



(51) International Patent Classification:

H01M 8/04 (2006.01) H01M 4/86 (2006.01)
H01M 8/10 (2006.01)

(21) International Application Number:

PCT/US2011/022801

(22) International Filing Date:

28 January 2011 (28.01.2011)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant (for all designated States except US): **UTC POWER CORPORATION** [US/US]; 195 Governor's Highway, South Windsor, Connecticut 06074 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **PARSONS, Jason B.** [US/US]; 238 Mountain Road, Manchester, Connecticut 06040 (US).

(74) Agent: **COON, Benjamin J.**; 400 West Maple Road, Suite 350, Birmingham, Michigan 48009 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

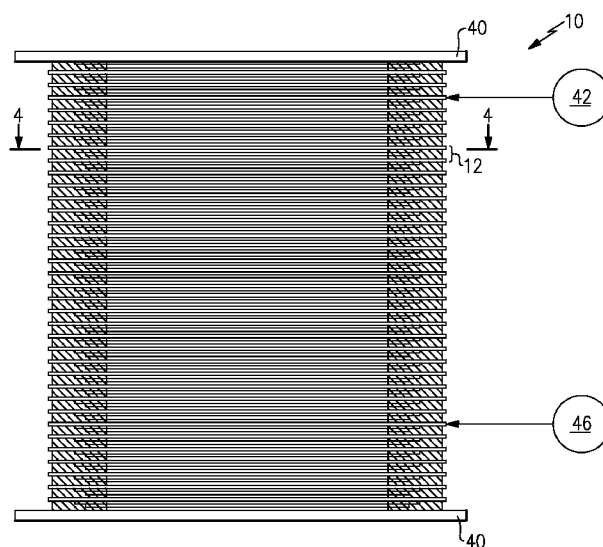
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: FUEL CELL SEAL



(57) Abstract: An example fuel cell seal assembly includes a seal configured to restrict flow of a fuel cell fluid through at least one of an outer lateral edge of a first gas diffusion layer, an outer lateral edge of a membrane electrode assembly, and an outer lateral edge of a second gas diffusion layer. The outer lateral edge of the first gas diffusion layer is laterally spaced from the outer lateral edge of the second gas diffusion layer. An example method of sealing a fuel cell interface includes limiting flow of a fuel cell fluid using a seal configured to restrict flow through an outwardly facing edge of at least one of a first gas diffusion layer and an outwardly facing edge of a second gas diffusion layer. The outwardly facing edge of the first gas diffusion layer is spaced from the outwardly facing edge of the second gas diffusion layer.

FUEL CELL SEAL

Statement Regarding Federally Sponsored Research

[0001] The embodiments of this disclosure were made with government support under Contract No. DE-FG36-07GO17005 awarded by the United States Department of Energy.

5 Therefore, the United States Government may have certain rights in this invention.

Technical Field

[0002] This disclosure relates generally to fuel cells. More particularly, this disclosure relates to a sealing arrangement for a fuel cell.

10

Description of Related Art

[0003] Fuel cell stack assemblies are well known and typically include multiple individual fuel cells. The individual fuel cells may each include a polymer electrolyte membrane (PEM) positioned between porous carbon electrode layers. One of the electrode layers operates as an anode. The other electrode layer operates as a cathode. The PEM and the porous carbon electrode layers together establish a membrane electrode assembly (MEA) or a catalyst coated membrane. Gas diffusion layers (GDLs) are located adjacent opposing sides of the MEA. The GDLs distribute fuel cell fluids, such as hydrogen and air, to the MEA.

15

[0004] A seal at the lateral perimeters of the GDLs and the MEA prevents reactants from mixing in the GDLs and leaking into their opposite manifolds, for example. The seals are typically injection molded.

20

SUMMARY

[0005] An example fuel cell seal assembly includes a seal that is configured to restrict flow of a fuel cell fluid through at least one of an outer lateral edge of a first gas diffusion layer, an outer lateral edge of a membrane electrode assembly, and an outer lateral edge of a second gas diffusion layer. The outer lateral edge of the first gas diffusion layer is laterally spaced from the outer lateral edge of the second gas diffusion layer.

25

[0006] An example fuel cell stack arrangement includes a membrane electrode assembly, a first gas diffusion layer positioned against a side of the membrane electrode

30

assembly, and a second gas diffusion layer positioned against an opposing side of the membrane electrode assembly. A seal is configured to restrict flow through the lateral outer edge of the first gas diffusion layer, the lateral outer edge of the second gas diffusion layer, or both. A lateral outer edge portion of the first gas diffusion layer extends lateral further than a lateral outer edge portion of the second gas diffusion layer.

[0007] An example method of sealing a fuel cell interface includes limiting flow of a fuel cell fluid using a seal configured to restrict flow through an outwardly facing edge of at least one of a first gas diffusion layer and an outwardly facing edge of a second gas diffusion layer. The outwardly facing edge of the first gas diffusion layer is spaced from the outwardly facing edge of the second gas diffusion layer.

