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Structure, Model and Energy Conservation of Proton Exchange Membrane Fuel Cells

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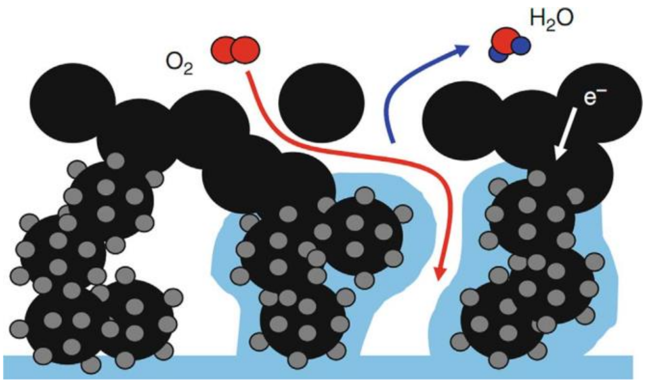
ABSTRACT: *Electric vehicles require fuel cells for the purpose of environmental protection and highly specific energy saving. This paper reviews the key technical issues regarding the application of vehicle PEMFC. It also discusses the relation between vehicle PEMFC membrane structures and electrode performance. The effect of mechanical vibration on dynamic response was investigated on an automobile vibrating platform.*

INTRODUCTION

The increase in world population resulted in depletion of fossil fuels. The demand for an effective fuel in replacement for fossil fuels challenges modern scientists. The only way to control the effects caused by the fossil fuels is to introduce a new source to meet the growing industrial demands. The major factor considered while choosing for the alternative fuel is the emission that affects the atmosphere. The greenhouse gases emitted from the fossil fuels plays a major role in atmospheric pollution. In order to overcome these factor, the alternate for fossil fuel will be fuel cells.

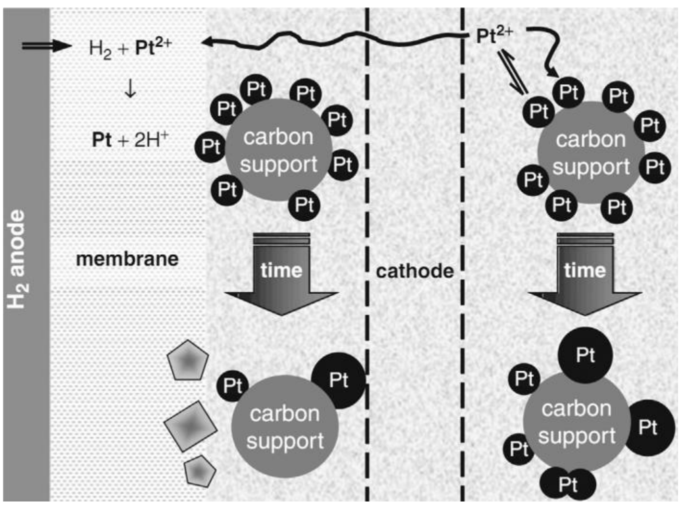
Electrode and Nano films interface modes of vehicle PEMFC

PEMFC is one of the complex system involving membrane materials, polymers, electrochemistry, interface, thermodynamics and Nano- energy. Due to the vehicles PEMFC continuous operation, if heat generated cannot generated in the setup that cannot be timely released, then its internal temperature will gradually rise and lowering strength, efficiency and output voltage of vehicle PEMFC.
Therefore, attention should be paid to the polymer film thermodynamics and interfacial effect, which is the core of PEMFC technology. Between the negative and positive electrode is the polymer proton exchange membrane, H+ move to the negative electrode to react and create H2O. During heavy load of electric vehicles, internal current density gets increased, it strengthens electro chemical reaction and more water is generated. At this point, if water is not drained, then the negative pole will be flooded out, and the normal electro chemical reaction is destroyed which results in PEMFC failure as shown in the fig.

