Introduction to Electrochemical (EC) Gas Sensors

INTRODUCTION

SGX electrochemical sensors detect gases by producing a chemical reaction between the gas and oxygen contained in the sensor. This reaction produces a small current, which is proportional to the concentration of the gas present. The sensor is, in effect, a type of fuel cell.

Reactions occur on two electrodes which when combined together produce the sensing process. These electrodes comprise small discs of porous PTFE onto which is deposited a thin layer of a catalytic metal.

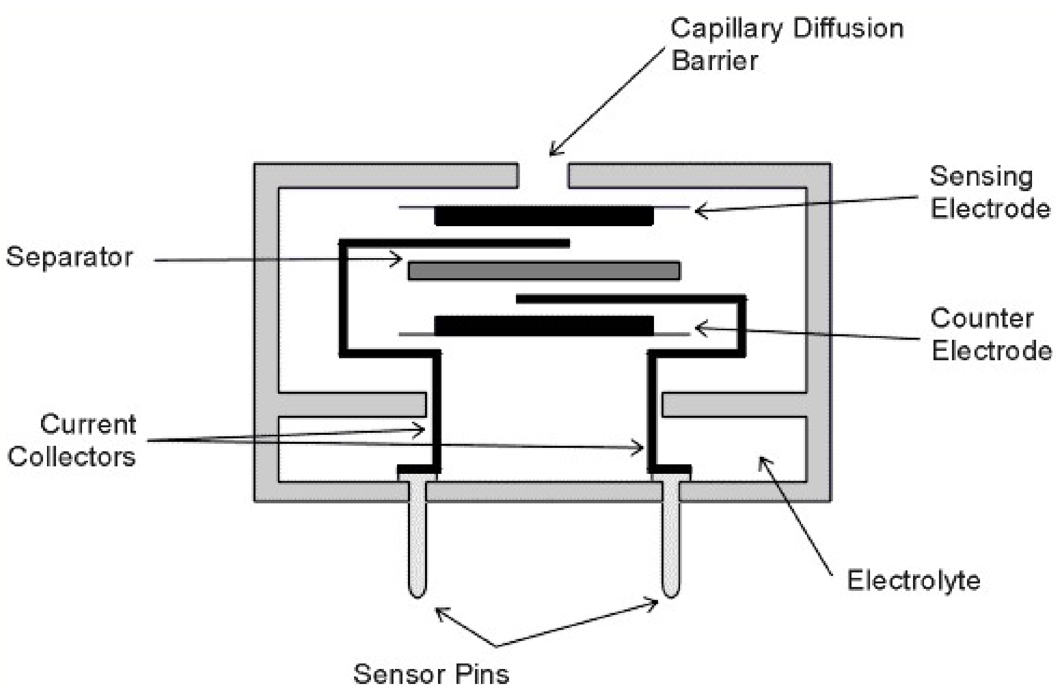
On the working electrode the target gas (carbon monoxide or hydrogen sulfide) react with water to produce either carbon dioxide or sulfuric acid, hydrogen Ions and 2 electrons On the counter electrode, oxygen reacts with hydrogen ions and electrons to form water, e.g.

Working Electrode: $CO + H_2O \rightarrow CO_2 + 2H+ +2e^-$

Counter Electrode: $\frac{1}{2}O_2 + 2H+ + 2e^- \rightarrow H_2O$

Overall: $CO + \frac{1}{2}O_2 \rightarrow CO_2$

Because the electrodes have a finite catalytic activity (which can change with time and temperature) it is necessary to limit the rate of diffusion of target gas into the sensor (using a barrier) to ensure the gas is efficiently reacted. This barrier takes the form of a small hole or capillary in the sensor housing (see below).



The electrodes need to be kept apart and wetted with an acid electrolyte to allow an ionic current to pass between them. This is done using discs of inert absorbent material or separators. These can be made from materials such as glass fibre.

The electrodes are connected to the external circuitry by thin metal strips or current collectors, attached to pins.

FUNCTION OF THE REFERENCE ELECTRODE

For maximum efficiency, the working electrode needs to run at zero volts compared with the counter electrode. When the electrode is reacting with the gas, a voltage is generated at the electrode surface. This voltage can result in a loss of electrode performance, i.e. the sensor response falls away as the gas concentration increases. By connecting another electrode (or reference electrode) to the working electrode, the voltage change is prevented and the potential clamped to zero volts.

IMPORTANCE OF OXYGEN

As described earlier, oxygen is needed for the counter electrode reaction to proceed. This oxygen is found dissolved in the electrolyte. Replenishment of the oxygen used in the reaction can be provided by oxygen in the sample gas or by diffusion of oxygen through the housing from gas behind the sensor. If the oxygen is not replenished, e.g. the sample gas contains no oxygen, then the counter electrode reaction will be affected and ultimately the reaction will change to one producing hydrogen gas by reducing protons. Generally there is enough oxygen present in the sensor for several hours of operation in anaerobic conditions.

CONCENTRATION RANGE AND OUTPUTS

SGX toxic sensors are designed to measure carbon monoxide and hydrogen sulfide in the parts per million range. This allows measurement of these gases in concentrations in the occupational exposure range that, for example, are 5 and 10 ppm for hydrogen sulfide for the 8 hour and 15 minute limits respectively. The outputs of the sensors (when run in a simple potentiostatic circuit as described in Electrochemical Sensors Application Note 2) are between 55 and 850 nA per ppm of gas.

CROSS-SENSITIVITY AND TEMPERATURE EFFECTS

SGX toxic electrochemical sensors, as with other EC sensors, may exhibit some response to other gases apart from the target gases. These responses arise from the gases being oxidised or reduced on the working electrode. The responses have been minimised by the choice of the electrode or by the fitting of an absorption filter directly behind the diffusion barrier in front of the working electrode. The levels of cross-sensitivity are detailed in each sensor datasheet.

Changes in the ambient temperature will affect both the zero signal of the sensor and the net sensitivity to the target gas. The electrodes used in SGX sensors have been optimised to reduce these temperature effects as much as possible, but some effects will still be observed. Further information is given in the individual sensor datasheets.