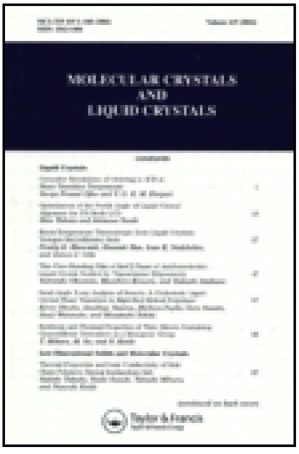

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THE RESPONSE CHARACTERISTICS OF ORGANIC GAS USING QCA COATED WITH POLYMERIC MATERIALS

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Abstract The new system for identification of organic vapours and analysis method of mechanism between organic vapours and sensitive materials were attempted using the resonant resistance and resonant frequency of Quartz Crystal Analyzer (QCA). The resonant resistance shift means rheological changes in sensitive LB films occurred by the adsorption of organic vapours, while the resonant frequency shift represent the mass of organic vapour loaded in or on the sensitive LB films. Thus we can obtain more accurate response mechanism of organic vapour using the resonant frequency and resonant resistance diagram. The organic vapour response mighit be devided by two type ; surface adsorption and penetration into sensitive material. The interface between inner side and surface of sensitive LB films is not clear yet. Organic vapours had different positions in the Frequency-Resistance (F-R) diagram as to the kinds and concentrations. Thus F-R diagram can be applied to the development of one-channel gas sensing system using the Quartz Crystal Analyzer.

INTRODUCTION

The piezoelectric effect of quartz crystal has been used as a transducer of gas sensor. In the gas sensing area using quartz crystal, the Sauerbrey equation which mean mass loaded on the quartz crystal have been used as analytical valuable[1]. Thus there are some difficulties because of the multi-component analysis and it was difficult to obtain information about response mechanism between organic gas and sensitive material. We adopted the resonant resistance concept to gas sensing area using quartz crystal microbalance (QCM). It has been well known that the resonant resistance shift is occured by qualitical changes of sensitive material deposited on the quartz crystal, while the resonant frequency shift the mass loaded on the quartz crystal. The method of resonant resistance (or admittance) have been used in the area of trace ion determination[2], phase transition of polymer blend[3], gelation monitoring[4] etc. If the resonant frequency and resonant resistance will be used as analytical valuable simultaneously, more simple method to identify gas and to analyze mechanism between gas and sensitive material may be obtained.

In this paper, the adsorption and desorption behavior of organic gas was investigated by using QCA (Quartz Crystal Analyzer) for ultra-thin sensitive LB film. We focused on the development of one-channel gas sensing system and analytical tools of response mechanism using the F-R (Frequency-Resistance) diagram.

THEORY

The relation between mass deposited on the quartz crystal and resonant frequency change was derived by Sauerbrey[1] as following;

$$\Delta f = - C \cdot \Delta m \quad (1)$$

where Δf is frequency shift, C is calibration constant, Δm is mass loaded on the quartz crystal. In the case of the AT-cut quartz crystal used in this study, the frequency shift of 1[Hz] is equal to mass loading of 1[ng]. The concept of resonant resistance was derived by Muramatsu[5], the change of resonant resistance represent rheological change in organic film deposited on the quartz crystal. In the Figure 1, electrical model(Figure 1(a)) can be converted to a mechanical model (Figure 1(b)) by using the electromechanical coupling factor k.

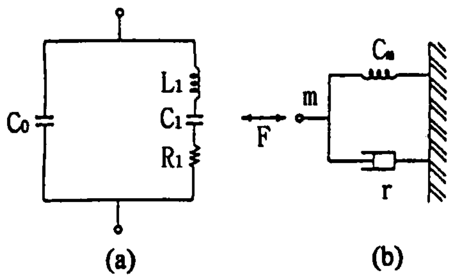

FIGURE 1 Electrical equivalant circuit (a) and mechanical model (b) of QCA

The resistance change in electrical circuit have relation with applied voltage loss. If the loss of applied voltage can be measured, the resistance change is obtained by following equation.

$$Rq = (Vi \ / Vq - 1) Ri \quad (2)$$

where Vi is applied voltage of quartz crystal. Vq is the out voltage on the other side of quartz crystal and can be measured by RF voltmeter. Resonant resistance which mean the rheological change in organic films deposited on the quartz crystal can be calculated by resonant admittance.

EXPERIMENTALS

The material used in this study was diether-2-monostearyl maleate-Diethyleneglycol methyl vinyl ether ($2C_{18}MA$-VE_2) synthesized in our Lab[6].. Langmuir-Blodgett(LB) technique was applied to transfer sensitive materials on the quartz crystal. And organic vapours such as methanol, ethanol, butanol, propanol were used as analytes. Experimental setup of batch-type and flow-type were used to investigate absorption and desorption pattern of organic vapours. Adsorption pattern of organic vapours was observed using batch-type, then the flow-type experimental setup was used to investigate the desorption pattern of organic vapours. The flow rate of carrier gas (N_2) was maintained as 1.0[m*l*/min] and temperature of response cell was 25[℃].