[0008] These and other features of the disclosed examples can be best understood from the following specification and drawings. The following is a brief description of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 shows a schematic view an example fuel cell stack assembly having selected portions of a seal assembly removed.

[0010] Figure 2 shows a close-up view of a lateral outer portion of the Figure 1 assembly.

[0011] Figure 3 shows an example mold used to mold a seal assembly of the Figure 1 assembly.

[0012] Figure 4 shows a section view at line 4-4 of Figure 1.

[0013] Figure 5 shows a close-up view of a lateral outer portion of another example fuel cell.

[0014] Figure 6 shows a close-up view of a lateral outer portion of yet another example fuel cell.

[0015] Figure 7 shows a close-up view of a lateral outer portion of another example fuel cell that uses a frame.

[0016] Figure 8 shows the Figure 7 frame and MEA.

DETAILED DESCRIPTION

[0017] Referring to Figures 1 and 2, an example fuel cell stack assembly 10 includes a multiple of a fuel cell 12. The example fuel cell 12 includes a polymer electrolyte membrane (PEM) 14 positioned between a first gas diffusion layer (GDL) 18 and a second gas diffusion layer (GDL) 22. A surface of the PEM 14 facing the first GDL 18 is coated with an anode electrode 26. An opposing surface of the PEM 14 faces the second GDL 22 and is coated with a cathode electrode 30.

[0018] A plate 34 is positioned against the first GDL 18. The plate 34 establishes channels (not shown) configured to deliver a fuel, such as hydrogen, from a fuel supply 42 to the first GDL 18. The fuel moves through the first GDL 18 to the anode electrode 26.

[0019] Another plate 38 is positioned against the second GDL 22. The plate 38 establishes channels (not shown) configured to deliver an oxidant, such as oxygen, from an oxidant supply 46 to the second GDL 22. The oxidant moves through the second GDL 22 to the cathode electrode 30.

[0020] The plate 34 establishes additional channels configured to deliver oxidant to another GDL 22a within the fuel cell stack assembly 10. Similarly, the plate 38 establishes additional channels configured to deliver fuel to a GDL 18a within the fuel cell stack assembly 10.

[0021] Pressure plates 40 clamp the fuel cell 12 within the stack. Bolts (not shown) are used in one example to facilitate applying the clamping force to the fuel cell 12 with the pressure plates 40.

[0022] In this example, the anode electrode 26, the PEM 14, and the cathode electrode 30 together form a membrane electrode assembly (MEA) 50 that provides electrical energy in a known manner when supplied with hydrogen and oxygen. Byproducts, such as water and heat, are generated as the hydrogen ions and oxygen combine proximate the cathode electrode 30.

[0023] The example fuel cell 12 includes a seal assembly 56 mounted about the peripheral portions of the first GDL 18, the MEA 50, and the second GDL 22. The example seal assembly 56 is configured to restrict flow of fuel cell fluid through at least a first outer lateral edge 60 of the first GDL 18, a second outer lateral edge 64 of the MEA 50, and a third outer

lateral edge 68 of the second GDL 22. Example fuel cell fluids having flow restricted by the seal assembly 56 include the hydrogen and oxygen supplied to the fuel cell stack assembly 10.

[0024] The example seal assembly 56 includes an impregnated portion 58, which corresponds to a portion of the seal assembly 56 impregnated within the first GDL 18, the PEM 14, or the second GDL 22. The example seal assembly 56 is uniform piece. That is, the example seal is formed as a single piece of material.

[0025] An upper surface 70 of the example seal assembly 56 includes an inner seal bead 72 and an outer seal bead 76. The inner seal bead 72 and outer seal bead 76 contact a downwardly facing surface 80 of the plate 34 to block flow of fuel cell fluids at an interface 84 between the seal assembly 56 and the plate 34.

[0026] In another example, a downwardly facing surface 80a of an adjacent seal assembly 56a includes one or both of the inner seal bead 72 and the outer seal bead 76. Other examples do not include the inner seal bead 72 or the outer seal bead 76.

[0027] Referring now to Figure 3, the example seal assembly 56 is injection molded to the lateral periphery of the first GDL 18, the MEA 50, and the second GDL 22. During the molding process, a molten seal material is injected from a mold supply 88 into a cavity 92 established by a mold 94. The molten material cools and cures within the mold 94. The mold 94 holds the position of the molten seal material during the cooling and curing. The mold 94 is removed after the molten material cools and cures.

[0028] In addition to injection molding, other example processes suitable for forming the seal assembly 56 include compression molding and transfer molding.

[0029] In this example, the first outer lateral edge 60 of the first GDL 18 is laterally spaced a distance d_1 from the second outer lateral edge 64 of the MEA 50, and is laterally spaced a distance d_2 from the third outer lateral edge 68 of the second GDL 22. Further, the third outer lateral edge 68 of the second GDL 22 is laterally spaced at distance d_3 from the second outer lateral edge 64 of the MEA 50.

