

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

1: Proton-exchange membrane - Wikipedia

The performance and durability of the fuel cells with silica glass membranes were improved by casting a thin-film of Nafion on the anode side of the thin, phosphosilicate glass membrane.

However, in traditional DMFCs, the use of a high concentration of methanol fuel results in a serious crossover of fuel through the proton-conductive membrane when a solid proton-conductive membrane is used. One type of commercially available solid proton-conductive membrane is available under the registered trademark Nafion from DuPont Chemical Co. The fuel crossover decreases not only the DMFC efficiency but also the voltage efficiency because it poisons the cathode and lowers cathode performance. Another problem when using a solid Nafion membrane fuel cell is the electromigration of water from the anode side to the cathode side which complicates water management in the fuel cell and limits the methanol fuel concentration. With continued reference to FIG. The composite PEM may be composed of a porous frit. A porous frit as used herein includes a finely porous material through which gas or liquid may pass such as a sintered glass or sintered ceramic. The porous frit of the composite PEM may be filled with one or more proton-conducting materials such as the perfluorinated sulfonic acid polymer commercially available under the registered trademark Nafion from DuPont Chemical Co. The porous frit may be filled by other proton-conducting materials and polymers such as poly para-phenylene sulphonic acid PPSA , polyvinylidene fluoride PVDF , and others. The pores of the composite PEM may be filled by soaking with the proton-conducting material in a solvent solution and then dried; thus, leaving the proton conducting material behind in the porous frit. Once dried, the surfaces of the composite PEM can be scraped and smoothed with a culling or polishing tool to clean off the unabsorbed material. The number and volume of the pores in the composite PEM may be adjusted and optimized for the desired proton-conductivity and cross-over. Palladium Pd , and Ruthenium Ru particles. For example, the anode-catalyst may be applied directly to the composite PEM by brush coating a metal catalyst such as a Platinum-ruthenium mixture to the anode side of the composite PEM. A current collector , such as a porous gold coating, may also be applied to the anode-catalyst. Likewise, the cathode-catalyst , such as an air-breathing cathode catalyst, may be applied to the cathode side by brushing or rolling on a metal catalyst layer such as a Platinum layer over the cathode side. A current collector , such as a porous gold coating, may then be applied to the surface of the cathode-catalyst. The current collector and the current collector may be connected to the external circuit. Alternatively, the anode-catalyst and the cathode-catalyst may be applied to the composite PEM by chemical vapor deposition techniques known by those of skill in the arts. Furthermore, the current collector and the current collector may be applied by chemical vapor deposition techniques. In another embodiment, the fuel cell may include a CO₂ vent which allows passage of any CO₂ gas generated by the fuel cell. The CO₂ vent may be composed of a hydrophobic material such as poly dimethyl siloxane to selectively allow the CO₂ to escape. The fuel cell may include an exit port allowing for the exit of H₂O and CO₂ from the cathode side. In yet another embodiment shown by FIG. The pores of the porous frit may be filled with one or more proton-conducting materials such as the perfluorinated sulfonic acid polymer commercially available under the registered trademark Nafion from DuPont Chemical Co. The porous frit may be filled by other proton-conducting materials and polymers such as poly para-phenylene sulphonic acid PPSA , polyvinylidene fluoride PVDF , and others as desired. The layer of glass may be deposited by chemical vapor deposition techniques. After the layer of glass has been deposited on the composite PEM , the anode-catalyst may be deposited on the glass layer and the cathode-catalyst may be deposited on the cathode side opposite the anode side. Both the anode-catalyst and the cathode-catalyst may be one or more metal catalysts such as Pt or a Pt-Ru mixture. The current collectors and may comprise a porous gold coating or other conductive coating and can be deposited over the anode-catalyst and the cathode-catalyst , respectively. Once the anode-catalyst , the cathode-catalyst and the current collectors and have been deposited the fuel container may be added to the anode side in order to complete the MEA. For

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

purposes of example only and not limitation, an appropriate fuel may include an organic fuel such as a hydrocarbon fuel. For example, liquid methanol may be a fuel used in a fuel cell according to the present invention. The methanol fuel may be diluted by water to the desired concentration. In still yet another embodiment, a fuel cell according to the present invention may be configured to resemble a battery such as a D, C, B, A, AA, or other desired size batteries commonly used in consumer electronics. For purposes of example only and not meant as a limitation, FIG. As described previously, the pores of the cylindrical porous frit may be filled with one or more proton-conducting materials such as the perfluorinated sulfonic acid polymer commercially available under the registered trademark Nafion from DuPont Chemical Co. The layer of glass may be deposited by chemical vapor deposition techniques as discussed previously and as known by those of skill in the art. An anode-catalyst may be deposited on the glass layer and a cathode-catalyst may be deposited on the cathode side which may be on the outside surface of the cylindrical PEM. Over the anode-catalyst and the cathode-catalyst current collectors and, respectively, may be deposited. The anode-catalyst and the cathode-catalyst may include a porous gold coating or other conductive coating. The anode side may also include an absorbent liner, such as a fabric like cotton, to provide uniform wetting of the anode side by a fuel. In this way, the battery would be operable in any orientation. The current collector deposited over the anode-catalyst can be connected to an external electrical contact such as a metal cap of the battery. Likewise, the current collector deposited over the cathode-catalyst may be connected to an external electrical contact such as a metal cap of the battery. Methyl cap and metal cap may be electrically insulated from each other. In this way, an electric current may be completed outside of the battery by connecting the external metal caps and the battery. This electric current may be used to power an electronic device. Porous frits approximately 0. In this way, the porous frit may become a composite proton-exchange membrane. The reactant gases for silicon dioxide were silane and nitrous oxide with a $N_2O: SiH_4$ ratio of 2. The phosphorus content in the PSG was 0. Atmospheric oxygen was used as the oxidant at the cathode. A fuel container was attached on the anode side and 8MM aqueous methanol solution was used as fuel. The frequency range for the impedance measurement was from 1 Hz to 1. However, each fuel cell used a different concentration of a methanol solution as fuel. The fuel cells were operated at room temperature and atmospheric oxygen was used as the oxidant. The frit thickness was 2 mm and pore size was 0. It can be seen that the cell had a high open circuit potential about 0. The performance of the cell with. These results indicate that the frit based composite membrane can effectively prevent the methanol permeation. The frit pore size ranged from 0. The cells were operated at room temperature. Because the membrane resistance for proton transportation decreases with the decreased frit thickness, the performance of the micro fuel cell was increased significantly when frit thickness decreased from 2 mm to 1. The frit thickness was 1. With the increased frit pore sizes, the open circuit potential of the cell decreased and the current density increased. As the fraction of Nafion in the composite membrane increased with the increased pore size, the methanol permeation through membrane also increased. Both open circuit potential and current density of the cell with glass membrane were higher than that without glass membrane. The results show that the glass membrane helps to prevent methanol permeation through the composite PEM. The frit can be filled by different inorganic or organic proton conductive materials. It can be seen that the cell with PPSA filled frit composite membrane has a higher open circuit potential than the cell with Nafion filled frit composite membrane. It will be obvious to those having skill in the art that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

