Testing a capacitive humidity sensor

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Abstract

MEMS sensors and their circuitry are developing at a high speed, which are widely adopted today to trace, control and link them to the various artifacts in working process. Capacitive humidity sensors with collagen-based dielectrics were designed, fabricated, and tested for use in physiological activity monitoring. The fabrication was optimized to support the 20 μm features of the photolithography masks and a 180 nm thick gelatin thin film. Using a controlled relative humidity chamber, the precision and accuracy of the humidity sensors' characters were showed by two ways were tested. A "High-Middle-Low Humidity" test determined the accuracy and the consistency of the devices; at the same time, a "High-Low Temperature Test" was used to gauge the same characters of the humidity in different situation. In the High-Middle-Low Humidity test, the capacitance was measured for ten minutes at low humidity, ten minutes at high humidity, and again thirty minutes at low humidity, sixty minutes at high humidity, in the end sixty minutes at low humidity.

For the High-Low Temperature Test, the capacitance was measured for ten minutes at 50% RH, 60% RH, 70% RH, and 80% RH, and goes back to 50%RH in every ten minutes with every 10% RH, and then again went for two more cycles in 36 ℃. From the result, as the humidity around the sensor has a trend to change, the capacitance of the sensor has the same trend to change.

1. Introduction

The characteristics of Micro-electromechanical systems (MEMS) are miniaturization, intelligent, multi-function and high integration. MEMS is involving aerospace, information and communication, biological, chemical, medical, automatic control, consumer electronics and weapons, and other areas of the application. Parts functions of sensor in MEMS is designed to feel the difference according to light movement, temperature, magnetic field, gravity, humidity, sound and other physical aspects of external environment.

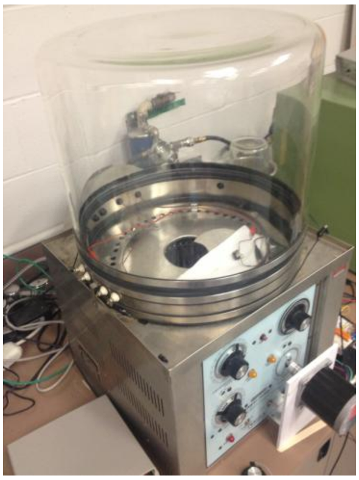
The technology of applications humidity sensors has been developed more than 20 years. Especially in industrial processing and environmental control area, humidity sensors play an important role. In automotive industry, humidity sensors can test the content of dedicated water in oil. In medical industry, humidity sensors can be used in respiration equipment, regulating gas flow and gas conditions to provide patients' outcomes. In agriculture, humidity sensor can sense the humidity level for green house, and give a signal to air conditioner. [1] A common unit to measure humidity is Relative Humidity (RH). RH represents the percentage of water vapor in a gas, such as air and argon.

The humidity sensor that is tested has no dielectrics, only air. A brief fabrication is using Scotch tape to forego a time-consuming photolithography process to mask the substrate, and treated with gelatin dielectrics. [4] Additionally, because of the gelatin is reasonably priced and readily available, we used gelatin dielectrics to build our humidity sensors on the sites. [6]

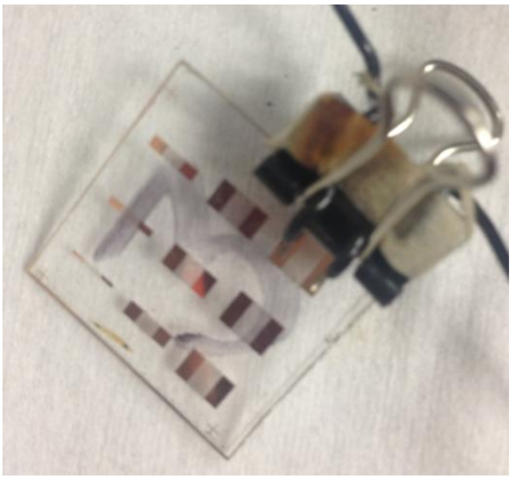
2. Testing

The tested sensors are all put into a Blue M Vapor-Temp Controlled Relative Humidity Chamber (see Figure 1) separately. Before to change the condition in humidity chamber, there is some other things need to be set up. setting up an initial time for a Nomad Omega OM-73 Temperature/Humidity Data Logger [2] is used to record the temperature and humidity in the Humidity Chamber, which need to be put beside the sensor which will be tested in the Humidity Chamber, and compare the change of the humidity and temperature to the RH with the sample's capacitance conveniently lately from the computer. The conductive silver paint is used to connect between the sensor and GLK Model 3000 Digital Capacitance Meter [3] by two wires with alligator clips. The capacitance meter records the capacitance in every 4 Hz and transmits the data via USB to a computer. [4]

The test has two parts. The first part is to make sure all the device can work together to set the humidity level in the Humidity Chamber and the data, which transmits to the computer, are correct. In the teat, keep the temperature in the Humidity Chamber is 36 ℃, and set the RH to 50% at the beginning. Turning on all the devices, and let the Humidity Chamber in 50% RH run for ten minutes. After ten minutes, turn the humidity controller to set 60% RH for ten minutes and keep going till the relative humidity reach to 90% RH. Do this cycle twice, in case the RH is not what it should be.



(a)



(b)

Figure 1. (a)Blue M Vapor-Temp Controlled Relative Humidity Chamber and (b) humidity sensors without dielectrics, between 100 μm to 20 μm width.

