Advanced Neural Science for Engineers
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Lecture 31
Introduction to Packaging for Neural Systems

Good day. Welcome to the NPTEL course, Advanced Neural Science for Engineers. Today, we have a TA session on the Introduction of Packaging for Neural Devices.

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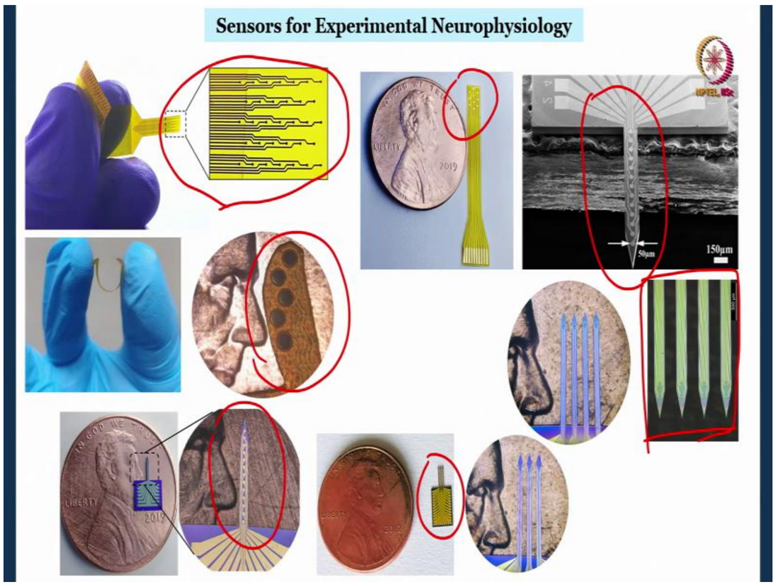

So, Professor Hardik might have shown you several devices that we fabricate and use for experimental neurophysiology. We work on several devices, electronics, packaging, so that, these devices can be implanted for long-term recording and stimulation in rodent models. Now, if you see here, we have flexible devices. Okay, this is a 33-channel flexible device on a poly made substrate. Then we have 10-channel devices.

Then we have micro needle arrays, which are silicon based for in depth recording or depth electrodes for deeper targets. Then multi-shanks of micro needles and things like that. So, each of these devices comes with its own design considerations, targeting different brain regions. So these is a single-shank microneedle, and then this is a 5 electrode surface neural implant.

So all these devices have its own applications, and depending on these applications, we have different electronic modules that has to be interfaced along with the implant and also the packaging as well. Now what am I talking about when I say the term packaging?

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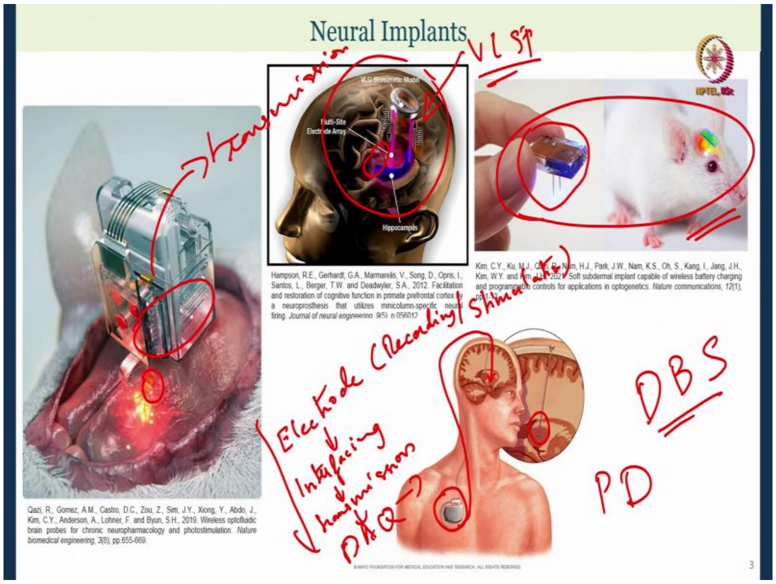

So, say, we have, I mean, people who have been following neurosciences for a long time would be aware of neural implants as such, which are available in market and in research stages. So there are implants available for rodents, just like in this image, or like in this case. So you can see the scale of the devices as such. So we have this a recording area, which is very small, and this is for a rodent model.

So you can assume the scale how big this device would be. And then there is electronic module for maybe wireless data transmission of recorded signals, or even wirelessly stimulating the brain region. Or the application actually would change for the disease model that we might be targeting. But in general, this may probably the scale at which one implant would be. Or if you look at the other rodent model I have shown here, it is very visible that, compared to human fingers how small the implant is, right?

So these are for rodent models. Now, when it comes to human models, we have DBS or Deep Brain Stimulation electrodes, which have been implanted for very long time. Now, maybe close to a decade or so, we have surgeries which are very successful in implanting deep brain stimulation electrodes in depth targets. So for the successful management of Parkinson's disease, okay? PD or Parkinson's disease.

So these implants are readily available, and you can see here this depth implant goes all the way. The connection goes to an electronic module or a package here, which stimulates the brain region at very specific time intervals. Then there are other devices also shown here. The flow would be that, we will have the electrode. Okay, from the electrodes for maybe a recording or stimulation, anything, I mean, it can vary from application to application.