2: Microfabricated Fuel Cell - GEORGIA TECH RESEARCH CORPORATION

Among the pioneers in micro fuel cells were Kelley, Deluga, and Smyrl (,) who created a miniature PEM fuel cell where all of the components were analogous to that of a large fuel cell, but made through thin-film electronic microfabrication techniques.

Dekel c, Andrew M. Herring d, Michael A. Kohl f, Anthony R. Kucernak g, William E. China Received 27th April , Accepted 4th August First published on 4th August This article provides an up-to-date perspective on the use of anion-exchange membranes in fuel cells, electrolysers, redox flow batteries, reverse electro dialysis cells, and bioelectrochemical systems e. The aim is to highlight key concepts, misconceptions, the current state-of-the-art, technological and scientific limitations, and the future challenges research priorities related to the use of anion-exchange membranes in these energy technologies. All the references that the authors deemed relevant, and were available on the web by the manuscript submission date 30 th April , are included. He was a postdoctoral researcher at the University of Surrey “ before appointment as Lecturer , Reader and Professor His research interests are focused on polymer electrolytes for clean energy and water systems: He left Rafael in to co-found CellEra, leading today a selected group of 14 scientists and engineers, developing the novel Alkaline Membrane Fuel Cell technology. Dr Dekel holds 14 battery and fuel cell patents. Hickner Professor Michael Hickner Associate Professor, Department of Materials Science and Engineering, Pennsylvania State University, USA focuses his research on the relationships between chemical composition and materials performance in functional polymers to address needs in new energy and water purification applications. His research group has ongoing projects in polymer synthesis, fuel cells, batteries, water treatment membranes, and organic electronic materials. In , he joined Georgia Tech. His research includes ionic conducting polymers, high energy density batteries, and new materials and processes for advanced interconnects for integrated circuits. He then studied polymer science at Nankai University His research interests cover membranes and related processes, particularly ion exchange membranes and controlled release. He was then promoted to lecturer, associate professor and full professor He was a visiting scientist at Cornell “05 and is an adjunct professor at Xiamen University. He is an editorial board member of Science China: He was vice-chair of the physical electrochemical division of the International Society of Electrochemistry “12 and China section chair of the Electrochemical Society “ Broader context Many electrochemical devices utilise ion-exchange membranes. Prior wisdom has led to the general perception that anion-exchange membranes that conduct negatively charged ions have too low conductivities and chemical stabilities especially in high pH systems for application in such technologies. This article reviews the key literature and thinking related to the use of anion-exchange membranes in a wide range of electrochemical and bioelectrochemical systems that utilise the full range of low to high pH environments. Preamble There is an increasing worldwide interest in the use of anion-exchange membranes including in the alkaline anion forms , in electrochemical energy conversion and storage systems.

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

3: Research trends - [PDF Document]

To address this issue on a Si-based micro fuel cell platform, we propose the use of conductive polypyrrole (PPy) and Nafion® composite film as a catalyst support layer to host the electrochemically deposited catalyst nanoparticles.

