

A Literature Review Paper on Enzyme Modified Filed Effect Transistor (ENFET) – Based Biosensors



ENGINEERING

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ABSTRACT

Enzyme Modified Field Effect Transistor (EnFET) has found spreading interest in the rapidly development field of biosensors. There is lots of detection methods have been developed by using EnFET in medical science. The principles, application and recently developed techniques of EnFET – based biosensors are reviewed.

INTRODUCTION

Enzyme Modified Field Effect transistors abbreviated as EnFET were firstly developed in 1980 by Caras and J. Janata . EnFET is a bioelectronics device which converts a biological or biochemical signal into an electrical signal. In EnFET device, enzyme system acts as a bioreceptor which recognizes a biological event and then through biocatalytic reaction transforms it into quantity detectable by an underlying ISFET. This idea was first given by Janata and Moss in 1976, but till 1980, no one was able to give accepted results related to this idea. Finally in 1980, Caras and J. Janata presented the first result regarding ISFET based penicillin sensor.

EnFETs have following significant characteristics and benefits -

- Small size and weight
- Fast response
- High reliability
- Low output impedance
- On chip integration of biosensors system
- Can be stored dry and require little routine maintenance
- Reduced acidic and alkaline errors in extreme pH ranges
- Can be reduced over an extremely wide temperature range and are sterilizable for use in biological, medical and pharmaceutical application.

OBJECTIVE OF STUDY:

- To study the construction method of EnFET.
- To study the basic working principle of EnFET
- To study the recent development of EnFET based biosensors.

CONSTRUCTION OF EnFET:

Enzyme modified field effect transistor is nothing but an Ion-sensitive FET device with an enzyme layer deposited above the insulating surface of ISFET or covered with an enzyme containing membrane. The attachment of enzyme or the enzyme-containing layer to the underlying inorganic gate insulator material of the FET is the most critical point of the construction of EnFET.

There are numbers of methods are currently invented to immobilize enzyme onto the gate insulator of an ISFET. It includes physical and chemical adsorption, entrapment within polymeric matrices, covalent binding, cross-linking by bi-functional cross-linking agents and mixed physi-

ochemical methods. The drop-on techniques and the spin coating or the dip coating of a mounted sensor chip into an enzyme solution are the simplest and most frequently used enzyme membrane deposition methods.

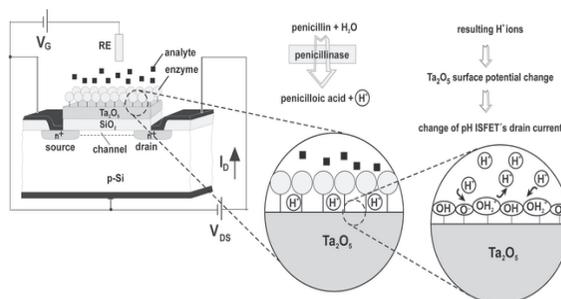


Fig:1 Structure and principle of function of a penicillin-sensitive ENFET (or PENFET).

BASIC WORKING PRINCIPLE of EnFET:

The general working principle of an EnFET can be explained as follows: when the enzymatic reaction of the enzyme with its substrate takes place, then either products are generated or reactants are consumed. At that time the change of concentration can be modified by the underlying ISFET. So there was a correlation between corresponding change of the ISFET signal and the original analyte concentration.

The first EnFET was penicillin-sensitive EnFET shortly known as PenFET. The enzyme penicillinase catalysis the hydrolysis of penicillin to penicilloic acid yielding a local pH change near the gate region of the ISFET. The change of output signal will be determined by the amount of penicillin in the sample solution. This working principle has been shown through the figure1. The corresponding enzymatic reaction of penicillin as follows:



The principle can be used by using any kind of enzyme such as glucose, urea penicillin, ethanol, lactose, sucrose, maltose, ascorbic acid, lactate, acetylcholine, organophosphorus pesticide, formaldehyde, creatinine etc.

RECENT DEVELOPMENT OF EnFET-BASED BIOSENSORS TECHNOLOGY:

Table1: The various development of EnFET has been listed below in:

Sr No	Analyte	Enzyme System
1	Glucose	Glucose Oxidase Glucose Oxidase/MnO ₂ Powder Glucose Dehydrogenase
2	Urea	Urease Penicillin G acylase Penicillin penicillinase

3	Sucrose	Invertase/glucose dehydrogenase Invertase/glucose oxidase/mutarotase
4	Maltose	Maltase Glucose dehydrogenase
5	Ethanol	Aldehyde dehydrogenase Alcohol dehydrogenase
6	Lactose	β -Galactosidase glucose dehydrogenase
7	Ascorbic Acid	Peroxidase
8	Creatinine	Creatinine deiminase
9	Formaldehyde	Alcohol oxidase
10	Acetylcholine	Acetylcholinesterase
12	Organophosphate compound	Organophosphate hydrolase
13	Fluorine-containing organophosphates	Organophosphorus acid anhydrolase

The most popular enzymes for EnFETs are glucose oxidase, urease and penicillinase, because of their suitability as model systems for EnFET studies, and because of their important role for the detection of glucose, urea and penicillin in many fields of application.

In the PenFET device there are two pH-sensitive ISFETs, one of which had on the top of the gate surface a membrane with covalently bound penicillinase enzyme and albumin, while the other hand on the top of the gate surface a membrane with only covalently bound albumin. Basic principle is that when penicillin was present in solution, penicillinase enzyme in the membrane catalyzed penicillin hydrolysis that resulted in the production of protons and therefore a local pH decreases in the gate area of the ISFET resulting into an increased drain current registered by the ISFET. After that this principle is developed day by day by using different enzymes and success also comes. After 1980, at the first international conference on chemical sensors held in 1983 in Fukuoka, Japan, two important piece of research works devoted to ISFET-based biosensors were reported- Y. Miahara et al. presented EnFET for urea and acetylcholine determination and Y. Hanazato and S. Shiono -EnFET for glucose determination. These are the beginning of EnFET-based biosensors journey. After that hundreds of research paper published about various aspects of EnFET development. In recent years much attention has been paid to development of these EnFETs device because they are manufactured by means of semiconductor techniques, which in due course assured progress in microelectronic development. The use of silicon in a wide variety of sensors is known well reviewed by Middlehock. Moreover IC group technology is the best way to decrease the primary cost of individual device and to set up its mass production. It enables nontraditional devices for computation and detection to be integrated and combined on the same crystal, with a buffer electronic system of information processing and storage. Therefore the development and manufacture of sensitive, specific, miniature and cheap EnFETs will undoubtedly cause global changes in the nature and the methods of information gathering with respect to objects and media in private life, medicine, biotechnology, agriculture, environmental monitoring etc. Due to these reasons, EnFETs at present have drawn much attention in four fields namely- medical, environmental, food safety and military, with medical applications being the dominant player.

CONCLUSION:

EnFET is microelectronics product and is playing a vital role in the development of bio-sensors because of its advantages such as small size of their sensitive area, robustness, rapid response, high sensitivity etc. lots of research work has been done and thousands of scopes are there to

invent more reliable EnFETs based biosensors and more commercial version of EnFETs yet to be invented.

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