Aspects in Cell Testing of Anode Supported Planar SOFC

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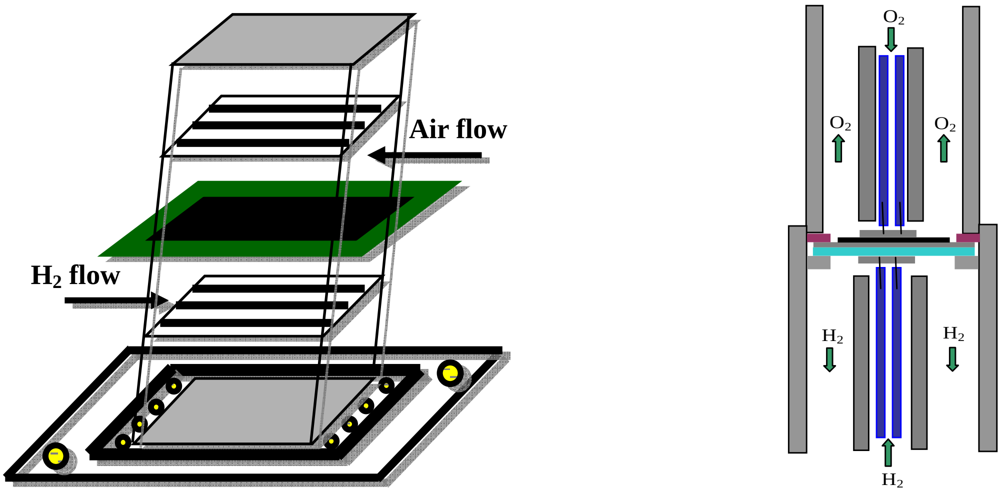
Abstract

Cell testing of anode-supported planar solid oxide fuel cells (SOFCs) in a relative large area has a specific importance for comprehensive understanding of electric and electrochemical properties of the single cells. There are many aspects concerning cell testing for large-area planar. SOFCs Testing house design, high temperature sealing, resistance of electrical current leads and contacts at interfaces all have important effects on electrical properties of the testing cell.A ceramic testing house is designed which is made of Al_2O_3 used in repeating and a long term measurements. A composite sealing configuration with a high temperature ceramic glass is designed. The testing set up has been developed to be appropriate to the temperature ranging from 600 to 900℃ for testing of single cell with an active area of 4×4cm^2. By our design of the high temperature sealing composite components, a maximum OCV of 1.176V was reached at 850℃. And a successful rate of 93.3% has been obtained in a critiera of OCV of more than 1V during the testing of our single cells recently. Furthermore, the composite components sealing is acted as a buffer for inserted pressure; as a result, single cells are protected within a pressure of 6 kg during the testing. Due to special designed sealing configuration, the cells after testing can be intact. The resistance of electrical current leads and contacts are reduced to around 10 mΩ to draw current effectively. Also, the EIS analysis is applied to differentiate the polarization and ohmic resistance of single cell during testing.

Introduction

Cell testing is conducted to assess their commercial viability and for continued cell development[1]. Button cells and large-area cells are generally tested, in which the schematic processes can be seen in Fig. 1[1-2].



a) Large-area cell b）Button cell

Fig.1The schematic diagram of cell testing

Fig.1a) shows the schematic diagram of testing for large-area cell, and b) for button cell. The technique of testing for button cell is widely used due to the application of ceramic tube as testing house and the ease of sealing. However, the active area of button cell is about $1cm^2$, which the small active area resulting in applying restricts for evaluation of planar SOFCs [2]. With different tothe small area of button cell, the active area of cell testing of large-scale planar SOFCs generally reaches 16 cm^2, which can evaluate the cell performance comprehensively and efficiently[6]. Therefore, the technique of testing for large-scale planar SOFCs is applied in some extent[6-8].There are many aspects concerning cell testing for anode supported planar solid oxide fuel cells (SOFCs) with large scale films. Testing house design, high temperature sealing, resistance of electrical current leads and contacts at interfaces all have important effects on electrical properties of the testing cell. Accordingly, the technique of cell testing for large-scale planar SOFCs needs improving and developing further.