[0030] In this example, the lateral spacing facilitates forming the impregnated portion 58 because the molten seal material flows against more of the surface area of the first GDL 18 and the PEM 14 during molding than if the first outer lateral edge 60, the second outer lateral edge 64, and the third outer lateral edge 68 were each laterally aligned. That is, when laterally spaced, the molten material is able to move through a lower surface portion 96 of the first GDL

18 and a lower surface portion 98 of the PEM 14 along path P to form the impregnated portion 58, in addition to moving through the first outer lateral edge 60, the second outer lateral edge 64, and the third outer lateral edge 68.

[0031] The first outer lateral edge 60, the second outer lateral edge 64, and the third outer lateral edge 68 are aligned parallel to each other in this example. In other example, one or more of the first outer lateral edge 60, the second outer lateral edge 64, and the third outer lateral edge 68 are positioned transverse to each other.

[0032] In one example, the a portion of the first GDL 18 and the second GDL 22 inboard the seal assembly 56 are compressed to reduce flash resulting from the molding.

[0033] The example seal assembly 56 comprises a nonsilicone seal material, such as EPDM rubber or FKM rubber.

[0034] Referring now to Figure 4 with continuing reference to Figure 1, the example seal assembly 56 has a picture frame type configuration. The first GDL 18 and the second GDL 22 are rectangular and have opposing sides longer than their other opposing sides. The PEM 14 is square and thus has opposing sides that are the same length as the other opposing sides of the PEM 14.

[0035] When arranged within the fuel cell stack 112, the longer sides X_1 of the first GDL 18 are arranged perpendicularly to the longer sides X_2 of the second GDL 22. Thus, as can be appreciated, the first outer lateral edge 60 of the first GDL 18 extends laterally further than the third outer lateral edge 68 of the second GDL 22 on two outboard sides of the fuel cell 12. Similarly, the third outer lateral edge 68 of the second GDL 22 extends laterally further than the first outer lateral edges 60 of the first GDL 18 on the other two outboard sides of the fuel cell 12.

[0036] Referring to Figure 5, another example fuel cell 112 includes an MEA 150 having a second outer lateral edge 164 that is coextensive with a third outer lateral edge 168 of a second GDL 122. A first GDL positioned has a first outer lateral edge 160 extending laterally beyond the second outer lateral edge 164 and the third outer lateral edge 168.

[0037] Referring to Figure 6, another example fuel cell 212 includes a first outer lateral edge 260 of a first GDL 218 laterally spaced from a second outer lateral edge 264 of a an MEA 250 and a third outer lateral edge 268 of a second GDL 222. In this example, the third outer lateral edge 268 of the second GDL 222 is coextensive with an outer lateral edge 299 of a seal assembly 256.

[0038] Referring to Figures 7 and 8, another example fuel cell 312 includes a frame 316 around the periphery of an MEA 350. In this example, a first outer lateral edge 360 of a first GDL 318 extends laterally past the MEA 350 to the frame 316. A third outer lateral edge 368 of a second GDL 322 extends past a second outer lateral edge 364 of the frame 316. The frame 316 is a polyethylene naphthalate material in one example.

[0039] Although the example fuel cell stack assemblies are PEM-based, a person skilled in art and having the benefit of this disclosure would understand other types of fuel cells that would benefit from the teachings of this disclosure.

[0040] Features of the disclosed examples include improved flow of the molten seal material during the molding process and formation of the impregnated portion of the seal assembly. In one example, the mold utilizes a reduced number of seal channels due to the improved flow of the molten seal material. Another feature includes a more compliant seal bead because the seal assembly, particularly the outermost portions of the seal assembly, lacks the resistance of two gas diffusion layers.

[0041] The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure. Thus, the scope of legal protection given to this disclosure can only be determined by studying the following claims.

CLAIMS

We claim:

1. A fuel cell seal assembly, comprising:

a seal that is configured to restrict flow of a fuel cell fluid through at least one of an outer lateral edge of a first gas diffusion layer, an outer lateral edge of a membrane electrode assembly, an outer lateral edge of a second gas diffusion layer, wherein the outer lateral edge of the first gas diffusion layer is laterally spaced from the outer lateral edge of the second gas diffusion layer.

2. The fuel cell seal assembly of claim 1, wherein the outer lateral edge of the membrane electrode assembly is spaced from the outer lateral edge of the first gas diffusion layer and the outer lateral edge of the membrane electrode assembly is laterally spaced from the outer lateral edge of the second gas diffusion layer.

3. The fuel cell seal assembly of claim 1, wherein a portion of the seal is impregnated within a portion of at least one of the first gas diffusion layer, the membrane electrode assembly, the second gas diffusion layer.

4. The fuel cell seal assembly of claim 1, wherein the seal comprises at least one seal bead configured to seal against a fuel cell plate.

5. The fuel cell seal assembly of claim 1, wherein the seal is secured about the periphery of the first gas diffusion layer, the membrane electrode assembly, and the second gas diffusion layer.

