electrode assembly 100 according to the first embodiment described above, in the region 120Rb where the electrolyte membrane 110 is easily damaged, hot-press joining is performed with pressurization conditions that yield a lower adhesive force than the region 120Ra where the electrolyte membrane 110 is not easily damaged. That is, in the region 120Rb where the electrolyte membrane 110 is easily damaged, hot-press joining is performed under pressurization conditions that are less likely to damage the electrolyte membrane 110. Accordingly, cross-leaks and short-circuits between the anode and the cathode due to damage sustained by the electrolyte membrane 110 during manufacture of the membrane electrode assembly 100 may be suppressed.

[0033] Also, hot-press joining is performed in the region 120Rc, which is on the outer periphery of the region 120Rb, under pressurization conditions such that the

adhesive force is greater than that in the region 120Rb. As a result, it is possible to inhibit peeling at the boundary between the anode gas diffusion layer 120a and the electrolyte membrane 110 at the outer peripheral portion of the anode catalyst layer 130a, and at the boundary between the cathode gas diffusion layer 120c and the electrolyte membrane 110 at the outer peripheral portion of the cathode catalyst layer 130c.

[0034] FIG. 3 is a view schematically showing the structure of a membrane electrode assembly 100A according to a second embodiment of the invention, with FIG. 3A being a plan view of the membrane electrode assembly 100A as viewed from the anode, and FIG. 3B being a sectional view of the membrane electrode assembly 100A taken along line III-III in FIG. 3A.

[0035] As shown in FIG. 3B, the membrane electrode assembly 100A is formed by laminating an anode catalyst layer 130a and an anode gas diffusion layer 120a, in the stated order, to one side of a proton-conducting electrolyte membrane 110, and laminating a cathode catalyst layer 130c and a cathode gas diffusion layer 120Ac, in the stated order, to the other side of the proton-conducting electrolyte membrane 110.

[0036] However, with the membrane electrode assembly 100A of this embodiment differs from the membrane electrode assembly 100 of the first embodiment in that the area of the anode gas diffusion layer 120a is smaller than the area of the cathode gas diffusion layer 120Ac. Also, the area of the cathode gas diffusion layer 120Ac is substantially equal to the area of the electrolyte membrane 110. Alternatively, the area of the cathode gas diffusion layer 120Ac may have a smaller area than that of the anode gas diffusion layer 120a, and the area of the anode gas diffusion layer 120a may be made substantially equal to the area of the electrolyte membrane 110. This structure also makes it possible to prevent short circuits from occurring between portions of an outer peripheral portion of the anode gas diffusion layer 120a and an outer peripheral portion of the cathode gas diffusion layer 120Ac that wrap around the edge of the electrolyte membrane 110 and come into contact with one other. The anode gas diffusion layer 120a may be regarded as to a first gas diffusion layer substrate of the invention, and the cathode gas diffusion layer 120c may be regarded as a second gas

diffusion layer substrate of the invention.

[0037] Furthermore, in this embodiment as well, a solid polymer electrolyte membrane is used as the electrolyte membrane 110. Also, carbon paper may be used as the gas diffusion layer substrate that constitutes the anode gas diffusion layer 120a and the cathode gas diffusion layer 120Ac. Alternatively, however, other materials that suitably diffuse gas and conduct electricity, such as carbon cloth, may also be used as the gas diffusion layer substrate.

[0038] The membrane electrode assembly 100A of this embodiment is also manufactured using a hot-press, which will be described later. The anode catalyst layer 130a and the cathode catalyst layer 130c have the same area and are formed on opposing regions sandwiching the electrolyte membrane 110. In FIG. 3A, the region 120Ra enclosed by the alternate long and short dash line, the region 120Rb enclosed by the broken line on the outer periphery nearest the region 120Ra, and the region 120Rc enclosed by the solid line on the outer periphery of the region 120Rb are the same as they are in the first embodiment. As shown by FIG. 3B, the region 120Rd on the outer periphery of the region 120Rb indicates the region where the anode gas diffusion layer 120a is not formed on the anode surface of the electrolyte membrane 110. Also, in this embodiment as well, hot-press joining is performed under the following conditions for each of the regions described above when manufacturing the membrane electrode assembly 100A. Below, the manufacturing process of the membrane electrode assembly 100A will be described.