Naeemi, " Airgap Interconnects: Lithographic and Dissolution Properties ," J. Bidstrup Allen, and P. Nicole An and P. Kohl, " Performance of carbon dioxide vent for direct methanol fuel cells. Kohl, " Performance of Li-ion secondary batteries in low power, hybrid power supplies. Kohl, " Anionic polysulfone ionomers and membranes containing fluorenyl groups for anionic fuel cells. Improvement in Thermally Decomposable Template. Modeling, Fabrication, and Characterization. Journal of the Electrochemical Society , 6 , pp Fâ€™F Photoacid Generators for Catalytic Decomposition of Polycarbonate. Journal of Applied Polymer Science , , pp â€™ Journal of Materials Chemistry , 17, pp â€™ Wafer-Level Packaging of Micromechanical Resonators. Journal of Microelectromechanics and Microengineering , 16, pp â€™ Electrochimica Acta , 51, pp â€™ Journal of The Electrochemical Society , 2 , pp Aâ€™ Journal of Microelectromechanical Systems , 15, pp â€™ Journal of Electronic Materials , 35, pp â€™ Journal of Materials JOM , 57 12 , pp 26â€™ Journal of the Electrochemical Society , 8 , p Aâ€™ Journal of Physical Chemistry B , , pp â€™ Journal of Microelectronics and Electronic Packaging , 2, pp â€™ Journal of the Electrochemical Society , 2 , pp E56â€™E Magnetically Bistable Switch Part 1. Modeling and Ultra Low Switching Energy. Sensors and Actuators A , 2 , pp â€™ Magnetically Bistable Switch Part 2. Journal of the Electrochemical Society , 1 , pp E9â€™E Journal of Micromachining and Microengineering , 15, pp 35â€™ Note this is an abstract Li, J. Journal of Power Sources , , pp â€™ Journal of Microelectronics and Electronic Packaging , 1, pp 47â€™ Journal of the Electrochemical Society , 8 , pp Aâ€™A Journal of Vacuum Science and Technology B , 22 3 , pp â€™ Plating and Surface Finishing , 91 2 , pp 40â€™ Electrochimica Acta , 49, pp â€™ Impact of Reactions on Mechanical Properties. Journal of Applied Polymer Science , 91 2 â€™ Note this is an abstract Gray, G. Journal of Microelectromechanical Systems , 13 1 , pp 51â€™ Photosensitive Polynorbornene Based Dielectric. Journal of Applied Polymer Science , 91, pp â€™ Sensitivity and Spatial Resolution. Li, Jun; Kohl, P. Journal of the Electrochemical Society , 8 , pp Câ€™C Journal of the Electrochemical Society , 9 , pp Hâ€™H Nanotechnology , 14, pp Journal of Microelectromechanical Systems , 12 2 , pp â€™ Journal of Applied Polymer Science , 89 , pp â€™ Electrical, Optical, and Mechanical Properties. Journal of the Electrochemical Society , 12 , pp Fâ€™F Chemically Bonded Porogens in Methylsilsequioxane I. Journal of the Electrochemical Society , 12 , pp Câ€™C Journal of Applied Polymer Science , 88, pp â€™ Journal of the Electrochemical Society , 31 10 , pp â€™ Note this is an abstract Wu, X. Journal of the Electrochemical Society , 10 , pp Gâ€™G Journal of the Electrochemical Society , 9 , pp Aâ€™A Journal of the Electrochemical Society , 8 , pp Hâ€™H Electrostatic actuators with intrinsic stress gradient I. Interconnect Opportunities for Gigascale Integration. Thermal decomposition kinetics of polynorbornene. Journal of the Materials Research Society , 17 3 , pp â€™ Variable Frequency Microwave Curing of Benzocyclobutene. Journal of the Electrochemical Society , 12 , pp Aâ€™A Porous Methylsilsequioxane for Low-k Dielectric Applications. Journal of Applied Polymer Science , 83 5 , pp â€™ Fabrication of microchannels using polycarbonates as sacrificial materials. Journal of Micromechanics and Microengineering , 11, pp â€™ Journal of the Electrochemical Society , 5 , pp Fâ€™F Journal of Vacuum Science and Technology B , 19 2 , pp â€™ Multilayer Planarization of Polymer Dielectrics. Journal of Microelectromechanical Systems , 10, pp â€™ Journal of Power Sources , 1â€™2 , pp â€™ Three-dimensional Dielectric Characterization of Polymer Films. Journal of Applied Polymer Science , 80, pp â€™ Journal of the Electrochemical Society , 4 , pp Aâ€™A Note this is an abstract Kohl, P. Air Gaps in 0. Electron Device Letters , 21 12 , pp â€™ Journal of the Electrochemical Society , , pp â€™ Journal of Polymer Science: Polymer Physics , 38 , pp â€™ Electrochemical and Solid State Letters , 3 5 , pp â€™ Journal of the Electrochemical Society , 12 , pp â€™ Functionalized Polynorbornene Dielectric Polymers: Adhesion and Mechanical Properties. Polymer Physics , 37, pp â€™ Journal of Vacuum Science and Technology A , 17 6 , pp â€™ Journal of the

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

Electrochemical Society , 5 , pp 115-118” Selective Wet Etching of Lithium Gallate. Journal of the Electrochemical Society , 5 , pp L88-L91” Electrochemical and Solid State Letters , 2 2 , pp 77-80” Silver Metallization for Advanced Interconnects. Macromolecules , , pp 115-118” Macromolecular Symposia , , pp 115-118” Development of a New Force Field for Polynorbornene. Journal of Electronic Materials , 27, p L

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

4: USA1 - Thin film glass composite catalyst electrode - Google Patents

Proton exchange membrane fuel cells 5, in honor of Supramaniam Srinivasan PEM fuel cells V, in honor of Supramaniam Srinivasan Other Creators. Fuller, Thomas Francis.

The authors have declared that no competing interests exist. Conceived and designed the experiments: Received Jan 2; Accepted Mar This article has been cited by other articles in PMC. Abstract The biosynthesis of the redox shuttle, phenazines, in *Pseudomonas aeruginosa*, an ubiquitous microorganism in wastewater microflora, is regulated by the 2-heptyl-3,4-dihydroxyquinoline PQS quorum-sensing system. However, PQS inhibits anaerobic growth of *P.* We constructed a *P.* The engineered strain exhibited an improved electrical performance in microbial fuel cells MFCs and potentiostat-controlled electrochemical cells with an approximate five-fold increase of maximum current density relative to the parent strain. Electrochemical analysis showed that the current increase correlates with an over-synthesis of phenazines. These results therefore demonstrate that targeting microbial cell-to-cell communication by genetic engineering is a suitable technique to improve power output of bioelectrochemical systems. Introduction Microbial fuel cells MFCs are bioelectrochemical devices in which viable electroactive biofilms EABs convert chemical energy directly into electrical energy [1] , [2] , [3]. In a typical two-chamber configuration, viable EABs in the anaerobic anode chamber oxidize organic substrates as part of its metabolic functions. In this manner, the electrons can flow through an external circuit across an electrical load, thus producing electrical power. The protons diffuse across a proton exchange membrane to the aerobic cathode chamber, where a biological or chemical catalyst promotes oxygen reduction and the formation of water to maintain overall charge balance. MFCs also enable simultaneous wastewater treatment and bioelectricity generation [4] , [5]. However, the main limitation for full-scale implementation of this technology is the slow anodic electron transfer processes occurring at the biofilm-electrode interface [6]. Common electrochemically active bacteria, such as *Geobacter sulfurreducens* [7] , [8] and *Shewanella oneidensis* MR-1 [9] , [10] , have been frequently used to produce bioelectricity in MFCs. Extracellular electron transfer occurs either through membrane associated cytochromes [11] , secretion of soluble electron shuttles or mediators [12] , [13] , [14] , or physical conductive appendages, termed as nanowires [15] , [16] , [17]. It produces phenazines as soluble redox mediators to enhance electron transport [18] , [19]. Phenazine biosynthesis is positively regulated by the *Pseudomonas* quinolone signal PQS system [20] , [21]. However, there are several factors which limit the bioelectricity generation of *P.* Firstly, the PQS system remains largely inactive due to the requirement of oxygen and thus this limits phenazine biosynthesis [22]. Secondly, PQS signaling represses anaerobic growth of *P.* Recent studies showed that synthetic PqsE can regulate phenazine biosynthesis without the presence of PQS signaling [21] , [25]. In this study, we constructed a PQS defective but phenazine over-producing *P.* The engineered strain showed much higher electrochemical activity and concentrations of pyocyanin in MFCs. We suggest that manipulation of the microbial signaling system might provide novel strategies to improve the power output of bioelectrochemical devices. Luria-Bertani LB medium [27] was used to cultivate both *E.* Transconjugants carrying transposon insertion were picked from the selective plates and inoculated into microtiter tray wells containing LB medium by using a Qpix2 robot Genetix. Mutants that produced reduced levels of pyocyanin were selected and saved for further analysis. For identification of the transposon insertion site, the sequence flanking the Mariner transposon in selected mutants was identified by arbitrary polymerase chain reaction PCR , as previously described [30] but with the following TnM specific primers: Its phenotype could be rescued by complementation with the provision of the pqsA-E operon in trans on plasmid pLG10 [20] , kindly provided by Dr. Colin Manoil Figure 1. The synthetic sPqsE over-expression vector [25] was kindly provided by Dr.

