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(54) Title: FUEL CELL DEVICE HAVING A LIQUID SOAK UP REGION

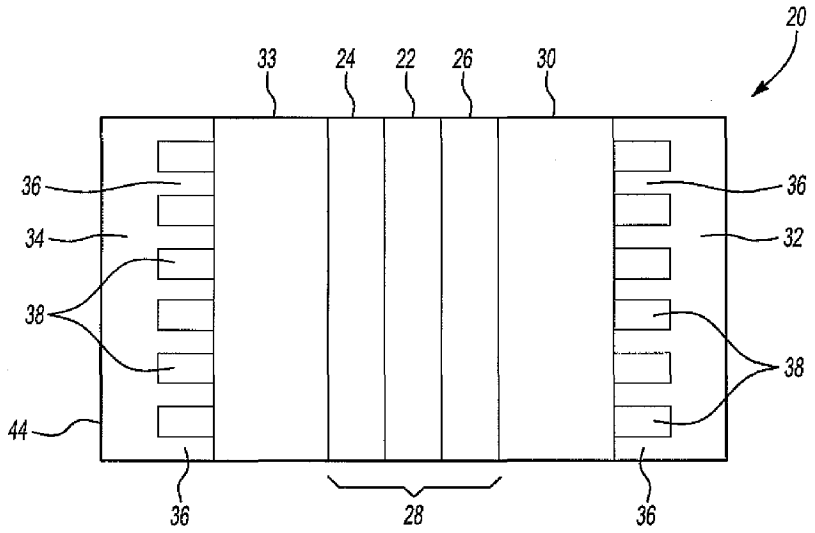


Fig-1

(57) Abstract: The fuel cell device includes an electrode assembly. A gas diffusion layer is on each side of the electrode assembly. A solid, non-porous plate is adjacent each of the gas diffusion layers. A hydrophilic soak up region is near an inlet portion of at least one of the gas diffusion layers. The hydrophilic soak up region is configured to absorb liquid water from the electrode assembly when the fuel cell device is shutdown.

FUEL CELL DEVICE HAVING A LIQUID SOAK UP REGION

BACKGROUND

[0001] Fuel cells are useful for generating electrical power. An electrochemical reaction occurs at a proton exchange membrane. Flow field plates are provided on each side of the membrane to carry reactants such as hydrogen and oxygen to the membrane for purposes of generating the electrical power. The flow field plates in some examples are solid, non-porous plates. Other example fuel cell arrangements include porous plates. There are advantages and drawbacks associated with each type of arrangement.

[0002] In solid plate fuel cell arrangements, for example, it is necessary to perform a flow field purge at shutdown to remove liquid water from the flow field channels. During the electrochemical reaction, liquid water is produced as a byproduct and tends to collect in the flow fields on the cathode side. If that liquid water remains there and temperatures drop sufficiently low, it will freeze and interfere with the ability to start up the fuel cell after it has been shutdown.

[0003] Typical purge procedures include using an air blower and a hydrogen recycle blower to remove the liquid water. One disadvantage of using such a purge procedure is that it introduces relatively large parasitic loads on the system when the fuel cell is no longer producing electrical power. Other issues associated with usual purge procedures are added system complexities and the risk of drying out portions of the fuel cell stack.

[0004] There is a need for a water management arrangement and strategy that reduces or eliminates purge requirements.

SUMMARY

[0005] An exemplary fuel cell device includes an electrode assembly. A gas diffusion layer is on each side of the electrode assembly. A solid, non-porous plate is adjacent each of the gas diffusion layers. A hydrophilic soak up region is near an inlet portion of at least one of the gas diffusion layers. The hydrophilic soak up

region is configured to absorb liquid water from the electrode assembly when the fuel cell device is shutdown.

[0006] In a fuel cell device having an electrode assembly, a gas diffusion layer on each side of the electrode assembly and a solid, non-porous plate adjacent each of the gas diffusion layers, an exemplary method of managing liquid distribution within the fuel cell includes providing a hydrophilic soak up region near an inlet portion of at least one of the gas diffusion layers. Liquid water is absorbed into the hydrophilic soak up region from the electrode assembly when the fuel cell device is shutdown.

[0007] The various features and advantages of this invention 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

[0008] Figure 1 schematically shows selected portions of an example fuel cell device.

[0009] Figure 2 schematically shows selected features of selected portions of the example of Figure 1.

[00010] Figure 3 shows the example of Figure 2 in another operating condition.

[00011] Figure 4 shows selected portions of another example fuel cell device configuration.