[0039] FIG. 4 is a view illustrating a manufacturing process of the membrane electrode assembly 100A according to the second embodiment. First, the anode catalyst layer 130a is formed on one side of the electrolyte membrane 110 and the cathode catalyst layer 130c is formed on the other side of the electrolyte membrane 110 (step S200). This forming method is the same as that used in the first embodiment.

[0040] Next, the anode gas diffusion layer 120a is hot-press joined to the surface of the anode catalyst layer 130a and the cathode gas diffusion layer 120Ac is hot-press joined to the surface of the cathode gas catalyst layer 130c (step S210).

[0041] In this step (i.e., step S210) in this embodiment, the regions 120Ra, 120Rb, and 120Rc are all hot-press joined under the same pressurization conditions as described in the first embodiment. Also, the region 120Rd is hot-press joined under pressurization conditions in which the pressurization temperature is 80 °C and the pressurization pressure is 5 MPa. These values may be set as appropriate taking into account the required adhesive force and the potential for damaging the electrolyte membrane 110. In this embodiment, the pressurization pressures Pa, Pb, Pc, and Pd in the regions 120Ra, 120Rb, 120Rc, and 120Rd, respectively, are set such that $Pd \geq Pa \geq Pc > Pb$. Also, in this embodiment, the pressurization times for the regions 120Ra, 120Rb, 120Rc, and 120Rd are the same.

[0042] Furthermore, in this embodiment, the pressurization pressure, pressurization temperature, and pressurization time are the same for the regions 120Ra and 120Rc, and the pressurization pressure for the region 120Rb is 0 MPa, so the hot-press joining is performed by hot-pressing only once in the regions 120Ra, 120Rb, and 120Rc. The pressurization pressure for the region 120Rd is 5 MPa, which is different from the pressurization pressures of the regions 120Ra, 120Rb, and 120Rc, so the hot-press joining in the region 120Rd is performed at a different timing than the hot-press joining in the regions 120Ra, 120Rb, and 120Rc.

[0043] The membrane electrode assembly 100A may be manufactured according to the manufacturing process described above. Also, in addition, a fuel cell may be manufactured by sandwiching this membrane electrode assembly 100A between an anode separator and a cathode separator.

[0044] Just like the membrane electrode assembly 100 according to the first embodiment, the membrane electrode assembly 100A according to the second embodiment described above also makes it possible to suppress cross-leaking and short-circuiting between the anode and the cathode from damage sustained by the electrolyte membrane 110 during the manufacturing of the membrane electrode assembly 100A. Also, peeling at the boundary between the anode gas diffusion layer 120a and the electrolyte membrane 110 at the outer peripheral portion of the anode catalyst layer 130a,

and the boundary between the cathode gas diffusion layer 120Ac and the electrolyte membrane 110 at the outer peripheral portion of the cathode catalyst layer 130c may be suppressed.

[0045] The membrane electrode assembly 100A according to the second embodiment further yields the following effects. That is, typically, when a membrane electrode assembly is applied to a fuel cell, a resin or rubber frame member (not shown) that functions as a gasket may be integrally formed on the outer peripheral portion of the membrane electrode assembly. In this case, the frame member is often formed by injection molding. During the injection molding of the frame member, material for forming the frame member is often injected from an outer peripheral portion of a mold into the mold. Accordingly, the inflow of the material may cause peeling at the boundary between the electrolyte membrane and the gas diffusion layer substrate. With the membrane electrode assembly 100A according to this embodiment, the region 120Rd, at the outermost peripheral portion of the cathode gas diffusion layer 120Ac, is hot-press joined to the electrolyte membrane 110 under pressurization conditions that result in a greater adhesive force than at the other regions of the membrane electrode assembly 100A, which inhibits peeling at the boundary between the cathode gas diffusion layer 120Ac and the electrolyte membrane 110 during injection molding. Furthermore, if the region 120Rd is embedded in the frame member, then cross leaking will not occur through the electrolyte membrane 110 even if the electrolyte membrane 110 sustains a relatively large amount of damage in the region 120Rd.

