IDC GAS SENSORS USING ORGANICALLY MODIFIED SILICATE LAYERS AS GAS-SENSING SUBSTANCES

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ABSTRACT

The dielectric properties of organically modified silicates change under the influence of gases such as NO_2, NH_3 and SO_2. Thin layers of these materials are applied as dielectric to thin film interdigital capacitors (IDC). It is possible thereby to detect changes of the dielectric properties of the layers through the change in the capacitance and conductivity of the capacitor. The results obtained with a layer optimized for SO_2 detection are presented; the layer is characterized by good linearity in the range of 2 to 10 vpm SO_2 and low cross sensitivity to humidity of up to 23000 vpm at 30°C.

1. Introduction

Poor selectivity often presents a major problem in the development of gas sensors; as a rule, a certain cross sensitivity exsists to many

gases and humidity. In most circumstances humidity concentrations exceed the concentrations of the gases primarily to be detected by several orders of magnitude, thereby favouring corrosion of the electrodes of the capacitor (35% r.h. at 21°C corresponds to 8,000 vpm, while SO_2 concentrations in the normal range of emissions lie between some 10 to 100 vpm). In addition to measure the gas sensitivity of the sensors it is therefore necessary to test their long-term stability under varying climatic conditions.

Gassensitive coatings presented here consist of organic modified silicates. They are prepared from substituted alkoxysilanes by hydrolysis and condensation via the sol gel process. A three dimensional network of siloxane bonds (Si-O-Si) forms an amorphous solid, as in the silica glass. The organic substistuents, connected to the network by silicon carbon bonds, can be chosen to give the material specific qualities for adsorbing gas molecules, specially NO_2, NH_3, CO, CO_2 and SO_2. In case of the SO_2-sensitive material some R's are tertiary amino groups (R: $-CH_2-CH_2-CH_2-N(CH_3)_2$) which - as known [1] - can form weak adducts with SO_2, some R's are hydrophobic propyl groups (R: $-CH_2-CH_2-CH_3$) to reduce the adsorption of water molecules.

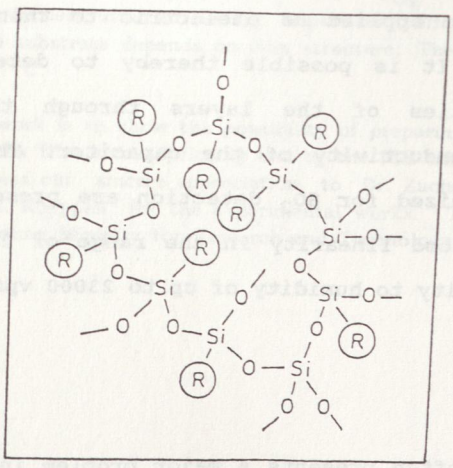

Fig. 1: Idealized structure of an organically modified silicate

2. Experiments and Results

Planar capacitors produced in accordance with the thin film technology are used as the sensor elements (Fig. 2). The coating solution produced by the sol/gel process is deposited by means of spin on coating and then cured.

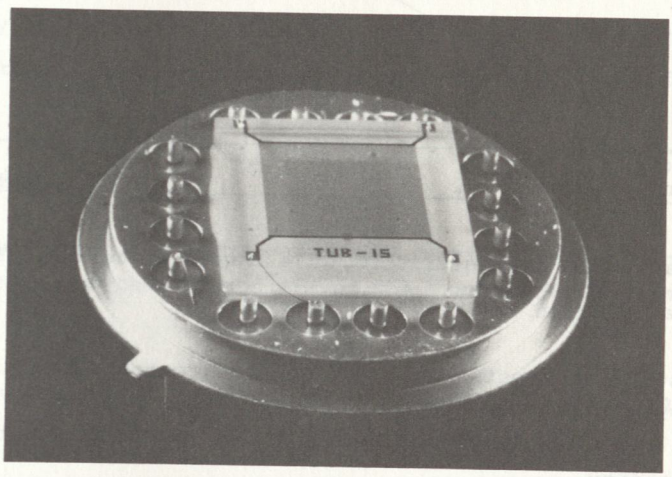

Fig. 2: Miniaturized IDC for gas detection mounted on a standard package

For testing the gas sensitivity test gas concentrations are prepared using mass flow controllers, such concentrations being defined on the basis of premixed test gases and nitrogen or synthetic air and brought into contact with the sensor elements. Adsorption of gas on the capacitor coating gives cause to a change of its dielectric constant and thus of the capacitor's capacitance. By way of example, Fig. 3 shows the capacitance curve of a capacitor as a function of the SO_2 concentration of the test gas.

