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Title: Design and Development of Surface Acoustic Wave Device based Chemical Vapor Sensor

Abstract

In the present age, industrialization is the main cause of environment pollution. Beside industrial pollution, terrorism is also becoming the threat to the human life due to the use of toxic chemical, gases and vapors by the terrorists. In the present scenario where every country is facing challenges from anti-social elements, scientific and technological advancement are required and suitable devices such as smart sensors are needed for reliable and timely detection of these toxic and harmful gases/vapors to protect the invaluable human life and property. Hence, great deals of research efforts are required towards the development of efficient gas sensing devices for practical applications. Such sensors should allow continuous monitoring of particular toxic or pollutants gases in the environment in a quantitative and selective way. Currently worldwide efforts are focused in engineering new sensor materials with novel design structures for improved response characteristics of the sensors. Although various gas sensing technologies are available these days but Surface Acoustic Wave (SAW) sensors are preferable because of their high sensitivity, low power consumption, room temperature operation, wireless detection and miniaturized size.

In the present research for PhD thesis, SAW devices working at different frequency were designed and simulated for the optimum parameters such as velocity, coupling coefficient, interdigitated electrode (IDT) width and gap, aperture and number of electrode pairs. The designed devices working at 70, 100, 150, 273 and 500 MHz with feature size 11.3µm to 1.57µm are fabricated successfully by conventional optical lithography technique. To obtain the desired sensitivity and selectivity, the SAW sensors have been fabricated with suitable polymer sensing layer for the detection of toxic chemical vapors and the effect of various interferants (volatile organic compounds (VOCs) and

diesel) for selective detection of DMMP on the polymer coated SAW vapor sensors has been studied in details. Different patterns are generated by the E-Nose with exposure to the simulant of CWA (DMMP) in presence of interferants. To accurately detect the presence of different simulants of CWA in the presence of interferants, an artificial Neural Network (ANN) algorithm is employed. ANN was found to predict accurately the presence and absence of an individual or mixture of different simulant vapors of CWA effectively.

Further a novel work has been carried to fabricate SAW micro interdigitated ultra-thin film capacitive humidity sensors using metal oxide film prepared by a simple low cost sol-gel method for measuring humidity in ppm level. Two interdigitated electrode thin film humidity sensors with small and large sensing area have been fabricated by modern optical lithography technique. The small sensing area sensor is examined for 20 to 97% RH and the large area sensor is examined for 175 to 625 ppm moisture in nitrogen gas. The sensitivities are found to be 7.2 pF/%RH and 14.25pF/100ppm for small and large area sensors respectively. We have found that both the sensors show improved response characteristics particularly response time in comparison to the other capacitive sensors reported in the literature.

Another important experimental work a novel γ-Al_2O_3 thin film based SAW humidity sensor for sensing humidity in the range of 3-85% RH has been developed. The sensitivities of the fabricated sensor are found to be 120Hz/ % RH at 3 % RH and 110 Hz /%RH for 3 to 20 % RH. We have found that the sensor shows improved response characteristics in terms of response and recovery time, reproducibility, hysteresis, drift due to aging and miniaturized size in comparison to the sensors reported in the literature for the same range. In summary, a reliable electronic nose (E-Nose), ultrathin film micro interdigitated capacitive humidity sensor and SAW humidity sensor have been developed for detection of toxic vapor and humidity.