[0046] While the invention has been described with reference to several embodiments, the invention is not limited to those particular embodiments. That is, the invention may be modified without departing from the scope thereof. Several possible modifications are described below.

[0047] In the process for manufacturing the membrane electrode assemblies 100 and 100A according to the embodiments, the anode catalyst layer 130a and the cathode catalyst layer 130c are formed on other sides of the electrolyte membrane 110 by applying and drying a catalyst ink. However, the invention is not limited to this. For

example, the anode catalyst layer 130a may instead be formed by applying and drying catalyst ink on the anode gas diffusion layer 120a, and the cathode catalyst layer 130c may also be formed by applying and drying catalyst ink on the cathode gas diffusion layer 120c and 120Ac. In addition, the anode catalyst layer 130a may be formed on both the electrolyte membrane 110 and the anode catalyst layer 120a, and the cathode catalyst layer 130c may be formed on both the electrolyte membrane 110 and the cathode catalyst layer 120c and 120Ac.

[0048] In the foregoing embodiments, the pressurization pressure changes while the pressurization temperature and the pressurization time are the same for each region, i.e., the region 120Ra, 120Rb, 120Rc, and 120Rd of the membrane electrode assemblies 100 and 100A during hot-press joining of the membrane electrode assemblies 100 and 100A. However, the invention is not limited to this. For example, at least one of plurality of pressurization conditions that include the pressurization pressure, the pressurization temperature, and the pressurization time, may be changed for each region.

[0049] In the first embodiment, the membrane electrode assembly 100 is provided with both the anode gas diffusion layer 120a and the cathode gas diffusion layer 120c, but the invention is not limited to this. For example, one gas diffusion layer, from among the anode gas diffusion layer 120a and the cathode gas diffusion layer 120c, may be omitted.

[0050] In addition being structured as the manufacturing method of a membrane electrode assembly described above, the invention may also be structured as a membrane electrode assembly that is manufactured according to the foregoing manufacturing method, as well as a fuel cell in which the membrane electrode assembly that is manufactured according to the foregoing manufacturing method is used, and a manufacturing method of that fuel cell. Also, the various additional elements described above may also be applied to each of these modes.

[0051] While the invention has been described with reference to example embodiments thereof, it is to be understood that the invention is not limited to the described embodiments or constructions. To the contrary, the invention is intended to

cover various modifications and equivalent arrangements. In addition, while the various elements of the disclosed invention are shown in various example combinations and configurations, other combinations and configurations, including more, less or only a single element, are also within the scope of the appended claims.

CLAIMS:

1. A manufacturing method of a fuel-cell membrane electrode assembly that includes a catalyst layer provided on both sides of an electrolyte membrane and a gas diffusion layer provided on at least one surface, the method comprising:

forming the catalyst layer in a region of at least one of the electrolyte membrane and a gas diffusion layer substrate that constitutes the gas diffusion layer, the region excluding a peripheral edge portion of the at least one surface and having an area smaller than the area of the gas diffusion layer substrate; and

joining the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate via pressure-joining such that the catalyst layer is arranged in a region between the electrolyte membrane and the gas diffusion layer substrate,

wherein the pressure-joining is performed in a catalyst layer non-forming region, where the catalyst layer is not formed, in the surface of the electrolyte membrane under a plurality of pressurization conditions which include pressurization pressure, pressurization temperature, and pressurization time during the pressure-joining, at least one of which is different from at least one of the pressurization conditions under which pressure-joining is performed in a catalyst layer forming region, where the catalyst layer is formed.

2. The manufacturing method according to claim 1, wherein the pressure-joining is performed under pressurization conditions such that an adhesive force between the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate in the catalyst layer forming region is greater than the adhesive force between the electrolyte membrane and the gas diffusion layer substrate in at least a portion of the catalyst layer non-forming region.

