



- (51) **International Patent Classification:**
H01M 8/02 (2006.01) *H01M 8/10* (2006.01)
- (21) **International Application Number:**
PCT/US2014/011806
- (22) **International Filing Date:**
16 January 2014 (16.01.2014)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
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- (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, BN, 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, IR, IS, JP, KE, KG, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

Published:

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

(54) **Title:** FUEL CELL COMPONENT HAVING MULTIPLE PORE SIZES

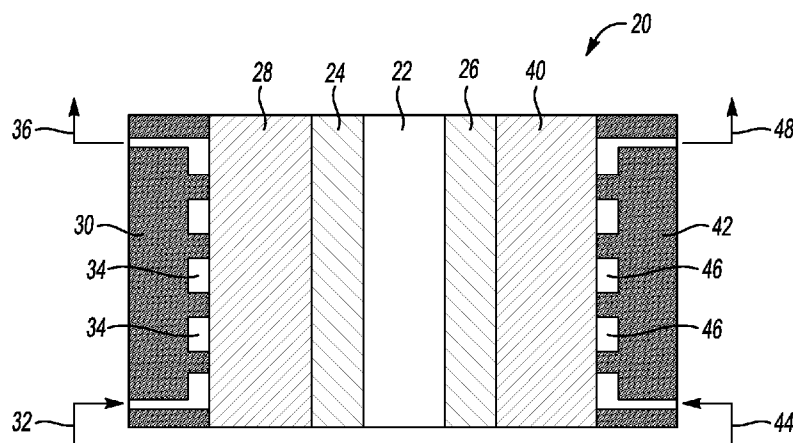


Fig-1

(57) **Abstract:** An illustrative fuel cell component includes a body that has a plurality of first pores. The first pores have a first pore size. A fluorinated carbon coating is on at least some of the body. The coating establishes a plurality of second pores in a coated portion of the body. The second pores have a second pore size that is smaller than the first pore size.

FUEL CELL COMPONENT HAVING MULTIPLE PORE SIZES

BACKGROUND

[0001] Fuel cells typically include a plurality of layers that facilitate an electrochemical process for generating electricity. There are various challenges associated with operating fuel cells. Managing fluid distribution and moisture content at various locations within a fuel cell assembly under various operating conditions is desirable for achieving satisfactory fuel cell performance. For example, polymer electrolyte membrane fuel cells may experience performance loss under high current density operation conditions because of localized flooding in a catalyst layer or gas diffusion layer, for example.

[0002] One approach at addressing this issue has been to incorporate TEFLON in a microporous layer or the gas diffusion layer. The hydrophobic nature of TEFLON may assist in preventing flooding at the catalyst layer-gas diffusion layer interface. Introducing TEFLON has the associated drawback of increasing the cost associated with the fuel cell. Additionally, the TEFLON may tend to fill pores that otherwise are useful for gas transport within the fuel cell. Further, a uniform distribution of TEFLON is not easily achieved which may still allow for localized flooding.

SUMMARY

[0001] An illustrative fuel cell component includes a body that has a plurality of first pores. The first pores have a first pore size. A fluorinated carbon coating is on at least some of the body. The coating establishes a plurality of second pores in a coated portion of the body. The second pores have a second pore size that is smaller than the first pore size.

[0002] The fluorinated carbon coating and the second pores are useful for avoiding flooding while still facilitating gas transport through the body.

[0003] In an example fuel cell component having one or more features of the fuel cell component of the previous paragraph, the first pore size is at least four times larger than the second pore size.

[0004] In an example fuel cell component having one or more features of the fuel cell component of either of the previous paragraphs, the first pore size is about 200 microns and the second pore size is between about 1 and about 50 microns.

5 [0005] In an example fuel cell component having one or more features of the fuel cell component of any of the previous paragraphs, the fluorinated carbon coating comprises an ink composition.

[0006] In an example fuel cell component having one or more features of the fuel cell component of any of the previous paragraphs, the ink composition comprises fluorinated carbon CFx-2010, fluorinated carbon CFx-3000 and FC-3283 solvent.

