Electrochemical characterisation of the third-order Ruddlesden-Popper phase $Pr_4(Ni_{0.9}Co_{0.1})_3O_{10-\delta}$

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Mixed ionic electronic conducting rare-earth nickelates $A_{n+1}Ni_nO_{3n+1}$ (n=1-3, A=La, Pr, Nd) from the Ruddlesden-Popper (RP) series have attracted considerable interest as alkaline earth-free air electrode materials for high-temperature fuel cells (SOFC) and electrolyser cells (SOEC). In this study, the third-order (n=3) RP-phase $Pr_4(Ni_{0.9}Co_{0.1})_3O_{10-\delta}$ (PNCO43) is investigated with respect to its structural stability, electronic conductivity and oxygen surface exchange kinetics. A two-step sintering process was applied in order to obtain pellets with ~88% relative density. Conductivity measurements as a function of temperature and oxygen partial pressure yield electronic conductivities above 250 S cm^{-1}, which are significantly higher than those of the Co-free compounds $Pr_4Ni_3O_{10-\delta}$ and $Pr_2NiO_{4+\delta}$ [1]. Dense thin film microelectrodes of PNCO43 were prepared by pulsed laser deposition on yttria-stabilised zirconia single crystal substrates followed by photolithographic patterning. Oxygen surface exchange properties and chemical capacitances were determined between 550°C and 850°C, based on individual resistive and capacitive processes of the microelectrodes obtained by electrochemical impedance spectroscopy. The results show that PNCO43 features fast oxygen surface exchange kinetics with low dependency on oxygen partial pressure and can thus be considered a promising alkaline earth-free material for SOFC and SOEC air electrodes below 800°C.

[1] V. Vibhu, A. Rougier, C. Nicollet, A. Flura, S. Fourcade, N. Penin, J.-C. Grenier, J.-M. Bassat, J. Power Sources 317 (2016) 184-193.