

Solid Electrolyte Oxygen Sensor Operating at Low Temperatures

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Y_2O_3 (12 mol%)-stabilized zirconia oxygen sensors with the addition of 0 to 2 mol% Sc_2O_3 and/or 0.5 mol% CaO were fabricated for operation at low temperatures between 300°C and 500°C. Yttria-stabilized zirconia (YSZ) oxygen sensors usually operate at high temperatures above 600°C. YSZ with 0.5 mol% Sc_2O_3 exhibited the electromotive force (EMF) variation of 130 mV in the oxygen partial pressure range of 0.01~10% at the operating temperature of 300°C.

1. Introduction

In recent years, zirconia-based oxygen sensors have been widely used for combustion control, especially for automobiles, atmosphere control in furnaces and for monitoring the oxygen concentration in molten metals. It is well known that oxygen sensors are used to optimize the vehicle performance with respect to exhaust emissions to realize economic fuel consumption. Pure zirconium dioxide (ZrO_2) has a monoclinic crystallographic structure at ambient temperature. Upon raising the temperature, the oxide undergoes a phase transition to a tetragonal structure at 1170°C and to a cubic one at 2370°C.⁽¹⁾ The martensitic phase transformation from the tetragonal to the monoclinic structure is accompanied by a considerable volume expansion of 3~5%, which invariably results in cracking of the material even on a small scale. This volume instability causes the ceramic to crumble.⁽²⁾

ZrO_2 -based solid solutions with aliovalent (lower valency than zirconium, i.e., less than