10 [0007] In an example fuel cell component having one or more features of the fuel cell component of any of the previous paragraphs, the ink composition comprises about 2 grams of the fluorinated carbon CFx-2010, about 1 gram of the fluorinated carbon CFx-3000, about 57 grams of the FC-3283 solvent and a carbon to ink ratio of about 5%.

15 [0008] In an example fuel cell component having one or more features of the fuel cell component of any of the previous paragraphs, the ink composition comprises about 0.5 gram of the fluorinated carbon CFx-2010, about 2 grams of the fluorinated carbon CFx-3000, about 31 grams of the FC-3283 solvent and a carbon to ink ratio of about 7.5%.

20 [0009] In an example fuel cell component having one or more features of the fuel cell component of any of the previous paragraphs, the coating is applied to at least one side of the body.

[00010] In an example fuel cell component having one or more features of the fuel cell component of any of the previous paragraphs, the coating is applied to two
25 sides of the body.

[00011] In an example fuel cell component having one or more features of the fuel cell component of any of the previous paragraphs, the coating is applied to substantially all of the body.

30 [00012] An illustrative method of making a fuel cell component includes providing a body having a plurality of first pores with a first pore size. A fluorinated carbon coating is applied to at least some of the body for establishing a plurality of second pores in a coated portion of the body. The second pores have a second pore size that is smaller than the first pore size.

[00013] In an example method having one or more features of the method of the previous paragraph, the first pore size is at least four times larger than the second pore size.

5 [00014] In an example method having one or more features of the method of any of the previous paragraphs, the first pore size is about 200 microns and the second pore size is between about 1 and about 50 microns.

[00015] In an example method having one or more features of the method of any of the previous paragraphs, the applying comprises spraying a fluorinated carbon ink composition on at least some of the body.

10 [00016] In an example method having one or more features of the method of any of the previous paragraphs, the ink composition comprises fluorinated carbon CFx-2010, fluorinated carbon CFx-3000 and FC-3283 solvent.

[00017] In an example method having one or more features of the method of any of the previous paragraphs, the ink composition comprises about 2 grams of the
15 fluorinated carbon CFx-2010, about 1 gram of the fluorinated carbon CFx-3000, about 57 grams of the FC-3283 solvent and a carbon to ink ratio of about 5%.

[00018] In an example method having one or more features of the method of any of the previous paragraphs, the ink composition comprises about 0.5 gram of the fluorinated carbon CFx-2010, about 2 grams of the fluorinated carbon CFx-3000,
20 about 31 grams of the FC-3283 solvent and a carbon to ink ratio of about 7.5%.

[00019] In an example method having one or more features of the method of any of the previous paragraphs, the applying comprises applying the coating to at least one side of the body.

[00020] In an example method having one or more features of the method of any of the previous paragraphs, the applying comprises applying the coating to two
25 sides of the body.

[00021] In an example method having one or more features of the method of any of the previous paragraphs, the applying comprises applying the coating to substantially all of the body.

30 [00022] The various features and advantages of at least one disclosed example embodiment will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[00023] Figure 1 schematically illustrates selected portions of an example fuel cell assembly designed according to an embodiment of this invention.

[00024] Figure 2 schematically illustrates an example method of making a fuel cell component according to an embodiment of this invention.

[00025] Figure 3 schematically illustrates selected features of an example fuel cell component designed according to an embodiment of this invention.

DETAILED DESCRIPTION

10 [00026] Figure 1 schematically shows a fuel cell assembly 20. This example includes a polymer electrolyte membrane 22 situated between an anode catalyst layer 24 and a cathode catalyst layer 26. The anode catalyst layer 24 is situated next to a gas diffusion layer 28. A reactant flow field plate 30 facilitates directing a reactant, such as hydrogen, toward the gas diffusion layer 28 so that the reactant may reach the catalyst layer 24 for accomplishing the electrochemical reaction within the fuel cell
15 20. The example reactant flow field plate 30 includes a plurality of channels 34 along which the reactant, such as hydrogen, flows during fuel cell operation.

[00027] The cathode catalyst layer 26 is next to another gas diffusion layer 40. A cathode reactant flow field plate 42 is provided next to the gas diffusion layer 40.
20 The cathode flow field plate 42 includes a plurality of channels 46 through which a reactant, such as oxygen, flows so that the reactant may reach the catalyst layer 26 to facilitate the electrochemical reaction in the fuel cell assembly 20.