6. The fuel cell seal assembly of claim 5, wherein the outer lateral edge of the first gas diffusion layer extends laterally past the outer lateral edge of the second gas diffusion layer on a first outboard side of the fuel cell seal assembly, and the outer lateral edge of the second gas diffusion layer extends laterally past the outer lateral edge of the first gas diffusion layer on a second outboard side that is transverse to the first outboard side.

7. The fuel cell seal assembly of claim 1, wherein the seal is an injection molded seal.

8. The fuel cell seal assembly of claim 1, wherein the seal is a uniform piece.

9. The fuel cell seal assembly of claim 1, wherein an outer lateral edge of a first gas diffusion layer, an outer lateral edge of a membrane electrode assembly, and an outer lateral edge of a second gas diffusion layer face outwardly from the same side of the fuel cell seal assembly.

10. A fuel cell stack arrangement, comprising:

a membrane electrode assembly;

a first gas diffusion layer positioned against a side of the membrane electrode assembly, the first gas diffusion layer having a lateral outer edge facing a first direction;

a second gas diffusion layer positioned against an opposing side of the membrane electrode assembly, the second gas diffusion layer having a lateral outer edge facing the first direction; and

a seal configured to restrict flow through the lateral outer edge of the first gas diffusion layer, the lateral outer edge of the second gas diffusion layer, or both, wherein the lateral outer edge of the first gas diffusion layer and the lateral outer edge of the second gas diffusion layer are laterally spaced from each other.

11. The fuel cell stack arrangement of claim 10, wherein the membrane electrode assembly comprises a polymer electrolyte membrane.

12. The fuel cell stack arrangement of claim 10, wherein the lateral outer edge of the first gas diffusion layer and the lateral outer edge of the second gas diffusion layer are aligned parallel to each other.

13. The fuel cell stack arrangement of claim 10, wherein the lateral outer edge of the first gas diffusion layer extends laterally beyond the lateral outer edge of the second gas diffusion layer.

15. The fuel cell stack arrangement of claim 13, wherein the first gas diffusion layer has a second lateral outer edge facing a second direction that is perpendicular to the first direction, and further wherein the second gas diffusion layer has a second lateral outer edge facing the second direction, the second lateral outer edge of the second gas diffusion layer extending laterally
5 beyond the second lateral outer edge of the first gas diffusion layer.

16. The fuel cell stack arrangement of claim 13, including a frame about the periphery of the membrane electrode assembly, the frame configured to restrict flow through a lateral outer edge of the membrane electrode assembly.

