



(86) Date de dépôt PCT/PCT Filing Date: 2006/03/31
(87) Date publication PCT/PCT Publication Date: 2006/11/16
(45) Date de délivrance/Issue Date: 2012/03/27
(85) Entrée phase nationale/National Entry: 2007/11/06
(86) N° demande PCT/PCT Application No.: EP 2006/002927
(87) N° publication PCT/PCT Publication No.: 2006/119825
(30) Priorité/Priority: 2005/05/11 (DE10 2005 022 484.9)

(51) Cl.Int./Int.Cl. *H01M 8/02* (2006.01),
H01M 4/86 (2006.01), *H01M 8/10* (2006.01)

(72) Inventeurs/Inventors:
HELMBOLD, AXEL, DE;
SALAMA, KARIM, DE;
REIBEL, DENIS, FR;
WAGNER, KLAUS-DIETMAR, DE;
BOCK, ACHIM, DE;
WAGENER, SILKE, DE

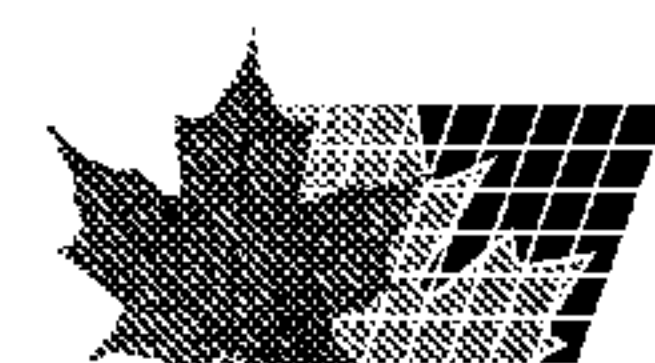
(73) Propriétaire/Owner:
CARL FREUDENBERG KG, DE

(74) Agent: BORDEN LADNER GERVAIS LLP

(54) Titre : COUCHE DE DIFFUSION DE GAZ, ARRANGEMENT ET METHODE DE PRODUCTION
(54) Title: GAS DIFFUSION LAYER, ARRANGEMENT AND METHOD FOR THE MANUFACTURE THEREOF

(57) **Abrégé/Abstract:**

A gas diffusion layer, including at least two actively connected functional areas (2a, 2b), whereby the first area (2a) has a porous structure and the second area (2b) is constructed as stabilization zone, achieves the object of providing a system which realizes a problem-free operation of a fuel cell with optimization of its efficiency. An arrangement including two gas diffusion layers as well as a process for the manufacture of the gas diffusion layer also achieves the mentioned object.



ABSTRACT

A gas diffusion layer, including at least two actively connected functional areas (2a, 2b), whereby the first area (2a) has a porous structure and the second area (2b) is constructed as stabilization zone, achieves the object of providing a system which realizes a problem-free operation of a fuel cell with optimization of its efficiency. An arrangement including two gas diffusion layers as well as a process for the manufacture of the gas diffusion layer also achieves the mentioned object.

Gas Diffusion Layer, Arrangement and Method for the Manufacture Thereof

Field of the Invention

The invention relates to a gas diffusion layer. The invention further relates to an
5 arrangement including two gas diffusion layers. Finally, the invention relates to a process
for the manufacture of a gas diffusion layer.

Background Art

Gas diffusion layers are used in fuel cells. The conventional construction of a fuel
10 cell is characterized by a succession of layers of a bipolar plate with gas distribution
structure, a gas diffusion layer and a reaction layer. These layers are compressed for the
minimization of contact resistances. In order to achieve a homogenous compression not
influenced by tolerances in thickness, an elasticity of the gas diffusion layer which is as
high as possible is desired.

