Abstract

The demand for reliable, low cost, compact and sensitive biosensors for the detection of disease causing pathogens is ever increasing in present time. Field Effect Transistor (FET) based biosensors have been serving that purpose for past few years quite effectively. This area has attracted much attention for development of reliable point of care sensors for detection of some acute diseases. However, glutathione (GSH), a central antioxidant found naturally in animals is a biomarker of cancer whose detection is yet to reach that level. Overexpression of glutathione has been observed due to oxidative stress in malignant tissues. But detection of glutathione is so far based on traditional methods. This work aims to develop an electrochemical biosensor device for detection of glutathione using a single platform technology, where nanomaterial - Glutathione-S-Transferase (GST) ensemble might be helpful for rapid and efficient detection of cancer in lab to clinical samples.

Design, fabrication and characterization of a novel device based electrochemical detection method of glutathione is the prime focus of this thesis. The device is a FET device, channel material of which consists of a conjugation of ZnO nanoparticles and purified recombinant GST protein. The novel concept of incorporating a protein in a channel material is reported here for the first time. The device successfully and selectively detects and quantifies glutathione as compound and as well as a human cell component. The device was also tested successfully with cultured HeLa and MCF-7 cancer cells and HEK (Human Embryonic Kidney) normal cells and it was found that the device could detect enhanced concentration of glutathione in cancerous cells, which indeed is the first step towards detecting certain types of acute cancer diseases. The device can be further improved upon by keeping primary working principle the same, in order to meet the requirements to make a deliverable product for marketization.

In summary, the main contribution of this thesis is the design, fabrication and characterization of a Glutathione-S-Transferase incorporated ZnO nanoparticles based Field Effect Transistor biosensor for detection of glutathione and its associated types of cancers. First contribution of this thesis is the development of a functionalized channel layer for the FET structure which consists of ZnO nanoparticles and GST conjugate.

The second major contribution of this thesis is design and fabrication of a FET structure for biosensing purpose. Simulation studies were carried out in order to find an optimized structure. Subsequently, the device was fabricated on a Si wafer using optical lithography technique. Then, the functionalized channel layer was deposited and the thesis involves characterization results of fabricated devices.

The third major contribution of this thesis is characterization of fabricated devices for detection of glutathione in cancer cells. The results show enhanced glutathione concentration in cancer cells compared to that of normal cells. The conclusion of the thesis gives an insight into the future prospects of this work and its possibility to be used as a point-of-care device.