Biochip: Types and Applications

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Abstract— The first biochip was invented by an American company namely Affymetrix, and the product of this company is GeneChip (DNA microarrays). The biochip products comprise the number of individual DNA sensors used for sensing defects. Biochip plays an essential role in the field of biology research like systems biology as well as disease biology. While the number of clinical applications is rising. Biochip is a set of microarrays which are placed on a strong surface of a substrate to allow thousands of reactions to be performed in less time. The combination of molecular biology, biochemistry, and genetics includes the development of biochip. For analyzing organic molecules connected with a live organism biochips are used. This article discusses what is Biochip, components of biochip, types, and its applications.

Keywords: Biochip

I. Introduction

A biochip is a set of diminished microarrays that are placed on a strong substrate that allows many experiments to be executed at the same time to obtain a high throughput in less time. The device contains millions of sensor elements or biosensors. biochip can be considered as a microreactor that can detect a particular analyte like an enzyme, protein, DNA, biological molecule or antibody. The main function of this chip is to perform hundreds of biological reactions in a few seconds like decoding genes (a sequence of DNA).A biochip's surface area is no larger than a fingernail. The biochip is being used in toxicological, protein, and biochemical research in addition to genetic applications. Biochips can also be used to rapidly detect chemical agents used in biological warfare so that defensive measures can be considered.

II. Components of Biochip

The Biochip comprises of mainly two components the transponder and reader.

A. Transponder

Transponders are of two types' namely active transponder and passive transponder. This transponder consists of four parts such as antenna coil, computer microchip, glass capsule, and a tuning capacitor. The computer microchip stores a unique identification (UID) number that ranges from 10 digits to 15 digits long. The antenna coil is very small, primitive and this type of antenna is used to send and receive the signals from the scanner or reader. The charging of the tuning capacitor can be done with the small signal i.e, 1/1000 of a watt which is sent by the operator.

The glass capsule holds the antenna coil, capacitor, and microchip, and it is made with a biocompatible material namely soda lime glass.

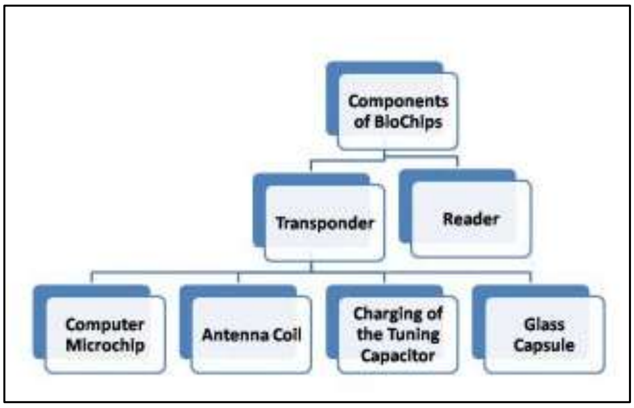

Fig. 1: components of biochip

The transponder is the actual biochip implant. It is a passive transponder, meaning it contains no battery or energy of it's own.

In comparison, an active transponder has a power source. Because the passive biochip contains no battery, or nothing to wear out, it has a very long life, up to 99 years, and no maintenance. Being passive, is inactive until the reader activates it by sending it a low-power electrical charge.The reader "reads" or "scans" the implanted biochip and receives back data (in this case an identification number) from the biochip.

B. Reader

The reader comprises of a coil namely "exciter" and it forms an electromagnetic field through radio signals. To activate the biochip It offers the required energy (<1/1000 of a watt). The reader carries a receiving coil for receiving the ID number or transmitted code sent back from the excited implanted biochip

C. Computer Microchip:

The microchip stores a unique identification number from 10 to 15 digits long. AVID (American Veterinary Identification Devices), claims their chips, using a nnn-nnn-nnn format, has the capability of over 70 trillion unique numbers.The unique ID number is "etched" or encoded via a laser onto the surface of the microchip before assembly. It is not possible to alter the number once it is encoded. The microchip also contains the electronic circuitry necessary to transmit the ID number to the "reader".

D. Antenna Coil:

Antenna coil is normally a simple, coil of copper wire around a ferrite or iron core. This tiny, primitive, radio antenna "receives and sends" signals from the reader or scanner.

E. Tuning Capacitor

The capacitor stores the small electrical charge (less than 1/1000 of a watt) sent by the reader or scanner, which activates the transponder. This "activation" allows the transponder to send back the ID number encoded in the computer chip. The capacitor is tuned to the same frequency as reader Because "radio waves" are utilized to communicate between the transponder and reader.

F. Glass Capsule:

It is a small capsule, the smallest measuring 11 mm in length and 2 mm in diameter, about the size of an uncooked grain of rice that "houses" the microchip, antenna coil and capacitor. The capsule is made of bio-compatible material such as soda lime glass .After assembly, the capsule is hermetically (air-tight) sealed, so no bodily fluids can touch the electronics inside. A material such as a polypropylene polymer sheath is attached to one end of the capsule, Because the glass is very smooth and susceptible to movement, This sheath provide a compatible surface which the bodily tissue fibers bond or interconnect, resulting in a permanent placement of the biochip.

III. TYPES OF BIOCHIPS

There are three types of Biochips available namely DNA microarray, micro-fluidic chip, and protein micro array.