3. The manufacturing method according to claim 2, wherein the catalyst layer non-forming region includes a first catalyst layer non-forming region on an outer

periphery closest to the catalyst layer, and a second catalyst layer non-forming region on an outer periphery of the first catalyst layer non-forming region; and the pressure-joining is performed under the pressurization conditions such that the adhesive force between the electrolyte membrane and the gas diffusion layer substrate in the second catalyst layer non-forming region is greater than the adhesive force between the electrolyte membrane and the gas diffusion layer substrate in the first catalyst layer non-forming region.

4. The manufacturing method according to claim 3, wherein the membrane electrode assembly is provided with a first gas diffusion layer substrate that is joined to one side of the electrolyte membrane and a second gas diffusion layer substrate that is joined to the other side of the electrolyte membrane, as the gas diffusion layer; the area of the first gas diffusion layer substrate is smaller than the area of the electrolyte membrane; the area of the second gas diffusion layer substrate is larger than the area of the first gas diffusion layer substrate; and the pressure-joining is performed under the pressurization conditions such that the adhesive force between the electrolyte membrane and an outermost peripheral portion of the second gas diffusion layer substrate is greater than the adhesive force between the electrolyte membrane and the second gas diffusion layer substrate in the second catalyst layer non-forming region.

5. The manufacturing method according to any one of claims 1 to 4, further comprising:

forming a frame member that functions as a gasket on an outer peripheral portion of the catalyst layer non-forming region.

6. A fuel-cell membrane electrode assembly that includes a catalyst layer provided on both sides of an electrolyte membrane and a gas diffusion layer provided on at least one surface, the fuel-cell membrane electrode assembly characterized in that:

the catalyst layer is formed between the electrolyte membrane and the gas diffusion layer, in a region which excludes a peripheral edge portion of a surface of a gas diffusion

layer substrate that constitutes the gas diffusion layer, and has an area smaller than the area of the gas diffusion layer substrate; and

i) the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate, or ii) the electrolyte membrane and the gas diffusion layer substrate are joined together by pressure-joining in a catalyst layer non-forming region, where the catalyst layer is not formed, in the surface of the electrolyte membrane under a plurality of pressurization conditions, which include pressurization pressure, pressurization temperature, and pressurization time, at least one of which is different from at least one of the pressurization conditions under which pressure-joining is performed in a catalyst layer forming region, where the catalyst layer is formed.

7. A fuel-cell membrane electrode assembly that includes a catalyst layer provided on both sides of an electrolyte membrane and a gas diffusion layer provided on at least one surface of the electrolyte membrane, the fuel-cell membrane electrode assembly characterized in that:

the catalyst layer is formed between the electrolyte membrane and the gas diffusion layer, in a region which excludes a peripheral edge portion of a surface of a gas diffusion layer substrate that constitutes the gas diffusion layer, and has an area smaller than the area of the gas diffusion layer substrate; and

adhesive force between the electrolyte membrane, the catalyst layer, and the gas diffusion layer substrate in a catalyst layer forming region in the surface of the membrane electrode assembly, where the catalyst layer is formed, is greater than the adhesive force between the electrolyte membrane and the gas diffusion layer substrate in a catalyst layer non-forming region, where the catalyst layer is not formed, in the surface of the membrane electrode assembly.

