TRENDS IN MEMS FOR HEALTH CARE

There are many applications of MEMS in human body which are being implanted in the human.

1. Pacemaker

- It is also known as artificial pacemaker of heart.
- It is small device implanted onto the heart which uses the battery.
- It sends electrical impulses which helps in heart beat rhythm.
- It is used when the heart natural pacemaker is defective and makes the heart to beat in regular rhythm.

2. Capsule Endoscopy

- It is used for imaging the digestive tract.
- It poses video, light source and transmitter.
- 50,000 images can be transferred during 8 hours of exposure
- It does not require skill technician
- It follows natural peristaltic movements of digestive tract.

3. Cochlear Implant

- It is a prosthetic device which is used as a hearing aid.
- It consists of microphone, signal processor RF transmitter, implant KF receiver, converter and electrode array.
- It can stimulate cochlear nerve and produces high quality device.

4. Artificial Retina

- It is a electronic device implanted in eye which restores the vision.
- This device captures visual signal and send to brain in form of electrical impulses.
- Video camera mounted on glass which captures images and are converted to a signal on a implanted material and they relay to the optic nerve.

5. Heart Tissue Production

- Heart cells are grown and subjected to electrical current, so they react like heart muscles.
- They can be grafted upon where heart muscles are weak end.
- It will produce heart rhythm in a regular waveform.

DRUG DELIVERY SYSTEM

- Drug delivered systems are engineered technology for the targeted delivery or controlled release of therapeutic agent.
- Drugs have long been used to improve health and extent life.
- The practice of drug delivery has changed dramatically in last few decades and even greater changes or anticipated in a near future.
- Biomedical engineers are contributed to the development of number of new models of drug delivery that have entered clinical practice.
- Side effect have been limited by this drug delivery method for many diseases such as cancers, neutrodegenerative disease and infectious diseases.
- Drug delivery system controls the rate at which a drug is released and location in the body where it is released.

Different modes of drug delivery system.

- Conventional route
- Sustained drug delivery system
- Controlled drug delivery system
- Implantable drug delivery system
- Transdermal drug delivery system

Conventional route

- Conventional dosage form compromises solution, suspension and emulsion (liquid dosage form).
- Capsule, tablet etc. (solid dosage form)

Mode of action

- When rapid efficient absorption of drug is desired for GI tract it represents the oral dosage form of choice.
- Drugs in suspension are also readily disorders the large available surface area of the dispersed solid facilitates rapid dissolution and absorption.

Sustained drug delivery system

- Sustained release dosage form are designed to release a drug at a pre-determined rate by maintaining a constant drug level for a specific period of time with minimal side effect.
- This can be achieved through a variety of formulation including liposome and drug polymer conjugates.
- Liposome have been used via a variety of administration route including intravenous, intramuscular, intraperitoneal and oral
- The half life of liposome ranges from few minutes to few hours depending upon the size and lipid composition.

Mode of action

- Active agents are coated with the carrier molecule such as liposome which resulted in the complex called hapten carrier molecule. This complex by macrophage results in phagocog** carrier molecule forms a phagolysosome complex by fusing with lysosome. This phagolysosome fuses with the phagocytic cell and releases the drug towards the target site of a predetermined level.

Controlled drug delivery system

- Controlled release system have become very useful tool in medical practice.
- Controlled release system maintains constant therapeutic concentration of the drug within a therapeutic range of drug over prolonged period.
- Controlled delivery system offers an alternative approach to regulate both duration and localization of therapeutic agents in control delivery the active agents combined with a synthetic components to produce a delivery system.
- It frequently involves combination of active agents with inert polymeric material for the release of the drug. eg: chemically controlled system.
- Drug molecule is chemically linked to the backbone of the polymer
- In the body, in the presence of enzymes and biological fluid, chemical hydrolysis or enzymatic cleavage occurs with concomitant release of the drug at a control rate.

Implantable drug delivery system: eg. Program controlled insulin dosing

- It is also known as artificial pancreas
- This insulin pump delivers insulin through a catheter inserted in the body
- This device can deliver insulin in two ways: i) The fixed program unit with the pre-set 24 hour rate per time profile ii) The demand program unit which is basal rate preselected and a supplementary dose is trigger at mean time.
- Treatment drug delivery patch in contact to the skin for iontophoretic delivery.
- An electrode of the same polarity at a charge of the drug is placed in the reservoir.
- The electrical circuit is completed by the application of second electrode of the opposite polarity at different skin site.