DETAILED DESCRIPTION

[00012] Figure 1 schematically shows selected portions of a fuel cell device 20. A proton exchange membrane 22 is positioned between catalyst layers 24 and 26. One of the catalyst layers 24 or 26 is a cathode catalyst layer while the other is an anode catalyst layer. The membrane 22 and the catalyst layers 24 and 26 are collectively referred to as an electrode assembly 28. The electrochemical reaction for producing electrical power within the fuel cell device 20 occurs at the electrode assembly 28.

[00013] A first gas diffusion layer 30 is positioned against the catalyst layer 26. The gas diffusion layer 30 in one example is hydrophobic. In another example, the gas diffusion layer 30 is hydrophilic. A first flow field plate 32 is positioned adjacent the gas diffusion layer 30.

[00014] Another gas diffusion layer 33 is positioned adjacent the catalyst layer 24. In one example, the gas diffusion layer 33 is hydrophobic. In another example, the gas diffusion layer 33 is hydrophilic. A second flow field plate 34 is positioned adjacent the gas diffusion layer 33.

[00015] In this example, the flow field plates 32 and 34 comprise solid, non-porous plates.

[00016] Figure 2 schematically shows a hydrophilic soak up region 40 near an inlet portion 42 of the gas diffusion layer 33. During normal fuel cell operating conditions, the soak up region 40 remains essentially dry as dry gases are introduced to the fuel cell.

[00017] The soak up region 40 in one example is in an electrochemically inactive region of the gas diffusion layer 33. In another example, the soak up region 40 is at least partially in an electrochemically active region.

[00018] Upon shutdown of the fuel cell device, the gas flow stops. There is liquid water byproduct present within the fuel cell device. At least some of that liquid water flows as schematically shown by the arrows 44 in Figure 3 across the electrode assembly 28 and into the soak up region 40. The arrows 44 are intended to show in-plane and through (or cross) –plane liquid water movement across the electrode assembly 28. The water that is absorbed by the soak up region 40 may come from the flow field channels 38, the catalyst layers, the catalyst-bi-layer interface and the macro porous layer within the fuel cell device. The soak up region 40 allows for drawing water away from the electrode assembly so that if any such water were to freeze, it will not interfere with reactants reaching the electrode assembly during a subsequent start up of the device.

[00019] In one example, a hydrophilic material or treatment is applied or added to the gas diffusion layer 33 in the region 40. Example hydrophilic materials include carbon, nafion and a wettable polymer. The hydrophilic treatment can include materials such as carbon, either naturally hydrophilic or rendered hydrophilic with treatments such as metal oxides, and polymers that can absorb water such as nafion. In such examples, the chemical properties of the absorbing material tends to draw water into the soak up region 40.

[00020] The gas diffusion layer 33 is porous. In one example, the hydrophilic material fills at least some of the pores in the region 40.

[00021] In another example, the soak up region 40 is established by controlling pore sizes in the corresponding gas diffusion layer 33. For example, configuring a hydrophilic gas diffusion layer 33 with larger pores outside of the soak up region 40 and smaller pores within the soak up region 40 will cause water to move toward the soak up region 40. The smaller pore size tends to draw in water because of the capillary dynamics associated with them. As known, smaller sized pores introduce larger capillary forces that tend to draw liquid into such pores more so than a comparatively larger pore.

[00022] One way of achieving smaller pores includes treating the soak up region 40 with hydrophilic carbon to establish smaller pores. At least some of the pores in the soak up region 40 are smaller in such an example. It is not necessary for all pores in the soak up region 40 to be smaller than other pores in the adjacent catalyst layer or a remainder of the gas diffusion layer. Some of the pores in one example soak up region 40 are the same size as other pores outside of that region.

[00023] The example soak up region 40 includes a plurality of pores. The catalyst layer 24 includes a plurality of pores. The pores of the soak up region 40 have a first size and the pores of the catalyst layer have a second pore size. The second pore size is at least as large as the pore size of the soak up region 40. In this example, the second pore size is larger such that the pores in the soak up regioin 40 are smaller than the pores of the catalyst layer 24. Having smaller pore size in the soak up region 40 compared to those in the catalyst layer 24 facilitates drawing water into the soak up region 40. Providing the smaller pores facilitates absorbing water into the soak up region 40 and using the soak up region 40 as a reservoir for the water.

