Microsensors, Implantable Devices and Rodent Surgeries for Biomedical Applications
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Week - 01
Lecture - 01

Welcome to the class, as you know in this course we will be talking about microsensors, we will talk about implantable devices, and how rodent surgeries are performed to implant those devices, when I talk about rodent surgeries it is all related to the brain. Now, if we understand how the micro sensor fabrication process is there, and finally, fabricate these devices, what is the role of this fabrication, and why do we need to learn all these things? So, the whole focus of this course would be on understanding the brain signals or we can say neural signals. We will talk about the difference between EEG and ECOG, what are the local field potentials, how we can use these implantable devices to understand the efficacy of anti-epileptic drugs, how these devices are flexible and also on a silicon substrate can be used to acquire the neural signals, what kind of electronic modules we can design to stimulate a certain part of the brain. What are the different non-invasive technologies that can be used to understand or diagnose epilepsy, what are the non-invasive technologies that can be used to understand hearing deficits, what are the non-invasive technologies that can be used to understand attention or memory because with aging the memory and attention declines right. So, this can be a good approach to understanding the attention and memory of geriatrics.

We will also look into the application of these implantable devices in Parkinson's. We will further understand the surgery, and the way surgery is performed and not only will we look into some slides that will talk about surgery, but we have planned to take the video right and show you how it is done in real-time. So, as you know this course we have two instructors, Dr. Shabir Girishan who is an associate professor at Ramaiah Medical College and he is also a neurosurgeon.

So, we should learn about the brain right, and where better to go and learn about the brain than to a neurosurgeon? The second instructor is myself and in our introduction, we will discuss a bit about what we do here in the lab, where we fabricate these devices, design the electronic modules, interface them, and then understand the data that we acquire or design the electronics such that we can apply electrical stimulation. Thus the course will be taught by two instructors as it is an interdisciplinary course. So, let us start enjoying the different topics and before going towards different topics let us understand what kind of facilities we have because I will be recording some of the tools in the clean room. So, in our department which is Electronic System Engineering at the Indian Institute of Science in Bangalore, three laboratories focused on

developing sensors, transducers, and minimally invasive, non-invasive technologies for healthcare applications.

One of the labs is known as nano fab for advanced microsensors or microsystems and biomedical devices for clinical research. As you can see a picture of the lab from outside and then a few tools that you can see from the window and we will be teaching you about most of these tools. One is through the lectures and the second while we record how the tools are operated. So, we will try to bring both the flavors theory plus a recording of the tools when they are being operated by one of the TAs. So, what are the different tools you will be learning? We will talk about it in the next few slides.

But just to give a little bit of a glimpse this is a clean room class 1000/10000 clean room. We have the EB u operator is called the electron beam mu operator, we have the thermal U operator, we have a sputtering system, we have photolithography, wire bonders, microscopes, wet etching, we have several characterization tools, and as we go into the depth you will understand what is the reason of wearing this gowns that you can see in one of the photos right on the bottom left that is a reason of wearing this gown and we will discuss when we go and understand more about the clean room. So we have another lab where again we will record some of the tools and this is mainly focused on the characterization all right. So, we have the NIDEC system, we have a micromanipulator, we have several kinds of different pumps, and we have the BC ah BSL 2 which is the biosafety level 2 facility. We have an autoclave system and inverted microscopes and we will try to cover as many things as possible right which are relevant to the devices that we are going to fabricate and characterize ok.

So this is the second lab that we will be discussing. Now let us go to the next slide. This slide also shows the part of or the sections of the lab right you can see that an engineer is working on the electronic module another engineer is working towards how to use the desiccator. A desiccator is a chamber in which you can place the device and you can create a vacuum. Thus you can store the device for a longer time right these are called desiccators.

The desiccator's main purpose is to store and not to carry. However for certain constraints that we have sometimes you may see students carrying the desiccator from one place to another which is not really for a long time. However, the primary purpose of the desiccator is to store the samples in a proper vacuum. So, you can see another slide which is on the top right showing the NI deck card and we will try to record a part of it as a TA class. So, to give you more understanding of how to utilize the NI for data acquisition or for developing a kind of UI right for this for electronics and related studies.