Bio-Chip

- Bio-Chip is the collection of microarray arranged on a solid substrate
- It can perform millions of mathematical operations.
- A micro-chip can also perform thousands of biological operations.
- It increases the speed of identification of genes.

Components of Bio-Chip

- There are 2 components of bio-chip i) Transponder ii) Reader / scanner.

Transponder

- It is a device for receiving a radiosignal and automatically transmit it to a different signal.

Reader / Scanner

- It consist of an exciter coil which creates electromagnetic signals.
- It provides energy to activate the implanted chip
- It also carrier a receiver coil to receive ID number.
- It contains the software and components to decodes and all this is done in milliseconds.

Working

Reader transmits a low power radio signal and activate the implanted bio-chip

↓

ID numbers are transmitted by transponder and received by reader

↓

Reader displays the ID number on the readers LCD display

Bio-Chip Implant

- It is injected by the hypodermic syringe beneath the skin
- Injection is safe and simple
- Anesthesia is not required
- Route of injection depends upon the type of implanted material and their application.

Application

- In the bio-chip, tracing of any person in the world is very easy.
- It stores all the data information and has the potential to replace passport, medical records etc.
- Medicinal implementation of bio-chip are glucose detector, oxygen sensor, blood pressure sensor etc (explain all the sensor briefly).

Advantages

- It is smaller in size
- It performs of biological reaction in few seconds
- It increases the speed of diagnosis
- It is very faster and powerful technique

Needle Electrode (Micro needle)

- It is used to record peripheral nerves action potential
- It is used to reduce movement artifacts and interface impedance.
- These electrodes merely penetrate skin and are placed parallel to the skin surface.
- Basic needle consists of a solid needle made up of stainless steel (SS) with sharp point.
- Needle insulated with varnish and tip is left exposed.

- Lead wire attached to the other end of needle and encapsulated in a plastic hub to protect it.
- It is mainly used in EMG.

2nd type

- Used to monitor ECG continuously during surgery
- Has SS hypodermic needle placed subcutaneously an each limb
- Lead wires with connectors connects the electrode to the monitor
- Epoxy resin fills the human and once it is set, needle is inserted card serves as active electrode.

3rd type

- Bipolar coaxial electrode

4th type

- It has a fine wire made of SS with diameter 25 – 125 μm insulated with varnish
- Lip is introduced into lumen for needle
- It is inserted through skin into muscle.
- Coiled wire also used.
- If one monopolar needle electrode → one wire is used for measuring electrode and other a separate reference electrode.
- The bipolar needle electrode → 2 wires are used, one as reference and other as measuring electrode.

Neuroprothetics

- Neuroprosthetics is a discipline related to neuroscience and biomedical engineering concerned with developing neural prosthesis.
- There are sometimes contrasted with a brain computer interface which connects the brain to a computer rather than a device meant replace missing biological functionality
- Neural prosthetics are a series of device that can substitute a motor, sensory or cognitive mortality that might have been damaged as a result of an injury or a disease.

Visual prosthetics

- The visual prosthetics can create a sense of image by electrically stimulating neurons in the visual system.
- A camera would wirelessly transmit to an implants the implant would map the image across an array of electrode.
- The array o electrodes has effectively stimulate 600 – 1000 locations, stimulating optic neuron in the retina thin creating an image.
- A visual prostheses system consists of an external or implantable imaging system which acquires and process the video.

- Power and data will be transmitted to the implant wirelessly by the external unit.
- The implant uses the received power / data which converts the digital data into analog output which will be delivered to the nerve via microelectrode.
- Photoreceptors are the specialized neurons that convert photons into electrical signal.

Auditory prosthetics: eg. Cochlear implant these devices substitute the function performed by the ear drum.

- A microphone on external unit gathers the sound and process it, the processed signal is then transferred to an implanted unit that stimulated the auditory nerve via a microelectrode array.
- Three main categories for auditory prosthetics cochlear implant cochlear electrode arrays are implanted.
- Auditory brain stem implant – ABI electrode array stimulates the cochlear nuclear complex.
- Auditory mid brain implant – AMI stimulates auditory neurons in the inferior colliculus.