[00024] In one example, the gas diffusion layer 33 is on the anode side of the fuel cell device. Positioning the soak up region 40 on the anode side facilitates removing water from the cathode side, which is where byproduct liquid water tends to collect during fuel cell operation. Using the soak up region 40 for removing at least some of the water from the cathode side flow field channels and from the electrode assembly 28 is useful for avoiding difficulties with subsequently starting the fuel cell device in low temperature conditions.

[00025] Another example includes a soak up region 40 on a cathode side. In such an example, the soak up region 40 is positioned to draw water away from the electrode assembly 28.

[00026] The example of Figure 4 includes a soak up region 40 in the gas diffusion layer 33. This example also includes a soak up region 40' in the adjacent flow field plate 34 near the fuel inlet on the corresponding side of the fuel cell device. Providing an additional area of soak up region 40' in the flow field plate 34 adjacent the gas diffusion layer 33 provides additional water retention capability away from the areas in the fuel cell device where frozen water could present difficulty during a start up under cold conditions.

[00027] One feature of the disclosed examples is that a purge procedure can be minimized or eliminated, which simplifies a shutdown procedure and enhances the economies of the fuel cell arrangement. In some examples, some purge procedure may be used in combination with the soak up region 40 for purposes of managing the distribution of liquid water within the fuel cell during shutdown. For example, some dry gas is introduced into the flow field channels on the cathode side but in a lesser amount or for a shorter time compared to previous purge cycles. In other examples, no purge procedure is needed.

[00028] 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 invention. The scope of legal protection given to this invention can only be determined by studying the following claims.

CLAIMS

We claim:

1. A fuel cell device, comprising:

an electrode assembly;

a gas diffusion layer on each side of the electrode assembly;

a solid, non-porous plate adjacent each of the gas diffusion layers; and

a hydrophilic soak up region near an inlet portion of at least one of the gas diffusion layers configured to absorb liquid water from the electrode assembly when the fuel cell device is shut down.

2. The fuel cell device of claim 1, wherein the hydrophilic soak up region is on the gas diffusion layer on an anode side of the electrode assembly.

3. The fuel cell device of claim 2, including the hydrophilic soak up region near an inlet portion of the solid, non-porous plate on the anode side of the electrode assembly.

4. The fuel cell device of claim 1, wherein the hydrophilic soak up region is at least partially on an electrochemically inactive area on the at least one gas diffusion layer.

5. The fuel cell device of claim 1, wherein the hydrophilic soak up zone has pores of a first size and the electrode assembly includes a catalyst layer immediately adjacent the at least one gas diffusion layer, the catalyst layer is porous having pores of a second size that is at least as large as the first size.

6. The fuel cell device of claim 5, wherein the second size is larger than the first size.

7. The fuel cell device of claim 1, wherein the hydrophilic soak up region comprises a hydrophilic material associated with the at least one gas diffusion layer, the hydrophilic material comprising at least one of carbon or a wettable polymer.

8. The fuel cell device of claim 7, wherein the at least one gas diffusion layer is porous and the hydrophilic material at least partially fills at least some pores of the inlet region of the at least one gas diffusion layer.

9. The fuel cell device of claim 7, wherein the hydrophilic material is applied to at least some of the material of the inlet portion of the at least one gas diffusion layer.

10. The fuel cell device of claim 1, wherein the hydrophilic soak up region remains essentially dry during operation of the fuel cell device.

11. A method of managing fluid in a fuel cell including solid, non-porous plates and gas diffusion layers associated with an electrode assembly, the method comprising the steps of:

providing a hydrophilic soak up region near an inlet portion of at least one gas diffusion layer; and

absorbing water from the electrode assembly into the hydrophilic soak up region when the fuel cell is shut down.

12. The method of claim 11, wherein the hydrophilic soak up region remains essentially dry during operation of the fuel cell.

13. The method of claim 11, wherein liquid water in the electrode assembly moves into the hydrophilic soak up region when the fuel cell is shut down.

14. The method of claim 11, comprising

introducing dry air into at least flow field channels of the non-porous plates when the fuel cell is shut down.

15. The method of claim 11, comprising providing the hydrophilic soak up region on the gas diffusion layer on an anode side of the electrode assembly.

16. The method of claim 15, comprising providing the hydrophilic soak up region near an inlet portion of the solid, non-porous plate on the anode side of the electrode assembly.

17. The method of claim 11,comprising providing the hydrophilic soak up region at least partially on an electrochemically inactive area on the at least one gas diffusion layer.

18. The method of claim 11, comprising providing pores in the hydrophilic soak up zone having a first size and providing pores on a catalyst layer of the electrode assembly having a second size that is at least as large as the first size.