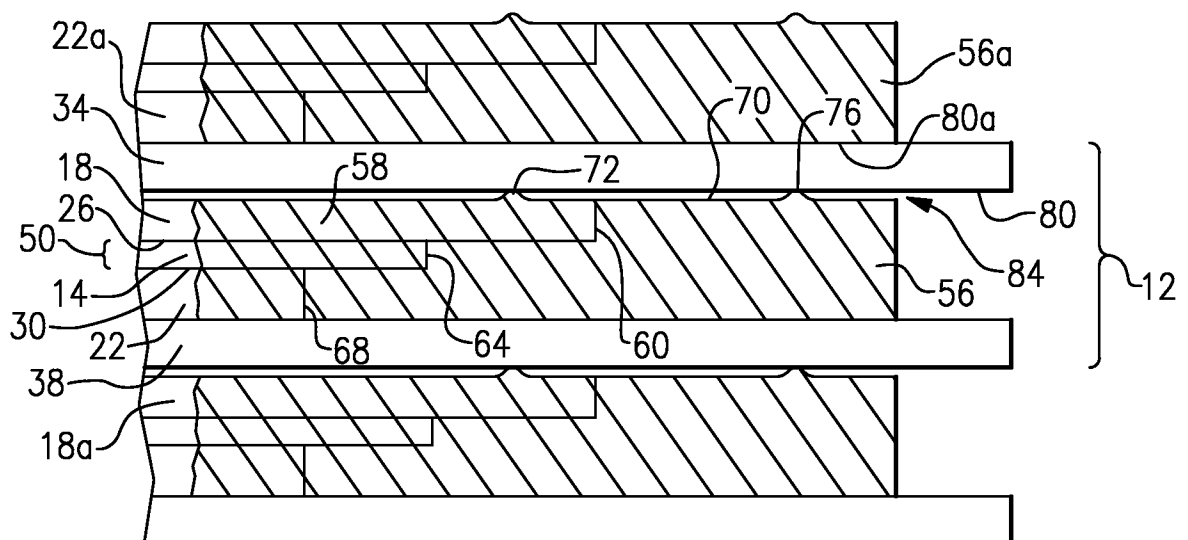
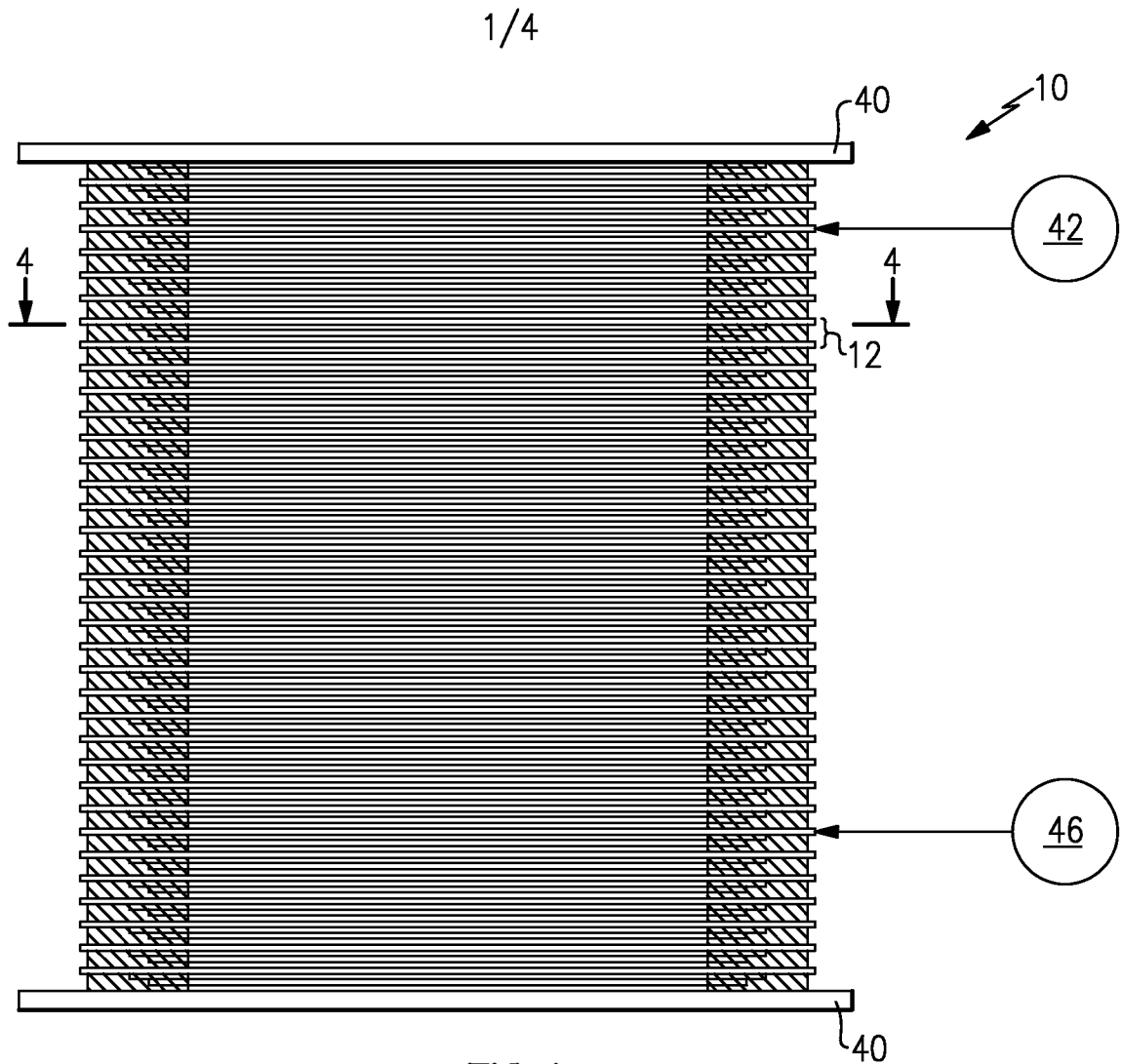
10 17. A method of sealing a fuel cell interface, comprising:

includes limiting flow of a fuel cell fluid using a seal configured to restrict flow through at least one of an outwardly facing edge of a first gas diffusion layer and an outwardly facing edge of a second gas diffusion layer, wherein the outwardly facing edge of the first gas diffusion
15 layer is spaced from the outwardly facing edge of the second gas diffusion layer.

18. The method of claim 17, wherein the outwardly facing edge of the first gas diffusion layer and the outwardly facing edge of a second gas diffusion layer are parallel.

20 19. The method of claim 17, including impregnating a portion of the first gas diffusion layer and a portion of the second gas diffusion layer with a portion of the seal.

20. The method of claim 17, wherein the outwardly facing edge of the first gas diffusion layer or the outwardly facing edge of a second gas diffusion layer is laterally aligned with an outwardly
25 facing edge of a membrane electrode assembly.



