Mixed ion and electron conducting ceramics for gas sensors

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Mixed ionic and electronic conducting perovskite-type $BaM_{0.33}Nb_{0.34-x}Fe_xO_{3-\delta}$ (M = Ca, Mg) have been prepared using solid state synthesis method. In-situ and ex-situ powder X-ray diffraction (PXRD) measurements at 30-800 °C showed high chemical stability of the synthesized materials under the CO_2 environment. Room temperature PXRD with Rietveld refinement and HR-TEM electron diffraction results confirmed the formation of perovskite-type $BaMg_{0.33}Nb_{0.34-x}Fe_xO_{3-\delta}$ (*Pm-3m*) and $BaCa_{0.33}Nb_{0.34-x}Fe_xO_{3-\delta}$ (*Fm-3m*) without any impurity phases. The sensing behavior has been characterized by electrochemical AC impedance spectroscopy and dc measurements at 300-700 °C by introducing different ppm level of CO_2 (0-1500 ppm) mixed with dry synthetic air. The increase in CO_2 level (ppm) lowered the resistance of the pellets. Interestingly, Fe-doping in $BaM_{0.33}Nb_{0.64}O_3$ improved the sensing properties by raising the total conductivity significantly (Fig. 1) [1, 2]. t_{90}, time required by sensor to reach 90% of its final stable reading (current density), also reduced by increasing the Fe-content. The highest t_{90} of 4 min for $BaM_{0.33}Nb_{0.33-x}Fe_xO_{3-\delta}$ (x = 0.33) was obtained under CO_2 atmosphere at 700 °C. $BaCa_{0.33}Nb_{0.33-x}Fe_xO_{3-\delta}$ (x = 0.33) exhibited an excellent long-term stability reassuring its possibility as a promising solid state CO_2 sensor.

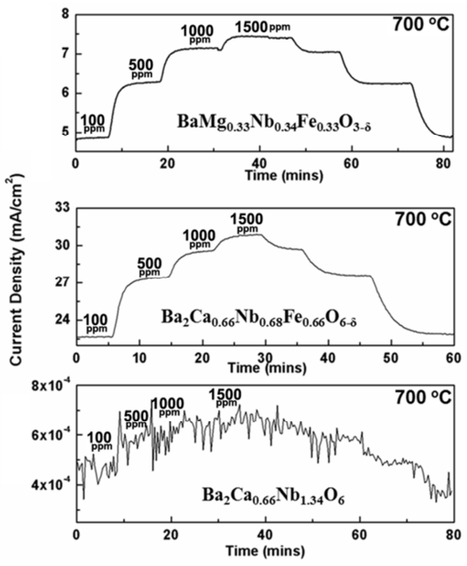

Figure 1. Response and recovery transients of $BaCa_{0.33}Nb_{0.67}O_3$, $BaCa_{0.33}Nb_{0.34-x}Fe_xO_{3-\delta}$ and $BaMg_{0.33}Nb_{0.34-x}Fe_xO_{3-\delta}$ at 700 °C using 3000 ppm CO_2 mixed in dry synthetic air [1, 2] (applied voltage = 0.1V).

References

1. R. Kannan, S. Mulmi, and V. Thangadurai, *J. Mater. Chem.*, DOI: 10.1039/C3TA10572E.
2. S. Mulmi and V. Thangadurai, *J. Electrochem. Soc.* 160, B95 (2013).