15 Elastic gas diffusion layers infiltrate, however, into the gas channels of a fuel cell.
In gas distributors of fuel cells in the automotive field, the channels are of small depth and
are relatively wide. The channel depth is less than 400 μm , the channel width is more than
1000 μm . These dimensions are necessary to comply with the demands on the fuel cells.
The pressure drop within a conduit is not linear but proportional to the inverse of the
20 fourth power of the radius of a conduit. Therefore, a small infiltration of the gas diffusion
layer into the channels leads to a significant pressure drop in a cell. This results in a
reduction of its efficiency because of parasitic losses in the compressor.

At the same time, the contact pressure of the gas diffusion layer onto the reaction
layer or a membrane in the region of the channel is small. This results in an increased
25 contact resistance in this region, which additionally reduces the efficiency of the cell.

In the case of pressure differences between anode and cathode of the fuel cell, one
must also fear a bending of the gas diffusion layer. Therefore, carbon fiber papers with a
very high tension module are almost exclusively used for those applications. However,
past a certain thickness, those papers used can no longer be rolled up and can therefore not
30 be continuously manufactured or processed.

The gas diffusion layers known from the prior art therefore have disadvantages in
many aspects.

Summary of the Invention

It is now an object of the invention to provide a system which realizes a problem free operation of a fuel cell while optimizing its efficiency.

5 A gas diffusion layer accordingly includes at least two actively connected functional areas, whereby the first area has a porous structure and the second area is constructed as a stabilization zone.

10 It was first discovered in accordance with the invention that a gas diffusion layer must have different functional areas for an optimal functioning. It was recognized in a second step that the provision of a stabilization zone prevents that the first area is forced into the gas channels of a fuel cell during compression of the gas diffusion layer. It is ensured in an ingenious way that the gas diffusion layer can be subjected to pressure in a sufficient degree in order to reduce the contact resistance of the gas diffusion layer. It is further guaranteed that the gas diffusion layer does not force into the gas channels. The constructive realization of the gas diffusion layer in accordance with the invention
15 therefore optimizes the efficiency of a fuel cell and ensures its problem free operation. Therefore, the above mentioned object is achieved.

In an especially advantageous manner, the first area can have a higher compressibility than the second area. This concrete embodiments insures that the first area can be compressed without problem, while the second area has an increased stability. This
20 increased stability insures that the second area does not force into cavities which are adjacent thereto.

The first area can be made more elastic than the second area. This concrete embodiment allows an evening out of unevenness or structures which are forced onto the first area. The first area can thereby provide an especially good sealing.

25 The first area can have a smaller tension module than the second area. This embodiment ensures that the first area bends more readily than the second. The gas diffusion layer as a whole could be characterized by a bending module of less than 1 GPa. A gas diffusion layer which has such a bending module can be rolled up without problem.

This allows a continuous manufacture of the gas diffusion layer, since it can be wound up onto rollers without breakage.

The areas can be constructed as layers or flat laminates. In this concrete embodiment, pre-manufactured and differently treated layers can be connected with one another without problem. It is thereby possible to adapt the respective layers differently and individually to selected parameters.

The areas can be constructed as non-woven fabrics, woven fabrics, knitted fabrics, meshes or nettings. The use of these materials provides the gas diffusion layer with a special stability. Furthermore, these materials are commercially available without problem so that a manufacture of the gas diffusion layer can be realized without problem.

The first area can be made as a non-woven fabric including carbon fibers. It is thereby possible that the first area is constructed as a coarse non-woven including carbon fiber objects or carbon objects. It is also possible to construct the first area as a woven fabric, knitted fabric, mesh or netting. The use of carbon fibers provides the first area with a special electrical conductivity.

The fleece can include up to 30% per weight binder fibers and can have a surface weight of 30 to 300 g/m². The use of up to 30 weight percent binder fibers ensures that the desired functional physical and chemical properties of the respective area are not excessively affected. The selected surface weight allows a mechanical solidification of the non-woven fabric. It is thereby possible that the non-woven fabric is mechanically solidified by high pressure fluid jets at pressures of 100 to 300 bar.

