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_{x}CuO_{2.5} (LSCu) system at 0.2 ≤ x ≤ 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°C to 800°C. 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_{x}CuO_{2.5} 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} shows the highest conductivity of σ=2400-830 S/cm from room temperature to 800°C. This value is much higher than that of LSM (~180 S/cm at 800°C), which is the most commercially used as cathode material for SOFC.

To examine the structure stability of La_{1-x}Sr_{x}CuO_{2.5+y} (x=0.2, 0.25, 0.3), against YSZ (which is often used as electrolyte of SOFC). The LSCu and YSZ powder were mixed and then heated at 800°C and 900°C. Fig.2 shows the XRD patterns of powder mixture after being annealed at (a) 800°C for 1000 hours, and (b) 900°C for 10 hours. From these XRD pattern, La_{1-x}Sr_{x}CuO_{2.5} shows a good stability against YSZ at 800°C. However, the La_{1-x}Sr_{x}CuO_{2.5} reacted with YSZ and formed SrZrO_{3} at 900°C for 10 hours. Therefore, using as a cathode material of an intermediate temperature SOFC with YSZ electrolyte, operating at a temperature under 800°C is appropriate.

Fig.3 shows the cathodic overpotential curves for La_{1-x}Sr_{x}CuO_{2.5} (x=0.2, 0.25, 0.3) as a function of current density at 800°C in air. The cathodic overpotential increased linearly when current density increased from 0 to 150 mA/cm² and then leveled off when the current density exceeded 150 mA/cm². The La_{0.7}Sr_{0.3}CuO_{2.5} showed the lowest cathodic overpotential in LSCu/YSZ system.

Tetragonal perovskite LSCu (0.2 ≤ x ≤ 0.3) provided a high electrical conductivity, and structure stability react with YSZ at 800°C. 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.