FABRICATION OF HIGH PERFORMANCE (La,Sr)MnO_3 CATHODE BY ION IMPREGANATION

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Strontium doped $LaMnO_3$ (LSM) perovskites are the most investigated cathode materials for solid oxide fuel cell (SOFC) due to its high electrochemical activity for the O_2 reduction reaction, good stability and compatibility with Y_2O_3-ZrO_2 (YSZ) electrolyte (1). However, due to its low oxygen ion conductivity and high activation energy LSM is limited in the application as cathodes for SOFC operating at intermediate temperatures of 600-800^{o}C. Attempts have been made to improve the performance of LSM-based materials, notably in the development of LSM/YSZ composite cathodes (2,3). Another alternative is to develop mixed ionic and electronic conducting (MIEC) materials such as (La,Sr)(Co,Fe)O_3 perovskites (4,5). However, use of such MIEC materials requires the introduction of thin interlayer such as ceria to inhibit the formation of resistive reaction products between zirconia electrolyte and LSCF cathodes (6). The introduction of additional electrolyte layer increases the complexity of the cell structure, the fabrication cost and instability in the stack due to the difference in the thermal expansion coefficient.

We have shown recently that ion impregnation is an effective method in the improvement of the microstructure and electrode performance of Ni/YSZ cermet anodes (7). This indicates that impregnation method can be used effectively to deposit electrocatalytic phase into the LSM porous electrode structure to improve the performance of the cathodes without diminishing the advantages of the stability and compatibility of LSM electrode materials with YSZ electrolyte in SOFC. This paper investigated the ion impregnation process and the effect on the electrochemical activity of conventional LSM electrodes. The results demonstrate the feasibility of the ion impregnation method in the development of high performance cathodes based on conventional LSM materials.

Fig.1 shows the schematic diagram of the ion impregnation process for the fabrication of high performance LSM electrodes. $La_{0.72}Sr_{0.18}MnO_3$ (LSM) electrode coating was applied to YSZ electrolytes by screen printing, followed by sintering at 1150^{o}C for 2 h in air. Electrode coating thickness was 30 to 50 μm and electrode area was 0.5 cm^2. The ion impregnation solutions used were 3M $Gd_{0.2}Ce_{0.9}(NO_3)_x$ nitrite. After ion impregnation treatment, LSM cathodes were heated at 850^{o}C for 1 h. Fig. 2 shows impedance of LSM electrode with and without $Gd_{0.2}Ce_{0.9}(NO_3)_x$ impregnation. EIS was measured at 700^{o}C in air. For pure LSM electrode, electrode polarization resistance (R_E) was 26.4 Ωcm^2. After repeating the 3M $Gd_{0.2}Ce_{0.8}(NO_3)_x$ impregnation for three times, R_E was reduced to 0.72 Ωcm^2, a reduction in electrode polarization resistance by 36 times. As $(GdCe)O_2$ is most likely formed after the decomposition of $Gd_{0.2}Ce_{0.8}(NO_3)_x$ nitrite solutions (7), deposition of fine and oxygen ion conducting $(GdCe)O_2$ particles along the LSM grain boundaries and at the electrode and electrolyte interface region would effectively extend the three phase boundary area for the O_2 reduction reaction and thus increase the electrochemical activity of the LSM electrodes. This would be similar to the effect of the introduction of YSZ phase to the LSM electrodes on the promoting of the O_2 reduction reaction rate (2,3). In comparison to pure LSM, the electrode polarization performance was also improved significantly after ion impregnation treatment.

The performance of LSM electrodes with various ion impregnation solutions was discussed.

Reference

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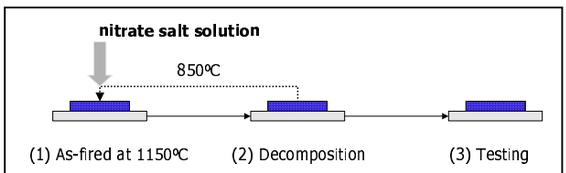

Fig.1. Ion impregnation process.

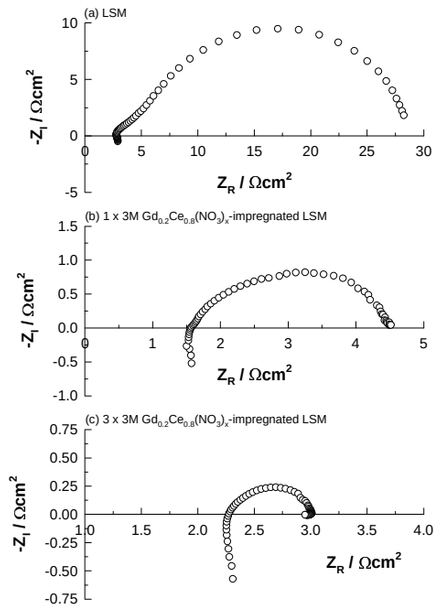

Fig.2. Impedance curves of O_2 reduction on LSM with and without 3M $Gd_{0.2}Ce_{0.8}(NO_3)_x$-impregnation, measured at 700^{o}C in air.