The non-woven fabric can be solidified by fluid jets and densified by calendaring. These measures increase the strength of the non-woven in a particular manner. It is further possible to emboss structures into the non-woven or to dimension the fleece by way of the calendaring.

The non-woven can be carbonized at 800 to 2500°C. The carbonization of the non-woven ensures a further solidification. Furthermore, the electric conductivity of the non-woven can be increased with the carbonization.

The second area can include a wet laid non-woven fabric. This area can be electrically conductive. It serves especially for the stabilization of the whole gas diffusion layer and need not achieve any further object. This area can include carbon fibers. The second area can be made electrically conductive by the use of carbon fibers.

The second area can be constructed as a coating. The provision of a coating allows an especially thin construction of the second area. This results in an especially compact construction of the gas diffusion layer as a whole.

5 The coating can include a carbonizable binder agent. The use of a carbonizable binder agent allows the stabilization of the gas diffusion layer.

10 The coating can have a surface weight of 1 to 100 g/m². The selection of the surface weight within this range ensures sufficient stability of the gas diffusion layer. It is especially ensured that the gas diffusion layer can be rolled up without problem and without breaking. The coating can include resins and/or thermoplastic materials. The selection of these materials ensures a problem-free processing, since they combine with most of the common fiber materials. It is especially possible to apply the coating so thin that at most 10% of the surface of the first area are covered. Pitches or tars from coal tar, petroleum, wood or mixtures thereof, phenolic resins, furan resins, epoxy resins, polystyroles, polyacrylates, acrylnitrilbutadiens, styrolterpolymer, melamine resins, 15 phenolinovollaquers with hexamethylenetetramine, phenol epoxide precondensates, copolymers, modified polymers or mixtures of the listed compounds can be used as carbonizable binder agents. Even saccharides, for example, mono saccharoses such as household sugar, are suitable therefor. All these binder agents are distinguished by an especially good processability. However, binder agents which cannot be carbonized are 20 also possible. For example, polytetraflouroethylene is conceivable, which is distinguished by especially hydrophobic properties.

25 The second area can include polyvinyl alcohols, soot, graphite, metals, carbon fibers or metal fibers. It is especially conceivable that these admixtures are used in a second area which is constructed as a coating. The use of polyvinyl alcohols allows the adjustment of the porosity of the second area. The admixture of soot, graphite or metal allows an improvement of the electrical conductivity of the second area. An improvement of the strength can be achieved by admixture of carbon fibers or metal fibers.

30 The gas diffusion layer can have a progressive construction. A progressive construction can be described by gradients. It is especially conceivable that the gas diffusion layer consists of a uniform material which with respect to its bending stiffness and tension module or other mechanical properties is characterized by gradients in different spatial directions. With this background, it is conceivable, for example, that the

compressability of the first area continuously decreases in direction of the second area. Such a continuous decrease is conceivable with respect to all mechanical properties in all spatial directions. The gas diffusion layer can hereby be adapted to pre-selected spatial conditions.

5 The above mentioned object is further achieved with an arrangement including two gas diffusion layers of the above described type, whereby the gas diffusion layers are oriented with their first areas towards one another and their second areas away from one another.

10 In order to avoid repetition, reference is made with respect to the inventive activity to the construction of the gas diffusion layer as such. The arrangement in accordance with the invention is distinguished especially in that the bending module of such a pairing is at least 25% higher than if the second areas were positioned towards one another.

15 Totally independent from the requirements of a fuel cell, in which the described gas diffusion layers are used, it is also conceivable to provide an arrangement wherein the second areas of two gas diffusion layers are positioned towards one another.

 The above mentioned object is further achieved by a process for the manufacture of an above described gas diffusion layer wherein, a first area with porous structure is associated with a second area which is constructed as a stabilization zone.

20 In order to avoid repetition, reference is made with respect to the inventive activity to the embodiments of the gas diffusion layer as such.

