INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Surface Acoustic Wave Resonators with Trenches and High Aspect Ratio Structures for Gas Sensing Applications

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SHORT ABSTRACT

The thesis mainly focuses on the investigation of the structural changes in conventional SAW one-port resonator for sensing application leading to higher sensitivity. Two structural changes are proposed, i) introducing trenches between the IDT fingers and ii) adding high aspect ratio structures. Finite element (FE) analysis of the proposed devices shows that the resonance frequency of the devices decreases with increase in trench depth or height of HAR structure. The maximum change in frequency with respect to change in trench depth or height of HAR structure is observed at a particular trench depth of about 0.14λ and height of about 0.1λ for nickel IDT and 0.19 λ for SiO_2 HAR structures for Y cut Z propagating lithium niobate (YZ $LiNbO_3$) piezo-substrate.

The simulations using the proposed structures with optimized trench depth or with optimized height of HAR structure are carried out for the detection of DMMP using BSP3 polymer or SXFA and H_2 using Pd as the sensing material. The sensing material is placed at the bottom of the trench or in the space between HAR structures. An increase in resonance frequency is observed in proposed devices. The detailed analysis of individual effect of change in density and thickness of sensing film due to absorption of gas in the proposed devices has revealed that the swelling of sensing film due to absorption of gas decreases the effective trench depth or the effective height of HAR structures leads to increase in resonance frequency. For sensing DMMP gas, a sensitivity of approximately 35 kHz/mg/m^3 is shown in proposed device with trenches and in the case of proposed HAR structure devices the sensitivity observed is approximately 5.64 kHz/mg/m^3 for thick nickel IDT structure and 6.15 kHz/mg/m^3 for SiO_2 HAR structure.

The fabrication of one-port SAW resonators with SiO_2 HAR structure followed by experimental validation of potential application in sensing gases are carried out. A batch of fabricated devices is used to detect H_2 gas with Pd sensing film deposited between SiO_2 HAR structures. Another batch of fabricated devices is used to detect TCE vapor with PIB sensing film. Experimental results show an increase in resonance frequency with increase in concentration of H_2 and PIB gases as predicted in simulations. A sensitivity of 30 kHz/% equivalent to 3 Hz/ppm of H_2 gas is obtained from the experiment.