Now these are some of the sensors that we fabricate in our lab, but our focus will be mostly towards the right side of it. So, you can see we have 2 sensors for tissue phenotyping right now

and we have sensors for experimental neurophysiology. So, we will understand how you can fabricate that. So, what are these sensors, what are these devices that you can see? Now there is a difference between device and sensor, transducer and sensor, transducer in a device, or sensor in a device or a chip consisting of many sensors.

So, we will look into all these terms while we understand the topics in depth. But for now, let us see these different photographs. The first one that you see on the left top here is a flexible device as you can see this is flexible, you can see from this photograph it is flexible on which some electrodes are patterned. So, there are 32 electrodes in total.

These 32 microelectrodes are patterned on this flexible substrate to acquire the neural signals from the brains of rodents. So, when we implant the device it will touch the brain, and from that point on what we understand is a little bit different of course, doctor Shabari will be talking about neurosurgery or the brain and how it is anatomy is there that will be different. Let me discuss this from some other perspective. So, to make it a little bit easier for engineers to understand, of course, we need to understand how anatomy is done by a doctor, but let us understand from an engineering perspective. So, I will put it in very simple terms.

If we take the signals from the forehead or the head these are devices or electrodes which are called EEG wet electrodes or electroencephalogram wet electrodes because these electrodes are used with gel the Ag/ Ag Cl electrode is used with gel and they are stuck at different parts of the head. The different regions are as per 10-20 system. So, we will see it in a few slides. Now when we acquire these signals these are non-invasive. So, I use the term non-invasive, I use the term minimally invasive sometimes I use the term invasive then we will look at in vivo then we look at x vivo then we look at in vitro.

So, what are these terms? Let us start with the invasive, minimally invasive, and non-invasive ok. First, let us talk about invasive open heart surgery. It is invasive, and liver transplant is invasive. Minimally invasive is using a catheter for treating AFib atrial fibrillation it is an arrhythmia, it is one of the arrhythmias where the heart starts pumping unevenly or using the glucose monitor system you you pinch the finger the needle goes in and the blood comes out and that is minimally invasive all right catheters urinary, catheters minimally invasive. Now we talk about non-invasive, non-invasive is where it is not invaded. So, we put EEG electrodes and non-invasive ECG electrodes. ECG stands for electrocardiography or cardiogram and ECG electrodes are also non-invasive if placed outside the body. So, non-invasive is easy.

So, now, if someone asks you what is invasive, what is minimally invasive, and what is non-invasive you can easily answer those questions. Again breath monitor, alcohol monitor, and ethanol monitor are all non-invasive because we are using the breath right. So, the device is not within our body. So, it is a non-invasive technology to either screen or diagnose a certain disease.

So, EEG electrodes are why we talk about all these things because we talk about the rat's brain, and when I say brain generally we think where is the brain someone says here, but where is it?

So, it is a forehead when you open it right then you see that there is a skull. Skull when you open it is called craniotomy. Craniotomy is removing part of the skull and when you remove that part of the skull you will see dura. When you take out or remove the dura it is a thin layer you will see the brain and it is kind of wet because there is a CSF cerebrospinal fluid. So, we are talking about acquiring the signals from the brain of a rat, not non-invasive it is invasive or you can say minimally invasive because we place the device and structure it. But the whole idea of me talking about this non-invasive or minimally invasive or invasive is to make you understand what are the differences.

Now let me take a little bit slightly diverted, but important topics or terms in vivo are within the body in vivo all right. Suppose I experiment on rat brains we are performing in vivo experiments. Suppose I take the tissues out of the rat's body and understand its properties, it is an ex vivo. We are taking the tissue out and studying ex vivo. Suppose we have cells and we grow spheroid right or organoids from the cell in a laboratory is called in vitro. So, now, 3 terms ex vivo, in vivo, and in vitro before that we learnt about invasive, minimally invasive, and non-invasive.

So, 3 terms we have learned are invasive, minimally invasive, and non-invasive 3 terms here we have learned about ex vivo, in vivo, and in vitro. So, these terms will be used often and you should understand when I say we are going to now show you the in vivo experiment, the experiment that is within the body. So, we will try to put things in perspective that are easier for most of you to understand. It is very difficult to kind of teach which topics that we can teach that can be understood by every one of you. Some of you will like some topics, some of you like other topics, most of you will understand one thing, and other people will understand a second thing. It is all about how we also learn and over some time digest by learning more and understanding more by ourselves.

Suppose some of the topics are there and maybe it is not touched upon. Go back, see from books, see from Google what those topics are right.