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Title: Nanostructure active moisture sensor fabricated by thin film technology

Abstract

Humidity is to be measured precisely and accurately in different types of industrial and home applications. Dynamic range of humidity measurement is very wide ranging from traces of humidity in ppm or ppb to very high percentage relative humidity (%RH). The cost of the humidity sensor for different ranges and applications varies from few dollars to thousands of dollars. A simple humidity sensor, covering measuring range from 10% to 98**%,** is available in only few dollars but a trace moisture sensor, with ppm range measurement, is available in around thousand dollars. Aluminium oxide (Al_2O_3) both thick and thin film is one of the most suitable ceramic sensing materials that have potential to measure wide range of humidity. Extensive research work has been carried out to utilize this material for measuring low humidity. The main focus of this thesis is on the design and development of moisture sensor using metal oxide for trace moisture sensing with emphasis on, high sensitivity, long term stability, fast response, and good stability. It is aimed to fabricate the device at low cost using simple, batch producible sol-gel method. The boehmite Al_2O_3 sol solution has been prepared successfully by adopting the Yoldas method. The highly porous sensing thin film with large surface area is achieved by varying sol parameters such as (i) amount of precursor, aluminium sec-butoxide (ii) water (iii) amount of electrolyte (iv) amount of binder like polyvinyl alcohol (v) surfactant ethyl acetoacetate (EAcAc) and polyethylene glycol.

Surface morphology has been examined by characterization techniques such as XRD, BET, SEM and AFM. High porosity and large surface area of film has been optimized by sintering of different thin film samples at different temperature and time.

Different types of parallel plate thin dielectric films capacitive sensors are fabricated for measuring humidity in different ranges such as (i) 0-10% RH (ii) 100-600 ppm (iii) 0-25 ppm and (iv) 0-100 ppm.

Fabrication steps are almost identical. However, thickness, pore morphology and the sensing area of the sensing films are different.

All the sensors have been tested to determine (i) sensitivity (ii) response and recovery time (iii) repeatability/reproducibility (iv) hysteresis (iv) drift due to ambient temperature and aging (v) cross-sensitivity. The sensor shows significant sensitivity, fast response, high repeatability, very low hysteresis, negligible drifts and cross-sensitivity to organic vapors. However, the response characteristics vary according to sensor geometries, pore morphology and moisture range. It was found that the stability of the pure alumina sol can be improved by addition of fixed amount of EAcAc surfactant but it decreases the sensitivity of a sensor. Sensitivity has been enhanced by varying the area of sensing film without changing pore morphology. Another capacitive sensor fabricated on fluorine dope tin oxide substrate (FTO) has been proposed for the first time. Experimental results show that the γ-Al_2O_3 film has better adhesion on the FTO plate. The film has uniform thickness and lesser shorting problem thus improving the yield ratio. The top electrode is also made of silver paste which is much cheaper than gold electrode used in commercial device and other reported work. The parameters of the sensor using FTO plate is compared with Al_2O_3 gold electrode moisture sensor. It has been found that some of the parameters of the FTO based moisture sensor are better than the gold electrode based sensor. Thus the cost of FTO based moisture sensor can be reduced further because of avoidance of costly gold electrode, cheaper substrate, reduced number of steps of fabrication and batch fabrication. Finally a low cost dedicated moisture measurement system has been developed for measuring trace moisture. The output of interface electronics has been interfaced to the microcontroller through ADC. Measurement of moisture in PPM has been displayed on LCD through microcontroller.