Sr-doped lanthanum copper oxides as Novel Electrode for Solid Oxide Fuel Cells

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Formation of the solid solution with tetragonal perovskite structure has been found in the $La_{1-x}Sr_xCuO_{2.5-\delta}$ (LSCu) system at $0.2 \leqq x \leqq 0.3$. The substitution of lanthanum with strontium leads to increase in electrical conductivity and oxygen vacancies concentration. Such a mixed electronic and oxygen-ionic mixed conductor in this study was investigated as a novel cathode material for solid oxide fuel cell operating in intermediate temperature of 600℃ to 800℃. Thus, the electrical conductivity, oxidization state of copper ions, cathodic overpotential, thermal expansion, and reactivity with yttria-stabilized zirconia (YSZ) were examined in the study.

Temperature dependence of electrical conductivity of $La_{1-x}Sr_xCuO_{2.5-\delta}$ perovskite in air is shown in Fig.1. The electrical conductivity increases with increasing strontium content. The $La_{0.7}Sr_{0.3}CuO_{2.5-\delta}$ shows the highest conductivity of σ=2400-830 S/cm from room temperature to 800℃. This value is much higher than that of LSM (~180 S/cm at 800℃), which is the most commercially used as cathode material for SOFC.

To examine the structure stability of $La_{1-x}Sr_xCuO_{2.5-y}$ (x=0.2, 0.25, 0.3), against 8YSZ (which is often used as electrolyte of SOFC). The LSCu and 8YSZ powder were mixed and then heated at 800℃ and 900℃. Fig.2 shows the XRD patterns of powder mixture after being annealed at (a) 800℃ for 1000 hours, and (b) 900℃ for 10 hours. From these XRD pattern, $La_{1-x}Sr_xCuO_{2.5-\delta}$ shows a good stability against YSZ at 800 ℃. However, the $La_{1-x}Sr_xCuO_{2.5-\delta}$ reacted with YSZ and formed $SrZrO_3$ at 900℃ for 10 hours. Therefore, using as a cathode material of an intermediate temperature SOFC with YSZ electrolyte, operating at a temperature under 800℃ is appropriate.

Fig.3 shows the cathodic overpotential curves for $La_{1-x}Sr_xCuO_{2.5-\delta}$ (x=0.2, 0.25, 0.3) as a function of current density at 800℃ in air. The cathodic overpotential increased linearly when current density increased from 0 to 150 mA/cm^2 and then leveled off when the current density exceeded 150 mA/cm^2. The $La_{0.7}Sr_{0.3}CuO_{2.5-\delta}$ showed the lowest cathodic overpotential in LSCu/YSZ system.

Tetragonal perovskite LSCu ($0.2 \leqq x \leqq 0.3$) provided a high electrical conductivity, and structure stability react with 8YSZ at 800℃. LSCu also display excellent cathodic polarization behaviors as SOFC electrodes. Therefore, LSCu could be a very attractive cathode material for practical applications for intermediate temperature SOFCs.

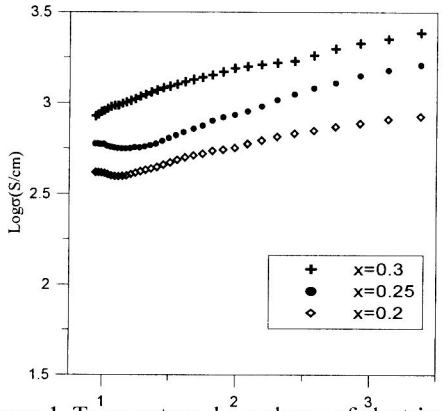

Figure 1. Temperature dependence of electrical conductivity for $La_{1-x}Sr_xCuO_{2.5-\delta}$.

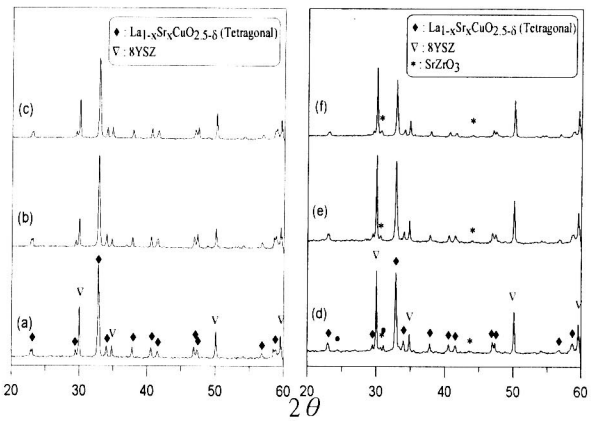

Figure 2. XRD pattern of $La_{1-x}Sr_xCuO_{2.5-\delta}$ and YSZ powder mixture annealed at 800℃ for 1000 hours (a)x=0.2, (b)x=0.25, (c) x=0.3, and 900℃ for 10 hours (d)x=0.2, (e)x=0.25, (f) x=0.3.

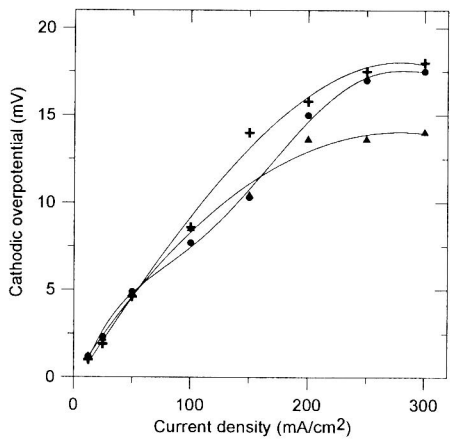

Figure3. Cathodic overpotential curves for $La_{0.8}Sr_{0.2}CuO_{2.5-\delta}$(+), $La_{0.75}Sr_{0.25}CuO_{2.5-\delta}$(●), and $La_{0.7}Sr_{0.3}CuO_{2.5-\delta}$(▲) measured at 800℃.