Design of testing house for large-area planar SOFCs

Cell house is a carrier for testing of single cell, and the ceramic tube is usually adopted for testing button cell [3]. The carrier is also important for cell testing of large-scale planar SOFCs. The design of testing house requires two factors: the coefficient of thermal expansion and the lifetime test for single cell. Consequently, the ceramic which is made by Al_2O_3 was selected due to its small coefficient of thermal expansion according to the reference reported [8].

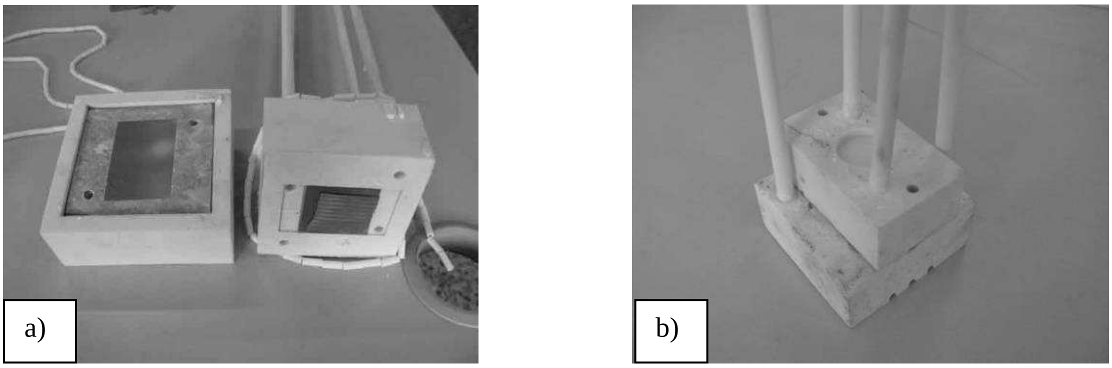


Fig.2 The self-designed testing house

Fig.2 presents the self-designed testing house, in which the area of single cell is $7×7cm^2$ and the active area is $4×4cm^2$, as seen in Fig.2a). The area of single cell is very large resulting in cell wasting, and making the sealing difficult by using of the testing house. In order to solve this problem, a new testing house was designed, as presented in Fig.2b). The area of single cell is reduced to $5×6cm^2$ keeping the active area constant with area of $4×4cm^2$. As a result, the problem was solved effectively.

Sealing of cell testing for large-scale planar SOFCs

High temperature gas sealing is a key problem for cell testing of SOFCs. To solve the problem of high temperature gas sealing, silicate glass, phosphate glass and Al_2O_3 ceramic glass were developed [9-13].

The high temperature sealant has been developed to be appropriate to the temperature ranging from 600 to 900℃ for testing of single cell with an active area of $4×4cm^2$. And a composite sealing configuration with a high temperature ceramic glass is designed. By the design of high temperature sealing composite components, a maximum OCV of 1.176V is reached at 850℃. And a successful rate of 93.3% has been obtained for the OCV of more than 1V during the testing of our single cells recently, as shown in Fig.3. Furthermore, the composite components sealing is acted as a buffer for inserted pressure. As a result, the single cell can be protected well under a pressure of 4~6 kg after testing, as presented in Fig.4.