[00028] The manner in which the fuel cell assembly 20 operates is generally known and, therefore, is not described in any further detail here. One way in which
25 the example fuel cell assembly 20 differs from previously known fuel cells is that the gas diffusion layers 28 and 40, or a microporous layer associated with them, include multiple pore sizes established by the manner in which the gas diffusion layers (or microporous layers) are made.

[00029] Figure 2 schematically illustrates an example method 50 of making the
30 gas diffusion layers 28 and 40. In Figure 2, the gas diffusion layer 28 is considered as an example but the same process may be used for making the gas diffusion layer 40 (or a microporous layer). The gas diffusion layer 28 begins as a body, such as a sheet or film, of a selected gas diffusion layer material. Carbon cloth or a material such as TORAY 30 is used in one example.

[00030] An applicator 52 applies fluorinated carbon schematically shown at 54 to at least some of the body of the gas diffusion layer 28. In some examples, only one side of the body is coated. In other examples, two oppositely facing surfaces of the body are coated with the fluorinated carbon. In still other examples the fluorinated carbon coats all or essentially all of the body.

[00031] Prior to the application of the fluorinated carbon, the body of the gas diffusion layer 28 includes a plurality of first pores schematically shown at 56. The first pores have a first pore size. In one example, the first pore size is approximately 200 microns. After the fluorinated carbon has been applied to at least some of the body of the gas diffusion layer 28, a coated portion includes a plurality of second pores schematically shown at 58. The second pores 58 have a second pore size, which is smaller than the first pore size. In some examples, the second pore size is in the range from about 1 micron to about 50 microns. In some examples, the first pore size is at least four times larger and up to 200 times larger than the second pore size.

[00032] Providing two different pore sizes in the gas diffusion layer with fluorinated carbon as the source of the smaller pores facilitates gas transport through the gas diffusion layer and a microporous layer of a fuel cell assembly while reducing or minimizing any flooding at high current density operating conditions. The fluorinated carbon provides a hydrophobic surface on at least some of the coated body. The fluorinated carbon coating is superior to a TEFLON coating because more pore volume is available for gas transport in the microporous layer and gas diffusion layer. The fluorinated carbon coating is also less expensive than utilizing TEFLON.

[00033] With the example arrangement, liquid water transport can be facilitated by the large surface area of carbon associated with the fluorinated carbon while also allowing for storing water without filling the pores otherwise used for gas transport. The fluorinated carbon coating has the potential for storing or retaining water because of the large surface area associated with the coating and the smaller pore sizes. Retaining water on the fluorinated carbon coated portions of the body may be useful for facilitating desired fuel cell performance in low current density operating conditions.

[00034] Figure 3 schematically illustrates an example coated portion of a fuel cell component, such as a gas diffusion layer or microporous layer. In this example, the body of the gas diffusion layer 28 includes carbon fibers represented at 60, which

establish the first pores 56 having a larger pore size. The fluorinated carbon coating 54 establishes the second pores 58 having the second, smaller pore size.

[00035] In one example, the fluorinated carbon coating comprises a microporous layer carbon black ink composition. One example coating includes
5 fluorinated carbon CFx-2010, fluorinated carbon CFx-3000 and FC-3283 solvent. One particular example includes approximately two grams of the fluorinated carbon CFx-2000, approximately one gram of the fluorinated carbon CFx-3000, about 57 grams of the FC-3283 solvent and a carbon-to-ink weight ratio of approximately five percent. Another example fluorinated carbon coating composition includes about 0.5
10 grams of the fluorinated carbon CFx-2010, about two grams of the fluorinated carbon CFx-3000, about 30.8 grams of the FC-3283 solvent and a carbon-to-ink weight ratio of about 7.5 percent.

[00036] The larger pores combined with the smaller pores effectively establishes a tortuous pathway through the body of the fuel cell component that
15 allows for gas transport while reducing or minimizing the possibility for flooding. The smaller pore sizes establish a vapor barrier that prevents flooding that otherwise might occur through the larger sized first pores. The smaller pores 58 also help with capillary action for liquid management. The high surface area carbon distribution provided by the fluorinated carbon coating combined with the relatively high
20 tortuosity of the pathways through the component provides a useful vapor barrier to prevent water vapor loss during high temperature operation conditions.