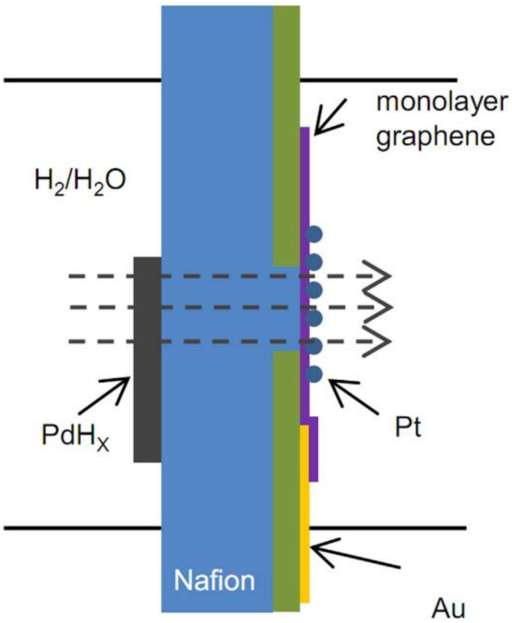


Nano-membrane water generation mechanism of PEMF

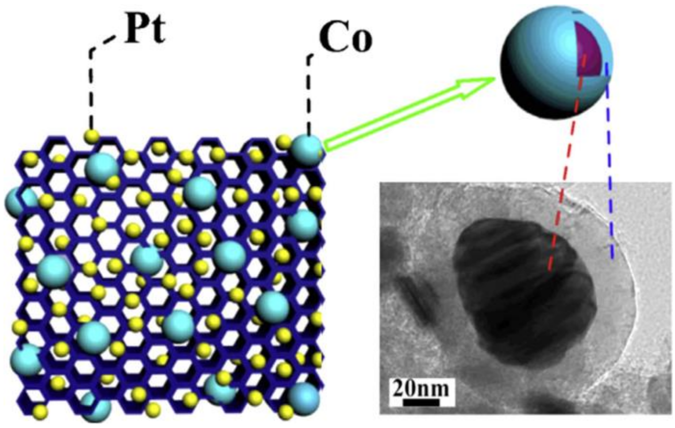
The catalyst layer is the electro chemical reaction takes place. In order to accelerate the reaction, the catalyst layer needs to have a larger area. By Reducing the Platinum particle size is the generally method to increase the area of reaction. But if the resultant water needs to be removed quickly from the anode if it is not removed then the reaction area will be flooded and reduced. Reducing the platinum Content in Nano composite catalyst while maintaining high catalyst activity, selectivity and the long life has become the core of catalysts research and film design for vehicle PEMFC.



PEMFC polymer Nano films, catalyst and interface effects we will review the design and characterization of low cost Nano catalyst, the formation mechanism of selective Nano channel and the transport efficiency of ions and electrons To develop a fuel cell energy system that includes highly dispersed, stable and active catalysts, both the interaction between the unique structure and a non-Platinum catalyst for energy storage are necessary.



Design, modification and characterization of durable catalyst Nanostructure

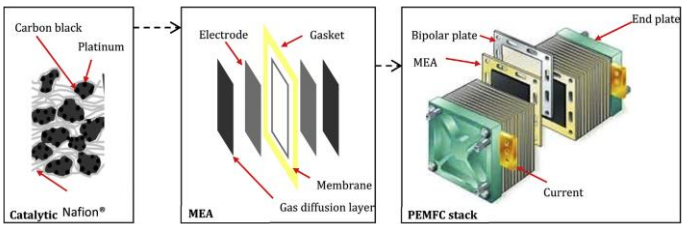


Design, construction and tunnel control of proton exchange membrane

Currently, the proton exchange membrane is designed to transfer ions and isolate the reactants. However, it is difficult to completely isolate the reactant molecules (particularly methanol) resulting in a "hybrid" potential effect. Their results showed that the highly selective channels influence the cell life and costs directly. The cost of new film is reduced by32%, performance improved by 30% and the ionic conductivity increased by 150%. This work is therefore very useful and has the potential to advance the use of electric vehicle around the globe. The life span is more than 3600h. cathode surface, oxygen is reduced and reacts with H+ ions to produce water. The reaction is a exothermic, and some of the heat is co-produced. Electrons moving between the electrodes create an electric current. A stack of several MEAs and bipolar plates placed successively between current collectors and packed with two end-plates, nuts and bolts is called the PEM fuel cell.

MEMBRANE ELECTRODE ASSEMBLY

As mentioned in the section above, the MEA is composed of one membrane, two electrodes and two GDLs. The sulfonated fluoropolymer membrane and GDL are manufactured separately. The assembly is achieved by applying a so-called "electrode-ink" on one of the components, i.e., either on the membrane named CCM, or on the GDL named CCB. The electrode ink is obtained by mixing platinised carbon (Pt/C) with a solution containing water, propanol and other aliphatic alcohols. The actual printing of the ink on the components can be realised at a large scale by two processes: (a) screen-printing an additional step can be introduced for CCM manufacturing by forming the catalyst layer on a Teflon support before transferring it onto the membrane by hot pressing. If the screen-printing process is used, viscous alcohols are added to the ink to obtain a paste. A gasket can be optionally added to the assembly to increase its resistance. Finally, all of the layers are hot-pressed so that solvents evaporate and the layers stick together.



