INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	Sai Krishna Santosh G
Roll Number	:	09610201
Programme of Study	:	Ph.D.

Thesis Title: Surface Acoustic Wave Devices on Silicon Substrate using Patterned and Thin film ZnO

Name of Thesis Supervisor(s)	:	Harshal B. Nemade
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SHORT ABSTRACT

Abstract – Surface acoustic wave (SAW) is a type of wave that propagates on the surface of an elastic material. The concentration of energy of these waves is higher at the surface and decreases exponentially along the depth of the material. In general SAW devices are realized on polished piezoelectric substrates in conjunction with metallic interdigital transducer (IDT) for the transduction of electric energy to acoustic energy and vice versa. Various types of surface waves like Rayleigh wave, shear horizontal wave, Bleustein-Gulyaev-Shimizu (BGS) wave, and Love wave are generated by choosing appropriate crystal cut of the piezoelectric substrate and guiding layers. Electric field generated by the IDT produces strain in the piezoelectric substrate and vice versa. Applying alternating voltage to the IDT results in the generation of SAW in the substrate. The operating frequency of a SAW device depends on the dimensions of IDT structure and acoustic velocity in the substrate.

As technology advances, there is always a need for superior SAW devices with improved stability, high electromechanical coupling coefficient, high frequency of operation, and low acoustic losses. The performance of SAW devices to some extent can be improved by employing piezoelectric and dielectric thin films over SAW devices. It is possible to realize SAW devices on non-piezoelectric substrates using piezoelectric overlay in conjunction with interdigital transducers. SAW devices on non-piezoelectric substrates like silicon, sapphire and diamond have been reported using films of piezoelectric materials like ZnO, CdS, and AlN. The SAW devices made on silicon can be integrated with circuits for lab on chip, signal processing and communication applications.

This thesis mainly focuses on the research work carried out on the realization of SAW devices on silicon substrate using ZnO in the form of either periodically patterned films or thin films. The first major contribution of the thesis is the investigation of transduction of SAW on silicon substrate using periodic patterns of ZnO to achieve SAW devices with high phase velocity and high coupling coefficient suitable to integrate with CMOS and IC circuits on a silicon substrate. The finite element simulations of the proposed SAW devices with patterned-ZnO on silicon are carried out using COMSOL Multiphysics and the results reveal the generation of surface modes having unique property of high coupling coefficient with high phase velocity. The fabrication design parameters are obtained using equivalent circuit model. We fabricated and tested the proposed patterned-ZnO SAW devices on silicon and verified the test results with simulation results of identical SAW devices as fabricated.

The second major contribution of this research work is to realize the proposed structure in the edge reflection (ER) type SAW devices which offer substantially small device area, since the device area on a silicon chip is crucial and minimizing the area of the SAW device would be of high priority in monolithic integration. The simulations of the proposed ER type SAW devices on silicon are carried out using COMSOL Multiphysics and the device parameters for the fabrication are obtained using equivalent circuit model. We have fabricated the proposed edge reflection type SAW devices on silicon and the testing of the fabricated devices confirms practicability of the proposed devices. In order to demonstrate an application of the proposed devices, we fabricated and tested coupled resonator filters and ladder filters using ER type SAW resonators on silicon substrate for RF signal processing applications.