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

5: Publications | Kohl Research Group

A glass composite catalyst electrode according to the present disclosure relates generally to proton-exchange fuel cells, including hydrogen fuel cells, direct methanol fuel cells, direct ethanol fuel cells, formic acid fuel cells, and the like.

However, in traditional DMFCs, the use of a high concentration of methanol fuel results in a serious crossover of fuel through the proton-conductive membrane when a solid proton-conductive membrane is used. One type of commercially available solid proton-conductive membrane is available under the registered trademark Nafion from DuPont Chemical Co. The fuel crossover decreases not only the DMFC efficiency but also the voltage efficiency because it poisons the cathode and lowers cathode performance. Another problem when using a solid Nafion membrane fuel cell is the electromigration of water from the anode side to the cathode side which complicates water management in the fuel cell and limits the methanol fuel concentration. With continued reference to FIG. The composite PEM may be composed of a porous frit. A porous frit as used herein includes a finely porous material through which gas or liquid may pass such as a sintered glass or sintered ceramic. The porous frit of the composite PEM may be filled with one or more proton-conducting materials such as the perfluorinated sulfonic acid polymer commercially available under the registered trademark Nafion from DuPont Chemical Co. The porous frit may be filled by other proton-conducting materials and polymers such as poly para-phenylene sulphonic acid PPSA , polyvinylidene fluoride PVDF , and others. The pores of the composite PEM may be filled by soaking with the proton-conducting material in a solvent solution and then dried; thus, leaving the proton conducting material behind in the porous frit. Once dried, the surfaces of the composite PEM can be scraped and smoothed with a culling or polishing tool to clean off the unabsorbed material. The number and volume of the pores in the composite PEM may be adjusted and optimized for the desired proton-conductivity and cross-over. Palladium Pd , and Ruthenium Ru particles. For example, the anode-catalyst may be applied directly to the composite PEM by brush coating a metal catalyst such as a Platinum-ruthenium mixture to the anode side of the composite PEM. A current collector , such as a porous gold coating, may also be applied to the anode-catalyst. Likewise, the cathode-catalyst , such as an air-breathing cathode catalyst, may be applied to the cathode side by brushing or rolling on a metal catalyst layer such as a Platinum layer over the cathode side. A current collector , such as a porous gold coating, may then be applied to the surface of the cathode-catalyst. The current collector and the current collector may be connected to the external circuit. Alternatively, the anode-catalyst and the cathode-catalyst may be applied to the composite PEM by chemical vapor deposition techniques known by those of skill in the arts. Furthermore, the current collector and the current collector may be applied by chemical vapor deposition techniques. In another embodiment, the fuel cell may include a CO₂ vent which allows passage of any CO₂ gas generated by the fuel cell. The CO₂ vent may be composed of a hydrophobic material such as poly dimethyl siloxane to selectively allow the CO₂ to escape. The fuel cell may include an exit port allowing for the exit of H₂O and CO₂ from the cathode side. In yet another embodiment shown by FIG. The pores of the porous frit may be filled with one or more proton-conducting materials such as the perfluorinated sulfonic acid polymer commercially available under the registered trademark Nafion from DuPont Chemical Co. The porous frit may be filled by other proton-conducting materials and polymers such as poly para-phenylene sulphonic acid PPSA , polyvinylidene fluoride PVDF , and others as desired. The layer of glass may be deposited by chemical vapor deposition techniques. After the layer of glass has been deposited on the composite PEM , the anode-catalyst may be deposited on the glass layer and the cathode-catalyst may be deposited on the cathode side opposite the anode side. Both the anode-catalyst and the cathode-catalyst may be one or more metal catalysts such as Pt or a Pt-Ru mixture. The current collectors and may comprise a porous gold coating or other conductive coating and can be deposited over the anode-catalyst and the cathode-catalyst , respectively. Once the anode-catalyst , the cathode-catalyst and the current collectors and have been deposited the fuel container may be added to the anode side in order to complete the MEA. For

