CONTEMPORARY METALLIC MATERIALS

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Chapter 019

Principle of Solid Electrolyte Oxygen Sensor

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Keywords: Oxygen sensor, Solid electrolyte, Electrochemical concentration cell, Fe-Cr alloys.

Abstract: The principle of solid electrolyte oxygen sensor has been discussed. An example of its' application in the high temperature oxidation of Fe-Cr alloys was given. In Ar-21%O_2 mixed gas, the oxygen chemical potential of the oxide formed on Fe-10~17Cr alloys is slightly smaller than the atmosphere. Electrochemical concentration cell using solid electrolyte provides an accurate measurement of surface oxygen potential, thus widely apply in oxygen sensing.

Introduction

In the industry and practical application, evaluation of gas concentration is important to continuously monitor the reaction environment. Solid electrolyte gas sensor is based on electrochemical concentration cell, which will generates electromotive force (emf) if there is concentration gradient of gas between the cells. Recently, many gas sensing materials have been developed. Stabilized zirconia oxygen sensor is one of important material that has been developed and successfully utilized in automotive, combustion, steel industries etc. In this paper, the principle of solid electrolyte oxygen sensor will be discussed with some example of application in high temperature oxidation of Fe-Cr alloys.

Measurement Principle

Calcia stabilized zirconia (CSZ) is well known as an ionic conductor widely uses as solid electrolyte in oxygen sensor / pump at high temperature. Fig. 1 shows a schematic diagram of an oxygen sensor using CSZ as electrolyte. If one side of oxygen partial pressure, $P_{O_2}^{I}$ is known value, the oxygen partial pressure in the closed system, $P_{O_2}^{II}$ can be measured. The electromotive force (emf) of this cell is expressed as Nernst equation below.

$$E = \frac{\mu_{O_2}^{I} - \mu_{O_2}^{II}}{4F} = \frac{RT}{4F} \ln \frac{P_{O_2}^{I}}{P_{O_2}^{II}} \qquad (19.1)$$

where R, T and F denote gas constant, temperature and Faraday constant, respectively.