 Advantageously, the areas can be together carbonized or graphitized. This embodiment allows an especially homogeneous construction of the gas diffusion layer as a whole. It is especially realized by this process step that the two areas have been subjected to the same manufacturing history, which unifies their material properties.

25 The areas can be compressed together at a contact pressure of 0.1 to 40 MPa and a temperature of 20 to 400°C. The use of suitable binder agents in this process step is conceivable. The use of binders ensures a stable connection of the two areas. This process step can furthermore include a lamination step at defined pressure and temperature conditions. The lamination step allows a selective pressure exposure of the gas diffusion
30 layer. It is furthermore conceivable that structures are embossed into the gas diffusion layer.

The first area can be subjected to a solidification. It is thereby conceivable that the first area is subjected to a mechanical solidification. With this background a first area constructed as a fiber mat can be solidified by high pressure fluid jets. During the treatment with high pressure fluid jets, the fibers are twirled and entangled with one another. A portion of the fibers has an orientation in Z direction, which means in direction of the thickness of the non-woven fabric, after this treatment. Optionally, the solidified non-woven is densified by mechanical densification to 30 to 90% of its starting thickness.

The first area can be subjected to a step-wise thermal treatment initially at a temperature of up to 1500°C and then up to 2500C. This processing step allows the carbonization or graphitizing of the first area in several steps.

All process steps can be repeated several times and in any sequence, as far as technically sensible.

Different possibilities exist to advantageously embody and further develop the present invention. Reference is thereby made to the following description of preferred embodiments of the invention by way of the drawings. In connection with the description of the preferred exemplary embodiments of the invention, generally preferred embodiments and further developments are also described.

Brief Description of the Drawings

In the drawing, the sole Figure shows an arrangement in a fuel cell which includes a gas diffusion layer with a porous structure and a stabilizing zone.

Exemplary Embodiment of the Invention

The sole Figure shows an arrangement within a fuel cell. A gas diffusion layer 2 is positioned between gas distributors 1. The gas diffusion layer 2 includes two actively connected functional areas 2a and 2b. The first area 2a is constructed as a porous structure. The second area 2b is constructed as a stabilization zone. The gas diffusion layer 2 is connected with an electrode 3 which is in connection with a membrane 4. The construction of the arrangement is symmetrical with respect to the membrane 4. Two examples for possible embodiments of such a gas diffusion layer are described in the following:

Example 1

A double layer gas diffusion layer is manufactured as follows:

The first layer is initially manufactured by carding individually crimped, oxidized polyacrylonitrile fibers and laying them into a mat. It is subsequently twirled and solidified by high pressure fluid water jets at a pressure of 150 bar. This is followed by a drying of this layer at 120°C. The first layer is then compressed at a temperature of 320°C by way of a calendar to the a thickness of 0.2 mm. A carbonization of the first layer at a temperature of 1400°C under a nitrogen atmosphere is subsequently carried out. The so manufactured first layer has a surface weight of 65 g/m².

The second layer is represented by a carbon fiber paper which is commercially available. This carbon fiber paper is manufactured under the trade name TGPH 30 by the company Toray Industries Inc., Japan. The two layers are layered one on top of the other during installation into a fuel cell and compressed. The first layer is thereby directed towards the membrane of a fuel cell.

Example 2:

The Example 2 provides a gas diffusion layer wherein the first layer is manufactured analogous to the first layer of Example 1. The first layer is differentiated from the layer of Example 1 only by its surface weight. The surface weight of the first layer according to Example 2 is 100 g/m². A coating functions as the second layer. The coating has a surface weight of 25 g/m² and consists of 80% soot and 20% phenol resin (type 9282 FP of the company Bakelite, Germany). The coating is point form, whereby the points have a diameter which is smaller than 0.5 mm. The coating provides a 27% one sided surface covering of the first layer. The coating is applied to the first layer by way of screen printing. A paste is used during screen printing which consists of 20% solids, namely soot and phenolic resin, and 80% water. After application of the paste by sieve printing, a drying is carried out at a temperature of 120°C, whereby the water portion evaporates. A tempering step at a temperature of 200°C leads to a reacting of the phenolic resin. A carbonization of the laminate under nitrogen atmosphere and at 1400°C is carried out subsequent to these manufacturing steps.