[00037] Using a rod coating technique for impregnating the component body with the fluorinated carbon coating provides a useful distribution of the first pores 56 and the second pores 58 that does not cause an undesirable gas pressure drop within a
25 fuel cell.

[00038] The disclosed example fuel cell component is useful as a gas diffusion layer or microporous layer to facilitate better fuel cell performance under a variety of operating conditions. In particular, higher current conditions will not have flooding otherwise associated with some fuel cell arrangements. Avoiding flooding avoids a
30 reduction in power output and fuel cell performance loss.

[00039] The preceding description is illustrative 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 invention. The

scope of legal protection given to this invention can only be determined by studying the following claims.

CLAIMS

I claim:

- 5 1. A fuel cell component, comprising
a body comprising a plurality of first pores having a first pore size; and
a fluorinated carbon coating on at least some of the body, the coating
establishing a plurality of second pores in a coated portion of the body, the second
pores having a second pore size that is smaller than the first pore size.
- 10
2. The fuel cell component of claim 1, wherein the first pore size is at least four
times larger than the second pore size.
3. The fuel cell component of claim 2, wherein
15 the first pore size is about 200 microns; and
the second pore size is between about 1 and about 50 microns.
4. The fuel cell component of claim 1, wherein the fluorinated carbon coating
comprises an ink composition.
- 20
5. The fuel cell component of claim 4, wherein the ink composition comprises
fluorinated carbon CFx-2010;
fluorinated carbon CFx-3000; and
FC-3283 solvent.
- 25
6. The fuel cell component of claim 5, wherein the ink composition comprises
about 2 grams of the fluorinated carbon CFx-2010;
about 1 gram of the fluorinated carbon CFx-3000;
about 57 grams of the FC-3283 solvent; and
30 a carbon to ink ratio of about 5%.

7. The fuel cell component of claim 5, wherein the ink composition comprises
about 0.5 gram of the fluorinated carbon CFx-2010;
about 2 grams of the fluorinated carbon CFx-3000;
5 about 31 grams of the FC-3283 solvent; and
a carbon to ink ratio of about 7.5%.
8. The fuel cell component of claim 1, wherein the coating is applied to at least
one side of the body.
10
9. The fuel cell component of claim 1, wherein the coating is applied to two sides
of the body.
10. The fuel cell component of claim 1, wherein the coating is applied to
15 substantially all of the body.

11. A method of making a fuel cell component, comprising the steps of:
providing a body comprising a plurality of first pores having a first pore size;
and
applying a fluorinated carbon coating to at least some of the body for
5 establishing a plurality of second pores in a coated portion of the body, the second
pores having a second pore size that is smaller than the first pore size.
12. The method of claim 11, wherein the first pore size is at least four times larger
than the second pore size.
- 10 13. The method of claim 12, wherein
the first pore size is about 200 microns; and
the second pore size is between about 1 and about 50 microns.
- 15 14. The method of claim 11, wherein the applying comprises spraying a
fluorinated carbon ink composition on at least some of the body.
15. The method of claim 14, wherein the ink composition comprises
fluorinated carbon CFx-2010;
20 fluorinated carbon CFx-3000; and
FC-3283 solvent.
16. The method of claim 15, wherein the ink composition comprises
about 2 grams of the fluorinated carbon CFx-2010;
25 about 1 gram of the fluorinated carbon CFx-3000;
about 57 grams of the FC-3283 solvent; and
a carbon to ink ratio of about 5%.
17. The method of claim 15, wherein the ink composition comprises
30 about 0.5 gram of the fluorinated carbon CFx-2010;
about 2 grams of the fluorinated carbon CFx-3000;
about 31 grams of the FC-3283 solvent; and
a carbon to ink ratio of about 7.5%.