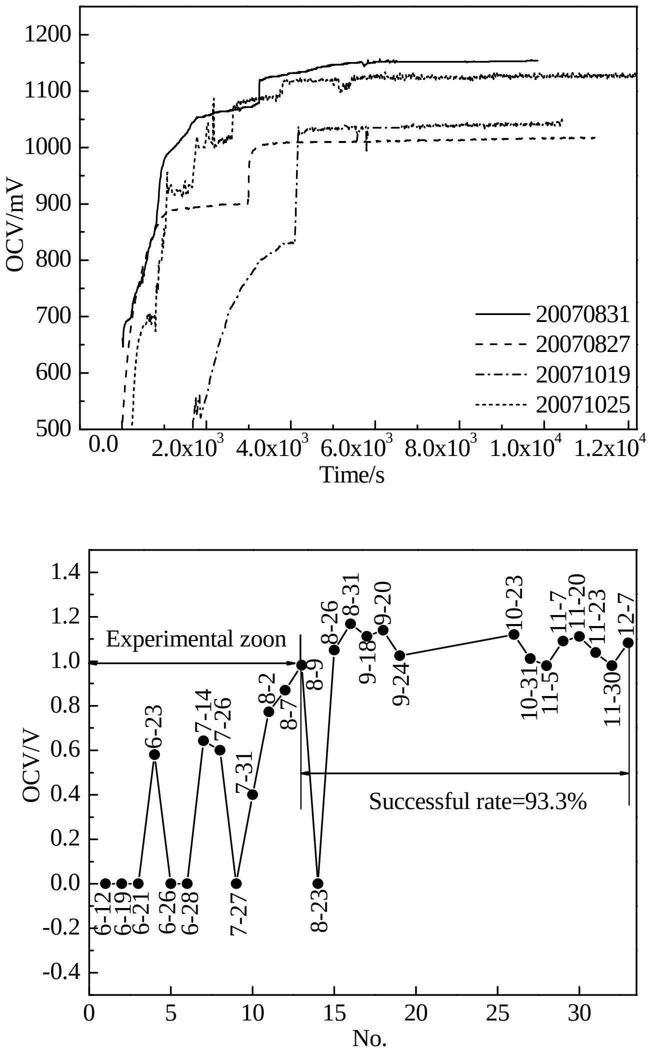


Fig.3 The successful rate for the OCV of more than 1V

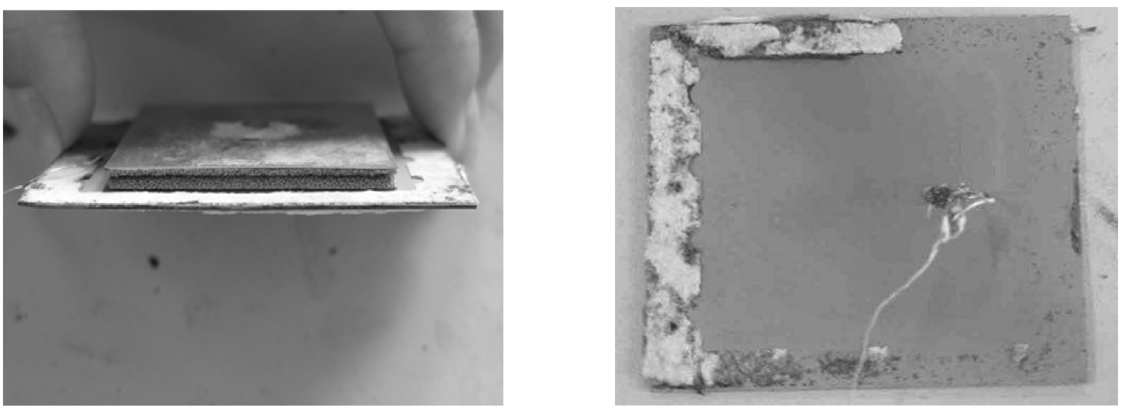
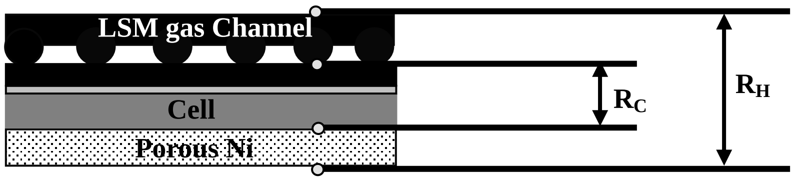


Fig.4 Single cell after testing

Resistance of cell testing for large-scale planar SOFCs

If the resistance besides of the contribution from single cell is large, the cell can not be discharged properly. Therefore, it is necessary to reduce this extra resistance, i.e the resistance of electrical current leads and contacts, to less than an extent to draw current. To decrease the resistance of electrical leads, appropriate metal wire was chosen, and the length of electrical leads should be shorted. Large area lead wires were selected. Ag can be used as an economic alternative in stead of Pt or Au when the cell measurement temperature becomes low than 850℃ and it has a very low resistivity, too.

