**Chemiresistive (metal oxide) sensors for detection of chlorine**

Synkera has developed a line of high-performance, rugged and reliable sensors based on nanostructured materials and micromachining. Synkera currently offers commercial sensors for detection of gases as such as $H_2$, VOCs, flammable gases (e.g. methane, propane), $NO_X$, $H_2S$ and $NH_3$. These sensors are all based upon advanced and highly tailored nanostructured materials, whose resistance changes as a function of the concentration of gas molecules at the sensor surface. At elevated temperatures, physisorption and chemisorption of gases on the surface of the metal-oxide sensors lead to changes in the electronic properties of the semiconductor material. This interaction is manifested in a predictable relationship between the level of gas concentration and a change in bulk resistivity of the sensor. In numerous applications, these existing sensors have been shown to be extremely long lasting, rugged and reliable.

## Chlorine Sensing

Synkera has recently performed some preliminary work on detecting $Cl_2$. Both thick and thin films have been evaluated, with extremely promising results. The responses were p-type in nature (resistance increases in the presence of chlorine gas) and quite strong, with response ratios >100 even at concentrations as low as 2 ppm $Cl_2$ (screen printed thick films). In this case, response ratio is defined as the resistance in challenge gas divided by the resistance in air. A brief study of operating temperatures showed that lower temperatures prompted the strongest sensitivity, albeit with slower response and recovery times, as compared to higher operating temperatures. Figure 1 shows the linearity of thick-film prototype sensors at higher $Cl_2$ concentrations and lower operating temperature. Figure 2 shows response curves for screen printed thick films at lower $Cl_2$ concentrations, and an operating temperature of 150°C.

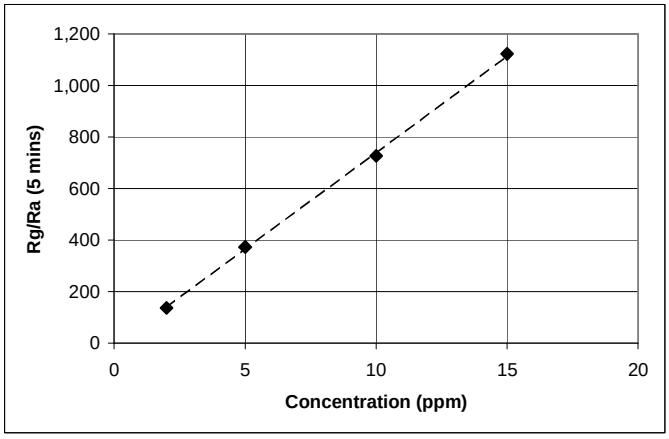


**Figure 1: Response ratio of thick film sensors to 2-15 ppm $Cl_2$, operating temperature ~100°C.**

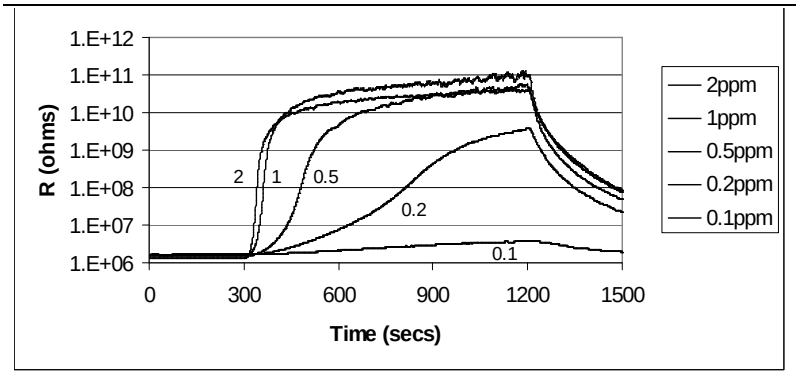


**Figure 2: Response of thick film sensors to lower $Cl_2$ concentrations, operating temperature ~150°C.**

Thinner $WO_3$ films prepared by spin coating sol gel solutions have shown good response and linearity, especially at lower

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concentration ranges of 0.1- 1 ppm (data not shown here). Saturation of response at higher concentrations is a concern. The effect of film thickness on response should be examined.

**Estimated Sensor Parameters:**

Heater power required for standard microheater design: 40- 60 mW

Heater voltage input: 0.4 to 0.8V

Prototype sensor cost $100 each

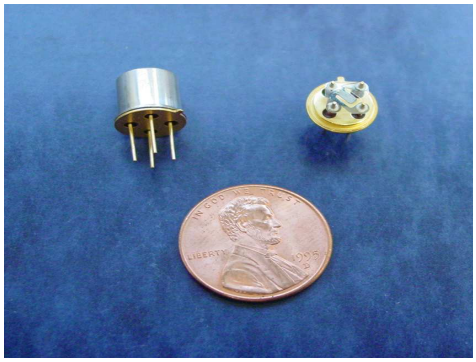

**Figure 3: Prototype (standard) microsensor packaged on TO-39 header, with and without protective**