18. The method of claim 11, wherein the applying comprises applying the coating to at least one side of the body.

19. The method of claim 11, wherein the applying comprises applying the coating
5 to two sides of the body.

20. The method of claim 11, wherein the applying comprises applying the coating to substantially all of the body.

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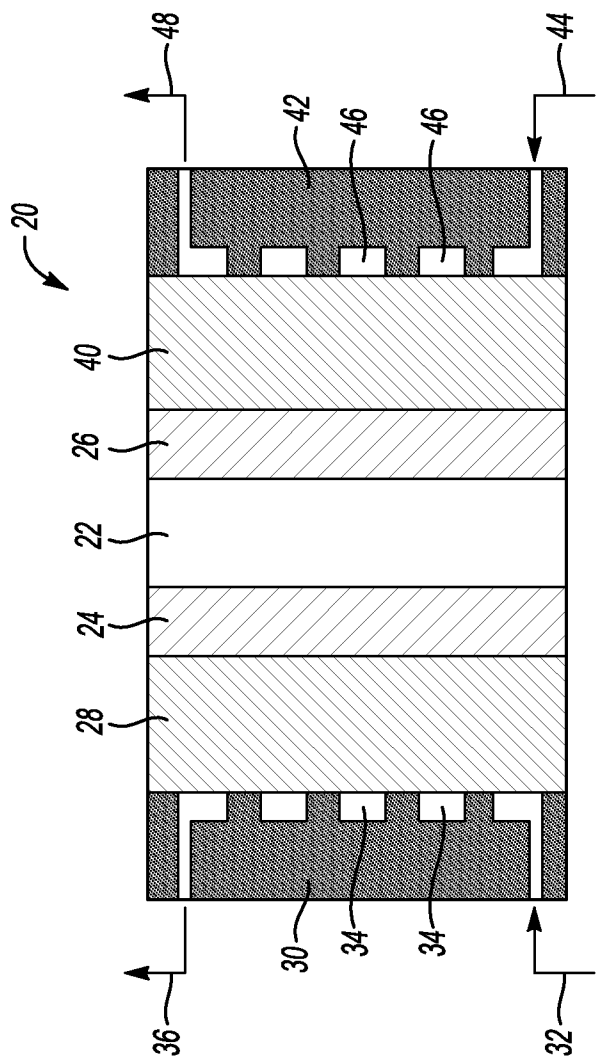