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

purposes of example only and not limitation, an appropriate fuel may include an organic fuel such as a hydrocarbon fuel. For example, liquid methanol may be a fuel used in a fuel cell according to the present invention. The methanol fuel may be diluted by water to the desired concentration. In still yet another embodiment, a fuel cell according to the present invention may be configured to resemble a battery such as a D, C, B, A, AA, or other desired size batteries commonly used in consumer electronics. For purposes of example only and not meant as a limitation, FIG. As described previously, the pores of the cylindrical porous frit may be filled with one or more proton-conducting materials such as the perfluorinated sulfonic acid polymer commercially available under the registered trademark Nafion from DuPont Chemical Co. The layer of glass may be deposited by chemical vapor deposition techniques as discussed previously and as known by those of skill in the art. An anode-catalyst may be deposited on the glass layer and a cathode-catalyst may be deposited on the cathode side which may be on the outside surface of the cylindrical PEM. Over the anode-catalyst and the cathode-catalyst current collectors and, respectively, may be deposited. The anode-catalyst and the cathode-catalyst may include a porous gold coating or other conductive coating. The anode side may also include an absorbent liner, such as a fabric like cotton, to provide uniform wetting of the anode side by a fuel. In this way, the battery would be operable in any orientation. The current collector deposited over the anode-catalyst can be connected to an external electrical contact such as a metal cap of the battery. Likewise, the current collector deposited over the cathode-catalyst may be connected to an external electrical contact such as a metal cap of the battery. Methyl cap and metal cap may be electrically insulated from each other. In this way, an electric current may be completed outside of the battery by connecting the external metal caps and the battery. This electric current may be used to power an electronic device. Porous frits approximately 0. In this way, the porous frit may become a composite proton-exchange membrane. The reactant gases for silicon dioxide were silane and nitrous oxide with a $N_2O: SiH_4$ ratio of 2. The phosphorus content in the PSG was 0. Atmospheric oxygen was used as the oxidant at the cathode. A fuel container was attached on the anode side and 8 M M aqueous methanol solution was used as fuel. The frequency range for the impedance measurement was from 1 Hz to 1. However, each fuel cell used a different concentration of a methanol solution as fuel. The fuel cells were operated at room temperature and atmospheric oxygen was used as the oxidant. The frit thickness was 2 mm and pore size was 0. It can be seen that the cell had a high open circuit potential about 0. The performance of the cell with. These results indicate that the frit based composite membrane can effectively prevent the methanol permeation. The frit pore size ranged from 0. The cells were operated at room temperature. Because the membrane resistance for proton transportation decreases with the decreased frit thickness, the performance of the micro fuel cell was increased significantly when frit thickness decreased from 2 mm to 1. The frit thickness was 1. With the increased frit pore sizes, the open circuit potential of the cell decreased and the current density increased. As the fraction of Nafion in the composite membrane increased with the increased pore size, the methanol permeation through membrane also increased. Both open circuit potential and current density of the cell with glass membrane were higher than that without glass membrane. The results show that the glass membrane helps to prevent methanol permeation through the composite PEM. The frit can be filled by different inorganic or organic proton conductive materials. It can be seen that the cell with PPSA filled frit composite membrane has a higher open circuit potential than the cell with Nafion filled frit composite membrane. It will be obvious to those having skill in the art that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims. A fuel cell comprising: The fuel cell of claim 1, further comprising an organic fuel. The fuel cell of claim 4, wherein the organic fuel is a hydrocarbon. The fuel cell of claim 5, wherein the hydrocarbon is methanol. The fuel cell of claim 6, wherein the methanol is diluted with water. The fuel cell of claim 1, wherein the proton-conducting material comprises a perfluorinated sulfonic acid polymer, poly para-phenylene sulphonic acid PPSA, polyvinylidene fluoride PVDF or mixtures thereof. The fuel cell of claim 1, wherein the anode catalyst and the cathode catalyst comprise one or more metal catalysts. The fuel

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

cell of claim 1 , wherein the anode catalyst and the cathode catalyst comprise Pt, Pd, Ru or mixtures thereof. The fuel cell of claim 1 , wherein the anode current collector and the cathode current collector comprise a porous gold layer. A membrane electrode assembly comprising: The membrane electrode assembly of claim 13 , wherein the proton-conducting material comprises a perfluorinated sulfonic acid polymer, poly para-phenylene sulphonic acid PPSA , polyvinylidene fluoride PVDF or mixtures thereof. The membrane electrode assembly of claim 13 , wherein the anode electrode catalyst and the cathode electrode catalyst comprise one or more metal catalysts. The membrane electrode assembly of claim 13 , wherein the anode electrode catalyst and the cathode electrode catalyst comprise Pt, Pd, Ru or mixtures thereof. A method of making a membrane electrode assembly comprising: A cylindrical direct methanol fuel cell comprising: US Fuel cell with porous frit based composite proton exchange membrane Active USB2 en Priority Applications 3.

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

6: Microfabricated Fuel Cells To Power Integrated Circuits - CORE

With continued reference to FIG. 1, to overcome the fuel cross over and water cross over common when using a solid proton-conducting membrane, a composite porous proton-exchange membrane (hereinafter "composite PEM ") may be used in the fuel cell

