Cathodic Properties of Strontium-doped Lanthanum Ferrite in Proton Conducting SOFC for Low Temperature

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The use of perovskite-type oxide as a cathodic material has received much attention due to the lowering of the operating temperature for SOFC and the low cost compared with platinum. Some perovskite-type oxides such as $La_{0.7}Sr_{0.3}CoO_3$ and $La_{0.7}Sr_{0.3}MnO_3$ showed the high cathodic performance for SOFC with oxygen ion conductor[1]; however, little is known for SOFC with proton conductor. Here we wish to report the cathodic performance of perovskite-type oxides when the $SrCe_{0.95}Yb_{0.05}O_{3-\alpha}$ exhibiting the proton conduction in hydrogen atmosphere at 873-1073 K[2] was used as a solid electrolyte in a H_2-O_2 fuel cell.

Fig. 1 shows the cathodic overpotential curves of $La_{0.7}Sr_{0.3}MO_3$ (M=Mn, Fe, and Co) electrodes in a H_2-O_2 fuel cell at 773-973 K. When the fuel cell was operated at 773 K, $La_{0.7}Sr_{0.3}FeO_3$ showed the lowest overpotential (η) among the cathodes tested in the present study; the order of η was $La_{0.7}Sr_{0.3}FeO_3$ < $La_{0.7}Sr_{0.3}MnO_3$ < $La_{0.7}Sr_{0.3}CoO_3$ which is different from that for a H_2-O_2 fuel cell with oxygen ion conductor[1]. This indicates that the most suitable cathode material for proton conductor is different from that for oxide-ion conductor. At higher temperature, the order of the overpotential is essentially the same. The influence of heat treatment temperature for cathodic overpotential was investigated for $La_{0.7}Sr_{0.3}FeO_3$ electrode. The results are shown in Fig. 2. The cathodic overpotential increased with the increase in the heat treatment temperature from 1273 to 1473 K. The SEM image of the surface of $La_{0.7}Sr_{0.3}FeO_3$ after electrochemical measurements showed that the sintering of $La_{0.7}Sr_{0.3}FeO_3$ particles was suppressed by the decrease in the firing temperature.

The cathodic overpotentials of $La_{0.7}Sr_{0.3}FeO_3$ and sputtered platinum were measured at 973 K by changing the partial pressure of oxygen, respectively. Then electrode resistance, R_{el}, can be estimated from the slope of I-V plots. It is commonly known that the R_{el} is the parameter to determine the rate-determining step of electrode reaction and R_{el} is proportional to $P_{O_2}^{\,n}$ where n-value gives the type of species involved in the electrode reaction. Fig. 3 shows the plots of log R_{el} against the log P_{O_2} when each $La_{0.7}Sr_{0.3}FeO_3$ and sputtered platinum was used as a cathode. The cathode resistance of $La_{0.7}Sr_{0.3}FeO_3$ was independent of P_{O_2} while that of sputtered platinum was proportional to $P_{O_2}^{-1/4}$. And we measured the overpotential of $La_{0.7}Sr_{0.3}FeO_3$ electrode as a function of P_{O_2} under wet condition. In this case also, n-value was found to be close to zero; however, the value of R_{el} under wet condition is larger than that under dry condition, indicating that R_{el} is independent of P_{O_2} and is dependent on P_{H_2O}. This result may suggest that the rate-determining step of cathode reaction on $La_{0.7}Sr_{0.3}FeO_3$ is different from that on sputtered platinum since the oxygen atoms adsorbed on $La_{0.7}Sr_{0.3}FeO_3$ with mixed ion-conductor of electron and oxide-ion can readily diffuse to the active site through not only surface but also the bulk.

1. Y. Takeda, R Kanno, M. Noda, Y. Tomida, and O. Yamamoto, *J Electrochem. Soc.*, **134**, 2656 (1987).
2. H. Iwahara, *Solid State Ionics*, **86-88**, 9 (1996).