RESULTS & DISCUSSION

In the fundamental pre-investigation, when organic vapour was injected to bare quartz crystal, resonant frequency shift was increased with amount of organic vapour but resonant admittance have no connection with that amount. Figure 2 shows the F-R diagram to verify the stabilization of quartz crystal analyzer deposited sensitive LB film.

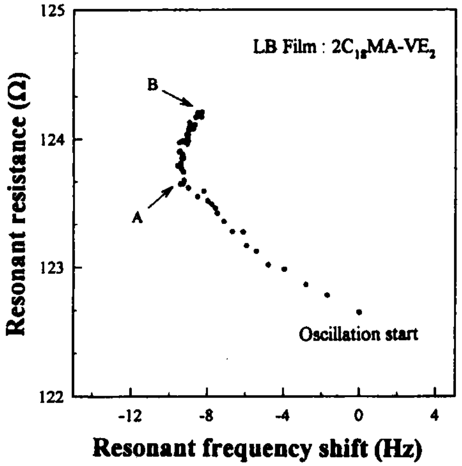

FIGURE 2 The F-R diagram to verify the stabilization of quartz crystal analyzer deposited sensitive LB film.

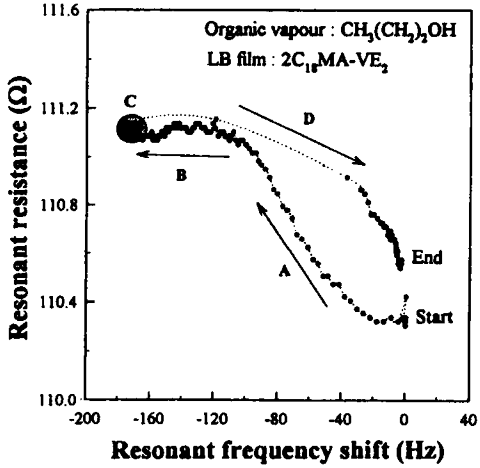

FIGURE 3 The F-A diagram for the injection of 50[$\mu\ell$] propanol vapour

We analyzed the adsorption and desorption response of organic vapour by using the frequency and resistance diagram. Figure 3 was obtained by the injection of 50[$\mu\ell$] propanol. At the Start position, the organic vapour was injected. There are three reaction process. In the process A, the frequency decrease were occurred by mass loaded on the sensitive material and resistance increase were occurred by the qualitical change of sensitive material, which was caused by penetration of organic vapour into sensitive material. The process B is the surface adsorption because only the frequency shift was occurred. But the interface between inner side and surface is not clear yet. And then frequency shift and resistance shift were maintained C area. This area is the special area to identify the kind and concentration of organic vapours. The process D is the desorption process of propanol by the injection of carrier gas(N_2).

Figure 4 shows the position of organic vapours in the F-R diagram when each organic vapours of 50[$\mu\ell$] was injected. They have different positions as to the kind of organic vapours in the same injection amount. This result was occurred by the different interaction between organic vapours and sensitive materials. The kind of interaction is not clear.

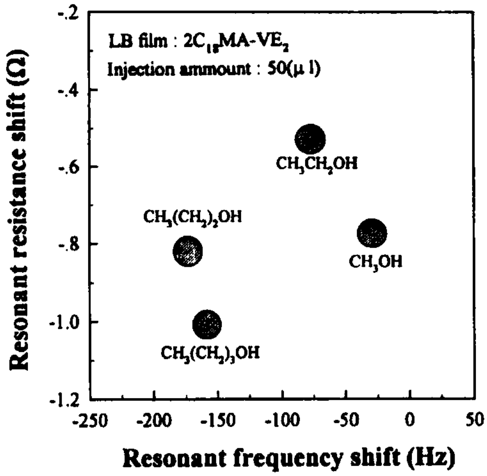

FIGURE 4 The position of organic vapours in the F-R diagram

CONCLUSIONS

The new system for identification of organic vapours and analysis method of mechanism between organic vapours and sensitive materials was attempted using the resonant resistance and resonant frequency of quartz crystal. The resonant resistance shift was occurred by the qualitical change of sensitive material. It will be useful to analyze the mechanism between organic vapours and sensitive materials using the F-R diagram. And the organic vapours have different positions in the F-R diagram. It means that F-R diagram has the possibility to be applied to the development of one-channel gas sensor using the quartz.

ACKNOWLEDGEMENTS

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