In one embodiment, one or more microfabricated fuel cells are built into a substrate such as a printed circuit board PCB or a printed wiring board PWB within an electronic device. The electrical energy that may be created by the integrated microfabricated fuel cells on the PWB can be used by the electronic components within and on the PWB. This is advantageous because the power source does not have to be separately packaged, have separate wiring, and have a separate enclosure. Also, a device with an integrated microfabricated fuel cell may be smaller without having to depend on a bulky battery as the power source. Further, an integrated microfabricated fuel cell may use a liquid power source, such as methanol, stored within a container of any shape and can be flexible so as to conform to available space. In one embodiment, the air holes and the cathode current collector may be sized as desired. The cathode current collector may be sputtered on the surface of the PWB and may include layers of titanium Ti , gold Au , copper Cu , chromium Cr , tungsten W , tantalum Ta , and other appropriate conductors. Now with reference to FIG. The sacrificial polymer may be polished to remove any excess polymer. The sacrificial polymer may comprise a poly propylene-carbonate PPC and a photoacid generator PAG and serve as a temporary placeholder in the microfabrication process. For example, after overcoating with additional fuel cell structures, the polymer can be converted into a gas through polymer decomposition. The gaseous polymer products can permeate through the overcoating and the resulting air-cavity can be used to form systems of microchannels to deliver air and fluid to the microfabricated fuel cell. A photo-patternable sacrificial polymer can be made by combining the polymer with the PAG. Upon ultraviolet UV irradiation, a PAG can produce an acid which can catalytically decompose the sacrificial polymer. A number of different PAG can be used when forming the sacrificial polymer such as 4-methylphenyl[4- 1-methylethyl phenyl], iodonium tetrakis pentafluorophenyl borate, and others. After the sacrificial polymer is spin cast on the cathode current collector , it may be soft baked to remove the solvent from the polymer. As show in FIG. The channels may be formed by exposing the photo-patternable sacrificial polymer to ultraviolet UV light and heat. The sacrificial polymer that is exposed to the UV light can then be removed during development by thermal decomposition. For example, as shown in FIG. For example, the cathode catalyst may be deposited by sputtering or painting a prepared catalyst ink containing carbon-supported platinum Pt on the surface of the remaining sacrificial polymer and the channel walls. As shown by FIG. With the air holes free from obstruction, the oxygen from the air may be free to contact the cathode catalyst and be used as the oxidant at the cathode of the microfabricated fuel cell. With continued reference to FIG. For example, the anode catalyst may comprise a platinum-ruthenium alloy layer sputter deposited on the surface of the PEM or a carbon-supported Pt-Ru catalyst ink painted on the surface of the PEM. The anode current collector may include a gold layer or other conductive layer deposited on the anode catalyst. In one embodiment, an molar M aqueous methanol solution may be used as fuel to power the microfabricated fuel cell. The inverted microfabricated fuel cell may be advantageous because the liquid fuel may be preventing from contact the PWB substrate which may cause delamination of the epoxy fiberglass construction. The external power circuit may include an electrical circuit extending from the anode current collector to the electrical device , and continuing to the cathode current collector. In this way, the external power circuit allows the electrons produced by the oxidation of the fuel at the anode to move from the anode, through the electrical device , and then back to the cathode. As discussed previously, protons generated at the anode may pass through the PEM and combine with oxygen in the air holes , and the electrons coming back from the external circuit , to form water on the cathode. The oxygen in the air holes may be provided by the ambient air either passively or by a forced air system. With reference now to FIGS. The cathode current

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

collector may be sized as desired. With reference to FIG. For example, the photo resist may be spin coated on the surface of the current collector layer and developed to produce the desired pattern. The photo resist may be comprised of a commercially available photo resist, such as AZ available from Hoechst Celanese. After developing the photo resist, the top layer of titanium may be etched away from the exposed region of the current collector, thereby revealing the underlying gold layer. As shown in FIG. After the channel walls are built up, the photo resist may be removed leaving the channel walls in electrical communication with the cathode current collector. The air holes may be configured to allow ambient air to contact the cathode catalyst of the completed microfabricated fuel cell. The air holes may be sized as desired. As illustrated by FIGS. As discussed previously, a sacrificial polymer, such as sacrificial polymer, may be deposited as a spin coat and comprise a poly propylene-carbonate PPC and a photoacid generator PAG and serve as a temporary placeholder in the microfabrication process. In one embodiment, the cathode catalyst may be deposited by sputtering or painting a prepared catalyst ink containing carbon-supported platinum Pt on the surface of the sacrificial polymer and the channel walls. The oxygen from the air may be free to contact the cathode catalyst through the air holes and serve as the oxidant at the cathode of the microfabricated fuel cell. With particular reference to FIG. The anode catalyst may comprise a platinum-ruthenium alloy layer sputter deposited on the surface of the PEM or a carbon-supported Pt-Ru catalyst ink painted on the surface of the PEM. The second current collector may include a gold layer deposited on the anode catalyst. In one embodiment, a fuel reservoir, such as fuel reservoir, may be attached on the anode side of one or more fuel cells to contain a liquid fuel that is oxidized by the microfabricated fuel cell. For example, an molar M aqueous methanol solution may be stored within the fuel reservoir and used as fuel to power the microfabricated fuel cell. At the cathode side, the oxygen in the ambient air may be circulated through the air holes and contact the cathode catalyst. The microfabricated fuel cells according to the disclosure, may operate in an inverted configuration with the anode below the cathode, or in the opposite orientation, with the anode above the cathode. As known by those of skill in the art, the multiple microfabricated fuel cells shown in FIG. For example, the external power circuit may include an electrical circuit wiring the multiple microfabricated fuel cells in series by connecting an anode current collector of one cell with the cathode current collector of the next. An electrical device may then be powered by completing a circuit connecting the terminal second current collector in the series with the cathode current collector at the beginning of the series not shown. An integrated microfabricated fuel cell constructed according to the disclosure may produce significant amounts of electrical power. Voltage curve for one embodiment of an integrated microfabricated fuel cell including a single layer anode catalyst and using an 8 M methanol solution as the fuel and air as the oxidant at room temperature. It can be seen that the microfabricated fuel cell had a high open circuit potential of approximately 0. Many variations and modifications may be made to the described embodiments of this disclosure without departing substantially from the spirit and principles of this disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the following claims.

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

7: Full text of "USPTO Patents Application "

A proton-exchange membrane, or polymer-electrolyte membrane (PEM), is a semipermeable membrane generally made from ionomers and designed to conduct protons while acting as an electronic insulator and reactant barrier, e.g. to oxygen and hydrogen gas.

