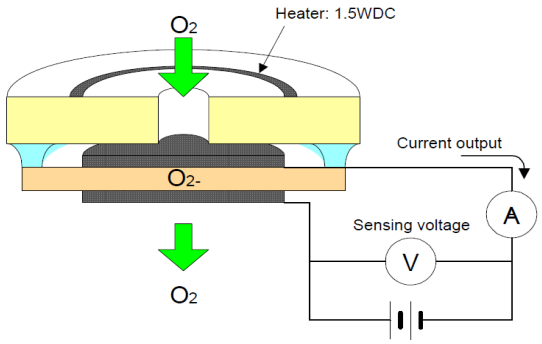
Pewatron Application Note PAN-02: Zirconia oxygen gas sensor;

From ppm up to 95% measurement range

The FCX zirconia oxygen sensor series comes with 4 different measurement ranges; 0…1000ppm, 0…5%, 0…25% and 0…95% (extendable to 98%). The construction of the individual sensors with respect to the measurement range have been done to meet requirements such as high accuracy, superior signal stability/ repeatability, fast response time and long operational lifetime of the sensor. The sensor output signal is in the µA range and it follows a logarithmic curve with increasing oxygen concentration.

Zirconium oxide (with proper dopant elements) when heated > 350 °C is penetrable for oxygen ions. The FCX oxygen series has the working point at 450°C. The heating element and the oxygen sensing element are bonded together ensuring a perfect thermal match and minimum power usage within the working point. A voltage applied to the oxygen-sensing element, pumps the oxygen out of a closed inner chamber (Figure below). At a constant gas pressure, the quantity of oxygen pumped out is equal to the quantity of oxygen molecules diffusing in through a small capillary hole. It is independent of the voltage applied between the electrodes within a certain range. The measurement current is proportional to the quantity of oxygen molecules pumped away. The relationship between the oxygen partial pressure p_{02} and sensor current I_s is given by the formula I_s = constant x ln (1 - p_{02} / p_t), where p_t is the total partial pressure in the system.



The FCX-ULL oxygen sensor measures the oxygen concentration in the range from 0…1000 ppm O_2, but also works under normal atmospheric conditions. Sensor lifetime is limited only by the total current through the sensor element. The accuracy of the FCX-ULL sensor can be very high, but it is very much dependent on the application and how the sensor is used in the application. The standard accuracy of +/-50 ppm can be improved by calibrating the sensor before each measurement or by measuring in a continuous mode. In the latter case, the resolution can be as good as a few ppm.

The FCX-UL oxygen sensor measures the oxygen concentration in the range from 0…5% O_2, but also works under normal atmospheric conditions. Sensor lifetime, like the FCX-ULL sensor, is limited by the total current through the sensor element. For oxygen concentrations in between 0 and 10.000 ppm the accuracy of the FCX-UL sensor is very good (+/-100 ppm). For oxygen concentrations above 10.000 ppm (i.e. between 1% and 5%), the accuracy is +/-1% of the signal. As with the FCX-ULL ppm oxygen sensor, accuracy and resolution can be improved based on the applied measurement & calibration procedure by the customer.

The FCX-ULL and FCX-UL sensors are almost linear in their response to the oxygen concentration. This can be seen from the equation above, because $p_{02}/p_t << 1$. Both sensors are also very fast responding with a T_{90} response time in order of seconds in forced flow mode.

The FCX-UC oxygen sensor measures the oxygen concentration in the range from 0…25% O_2.The response as a function of the oxygen concentration can be considered quasi-linear with a maximum error of 0.5% in the range from 13-17% oxygen. The FCX-UC oxygen sensor has a very long operational lifetime in air, and has a very stable signal output, which in turn minimizes the need for calibration. It can be calibrated in a single point and is therefore a very popular choice for oxygen transmitters in non-Ex environments.

The FCX-UWC oxygen sensor measures the oxygen concentration in the range from 0…95% O_2. It is by far the most used sensor for medical oxygen concentrators, but is also being used to measured oxygen quality/concentration in processes requiring high oxygen concentrations, like, for instance, in some controlled incubator applications. The signal stability and the accuracy at high oxygen concentration are very good, ensuring safe operation of any device based on the FCX-UWC sensor. The measurement range can be extended to 98% without loss of accuracy, but at the expense of the expected lifetime of sensor.

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