19. The method of claim 18, wherein the second size is larger than the first size.

20. The method of claim 11, wherein the providing comprises at least one of
treating a material of the at least one gas diffusion layer or
at least partially filling pores of the at least one gas diffusion layer
with a hydrophilic material comprising at least one of carbon or a wettable polymer.

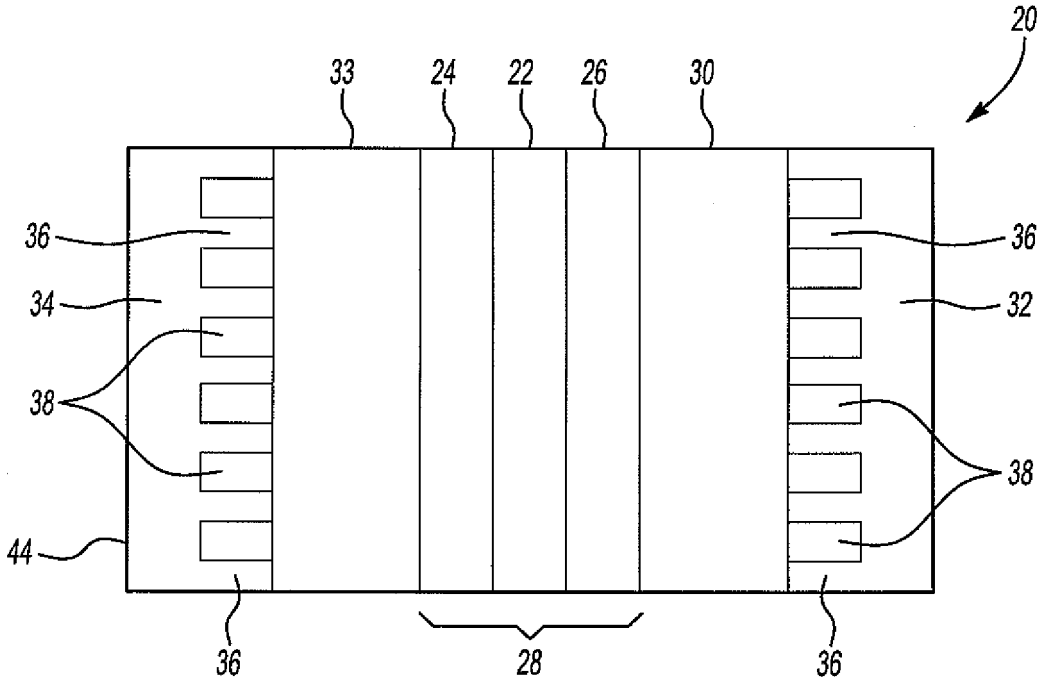


Fig-1

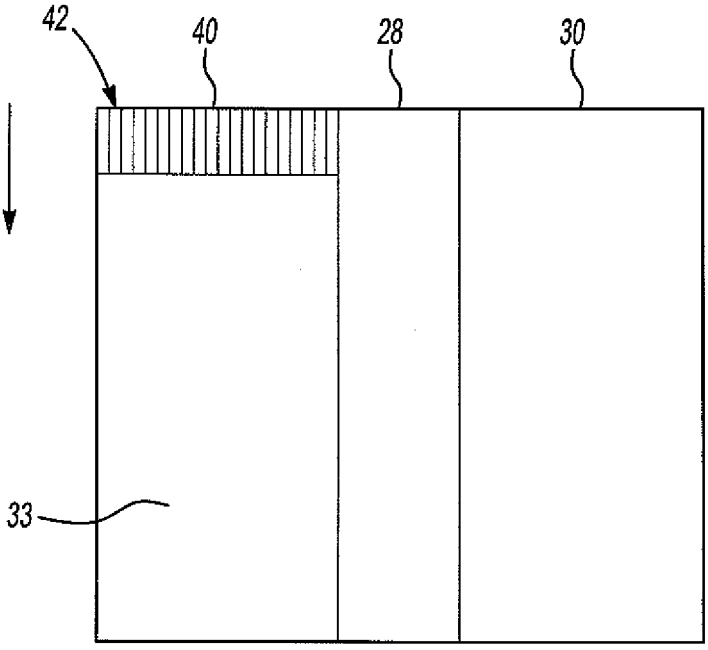


Fig-2

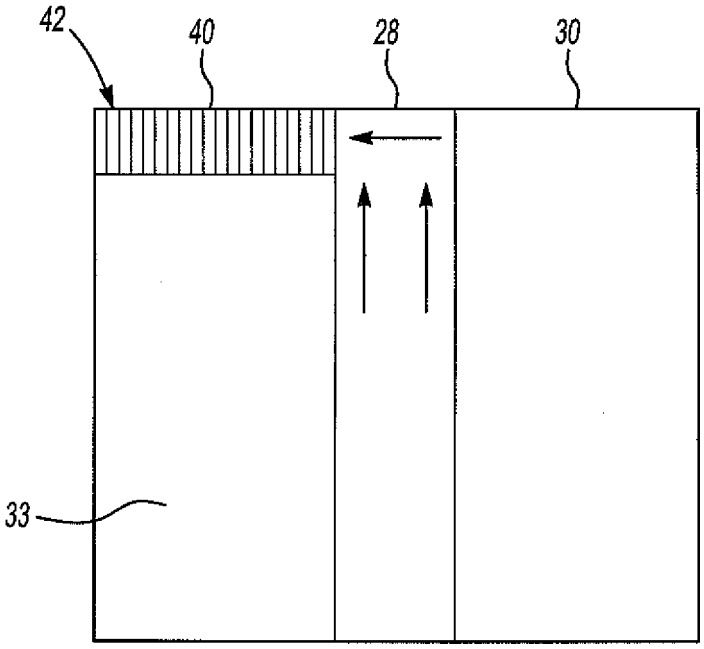


Fig-3

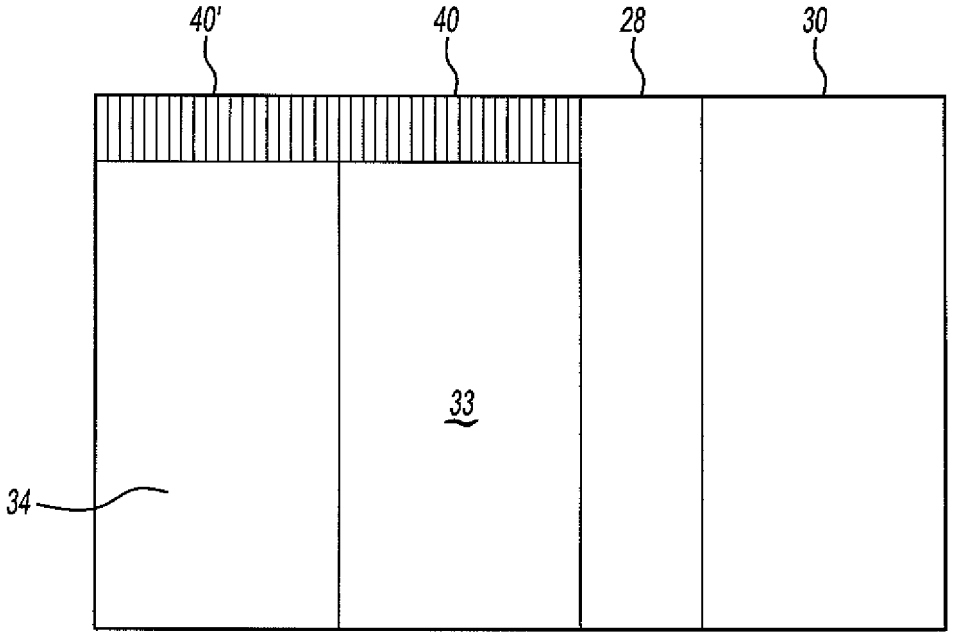


Fig-4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/076096

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M8/04 H01M8/02

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

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 492 044 B1 (WALSH MICHAEL M [US]) 10 December 2002 (2002-12-10)	1-4, 7-13, 15-17,20
Y	column 3, line 35 - line 60; claim 1 column 7, line 24 - line 28 column 6, line 38 - line 40 & US 5 660 048 A (BELDING WILLIAM A [US] ET AL) 26 August 1997 (1997-08-26) column 14, line 12 - line 62	5,6,14, 18,19
X	US 2005/181264 A1 (GU WENBIN [US] ET AL) 18 August 2005 (2005-08-18)	1-3,7, 10,11, 13,15,16
Y	paragraphs [0020], [0052], [0056], [0059]; figure 10	5,6,18, 19

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[X] Further documents are listed in the continuation of Box C.

[X] 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

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"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	Date of mailing of the international search report
26 May 2009	04/06/2009

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/076096

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2006/040150 A1 (YU PAUL T [US] ET AL YU PAUL TAICHIANG [US] ET AL) 23 February 2006 (2006-02-23) abstract -----	14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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