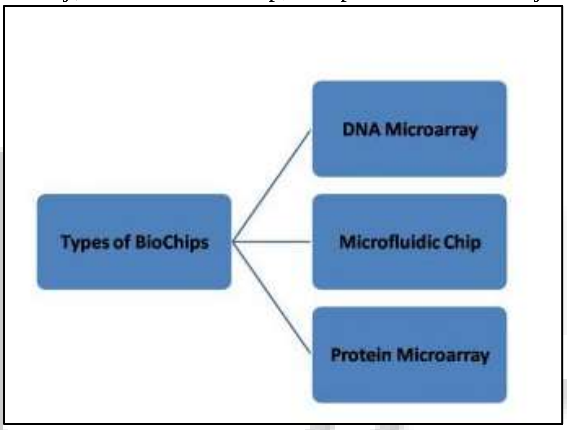

Fig. 2: Types of biochips

A. DNA microarray

DNA microarray (also commonly known as DNA chip or biochip) is a collection of microscopic DNA spots attached to a solid surface. DNA microarrays is used to measure the expression levels of large numbers of genes simultaneously or to genotype multiple regions of a genome. Each DNA spot contains picomoles (10^{-12} moles) of a specific DNA sequence, known as *probes* (or *reporters* or *oligos*). These can be a short segment of a genetic material under high rigidity situations that are used to hybridize a cDNA or cRNA (also called anti-sense RNA) sample (called *target*) under high-stringency conditions. Probe-target hybridization is usually detected and quantified to determine relative abundance of nucleic acid sequences in the target. The original nucleic acid arrays were macro arrays approximately 9 cm × 12 cm and the first computerized image based analysis was published in 1981. It was invented by Patrick O. Brown. its application is in SNPs arrays for polymorphisms in cardiovascular diseases, cancer, pathogens and GWAS analysis. Also for identification of structural variations and measurement of gene expression.

B. Microfluidic Biochips

Microfluidic biochips or lab-on-a-chip are a choice to usual biochemical laboratories and are transforming several applications like DNA analysis, molecular biology procedures, proteomics which is known as the study of proteins and diagnostic of diseases (clinical pathology). These chips are becoming more complex by using 1000's of components, but those components are designed physically called as bottom-up full-custom plan, which is a very large workforce.

Microfluidics is a multidisciplinary field that involves engineering, physics, chemistry, biochemistry, nan otechnology, and biotechnology.it refers to the behaviour, precise control, and manipulation of fluids that are geometrically constrained to a small scale (typically sub-millimeter) at which surface forces dominate volumetric forces. It has practical applications in the design of systems that process low volumes of fluids to achieve multiplexing, automation, and high-throughput screening. Microfluidics emerged in the beginning of the 1980s and is used in the development of inkjet printheads, DNA chips, lab-on-a-chip technology, micro-propulsion, and micro-thermal technologies. Typically microfluidic systems transport, mix, separate, or otherwise process fluids. In some applications, external actuation means are additionally used for a directed transport of the media. Examples are rotary drives applying centrifugal forces for the fluid transport on the passive chips. Active microfluidics refers to the defined manipulation of the working fluid by active (micro) components such as micropumps or microvalves. Micropumps supply fluids in a continuous manner or are used for dosing. Microvalves determine the flow direction or the mode of movement of pumped liquids. Often, processes normally carried out in a lab are miniaturised on a single chip, which enhances efficiency and mobility, and reduces sample and reagent volumes.

C. Protein Microarray

Protein biochips/microarrays are well-established tools for research .A protein microarray or protein chip method is used to follow the actions as well as connections of proteins, and to find out their function on a large scale. The main advantage of protein microarray is that we can track a large number of proteins in parallel. This protein chip comprises of a surface for supporting like microtitre plate or bead, nitrocellulose membrane, the glass slide. These are automated, rapid, economical, very sensitive, consumes less quantity of samples. The first methodology of protein chips was introduced in antibody microarrays of scientific publication in the year 1983. The technology behind this chip was quite easy to develop for DNA microarrays, which have turned into the most generally used microarrays.

IV. BIOCHIPS APPLICATIONS

The applications of biochip include the following.

By using this chip we can trace a person or animal anywhere in the world. This chip is used to store and update the information of a person like medical financial and demographics. A biochip leads to safe E-commerce systems.

These chips are effective in restoring the records of medical, cash, passport, etc.

The biochip can be applicable in the medical field as a BP sensor, glucose detector, and oxygen sensor.

V. Conclusion

The biochip space lies at the intersection between high technology chip manufacturing, signal processing, software skills and more traditional molecular biology and genomics. The market for biosensors and biochips is interdisciplinary and growing and has applications in a number of core research areas. This paper presents a valuable context addition for those in both academia and industry. As this fast maturing field already boasts sales of products, biochips are likely to have a significant business future. We can expect that advances in microfluidic biochip technology will enable the miniaturization of devices that will allow highly sensitive analysis of complex biological interactions in real time that to with a low cost perception.

Biochips promises to bring genomics, the study of all the genes in existing organisms, out of the research laboratory and into the everyday practice of medicine. If genomics delivers on its promise, health care will shift from a focus on detection and treatment to a process of prediction and prevention.

References

[1] Bruce, H., Robinson, Nadrian, Seeman, C., 1987, The design of a biochip: a self-assembling molecular-scale memory device. Protein Eng 1:295-300
[2] Stoughton, R.B.: Applications of DNA microarrays in biology. Annual Review of Biochem- istry 74, 53–82
[3] Jain, K.K., 2001, Biochips for Gene Spotting. Science 294:621–623
[4] Cady, NC (2009). "Microchip-based PCR Amplification Systems". Lab-on-a-Chip Technology: Biomolecular Separation and Analysis. Caister Academic Press.