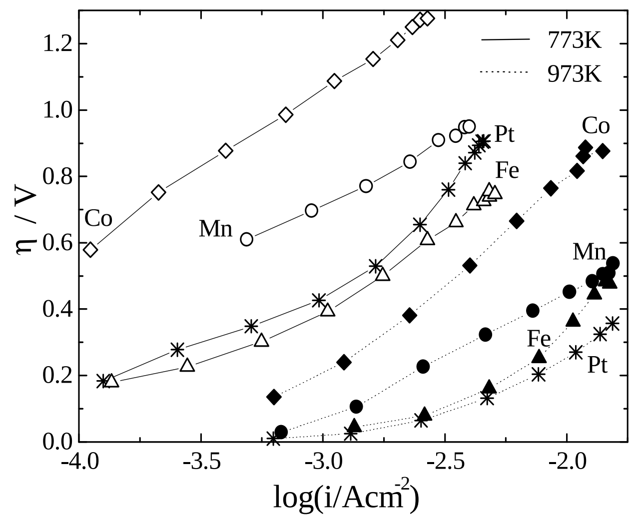

Fig.1. Cathodic overpotential curves in H_2, Pt| $SrCe_{0.95}Yb_{0.05}O_{3-\alpha}$|$La_{0.7}Sr_{0.3}MO_3$ (M=Mn, Fe, Co) at 773-973K. The electrodes were heated at 1473 K for 3h before the measurements.

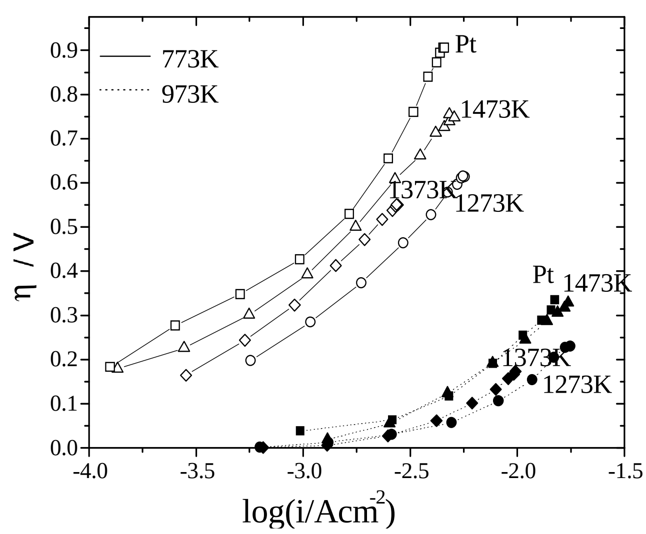

Fig.2. Cathodic overpotential curves in H_2, Pt| $SrCe_{0.95}Yb_{0.05}O_{3-\alpha}$|$La_{0.7}Sr_{0.3}FeO_3$ at 773-973K. The electrodes were heated at 1273 - 1473 K

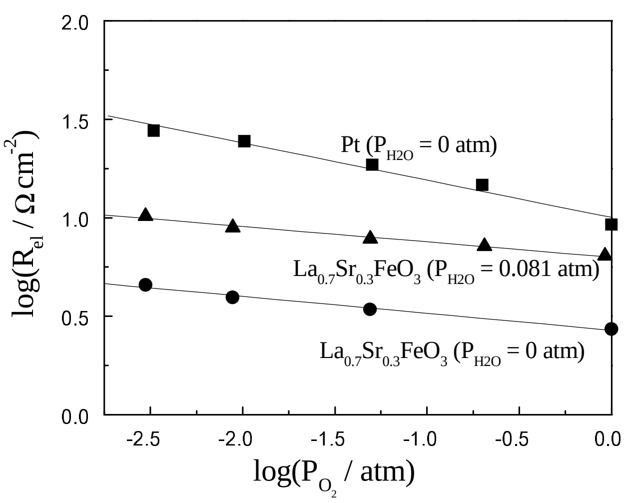

Fig.3. Plot of log R_{el} against log P_{O_2} at the cathode. (●) $La_{0.7}Sr_{0.3}FeO_3$ (P_{H_2O} = 0 atm), (▲) $La_{0.7}Sr_{0.3}FeO_3$. (P_{H_2O} = 0.081 atm), and (■) sputtered platinum (P_{H_2O} = 0 atm).