FIG. 1A

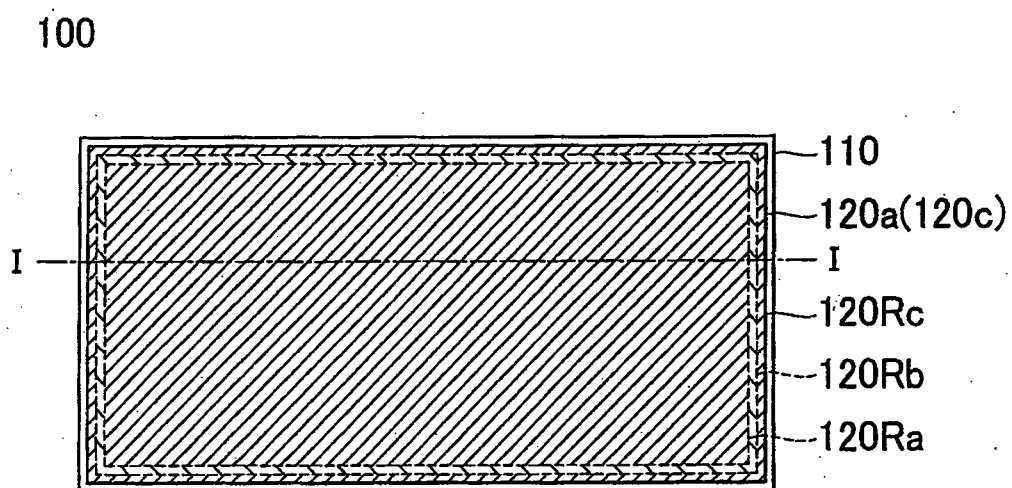


FIG. 1B

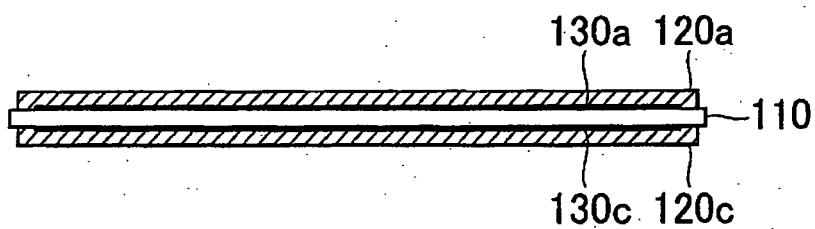


FIG. 2

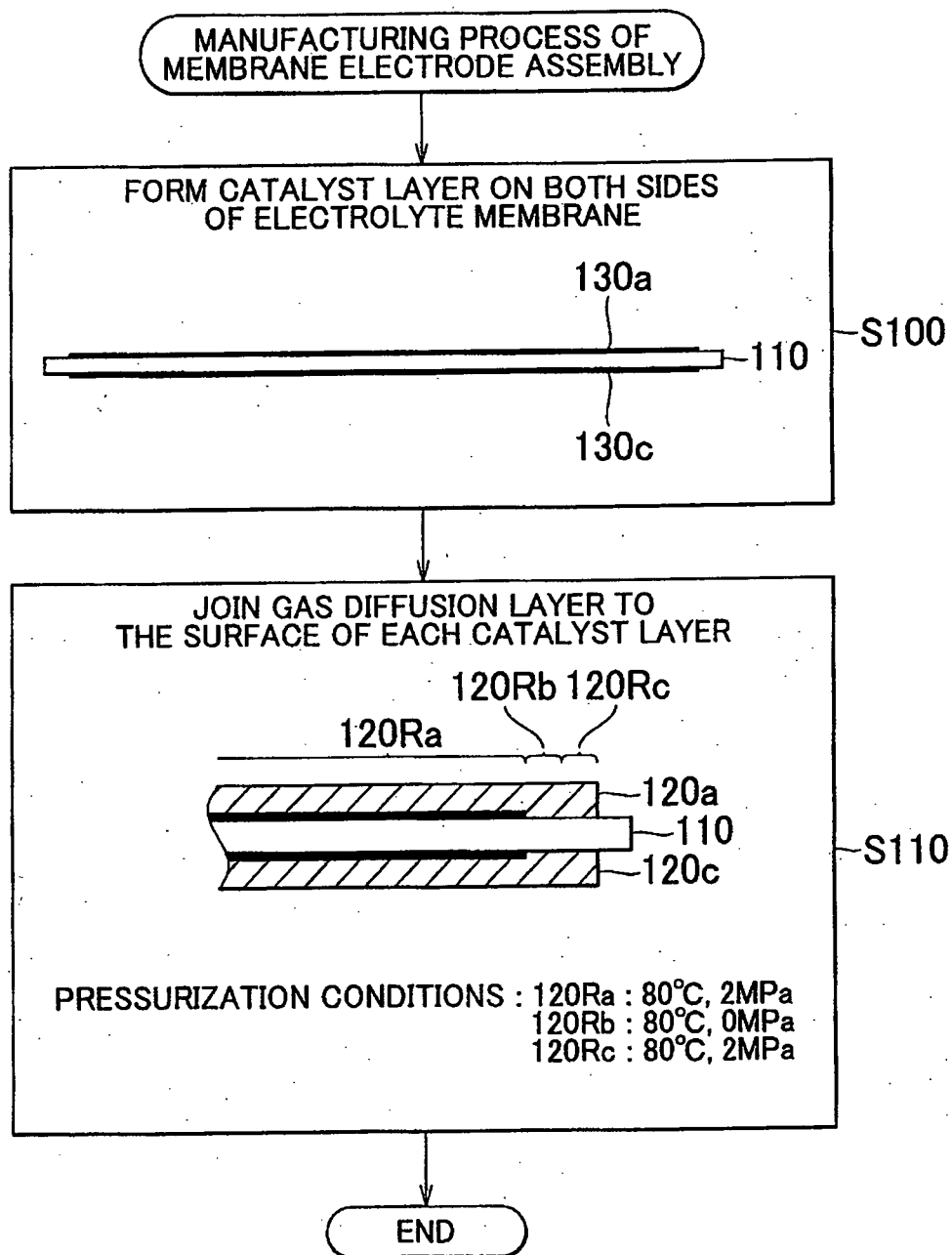


