Performance of Polyimide-Based Humidity Sensor

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Abstract – This paper reports performance of polyimide-based humidity sensor. The performance includes linearity, temperature dependence, frequency dependence and long-term stability. Linear response at 25°C was achieved between 230 pF at 25%RH and 256 pF at 90%RH. No significant temperature dependence was found. Frequency response was tested and showed variation in sensor outputs. Long-term stability has been tested for 114 days.

Index Terms – Humidity sensor, polyimide, parallel-plate, linearity

I. INTRODUCTION

Relative humidity sensors have been fabricated with various humidity-sensing materials: cellulose derivatives [1], electrolytes [2], ceramics [3], polymethyl methacrylate (PMMA) [4], and polyimide [5-8]. It is important to select humidity sensing materials, which meet a number of characteristics in order to work as useful humidity sensors. The characteristics in demand are good linearity, low hysteresis, stability at high humidity, humidity sensitivity, and reversible water uptake. Polyimide has shown desirable properties such as good linearity, high sensitivity to humidity, high thermal stability, relatively fast response time between 1s to 15min, reversible water uptake, and resistance to most chemicals [5-8]. In addition, polyimide is compatible with conventional semiconductor fabrication processes. This implies that a minimum additional cost is required to fabricate humidity sensors. In this paper, the performance of a miniature humidity sensor with polyimide is presented.

II. STRUCTURE AND FABRICATION

Polyimide is a dielectric material, changing its permittivity with respect to humidity. As humidity increases, the permittivity increases. This characteristic leads to the development of a capacitive-type humidity sensor. The designed sensor structure is a parallel-plate structure as shown in Fig.1. Polyimide between the two electrodes senses humidity. Silicon is used as a substrate and SiO2 is grown as an insulator on it. Chromium followed by gold was evaporated as a bottom electrode and removed unnecessary metals. Polyimide is spun-coated, heated, patterned, and cured. The thickness of polyimide is about 0.3μm. Again chromium followed by gold was evaporated as a top electrode with holes of 80μm diameter. Again polyimide layer is created as the same as previous way. This polyimide layer is a protective layer against dust. Overall dimension of humidity sensing area is 1.8mm×1.8mm. A fabricate humidity sensor is presented in Fig.2.

III. TEST RESULTS

All results presented in this section were obtained on the following conditions:
- In-house environmental chamber was used to test the sensor.
- Testing humidity range was between 25%RH and 90%RH.
- Ramping rate of %RH was 2%/min.
- 1Vp-p sinusoidal signal was applied.
- HP-4284A for frequency dependence test and GW LCR meter LCR-815 for the rest of test were used.

A. LINEARITY AND TEMPERATURE DEPENDENCE

The result in Fig.3 shows a linear response, changing in capacitance between 230pF at 25%RH and 256pF at 90%RH in case of 25°C. Overall response was about 26pF. No variation of capacitance was observed at three
temperatures 25°C, 35°C and 45°C. There is no temperature dependence within these temperature ranges.

B. Hysteresis

Solid line and dotted line in Fig.4 are the responses when relative humidity increased and decreased, respectively. Since dotted line doesn’t match with the solid line, the humidity sensor shows hysteresis. This hysteresis was eliminated when the humidity sensor was exposed to certain humidity for sufficient time. In other words, it takes polyimide longer time to release water molecules.

C. Frequency Dependence

Frequency response was tested at 500Hz, 1kHz, 10kHz, 50kHz, and 100kHz as Fig.5 shows. Linear response was observed at all frequencies. Response of a humidity sensor depends on frequency being applied. As the frequency increases, capacitance decreases.

D. Long-Term Stability Test

Long-term stability test has been carried out since the humidity sensor was fabricated. The humidity sensor has been exposed in normal office environment for 114 days. As Fig.6 shows, no significant response drift has been observed.

IV. Conclusion

Linear response of the humidity sensor was achieved and meets one design criterion. Due to the miniature size, capacitance is small but output is still readable. Observed hysteresis can be overcome if the humidity changes are slow enough. In other words, an application of humidity sensor does not require fast response time. Frequency response is a suitable indicator. Long-term stability is very important factor for sensors in terms of ability of the sensor to reproduce the same response. The humidity sensor has shown stable response for 114 days.
REFERENCES


