行政院原子能委員會
委託研究計畫研究報告

研製低溫 SOFC 單片電池、陰極、電解質及陽極材料

Study and fabrication of single cell, cathode, electrolyte and anode materials for low-temperature SOFC

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中文摘要

本計畫進行微米級厚度之單片電池(膜電極組)之研製，以期發展低溫 SOFC 單片電池研製技術。先研製適用於低溫之導氧離子材料 GDC 作為電解質材料，接著以其奈米級粉末研製電解質薄膜。接著塗佈本計畫另行研製之陽極材料，以及自行研製之適用於低溫之陰極材料，而完成 SOFC 單片電池(膜電極組)之研製。再封裝製成單片電池反應器，進行各項測試。

在製備 LSCF ($La_{0.58}Sr_{0.4}Co_{0.2}Fe_{0.8}$)氧化物粉末作為陰極材料方面，發現 Glycine-nitrate 製程最佳。以 500、600 ℃為操作溫度時，LSCF 的交流阻抗明顯地比 LSCF-GDC-Ag 要大很多，但於 LSCF 陰極層上塗上一薄層銀(Ag)膠，可以大幅地降低陰極的交流阻抗，可較 LSCF-GDC-Ag 複合陰極材料更佳。LSCF 陰極層上塗上一層銀膠為本計畫所發現最佳之低溫(500℃)陰極。此顯示複層陰極可有較材料方面之複合式改進有更佳之效果。

採用甲烷為燃料時，發現電流密度愈高的操作愈不易形成積碳，且所形成的積碳愈易於去除。但電流密度較低的操作有助於 CO_2 的生成，因而有助於甲烷的發電效率。因此，如何在陽極材料方面改進，在一定的電流密度之操作下，一方面減少積碳的生成，另一方面又促進 CO_2 的生成，應為努力的方向。

英文摘要

In this project, the study and fabrication of a single-plate cell (membrane-electrode assembly) with micro-meter thickness have been carried out in order to develop the fabrication technology of a single cell for low-temperature SOFC. The study and fabrication of the oxygen-ion conducting GDC materials suitable for low-temperature applications to be utilized as the electrolyte materials has been carried out first. Then, the nano-meter GDC powders are used to fabricate the electrolyte membrane. Next, the anode layer is coated onto the electrolyte membrane with the anode materials fabricated separately in this project. Then, the cathode materials, which have been studied for low-temperature applications in this project, are coated onto the other side of the electrolyte membrane. This completes the fabrication of a SOFC single cell. The single cell is then sealed into a reactor tube to form an electrochemical reaction unit and tested with various measurements.

In the preparation of the oxide powders of LSCF ($La_{0.58}Sr_{0.4}Co_{0.2}Fe_{0.8}$) as cathode materials, it was found that the Glycine-nitrate process is the best one. With an operation temperature of 500 or 600 ℃, the AC impedance of LSCF is apparently much higher than LSCF-GDC-Ag. However, when a thin layer of silver (Ag) paste has been coated onto the LSCF cathode layer, the AC impedance of the cathode can be lowered drastically so as to be lower than that of the composite LSCF-GDC-Ag cathode. This LSCF cathode layer with a coated layer of silver paste has been found to be the best low

temperature (500 ℃) cathode. This indicates that multiple-layer cathode can be better than improved composite cathode materials.

With methane as the fuel, it was found that the amount of the deposited carbon is less when an operation with higher current density is carried out and the deposited carbon can be removed in an easier way. However, an operation with lower current density is beneficial for the production of CO_2 and so for the generation efficiency of methane. Thus, an effort should be directed to improve the anode materials so as to reduce the formation of the deposited carbon and to improve the production of CO_2 at the same time under a certain current density.