FIG. 3A

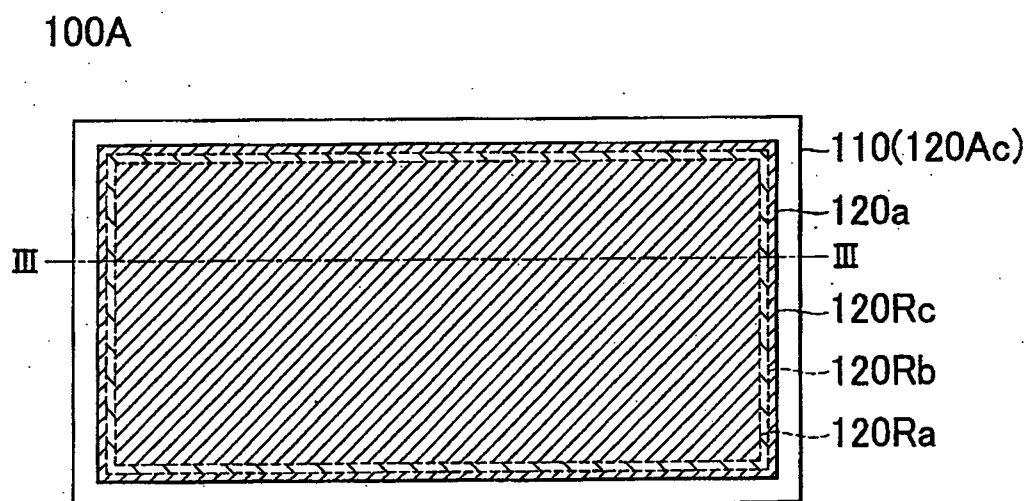


FIG. 3B

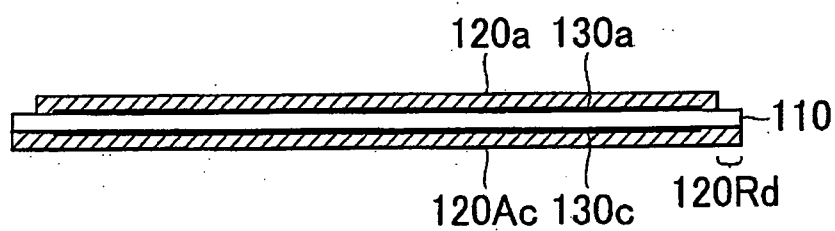


FIG. 4