Fig-1

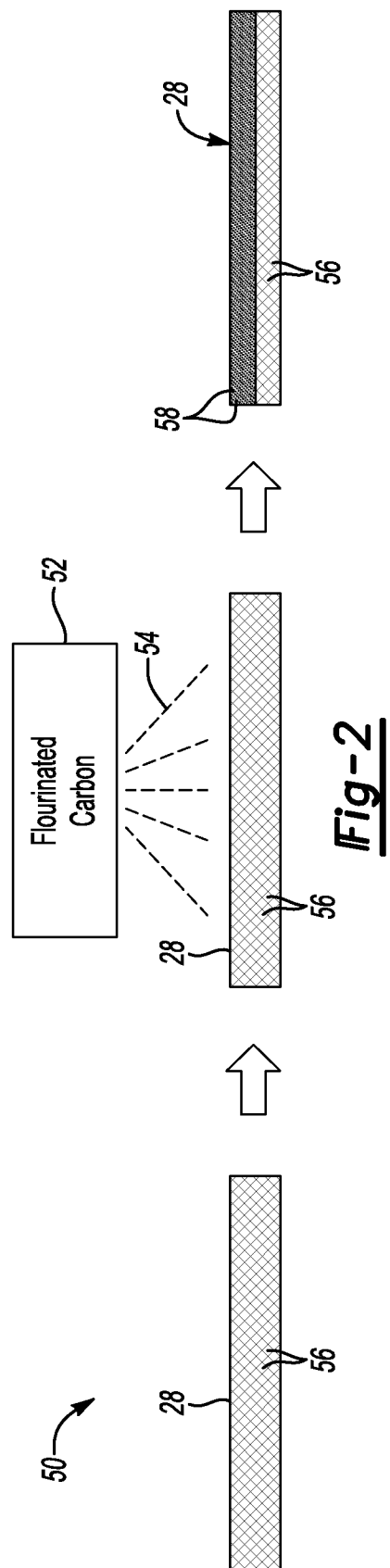


Fig-2

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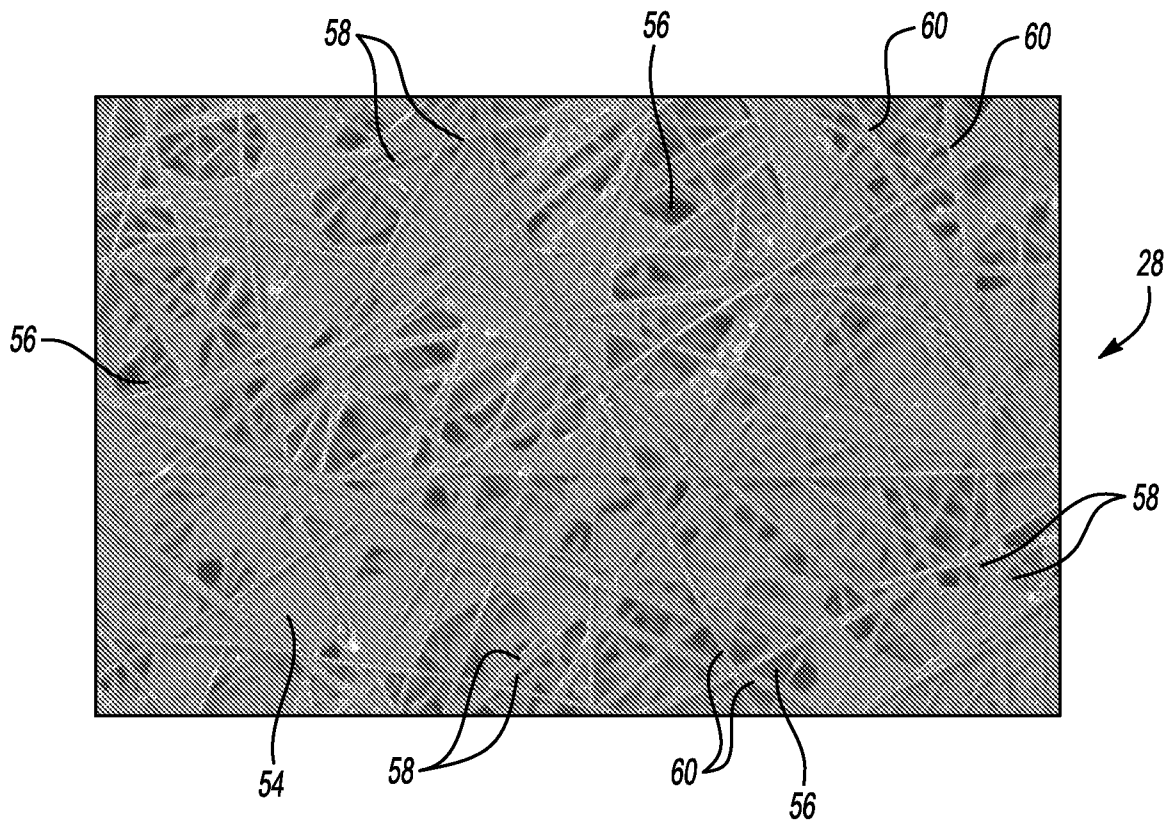


Fig-3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/011806**A. CLASSIFICATION OF SUBJECT MATTER****H01M 8/02(2006.01)i, H01M 8/10(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 8/02; H01M 8/10; B05D 1/00; D21H 13/50; H01M 4/88; H01M 4/86

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: gas diffusion layer, fluorinated carbon, microporous, pore size

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2680352 A2 (JNTC CO., LTD.) 01 January 2014 See abstract; paragraphs [0006] and [0087]-[0091]; and claims 1-11.	1-20
A	KR 10-2008-0047765 A (SAMSUNG SDI CO., LTD.) 30 May 2008 See abstract; paragraphs [0051]-[0059]; and claims 1-21.	1-20
A	US 6733915 B2 (BARTON, KELLY et al.) 11 May 2004 See abstract; columns 1-5; claim 1; and figure 1.	1-20
A	US 2009-0148726 A1 (JI, CHUNXIN et al.) 11 June 2009 See abstract; claim 1; and figure 2.	1-20
A	US 2011-0136044 A1 (HAN, KOOK IL et al.) 09 June 2011 See abstract; and claim 1.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"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

22 October 2014 (22.10.2014)

Date of mailing of the international search report

22 October 2014 (22.10.2014)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/011806

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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