Motor Prosthetics

- Devices which supports the function of autonomous nervous system includes the implant for bladder control.
- In the attempts to gain conscious control of the movement which includes electrical stimulation.

Bladder control implant.

- When the spinal cord injury leads to paraplegia, patients have difficult in empting their bladder and this can cause infection.
- This device is implanted over sacral anterior route ganglia of the spinal cord controlled by an external transmitter.
- It delivers intermitter stimulation which improved bladder implying.

Cognitive prosthetics

- Cognitive prosthetics can store the function to individuals with brain tissue loss due to injury, disease etc.
- The function of the damaged tissue can be rectified with integrated tissue.
- Brain plasticity suggest that the brain is capable of rewiring itself so that an area of the brain associated with a particular function can even perform function associated with another portion of brain. Eg: Auditory cortex can perform function simultaneous improves the auditory process cortex visual information.
- Implants could take advantage of brain plasticity to restore cognitive function even if the native tissue has been destroyed.

Spinal cord injury

- It consists of an implanted receiver stimulator, an external shoulder position sensor and a terminal electrode.
- The terminal electrode is placed on the motor point of a muscle. This enables a low electrical threshold to the utilized.
- The external sensor measures voluntary movement that occur in the countralteral shoulder and basis motor output command on this information.
- A radio frequency signal is then transmitted to the implanted receiver stimulator which converts to an electrical stimuli that depolarizes the peripheral nerve.

Shape Memory Implant

- Shape memory is a terms which dendex a material ability to return from a program frozen temporary shape the original permanent shape as a result of external physical stimulate (temp, tight, radiation etc) or chemical factor (pH change, ionic strength and solvents).
- The first materials in which the shape memory effect has been where metal alloys are in particular on alloy of nickel and titanium which has been applied in medical practice.
- Implant made up on an alloy have been applied in the bone surgery as a self blocking material for bond bones coral, maxillofacial surgery spine surgery.

Drawback

- Inflammation, corrosion, difficult removal after complete bone adhesion.
- SMA can be replaced by polymers due to the lower production cost, shape stability, widal range of shape change and production of complicated shape.

Shape Memory Effect

- Shape memory effect which conilines the right morphology of a polymer and the technology process is associated with its finer molecular structure
- For a polymer to have specific property it has to have atleast two molecular elements in its structure net points and switching segments.
- Two categories of shape memory polymers are distinguish in terms of the nature of bond which fix the original and temporary shapes.

Net points

- It determine the permanent shape
- Nature of bond: chemical, covlanet bond, physical – intermolecular intraction.

Switching segments

- It is responsible for fixing the temporary shape
- It possess the nature of reversible bond.
- Chemical → covalent bond physical → intermolecular interaction.

Biodegradable shape memory polymer

- Degradable shape memory materials have been found to be especially useful in low invasive tissue surgery.
- A shape memory implant of a temporary shape could be placed inside the body by requiring only a minimum surgery.
- After a pre-determined period or responding to an external stimulus it would assume permanent shape meeting the therapeutic requirements.
- After a period to heal the lesion the material would be reabsorbed which would prevent long term cellular response and other delayed undesired interaction between the body and the implant.
- Biocompatible shape memory polymer successfully replaced previously used implant made of metal alloys.
- They can be used to make surgical devices such as self locking staples and surgical pins.

Biocompatibility of polymers (in vivo)

- Synthetic materials which are foreign substances in a human body can be applied in vivo if they need fundamental criterion of the biocompatibility.
- This means that they have to remain non-toxic throughout the period of contact with tissues that they cannot induce inflammation, allergy, carcinogensis or mutagenic.
- Biocompatable shape memory implants or materials it is extremely difficult to get rid of certain compounds which are found in a finished product.
- Traces of such low molecule compound are released from implant polymer to the human body and have toxic effect on it as well as induce inflammation at te implant site.
- Toxic components should be avoided when designing the synthesis method and the composition of such material.
- Biocompatability is not only a result of the composition but also of the dimension and the shape of the material which induces cellular response (in vivo) for eg: large fragments of materials they induces a inflammatory condition if the dimension enable endocytosis by macrophages.
- It is also extremely important to make the right choice of the type of material from which the implant is to be made and to select the right shape so that its mechanical properties are appropriate for its role at the implant site.
- Synthesis involves introducing functional group into the skeleton of the degraded polyester chain which can cross link the materials when treated with the UV radiation.