Mikayla Smith and Robert F. Savinell Case Western Reserve University January, As portable electronic devices advance, with increases in operational speed, improved screen resolution, and higher functionality, there is an increased need for higher energy density and more efficient portable energy sources. Thus, more advanced energy storage to supplement or to replace batteries is needed. With a much higher energy density than current batteries, micro fuel cells could be one solution. Experts predict that, in the future, fuel cell batteries will be able to last two or three times longer than current batteries Grinberg and Skundin, There are differences in the definition of a micro fuel cell, some scientists considering it a very small fuel cell, while others include microfabricated conventional fuel cells within the definition. Independent of the definition, the electrochemical reactions that occur within are common to them all. Applications for portable energy storage devices are almost endless, but the specific requirements of application along with complications related to materials, structures, and manufacturing limitations lead to different design approaches. Despite this technology not yet being available in the marketplace, there is great hope for availability in the future. Much focus over the past two decades has been placed on fuel cells as a source for future large scale efficient energy conversion , however not as much attention has been given to micro fuel cells. However, good reviews of the work on micro fuel cells can be found in the literature see the Bibliography. Micro fuel cells have many similarities to conventionally sized fuel cells. The basic components needed for operation of micro fuel cells, such as electrodes , membranes , current collectors , and gas distribution, parallel those needed for conventional fuel cells, but in a miniaturized form. The material composition of the parts may differ however, because of the way the fuel cell is constructed and its processing conditions. Much like traditional fuel cells, micro fuel cells are often not self-contained, since elements such as fuel tanks lie outside of the cell and are connected to it separately. For this reason, some types of micro fuel cells alone are unable to replace batteries in portable electronic devices. Micro fuel cells are often fabricated using microfabrication processes. Microfabricated fuel cells, on the other hand, are not even necessarily small. Thus certain flow field components and other structures of a conventional fuel cell might be microfabricated in order to improve performance or to reduce cost. Examples of microfabricated processes include thin-film processes like those used to make silicon chips Kelley, To completely replace batteries, the micro fuel cell must be self-contained and all components including the fuel must be confined within the device. Other challenging design and materials issues include the elimination of pumps or compressors, and a capability to operate on atmospheric air, at ambient temperature and humidity. While various types of micro fuel cells such as those with solid oxide electrolytes are being developed, this article will focus on proton conducting polymer-based hydrogen-air and methanol-air fuel cells. Fuel cells - how they work Fig. The reactions occurring within a hydrogen-air fuel cell. Fuel cells are electrochemical devices that convert chemical energy from a fuel source into electrical energy by means of oxidation and reduction reactions. In this section we give a brief description of how conventional fuel cells work, and much more detail can be found in available text books and articles shown in the Bibliography. The choice of fuels might be hydrogen or methanol, which is oxidized at the anode , with the oxidant being oxygen from air which is reduced at the cathode. Figure 1 shows the reaction of a hydrogen-air polymer electrolyte fuel cell. Hydrogen oxidizes at the anode platinum catalyst - electrolyte interface causing it to dissociate into hydrogen ions and electrons. Released hydrogen ions are conducted through the electrolyte membrane to the cathode. Reduction then occurs at the cathode platinum catalyst-electrolyte interface see the Appendix for details. A proton exchange membrane PEM serving as the electrolyte is not electronically conductive , so the electrons that are released from the hydrogen are unable to

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

pass through it, but instead flow through an external circuit from the anode to the cathode. The flow of electrons within the circuit creates an electric current that can be used to power various electronic devices. The reaction will continue until all of the fuel is consumed; thus, the overall reaction equation in a hydrogen-air PEM fuel cell is the formation of water from hydrogen and oxygen. Another simple fuel for PEM fuel cells is methanol; and the same basic principles apply. In a direct methanol fuel cell, the oxidation of methanol and the reduction of oxygen result in the production of water and carbon dioxide and the water can be recycled to be used at the reaction occurring at the anode see the Appendix.

Components of fuel cells

The main structural elements of a conventional PEM fuel cell include two flow fields, two electrodes, a cathode, an anode, and a proton exchange membrane PEM. Figures 2 and 3 show the basic structure of a fuel cell. On the outermost ends of the fuel cell are two end plates that are bolted together to hold the fuel cell components together. The end plates are often massive because they hold multiple cells compressed together to boost the overall voltage. An electronically conducting flow field plate is placed against both the anode and the cathode which allows the gases to be fed to the electrodes.

The basic structure of a PEM fuel cell. A deconstructed fuel cell.

Electrolyte

An important component of the fuel cell is the electrolyte separator, as this is the medium through which ions travel from one electrode to the other, balancing the charges that occur because of the reactions. It is also the main structural component that distinguishes one type of fuel cell from another. The electrolyte should have a high ionic conductivity but also be very electronically resistive. If the PEM is too thin, a high amount of crossover of reactants occurs, but if it too thick, there is a high resistance and therefore a lower voltage output. A Nafion membrane requires hydration in order to conduct hydrogen ions, so operating under ambient conditions is a challenge since too low of hydration will increase cell resistance and too high hydration will cause water to flood the pores in the cathode electrode. Also, swelling of the polymer during fuel cell fabrication or during operation is a special challenge with micro fuel cells.

In hydrogen-air fuel cells, platinum nanoparticles are supported on the carbon micron-size particles that make up each electrode, but often the electrodes are at different loadings of catalyst material. In the case of methanol-air fuel cells an alloy of platinum and ruthenium is used as the catalyst for the anode because the ruthenium is able to electro-oxidize the carbon monoxide intermediates that are absorbed onto the platinum surface. The electrode structures of the catalyst layer are constructed to efficiently transport gaseous or liquid reactants, ionic products, and electrons. For this reason the structures are typically porous with a high surface area, and have electronically and ionically conductive components. The combination of the membrane with the anode and cathode electrode structures is called the membrane electrode assembly MEA. The GDL is an electrical conductor used to transport electrons while uniformly distributing gases to the catalyst layer. An ohmic voltage loss often occurring in a PEM fuel cell is due to electrical contact resistances between the GDL and the flow field plate. In hydrogen and methanol fuel cells, typically the GDL is composed of a version of carbon paper that is very porous and has been treated with a hydrophobic polymer. Ideally, the chemical reaction in the fuel cell should happen fast, efficiently, and effectively and the design and materials of these components of the cell determine these rates and efficiencies.