2/4

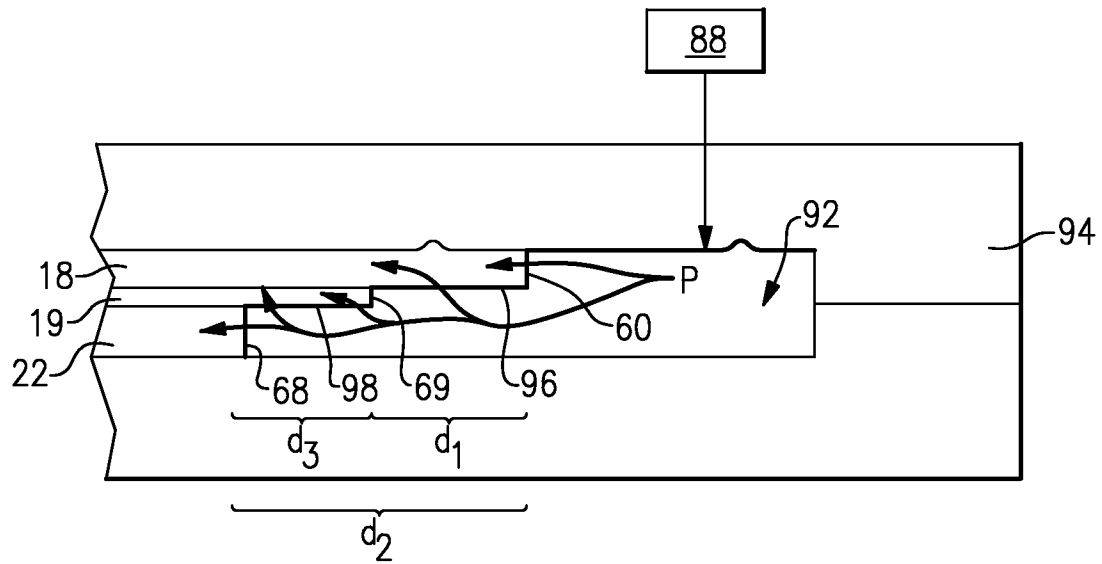


FIG. 3

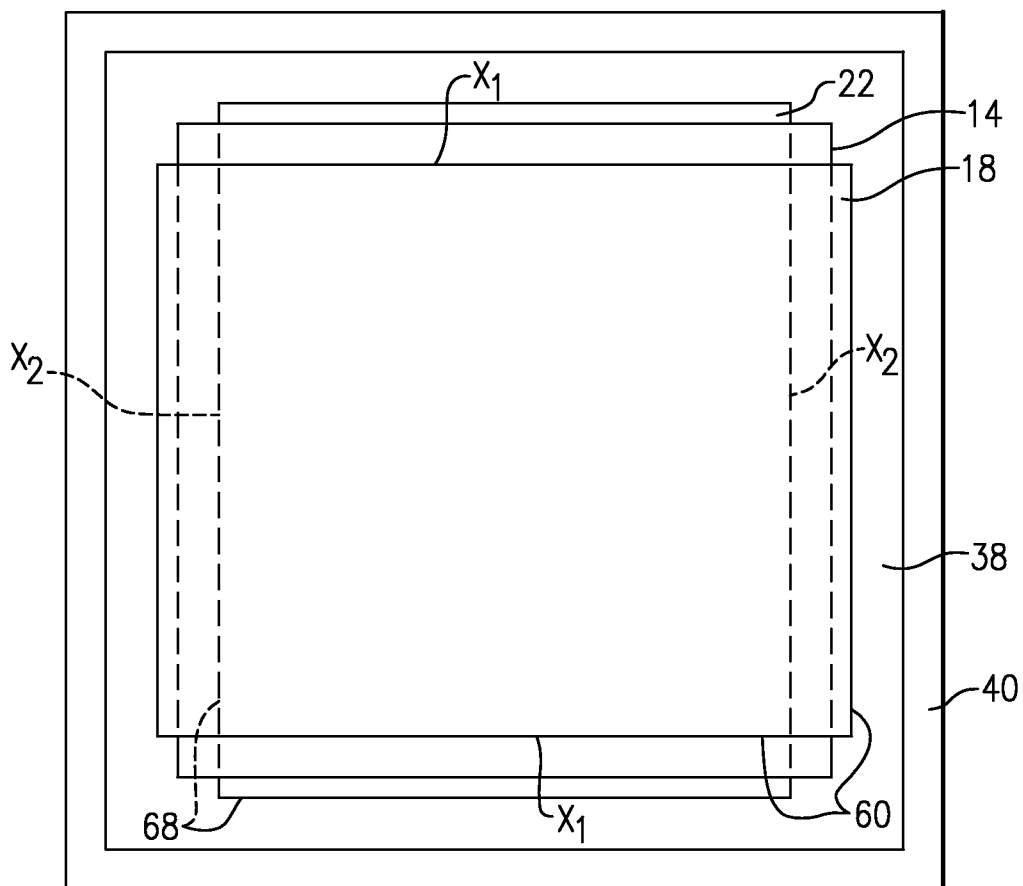


FIG. 4

3/4

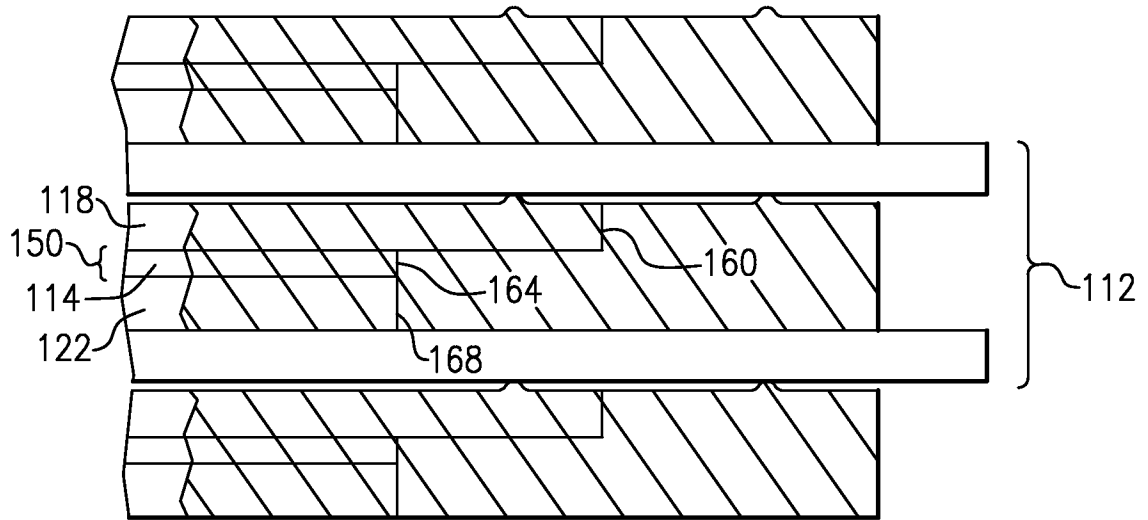


FIG.5

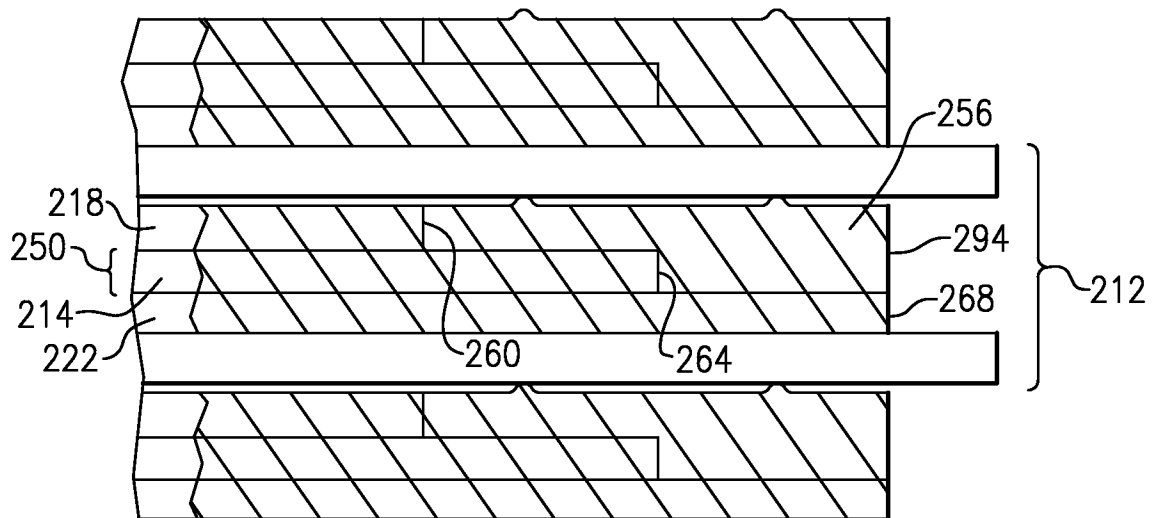


FIG.6

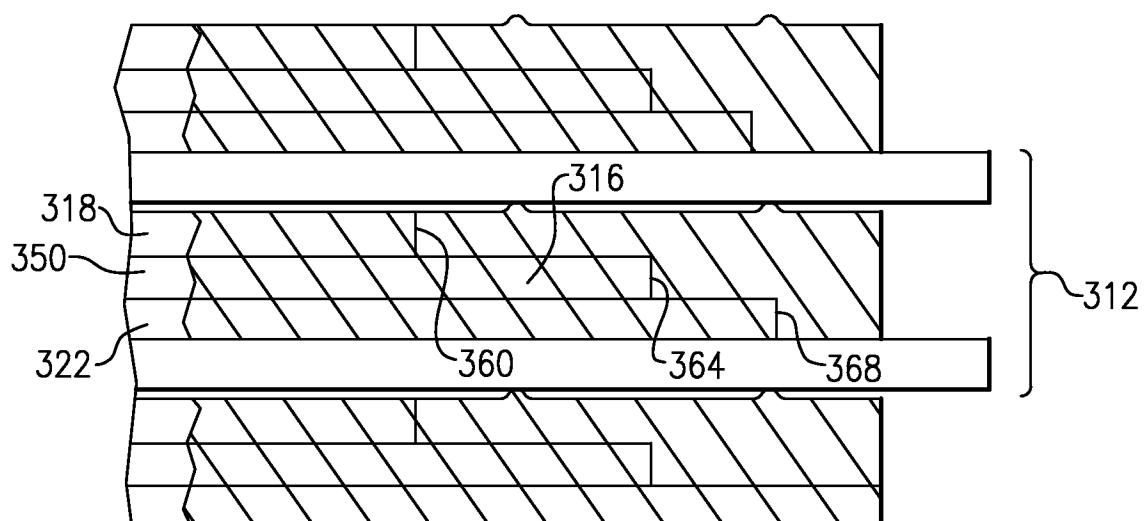


FIG.7

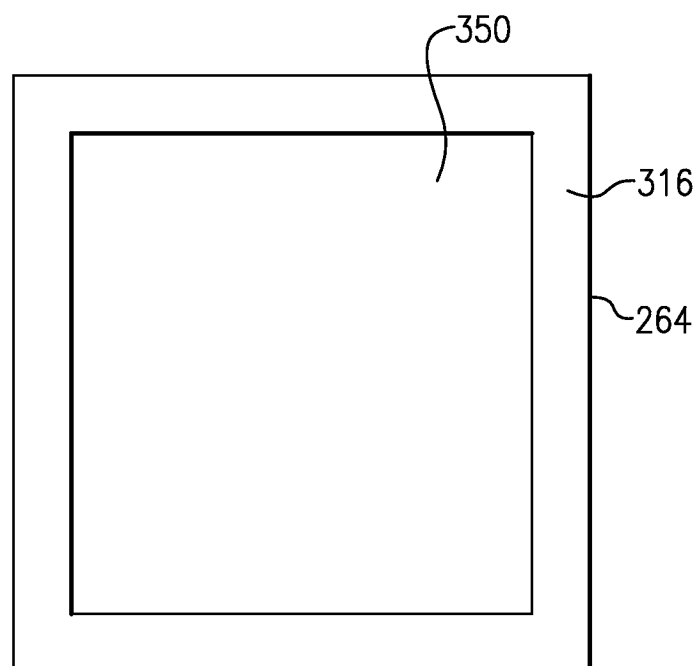


FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/022801**A. CLASSIFICATION OF SUBJECT MATTER*****H01M 8/04(2006.01)i, H01M 8/10(2006.01)i, H01M 4/86(2006.01)i***

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01M 8/04; B05D 5/12; H01M 2/08; H01M 8/02; H01M 8/10; H01M 4/88

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: seal, gasket, gas diffusion layer, fuel cell, lateral

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2008-041337 A (JAPAN GORE TEX INC.) 21 February 2008 See abstract, figures 3-5, paragraphs 11-38, claims 1-20.	1,4-13,15-18,20 2-3,19