The effect of different vibration amplitude and frequency

Effect of vertical and level vibration on transient response of PEMFC at 20 Hz frequency and 905 smL/min air flow rate. It can be seen that the voltage no response lager under shoot or overshoot under no vibration conditions, and it takes about 20 s to reach a new steady-state condition. Compared with the no vibration, the voltage are response exhibits larger fluctuations and then it takes about 50e80 s to reach a new steady-state condition under the vertical and level vibration amplitude of 3 mm and 4 mm. This can be explained that the time of the voltage reaches a new steady state mainly depends on water reasonable distribution in gas diffusion layer and flow channel. When the load changes from a low to a high level, the cathode gas diffusion layer generates large amounts of water, the vibration causes water fluctuations and the uneven distribution in the gas diffusion layer, which lead to the voltage fluctuation. Furthermore, it is show that the steady-state voltage under the vibration is higher than without vibration. The under-shoot is the voltage decreases continuously until it reaches the minimum level, this course takes about 1e5 s. The over-shoot is the voltage increase continuously until it reaches the maximum level, this course takes about 1e4 s. This may be because that sudden vibration of the PEMFC causes small droplets coalesce into larger droplets and then hinder the gas flow channel, which leads to the voltage fluctuation.

The effect of mechanical vibration on the water transport

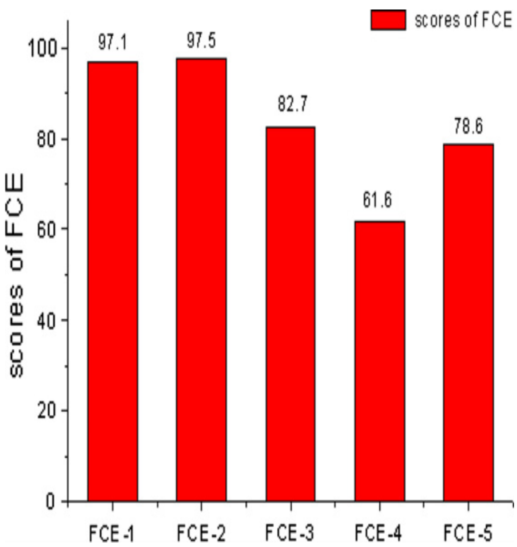
In order to explain the reason that mechanical vibration causes the voltage fluctuation, the experiments water transport in an anode flow channel were conducted for the transparent PEMFC under mechanical vibration and no mechanical vibration, respectively. The water transport progress in the anode flow channels under no vibration During this process, the gas was not humidified at the anode and the cathode, the flow rate was 70 mL/min at the anode and 1 L/min at the cathode, the temperatures was 40 _C, the transparent PEMFC was loaded at a constant current 5 A. At first, a water droplet suddenly migrates into and through the diffusion layer at the 5 min, From the enlarged picture shows, the water droplet is appearing close to the channel. After 8 min the water droplet grow larger, which lead to a complete blockage of the channel. The hydrogen-flow in channel is interrupted while a decline of voltage cannot be observed during the 8 min. This phenomenon can be explained that although gas channel was blocked by water droplet, the hydrogen flow could be distributed uniformly by diffusion through the gas diffusion layer. Then, the droplet keeps growing and changes shape gradually by blowing of hydrogen. Finally, the hydrogen pressure in the channel overcome the capillary force and the wall viscous wall force of the droplet, and the droplet was broken and flowed away. Before long an enormous undershoot and overshoot of voltage can be observed. The voltage falls from 0.50 to 0.47 V and overshoots to 0.51 V. The main reason for the fluctuation of the voltage is due to the decrease of the hydrogen pressure and the fluctuation of the hydrogen when the droplet was blown away. Notably, this phenomenon is very similar the voltage fluctuations under mechanical vibration the water column exudation and growth progress in the anode flow channel under no vibration. After 14 min, the water column was so larger that it was difficulty to be blown out of the channel when the hydrogen flow rate was 70 ml/min.

3D CFD modelling of a PEM fuel cell stack.

