Development of a High Temperature Total NO_x Sensor Using a Microporous Catalytic Filter

Nicholas F. Szabo, Prabir K. Dutta
The Ohio State University
Center for Industrial Sensors and Measurements
2041 College Rd., 291 Watts Hall, Columbus,OH 43210

There is an increasing need for harsh environment NO_x sensors due to increasing regulations and negative effect on health and the environment. A high temperature solid electrolyte NO_x sensor combined with a catalytic zeolite Y filter was developed and tested for its ability to sense 100-1000ppm NO_x which comprised pure NO, pure NO_2, or a mixture of NO and NO_2 in an O_2/N_2 background gas. The sensor body was composed of the solid electrolyte yttria stabilized zirconia (YSZ) and contained a combination of Pt or metal oxide electrodes as shown in Figure 1. One electrode was exposed to the sensing gas while the other was exposed to a fixed air reference.

It was found that the sensor element alone responded to pure NO and NO_2 gases in the opposite direction as demonstrated previously in the literature. Also a mixture of NO and NO_2 caused the sensor signal to decrease from that of the pure NO_x gases. In addition the sensor showed a high interference from CO. It would be desirable to have a sensor that gives a total NO_x signal in the same direction for NO and NO_2 and was insensitive to CO.

The use of a catalytic filter bed before the sensor to convert NO_x (either NO, NO_2 or a mixture) to a fixed equilibrium ratio defined by the temperature and O_2 level would be advantageous. For example any combination of NO, NO_2 or a mixture that is the same total NO_x would be equilibrated to the same NO/NO_2 ratio resulting in the same signal from the sensor. The filter could also oxidize the incoming CO to CO_2 where CO_2 is inactive on the sensor electrode. A catalytic filter bed composed of zeolite PtY was placed before the sensor in an attempt to achieve these results.

The YSZ sensor was placed in a quartz tube inside a tube furnace and maintained at a temperature between 400-600ºC. An external quartz tube maintained at 400-700ºC was placed outside the furnace and contained 80mg of the PtY powder. Gases were mixed with mass flow controllers at a flow rate of 100cc/min over the sensor.

The design using the PtY filter gave a total NO_x signal and was hardly affected by CO. Figure 2 shows the sensor trace in volts while the sensor and filter are at 500ºC. The PtY filter eliminates the interference of 600 or 1000ppm CO. In both cases first the baseline gas of $3\%O_2$ is flowed directly onto the sensor (the filter bypass) and then the CO is exposed to the sensor resulting in the signal. The gas flow is then switched to flow over the PtY filter bed and the signal returns to the baseline while CO is still flowing.

Figure 3 shows a calibration plot of the sensor at 500ºC and the filter varied from 400-700ºC for NO and NO_2 from 200-1000ppm. It is evident that the filter fully equilibrates the incoming NO and NO_2 as the resulting signal for each are nearly equal. It was found that the lowest sensor signal occurs when the filter and sensor are at the same temperature and that the signal can be increased if the sensor and filter are maintained at different temperatures.

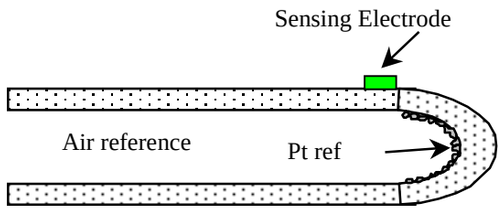

Figure 1: Schematic of Sensor

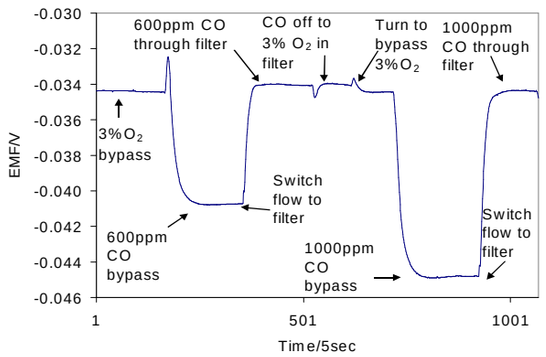

Figure 2: Demonstration of the PtY filtering ability for 600 and 1000ppm CO.

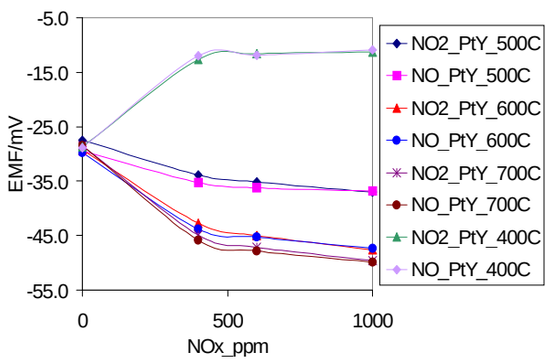

Figure 3: Sensor response at 500°C to NO and NO_2 when PtY bed is varied from 400-700°C