The contributions from contact resistances are from the interface at electrode and gas flow channel, interface at gas flow channel and current collection layer and so on. By using Ni mesh, the contact resistance in anode side can be ignored under a certain pressure due to metal characteritic of the reduced anode support. The gas flow channel in cathode side is made of LSM and the current collect is Pt. And the contact resistance in cathode side needs to be decreased due to relative high contact resistance between current collector (metal Pt or cathode) and oxide (cathode). In order to do so, LaSrMnO gas flow channel is wrapped up by Pt net. Using such configuration, the resistance of contacts and electrical leads can be reduced appropriately.



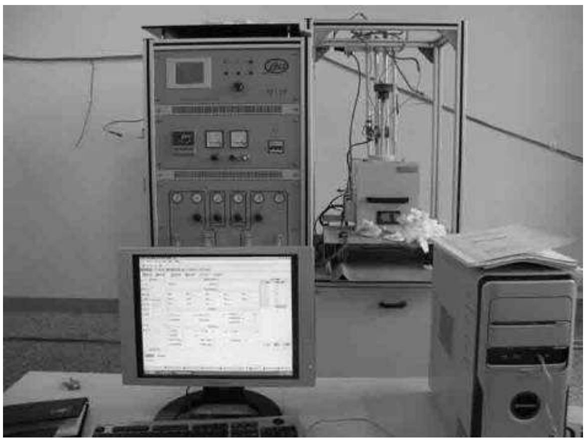


Fig.5 Set-up of cell testing for large-scale planar SOFCs

The set up of cell testing for large-area planar SOFCs was developed by the methods mentioned above, in which the voltage and current probes were distributed on two electrode sides and current collect sides respectively, as shown in Fig.5. The single cell was discharged at 850℃ using the set up, and the resistance of electrical current leads and contacts can be got, as shown in Fig.6. The slope of solid black points represents the inner resistance of single cell R_C, and the slope of solid white points represents the extra resistance of single cell including the resistance of electrical current leads and contacts R_H. It can be calculated that the Rc is about 36.54 mΩ and the R_H is about 44.53 mΩ. The sum of the resistance from contacts and current leads is 7.99 mΩ. This extra resistance is generally about 10 mΩ for our testing set up, as presented in Fig.7a).The difference in low frequency is about 14.89 mΩ by four wires and two wires method of the electrochemical impedance spectroscopy (EIS), which can be considered as the extra resistance of single cell. It can be found that the result shown in Fig.7b) by EIS is higher than that obtained by discharging in Fig.7a).

Especially, the electrochemical impedance spectra of large-area SOFCs presented in Fig.7b) by four wires method indicates the inner resistance of single cell, which including electrode polarization resistance R_{Ap+Cp} and ohmic resistance $2R_I+R_E$.