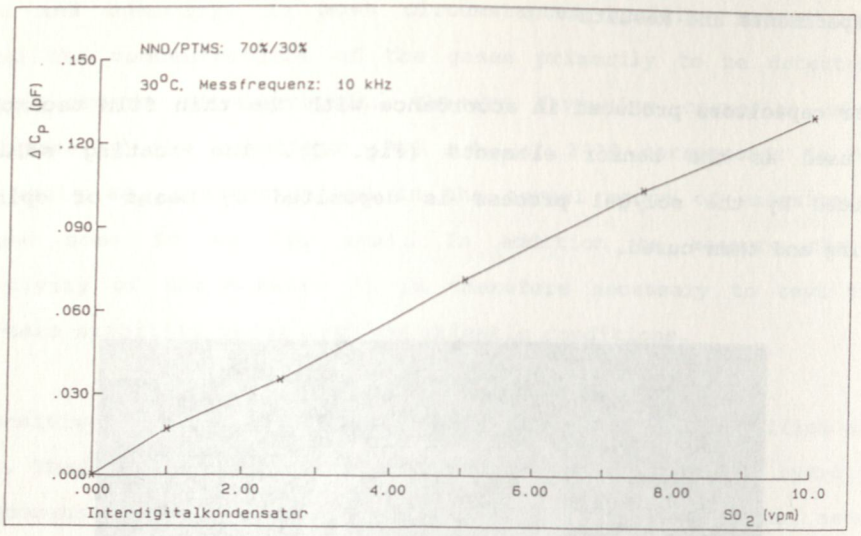

Fig. 3 Capacitance characteristic of a coated interdigital capacitor as a function of the SO_2 concentration

Long-term stability tests under defined environmental conditions were performed with a computer-controlled climate test chamber. Fig. 4 represents a typical capacitance curve of an IDC as a function of the time and humidity.

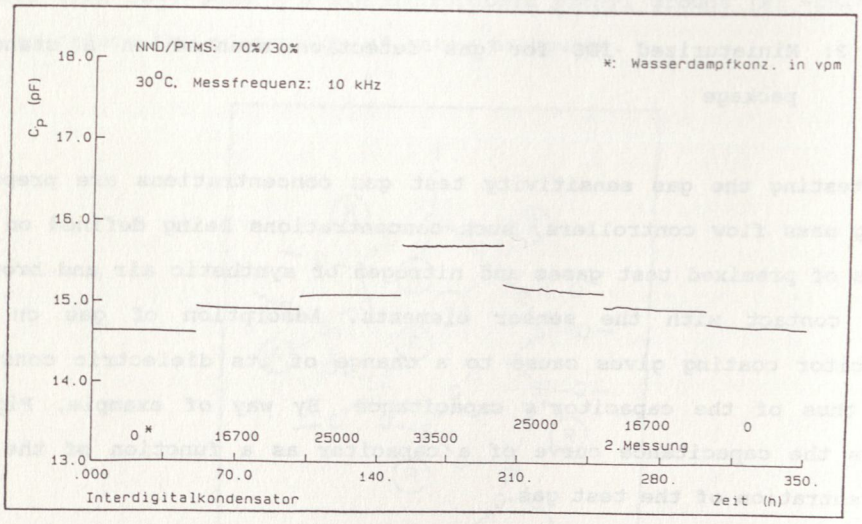

Fig. 4 capacitance curve of an IDC as a function of the time and humidity

3. Conclusion

The sensors presented here, which are based on Ormosil-coated interdigital capacitors, proved to be highly sensitive to SO_2 showing at the same time low cross sensitivity to humidity. Interdigital capacitors are highly suitable components for the development of new chemosensitive materials and new chemical sensors. They are equally suited for conductivity and capacitance measurements. The specific sensitivity and stability of sensors of this type can be optimized by matching the electrode material, the coatings and the coating technique.

Acknowledgement

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References

[1] J. Grundnes; S. D. Christian, J. Am. Chem. Soc. 90, 2239, (1968)