

# DEVELOPMENT AND CHARACTERIZATION OF ZIRCONIA-YTTRIA/ZIRCONIA-MAGNESIA COMPOSITES FOR DISPOSABLE HIGH TEMPERATURE OXYGEN SENSORS

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**Abstract:** Composite solid electrolytes based on mixtures of Y-TZP and Mg-PSZ were developed for detection of oxygen at high temperatures. The electrical characterization was carried out by the impedance spectroscopy technique and the thermal shock resistance by dilatometry. The speed (response time), the sensitivity and the selectivity were measured.

One of the most important industries nowadays is the steel industry. The fabrication of steel, mainly those for high technology applications, requires the knowledge of the level of oxygen dissolved during steel production, a process control carried out at temperatures as high as 1600 °C.<sup>1-4</sup> In steelmaking processes, the control of oxygen levels in the molten steel is done with Nernstian oxygen sensors based on magnesia-partially stabilized zirconia solid electrolytes (Mg-PSZ). The main reason for using these compounds in disposable commercial oxygen sensors, besides their high emf signal, is their high thermal shock resistance, necessary for detecting and amplifying the emf signal before disruption of the electrochemical cell (electrode/solid electrolyte-reference/electrode) caused by the abrupt insertion of the sensor in the molten steel. For certain industrial processes that require measurement of low oxygen potentials (< 50 ppm) at high temperatures, the electronic conduction of Mg-PSZ electrolyte introduces error in the emf values.<sup>2</sup>

In this work, we develop composite solid electrolytes taking advantage of the high thermal shock resistance of zirconia-magnesia ceramics and the high oxide ion conductivity of zirconia-yttria ceramics. These composites were prepared by thoroughly mixing  $ZrO_2:8\text{mol\% MgO}$  and  $ZrO_2:3\text{mol\% Y}_2O_3$  ceramic powders, pressing and sintering at 1500 °C. The evaluation of the thermal shock resistance was performed by dilatometric analysis in the room temperature - 1550 °C range in previously sintered pellets. The electrical behavior was evaluated by the impedance spectroscopy technique at 600 °C for separating the bulk and the grain boundary components of the electrical resistivity. Data on sensitivity, selectivity and response time of the composites to oxygen were collected in the 1000 °C -1300 °C range, using an yttria-stabilized zirconia electrochemical pump operating in the 90-900 ppm range of partial pressure of oxygen, and an yttria-stabilized zirconia oxygen sensor. The dependence of the emf signal of the  $O_2/Pt/composite-Cr-Cr_2O_3/Pt$  electrochemical cell on the oxygen content in the 100-600 ppm range at 1000 °C is shown in Fig. 1.

The main results show that the composites have similar thermal shock resistance and response time to the commercial zirconia-magnesia oxygen sensors. Moreover, the electrical response is improved.

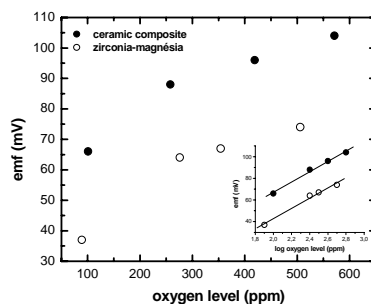


Fig. 1: Electrical response of  $(ZrO_2:8\text{mol\% MgO})_{0.5}(ZrO_2:3\text{mol\% Y}_2O_3)_{0.5}$  composite and zirconia-magnesia electrolytes as a function of the oxygen level at 1000 °C. Inset: its dependence on the logarithm of the oxygen level (Nernst law).

## References

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