ENVIRONMENTAL MONITORING OF CO_2 CONCENTRATION FLOWS WITH NOVEL FAST LI-GARNET BASED ELECTROCHEMICAL SENSOR

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Global energy production and consumption growth sets new environmental and energy challenges that require innovative solutions to store, track, transfer and monitor CO_2 flows. To date, the most common solution to monitor CO_2 involves either the use of expensive and energy-consuming near infrared gas sensors, or semiconducting metal oxide gas sensors in which adsorbed gases modify their resistivity. Both meet requirements in terms of response time and accuracy, however their limited working temperature ranges and power consumption give way for other types of sensors. Here, electrochemical sensors based on the Taguchi principle seem to be a suitable alternative, due to their simplicity, scalability and tracking sensibly changes in CO_2 concentrations with respect to their electromotive force pf the cell. Despite number of reports on the carbon dioxide sensing performance of devices based on sodium and lithium conductors such as NASICON and LISICON, the need of well performing, stable and power efficient devices is still not yet fully satisfied. Therefore new engineered electrolyte materials, such as doped lithium lanthanum zirconates, attract considerable attention for improving long-term chemical stability and faster kinetics.

In this work, we report on a new class of Taguchi-type carbon dioxide sensors, based on Li-ions conducting solid state electrolytes with fast conducting Li-garnet structures as an alternative to state-of-the-art NASICON based structures. Ceramic processing of the sensor unit based on a dense ceramic pellet electrolyte of $Li_{6.75}La_3Zr_{1.75}Ta_{0.25}O_{12}$ and thick film porous sensing electrodes based on Li_2CO_3-containing pastes are discussed. We elaborate on the ceramic fabrication routes for the pellet based sensor structures and structural stabilities investigated in terms of Raman Spectroscopy and X-Ray Diffraction showing the intended electrolyte and electrode crystal structures. The electrochemical performance of the system and electrode-electrolyte interface behavior is discussed in terms of electrochemical impedance spectroscopy. The sensing performance of the device is tested in steady gas flows at elevated temperatures in a range of 250-450ºC. The sensing performance results show stable response to carbon dioxide concentration change in a range of 0-8000ppm CO_2 with the 90% response time below 1min. Pellet based device exhibit high stability over cycling. The sensing resolution of the sensor is as large as 35mV per decade. V shows close to theoretical linear behavior over the measured range for the discussed device. Given this, pellet based sensor show potential application value in the detection of CO_2 gas for environmental monitoring with low energy requirements.