Design approaches to micro fuel cells

To enable a fuel cell to completely replace a battery, there are many design challenges that must first be overcome in order to make the fuel cell self-contained and portable. To be implemented as a battery, a micro fuel cell must operate at room temperature because it cannot contain heating or cooling devices and the membrane cannot require external humidification. Whether the fuel is hydrogen or methanol, the cell must be able to operate under atmospheric pressure and it must act passively, meaning there cannot be any pumps, fans, or compressors used to move the reactants. In addition, the device must be easy and safe to use and reliable. Fabricating the fuel cell device using methods of construction common for microfabricated electronics simplifies manufacturing and reduces cost. An extensive reviews on approaches to micro fuel cell design and materials is summarized in the literature see the Bibliography. Among the pioneers in micro fuel cells were Kelley, Deluga, and Smyrl, who created a miniature PEM fuel cell where all of the components were analogous to that of a large fuel cell, but made through thin-film electronic microfabrication techniques. Their

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

fuel cell was not completely self-contained however, and components such as the methanol fuel were heated. Their research and experimentation still profoundly affected the study of fuel cells, as they found that the performance of a micro fuel cell is able to very closely match that of a large fuel cell operating under similar conditions. A cross section of three consecutive hydrogen-air fuel cells. Wainright, Savinell, Liu, and Litt reported a design for a microfabricated polymer based fuel cell with on-board hydrogen storage which can operate passively as Figure 4 shows. The principle of their design lies in a planar array of edge collected cells where the cathodes would be all exposed directly to air and beneath the anodes would be a common fuel cartridge. The electrodes are interconnected through the edge of the individual cells. This is a special ability of the small size electrodes which would lead to high ohmic losses and non-uniform electrode activity for large electrodes. The main components of the cell such as the current collector , gas diffusion layer GDL , catalyst layers , and electrolyte were manufactured through a process of thick film printing. They report using a Nafion membrane deposition technique that gives a good quality and stable membrane film. On-board fuel storage was a main feature in the design shown in Figure 4. One way of storing hydrogen is to print a metal hydride ink, which has high volumetric hydrogen storage density, into the anode compartment. The anode can then be charged with hydrogen. For this to be a viable on-board storage, the metal hydride has to be charged with hydrogen relatively fast at low to moderate pressures and hydrogen must be delivered to the fuel cell at adequate rates. Another means of storing hydrogen fuel is through a chemical form, for example, such as stabilized sodium borohydride in aqueous solution because it is stable at room temperature for several months when its pH is about 10. When this solution comes into contact with a catalyst, a reaction occurs to separate out the hydrogen which is fed to fuel the cell see the Appendix. To design the cartridge with the catalyst included, a small well might be etched into the support structure with the catalyst printed at the bottom of the well see Figure 4. To activate the fuel cell, sodium borohydride solution is injected into the well. Upon solution contact with the catalyst, hydrogen bubbles up to the anode electrode structure. One drawback of this design is the orientation dependency of the cell. Methanol has been receiving much attention as a potential fuel source for micro fuel cells because it is cheap, easily stored and handled, and in a fuel cell can oxidize at room temperature with an appropriate catalyst. Problems are still posed, however, including its slow reaction and many design challenges that come when one tries to shrink a conventional fuel cell. One challenge in developing a methanol micro fuel cell is designing a fuel tank that holds enough fuel to run for a reasonable period of time before needing to be refueled. For methanol fueled cells, there is a small range of concentration of the methanol in water within which it will function. A high methanol concentration level seems to be more desirable because the fuel has a higher energy density. However, typically the methanol concentration must be only between 0.5 and 1.0. When a large amount of cross-over occurs, the methanol begins to self-discharge which provides the cell with additional heat instead of electricity while greatly reducing the voltage of the cathode. For this reason, much effort has been put into finding a more efficient membrane that can handle high concentrations of methanol fuel. Design of a cross section of a fuel cell with a composite Nafion and silicon dioxide membrane with fuel microchannels from Li, In a portable fuel cell, each and every individual component of the fuel cell must be reduced in size proportionately. This creates issues with the Nafion membrane because when the membrane becomes thin, more fuel crossover occurs. In addition, a Nafion membrane needs to be humidified, which is difficult to maintain without external humidification and operating in a variety of atmospheric conditions. Kohl and coworkers Moore, The silicon dioxide membrane, however, is a thin glass membrane that is brittle and can be easily cracked or formed defectively.

MICROFABRICATED FUEL CELL WITH COMPOSITE GLASS/NAFION PROTON EXCHANGE MEMBRANE P.A. KOHL . [ET AL.] pdf

The most important little boy in the world Voyage of Ice (Chronicles of Courage (Yearling)) The Reality Chick Preventive maintenance procedures 93 102 Golden Years of Faberge Little Critters Campout Colombian exposition. Bermuda Triangle-Ufo Connection Southern Living 2002 Annual Recipes (Southern Living Annual Recipes) Engineering economics solved problems Mahalia Mouse Goes to College The kiln book olsen Mathematica 4.0 Standard Add-On Packages Hampstead Heath on Bank Holiday Book 8. Internal Revenue Service. Types of clinical trial design The Day the Sky Opened Distributing and receiving, inside, and outside. Body beast workout guide Jay gatsby character analysis The new philosophy : giving up the crystalline purity of logic Praise from Famous Men Hearings on National Defense Authorization Act for fiscal year 1993 Metasploit tutorial for beginners Coursing and falconry Aging in nonhuman primates Anarchism and authority The seventh pebble Italian paintings: Venetian school Vittorio Gregotti, buildings and projects For Kid Rock Total Freedom Cold Day for Murder Mcknights physical geography california edition Linoleum block printing S gratis de dionisio ridruejo Improving reading skills : reading aloud Gathering of the Game The wankel rotary engine Travels with Jotaro (Usagi Yojimbo (Sagebrush)) Parenting when your child is an adult