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# Characteristics of $LaCo_{0.4}Ni_{0.6-x}Cu_xO_{3-\delta}$ ceramics as a cathode material for intermediate-temperature solid oxide fuel cells

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**Abstract**

In this study, the effects of Cu-ion substitution on the densification, microstructure, and physical properties of $LaCo_{0.4}Ni_{0.6-x}Cu_xO_{3-\delta}$ ceramics were investigated. The results indicate that doping with Cu ions not only enhances the densification but also promotes the grain growth of $LaCo_{0.4}Ni_{0.6-x}Cu_xO_{3-\delta}$ ceramics. The Cu substitution at $x \leq 0.2$ can suppress the formation of $La_4Ni_3O_{10}$, while the excess Cu triggers the formation of $La_2CuO_{4.032}$ phase. The p-type conduction of $LaCo_{0.4}Ni_{0.6}O_{3-\delta}$ ceramic was significantly raised by Cu substitution because the acceptor doping ($Cu'_{Ni}$) triggered the formation of hole carriers; this effect was maximized in the case of $LaCo_{0.4}Ni_{0.4}Cu_{0.2}O_{3-\delta}$ composition (1480 S $cm^{-1}$ at 500°C). Thermogravimetric data revealed a slight weight increase of 0.29% for $LaCo_{0.4}Ni_{0.4}Cu_{0.2}O_{3-\delta}$ compact up to 871°C; this is due to the incorporation of oxygen that creates metal vacancies and additional $h^{\bullet}$ carriers, partially compensating the conductivity loss due to the spin-disorder scattering. As the temperature of the $LaCo_{0.4}Ni_{0.4}Cu_{0.2}O_{3-\delta}$ compacts rose above 871°C, significant weight loss with temperature was observed because of the release of lattice oxygen to the ambient air as a result of Co (IV) thermal reduction accompanied by the formation of oxygen vacancies. A solid oxide fuel cell (SOFC) single cell with $Sm_{0.2}Ce_{0.8}O_{2-\delta}$ (electrolyte) and $LaCo_{0.4}Ni_{0.4}Cu_{0.2}O_{3-\delta}$ (cathode) was built and characterized. The Ohmic (0.256 Ω $cm^2$)