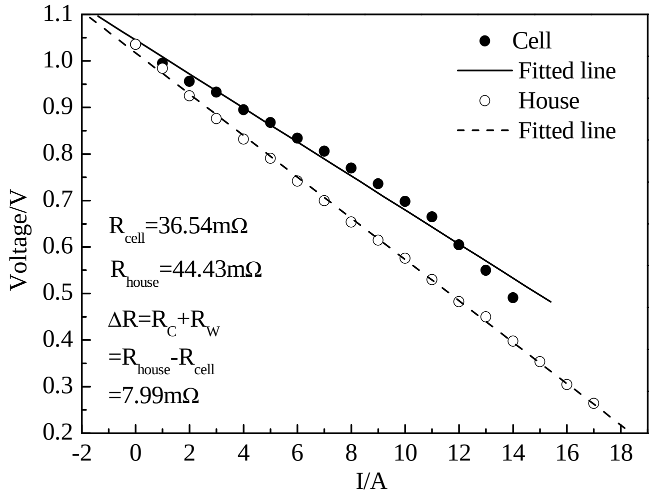


Fig.6 Resistance measurement of electrical current leads and contacts

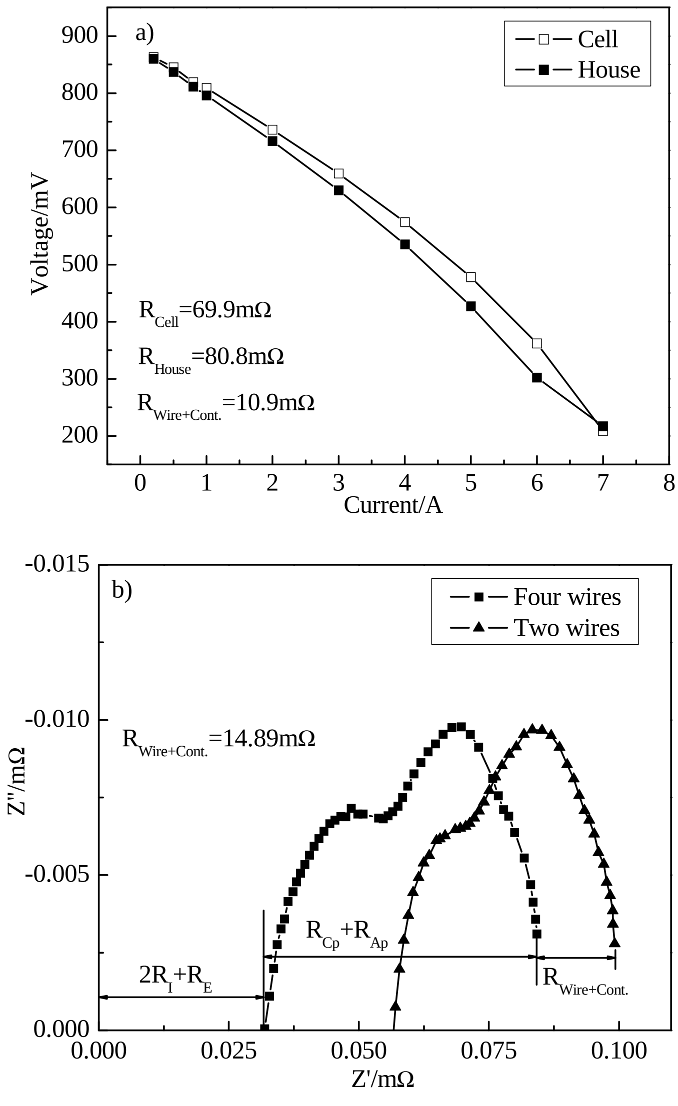


Fig.7 Resistance obtained by discharge and EIS

Conclusions

A ceramic testing house made of Al_2O_3 repeatly used in long term measurements is designed. A composite sealing configuration with a high temperature ceramic glass is developed. By our design of the high temperature sealing composite components, a maximum OCV of 1.176V was reached at 850℃ for testing of single cell with an active area of $4\times4cm^2$. And a successful rate of 93.3% has been obtained for the OCV of more than 1V during the testing of our single cells recently. Furthermore, the single cell is protected under a pressure of 6 kg during testing. Due to special designed sealing configuration, the cells after testing can be intact. The resistance of electrical current leads and contacts are reduced to 7.99 mΩ to draw current effectively. Also, the polarization and ohmic resistance of single cell can be differentiated clearly by EIS technique during testing.

Acknowledgement

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