For further preferred embodiments and improvements of the teachings in accordance with the invention, reference is made on the one hand to the general portion of

the description and on the other hand to the appended claims. In closing, it is especially emphasized that the above, arbitrarily selected exemplary embodiments only provide a discussion of the teachings of the invention but do not limit the invention to the exemplary embodiments.

CLAIMS:

1. A gas diffusion layer, comprising at least a first functional area and a second functional area operably connected to one another, the first area having a porous structure and a lower tension module than the second area, the second area being a stabilization zone constructed as a coating having a surface weight of 1 to 100 g/m², the gas diffusion layer having a bending module of less than 1 GPa.
2. Gas diffusion layer according to claim 1, wherein the first area has a higher compressibility than the second area.
3. Gas diffusion layer according to claim 1 or 2, wherein the first area is more elastic than the second area.
4. Gas diffusion layer according to any one of claims 1 to 3, wherein the first area is constructed as a non-woven fabric, a woven fabric, a knitted fabric, a mesh or a netting.
5. Gas diffusion layer according to any one of claims 1 to 4, wherein the first area is constructed as a non-woven fabric including carbon fibers.
6. Gas diffusion layer according to claim 5, wherein the non-woven fabric includes up to 30% per weight binder fibers and has a surface weight of 30 to 300 g/m².
7. Gas diffusion layer according to claim 5 or 6, wherein the non-woven fabric is solidified by fluid jets and densified by calendaring.
8. Gas diffusion layer according to one of claims 5 to 7, wherein the non-woven fabric was carbonized at 800 to 2500°C.
9. Gas diffusion layer according to any one of claims 1 to 8, wherein the coating includes a carbonizable binder agent.

10. Gas diffusion layer according to any one of claims 1 to 9, wherein the coating includes resins and/or thermoplastic materials.
11. Gas diffusion layer according to any one of claims 1 to 10, wherein the second area includes polyvinylalcohols, soots, graphites, metals, carbon fibers or metal fibers.
12. Gas diffusion layer according to any one of claims 1 to 11, having a progressive construction.
13. Arrangement including two gas diffusion layers according to any one of claims 1 to 12, whereby the gas diffusion layers are oriented with their first areas towards one another and with their second areas away from one another.
14. Process for the manufacture of a gas diffusion layer according to any one of claims 1 to 13, whereby a second area which is constructed as a stabilization zone is associated with a first area having a porous structure, the first area is subjected to a solidification and first and second areas are pressed together at a contact pressure of 0.1 to 40 MPa and a temperature of 20 to 400°C
15. Process according to claim 14, wherein the first and second areas are together carbonized or graphitized.
16. Process according to any one of claims 14 or 15, wherein at least one of the first and second areas is subjected to a stepwise thermal treatment at temperatures up to 2500°C.
17. Process according to any one of claims 14 to 16, wherein individual process steps are repeated several times.

Application number / numéro de demande: EP 2006/002927

Figures: 1

Pages: 1

Unscannable item(s)

received with this application

To inquire if you can order a copy of the unscannable items, please visit the
CIPO WebSite at [HTTP://CIPO.GC.CA](http://CIPO.GC.CA)

Item(s) ne pouvant être balayés

Documents reçus avec cette demande ne pouvant être balayés.

Pour vous renseigner si vous pouvez commander une copie des items ne
pouvant être balayés, veuillez visiter le site web de l'OPIC au [HTTP://CIPO.GC.CA](http://CIPO.GC.CA)