# CHAPTER 1

# INTRODUCTION

## 1.1 Prelude

A biosensor is an analytical device which incorporates a biologically active element with an appropriate physical transducer to generate a measurable signal proportional to the concentration of chemical species in any type of sample. Biosensors have many advantages, such as simple and low-cost instrumentation, fast response times, minimum sample pre-treatment and high sample throughput. Although biosensors are beginning to move towards the field testing and commercialization in United States, Europe and Japan, relatively few have been commercialized. Increased research in this area demands the development of novel materials, new and better analytical techniques, new and improved biosensors.

The biosensor is a device used for the detection of an analyte that combines a biological component with a physicochemical detector component. It consists of many parts such as the sensitive biological element, the probe and electronics. Biosensor is beneficial due to high selectivity and sensitivity. The resonant frequency of an oscillating piezoelectric crystal can be affected by varying mass at the crystal surface. Piezoelectric immune-sensor is capable of measuring a small change in mass.

The sensitive biological element (e.g. tissue, microorganisms, organelles, cell receptors, enzymes, antibodies, nucleic acids, etc.) is a biologically derived material or bio-mimetic component that interacts (binds or recognizes) with the analyte under study. The biologically sensitive elements can also be created by biological engineering. The transducer or the detector element (works in a physicochemical way; optical, piezoelectric, electrochemical, etc.) transforms the signal resulting from the interaction of the analyte with the biological element into another signal (i.e. transducers) that can be more easily measured and quantified. The biosensor reader device associated with electronics or signal processors that are primarily responsible for the display of the results in a user-friendly way. This sometimes accounts for the most expensive part of the sensor device. However it is possible to generate a user friendly display that includes transducer and sensitive element (holographic sensor). The readers are usually custom-designed and manufactured to suit the different working principles of biosensors.

The use of thin quartz crystals for the detection of small additions of bound mass to its surface has been reported over a period of more than 40 years. Due to its piezoelectricity the crystal can be made to oscillate, using simple electric circuitry in a shear mode and at a natural frequency, which is inversely proportional to the crystal thickness. The addition of mass bound to the surface will reduce this frequency. This illustrates a related technique where a film of a piezoelectric polymer and a membrane, with a high protein binding capacity are used.

## 1.2 Motivation

The National Cancer Institute (NCI) defines a biosensor as "a biological molecule found in blood, other body fluids, or tissues that is a sign of a normal or abnormal process or of a condition or disease. A biosensor may be used to see how well the body responds to a treatment for a disease or condition". Biosensors can be of various molecular origins, including DNA (i.e., specific mutation, translocation, amplification, and loss of heterozygosis), RNA, or protein (i.e., hormone, antibody, oncogene, or tumor suppressor). Cancer biosensors are potentially one of the most valuable tools for early cancer detection, accurate pretreatment staging, determining the response of cancer to chemotherapy treatment, and monitoring disease progression. Biosensors are typically detected in human fluids such as blood, serum, urine, or cerebral spinal fluid, but they can also be present in or on tumor cells. Most of the biosensors, however, have yet to demonstrate sufficient sensitivity and specificity for translation into routine clinical use or for treatment monitoring. This is an area that biosensor technology can potentially improve upon.

The early detection of cancer can significantly reduce cancer mortality and save lives. Thus, a great deal of effort has been devoted to the exploration of new technologies to detect early signs of the disease. They can be used for risk assessment, diagnosis, and prognosis and for the prediction of treatment efficacy and toxicity and recurrence.

## 1.3 Issues

The issues are ranging from the risk of false positives to the more complex issues of over-diagnosis and over-treatment. While early detection can certainly have benefits, it's not true that screening can only help—and can't hurt. Indeed, skeptics within the medical community, including the authors of the survey, have started to become more vocal in an effort to create a more balanced public view.

## 1.4 Objectives

- ❖ Design and simulation of SAW sensor based on PVDF thin film. (COMSOL)
- ❖ Design and simulation based on PVDF+ZnO composite thin film
- ❖ Design and simulation of SAW sensor on CoventorWare.

Currently, nano-indentation is the main commercial measurement technique for testing the main mechanical properties of thin films. Since PVDF is a good material for strain gauges, a sensor made of this material has good pressure and temperature change characteristics, hence, it is a common method to use PVDF piezoelectric film sensors for detecting ultrasonic signals. SAW have aroused attention as an effective non-destructive testing technique. Based on the SAW propagation along the surface, surface waves have an intrinsic interaction with the material surface, so this technique is an ideal method to detect the mechanical properties of near surface layers.

The experiment utilizes a PVDF piezoelectric sensor to detect SAW in thin films. PVDF has unique dielectric, piezoelectric and thermal effects, so it is capable of converting mechanical signals into electrical signals; and its output electric charge is proportional to the stress perpendicular to the surface. Recently, piezoelectric thin films including Zinc Oxide (ZnO) and Aluminium Nitride (AlN) have found a broad range of lab-on-chip applications such as bio sensing, particle/cell concentrating, sorting/patterning, pumping, mixing, nebulization and jetting. Integrated acoustic wave sensing/microfluidic devices have been fabricated by depositing these piezoelectric films onto a number of substrates such as silicon, ceramics, diamond, quartz, glass, and more recently also polymer, metallic foils and bendable glass/silicon for making flexible devices. Such thin film acoustic wave devices have great potential for implementing integrated, disposable, or bendable/flexible lab-on-a-chip devices into various sensing and actuating applications

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## 1.5 Tools Used

### Simulation Tools:

- Simulation Tool : COMSOL Multiphysics 5.0
- Operating System : Any Windows recent version / UBUNTU
- System Requirement : 32GB+ RAM, 320GB+ Hard Disk, HD Graphics

### Virtual Fabrication Tools:

- Fabrication Tool : CoventorWare 10
- Operating System : Any Windows recent version / UBUNTU
- System Requirement : 32GB+ RAM, 320GB+ Hard Disk, HD Graphics

## 1.6 Organization of the Thesis

The main objective of this project work is to design and simulation of a Surface Acoustic Wave (SAW) biosensor for cancer detection.

This chapter provides the introduction, motivation, issues, objectives and tools used in the project.

Chapter 2 being the literature survey is concerned about the ground work about the previously existing methods and formulation required from the previous works.

Chapter 3 provides the fundamentals of sensors which already exist and provides a clear idea for the development of SAW sensor.

Chapter 4 provides the methodology of the software and hardware required for the development of the SAW sensor.

Chapter 5 provides the basic of designing of sensors, material selection, tool used like COMSOL and CoventorWare.

Chapter 6 provides the results of both COMSOL and CoventorWare tool.

Chapter 7 provides the conclusion of the project and scope for future directions which can be implemented to increase the sensitivity of the developed sensor.

## 1.7 Summary

The chapter summarizes the basic introduction to the biosensor. The motivation, issues and objectives of the project work are discussed.