The second test is put the sensor (see Figure 1)into the humidity chamber, turning on all the devices as what the first part did. The wet level in the humidity chamber starts at 50% RH. In every ten minutes, change the humidity level to increase 10% until it reach to 80% RH, and then decrease 10% in every ten minutes to until it is back to 50% RH. Repeat this cycle 3 times, and then finish the test.

Since all the data saved in the computer, use notepad to open the files which contains humidity, date time, time, and capacitance, and put these data into an excel file. Save the file into a folder that can be used for the Matlab software. Open the Matlab, and type the code to plot the data as Figure 1 and 2 shows. The main function of the code is to call the purpose file from the folder and require variable to plot a better figure that automatically ignore the portion of data in error.

3. Results & Conclusion

The following Figure 2and 3 show the sensor without dielectrics, with 100 µm and 70 µm width humidity sensor as examples performed in the High- low test. The temperature is almost stay in 36 ℃, but as for the humidity changed, the temperature will change following the trend of humidity changed. As a result, the capacitance will change linearly when the relative humidity changed linearly. Also, when the temperature changed a little bit, the capacitance will change obviously. The change of capacitance also means when the humidity changes in the device, the device can be changed quickly.

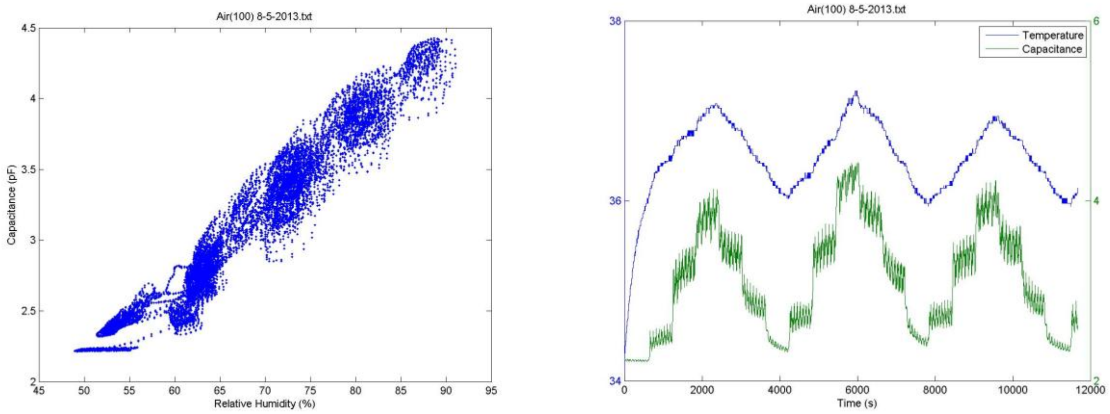


Figure 2. High-low test the capacitance of the humidity sensor Air 100µm width changes in different RH and temperature situation.

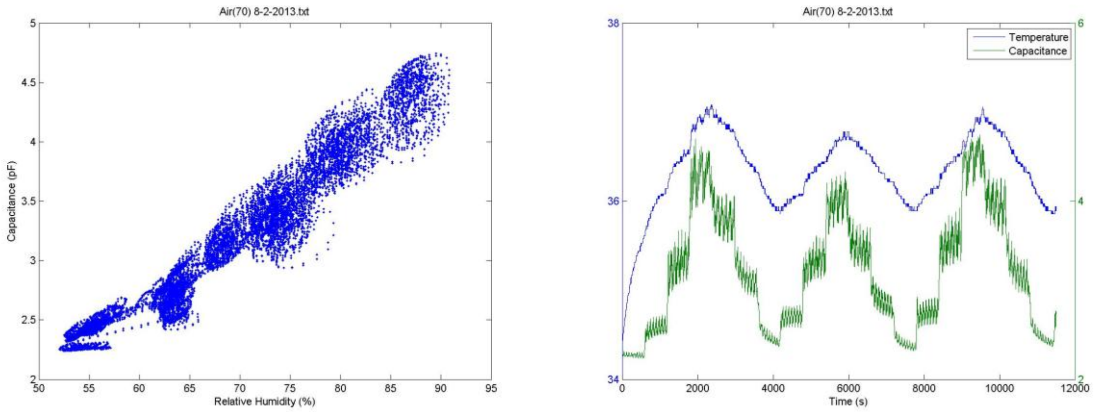


Figure 3. High-low test the capacitance of the humidity sensor Air 70µm width changes in different RH and temperature situation.

As we know for humidity sensors, the humidity range of the devices, the linearity, the sensitivity, and the capacitance range are usually important. In the test, the humidity sensor without dielectrics shows a relationship between the relative humidity and the capacitance.

On a macro, both Figure 1 and 2 display a linear line. We can preliminarily decide our humidity sensor possess linearity.

In the figure 1, the capacitance of 100μm width humidity sensor ranges from 2.25pF to 4.5pF approximately. Compared to the 70μm width humidity sensor, its capacitance ranges from 2.25pF which is the same as Figure 1 shows. However, it range can go to over 4.5pF but less than 5pF. For the relative humidity range, the data in the figure 1 is between 50% RH to 90% RH, and in Figure 2, the data range from 52% to 90% RH. In order to compare the sensitive of humidity sensors, we can observe the slope of the best fit line in each graph, or use the range of the capacitance divided by the range of the Relative Humidity. The slope of 100μm width humidity sensor is 0.056, and the slope of the 70μm width humidity sensor is around 0.060, higher than the 100μm width humidity sensor. From what we observe, we can conclude that the sensitivity for the humidity sensor without dielectrics possess a better linearity if the width of the sensor is narrow.

References and notes

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