A Low-Power Metal-Oxide Based Gas Sensing System

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Thick-film sensors deposited on ceramic heater substrates presently dominate the metal oxide gas sensor market. Such sensors commonly consist of small ceramic substrates with a heater circuit on the backside and electrodes and a gas sensitive metal oxide layer on the front side. Due to their relatively large size and poor thermal insulation such sensor elements normally require heating power inputs of about 1W to attain substrate temperatures of the order of 400°C, which are needed to operate metal oxide gas sensors properly. In addition all commercial sensors exhibit more or less pronounced cross sensitivities, which makes such sensors difficult to use in practice. As a consequence such sensors are often ruled out for use in more demanding safety applications.

In recent years many efforts have been devoted to developing micromachined heater substrates for metal oxide gas sensing layers to attain much lower levels of heating power consumption. Typically the power consumption of such micromachined sensor devices is an order of magnitude less than that of commercial thick-film devices. Such micromachined devices, which often use thin-film metal oxide materials, however, are plagued by the same kind of cross sensitivity problems as the commercial thick-film ones.

In the present paper we should like to report on a miniaturized gas sensing system that contains as a heart piece an array of four metal oxide gas sensors deposited on a micromachined silicon chip containing four independently heatable sensor platforms (Fig.1). We should like to show that such gas sensor arrays can provide superior gas distinction as compared to conventional thick-film gas sensing elements, operating at the same time within the heating power margin of a single thick-film gas sensing elements.

A top view onto the surface of such a gas sensor array is shown in Fig.1 and an assessment of its electrical power consumption level is given in Fig.2. In this latter figure we compare the heating power consumption of a single commercial thick-film gas sensing element with the heating power consumption of one of the micromachined hotplate sensors and finally the total power consumption of a micromachined four-sensor array including the power consumption of peripheral electronic circuits such as fast heater drivers, signal conditioning electronics and drift rejection circuits. This comparison illustrates the power consumption issue raised above.

The gas discrimination issue is dealt with by considering that the four sensor array shown in Fig.1 allows depositing up to four different kinds of metal oxide materials on top of the individual heater platforms and for operating these at four different temperatures which are optimal for detecting different kinds of gas species. In our presentation we will report gas sensing measurements with arrays formed by depositing one kind of metal oxide material on two of the hotplates and another material on the remaining two heater substrates. Each material then was heated to two different operation temperatures to attain four different kinds of gas response patterns from the four hotplate substrates. This rationale of shaping cross sensitivities is demonstrated in Figs. 3a and b.

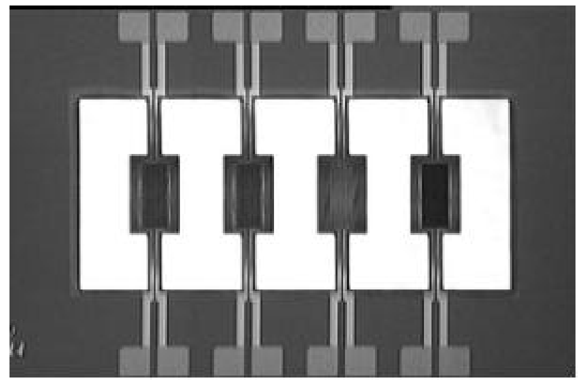

Fig.1: Top-down view of a four sensor micromachined array. The four hotplates are independently heatable. The power consumption is shown in Fig. 2

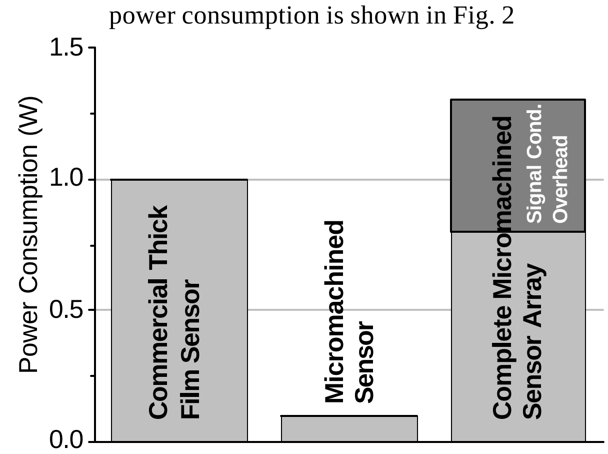

Fig.2: Comparing Power Consumptions. A full-fledged micromachined sensor array with heater driver needs about as much power as a single commercial thick film device. The additional power needed for signal conditioning electronics is also shown.

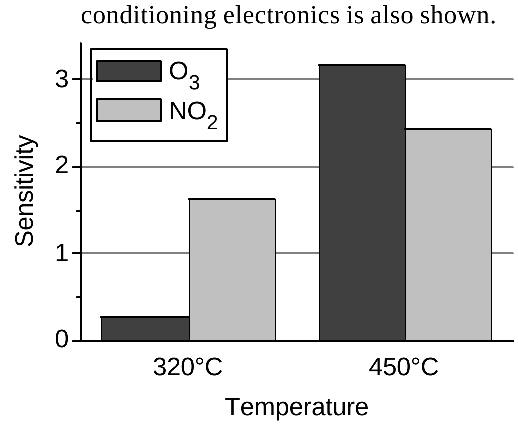

Fig.3a: Cross Sensitivity Shaping with temperature. The same kind of gas sensing material (in this case SnO2) will exhibit different cross sensitivities when operated at different temperatures.

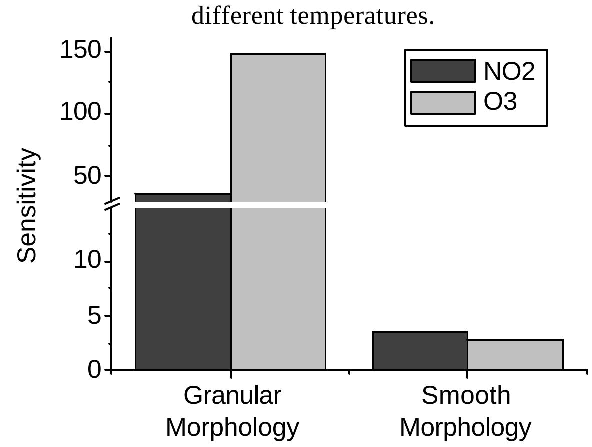

Fig.3b: Cross Sensitivity Shaping with film morphology. Tin oxide films of different morphology show different sensing patterns at the same operating temperature.