The aim of this paper is to improve the design of the stack and a new cooling method is proposed. The 3D modelling includes simulation of transfer of heat, fluid flow, electro chemical reactions in a PEMFC. Ansys and computational fluid dynamics code were used in this method. Lowest temperature was 300k at cathode inlet of oxygen. The detailed results of distributions of oxygen and hydrogen were obtained. The detailed results of distributions of oxygen and hydrogen were obtained. The model was solved with ANSYS/Fluent software. A workstation with Intel Xeon X5660 2.80 GHz processor and 48 GB RAM was used to perform the calculations. The results revealed the prediction of variation and distribution in temperature. Temperature is higher at the ribs of the cathode and also near the cathode outlet; temperature is low at the inlet. This model is an important step for further development of the stack design and the flow field of a PEM fuel cell stack.

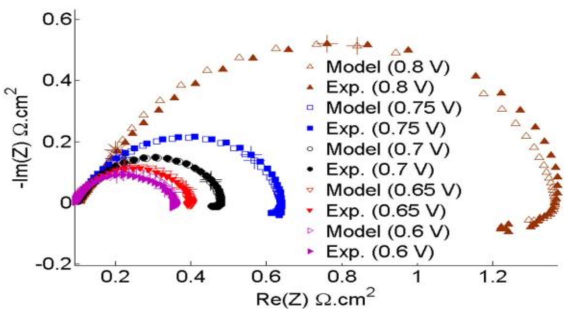
A method for evaluating the efficiency of PEM fuel cell engine

Efficiency is an important factor to reflect the performance of fuel cell engine (FCE). Evaluating efficiency should consider efficiency properties and common work conditions of FCE. In this paper, output power of FCE on real work conditions is analysed according to driving cycles, and four efficiency evaluation points are obtained, as well as their weighted values. Then, a scoring function is used to convert the efficiency values of four evaluation points into scores. Multiplying scores by their weighted values and adding them together, we can get overall scores of efficiency properties. This method can evaluate the efficiency performance of FCE reasonably and objectively. This paper does an exploratory research on the efficiency evaluation of FCE, and a method based on scoring is made to evaluate efficiency performance of FCE. According to driving cycles, output power of FCE on real work conditions is analysed and then four main operating modes of FCE are obtained. Considering test method of FCE efficiency and its properties, we get four efficiency evaluation points and their weights. Then proper scoring functions are made to score for the evaluation points. Multiplying scores by their weights and adding them together, we can get overall scores of FCE efficiency performance.



Study of anode and cathode starvation effects on the impedance characteristics of PEM-FC

Starvation is a phenomenon is a state where there is deficiency of fuel in anode or cathode. It is the deficiency of hydrogen and oxygen in anode and cathode respectively. The starvation of anode and cathode is studied by electro-chemical impedance spectroscopy. The impedance is measured when the anode is diluted with helium and cathode diluted with nitrogen to initiate starvation. In this measured impedance of the PEM-FC is with different stoichiometry ratio of anode and cathode in which the flow rates are kept constant. Starvation can be caused by the decrease in flow rates of the feeding gasses and also the flooding that affect the transport of the reactants to the reaction along anode and cathode. The cathode starvation affects the mid frequency arc of the plot which are plotted from the values of measured impedance. The anode starvation does not affect the plots of the measured impedance. The decrease in oxygen proportion in cathode is more effective when compared to the decrease in hydrogen concentration at the anode which could be the effect of slow cathode reaction. The anode flooding cannot be found using this method as the anode starvation cannot be captured by this plots. Comparison of measured and predicted impedances in different potentials



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CONCLUSION

In a focus of new energy vehicles, PEMFC provides the world's industrial development with an excellent opportunity for energy transformation. Explore the impact of nanostructures on the transfer and transmission of electrons and ions will lay the foundation for PEMFC electric vehicle with high performance and long life. The PEMFC voltage undershoot and overshoot behaviour under the mechanical vibrations is much larger than no the mechanical vibrations. The mechanical vibration causes the voltage oscillations is very similar to the flooding causes the voltage fluctuation. The PEMFC performance increased with the increase in the air stoichiometry. For the 1.5 air stoichiometry, the voltage fluctuation under vibration is bigger compared with no vibration. The MEA life-cycle impact can be reduced by 60% if electrode recycling is carried out at the end-of-life stage of the fuel cell by the H2O2/Solvent recycling process. Improve power generation efficiency, enhance environmental performance, pro long life and reduce costs. The efficiency reduction due to membrane failure is visualized which supports for the development of the PEMFC. The economic lifetime prediction suggests designers to choose optimal and choose suitable materials. Starvation study shows that cathode starvation affects whereas the anode starvation doesn't affect the plots. A proper efficiency calculation method which can be used in advancement of PEMFC. The CFD modelling quotes the areas to be improved.

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