Y	US 2003-0221311 A1 (SMITH, JEFFREY A. et al.) 04 December 2003 See abstract, figures 2-3, paragraphs 21-25.	2
Y	US 2008-0124458 A1 (OKABE, TATSUYA) 29 May 2008 See abstract, figure 3B, paragraph 34.	3,19
A	JP 2007-066766 A (NISSAN MOTOR CO., LTD.) 15 March 2007 See abstract, figures 1A-6, paragraphs 10-14, claims 1-18.	1-13,15-20
A	JP 2004-039385 A (HONDA MOTOR CO., LTD.) 05 February 2004 See abstract, figures 2,6, paragraphs 8-41, claim 1	1-13,15-20

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

10 OCTOBER 2011 (10.10.2011)

Date of mailing of the international search report

10 OCTOBER 2011 (10.10.2011)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 189 Cheongsu-ro,
Seo-gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

Cho Ki Yun

Telephone No. 82-42-481-8398



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/022801**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 14
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claim 14 is missing in this application.
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/022801

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2008-041337 A	21.02.2008	CA 2659193 A1 CN 101523647 A EP 2048730 A1 EP 2048730 A4 KR 10-2009-0074154 A US 2010-0047649 A1 WO 2008-016185 A1	07.02.2008 02.09.2009 15.04.2009 21.07.2010 06.07.2009 25.02.2010 07.02.2008
US 2003-0221311 A1	04.12.2003	None	
US 2008-0124458 A1	29.05.2008	CN 100499232 C CN 101032046 A0 EP 1796195 A1 EP 1796195 A4 JP 2006-107798 A KR 10-2007-0059158 A WO 2006-038497 A1	10.06.2009 05.09.2007 13.06.2007 24.03.2010 20.04.2006 11.06.2007 13.04.2006
JP 2007-066766 A	15.03.2007	None	
JP 2004-039385 A	05.02.2004	JP 3641622 B2	27.04.2005