We will have the electrode, then we will have an interfacing module, so interfacing. So in this case, we have this electrode here. I will just show once again, so we have this electrode here. Then there would be an interface circuit here, and then a transmissions circuit will be there somewhere, transmission, so that wireless monitoring is required. So why I would say, why we need wireless transmission later.

So we will have interfacing, then some transmission will be there, and then we will have a computer or say data acquisition. I would say data acquisition. So this much process would be there to record, stimulate, and then take data or send data, and processing the signals. So, the amount of the signals that we associate with neural implants is in the order of microvolts or less than millivolts range, so they are prone to very much noise and everything.

So people have now moved from data acquisition systems that are very remote to onsite devices. For example, VLSI enabled edge computing, and other tools are there, so most of the processing of this neural signals now happen on site, so that the amount of data that is being transmitted is very less. So the analog data that is being recorded from the brain will not be transmit as analog anymore, but will be converted into a digital domain and then transferred across using a wireless module.

So that is how the technology has evolved over the period of time, and with the advancement in microfabrication or nanofabrication and silicon based devices as such, the miniaturization has been easier. So the electrodes itself will have the electronics associated for processing or preamplification or a basic level of processing as close to the recording site itself. So that is how things are right now.

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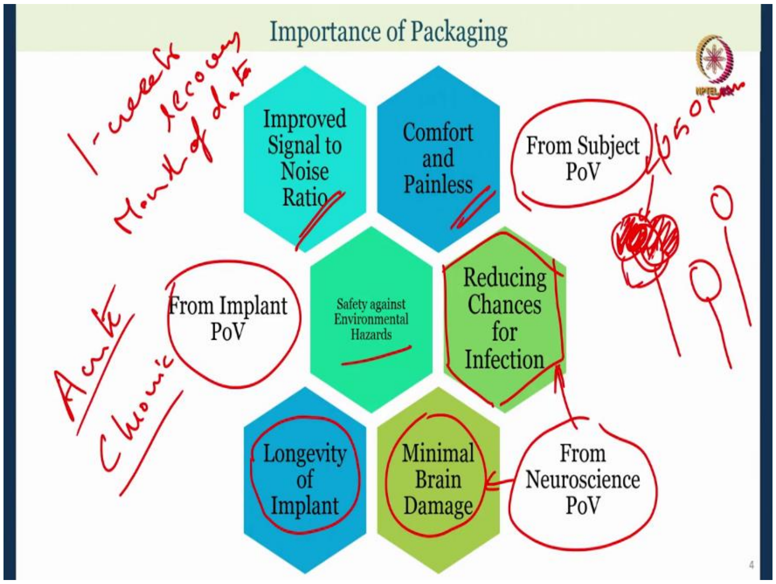

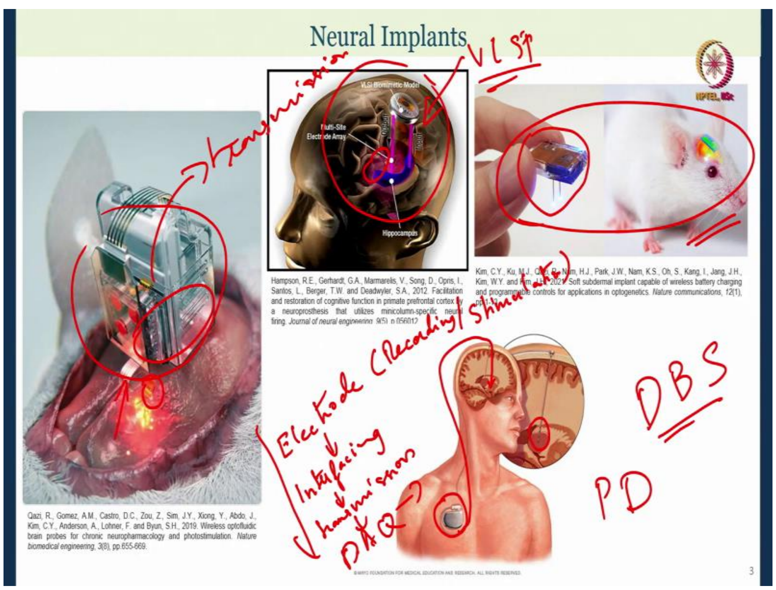

And now when we talk about packaging, I am yet to come to the exact scenario so that you will get an idea of it. So all this things that I have shown are all packages. So we have devices, we have some electronics, and then there is a mechanical embodiment that puts them all together. So this is what we call a package. In real life we see a lot of package, say this mouse would be a package.

So, it has electronics, it has some optical sensors, then it has a wheel and a switch, all those things. So this is a package. We would call this an electronic package. And now when it comes to a biomedical device, it is a biomedical package for specific application. So it will definitely have an interface between biological material or say tissue, so or brain, and the electronics. So now there is also a development in the field of what do we call it, Brain Computer Interfaces, which is all about this thing.

Now when we talk about packages, or what is its important as such, why do we have to discuss it for a course like this? So actually it is important is that say, let us say, from the point of view of the subject, or say it can be an animal model or human. From the perspective of an implant or the device that we implant for recording or stimulation, and from the perspective of neuroscience. I mean, there are far more perspectives to be taken care and far more considerations to be taken, I am just generalizing a few.

For example, from the point of view of an implant, it need to provide very high signal-to-noise ratio, so that the recorder signal will be good, so that we can resolve it for the pathology that we are targeting. So, so many consideration has to be taken there. So the implant has to be packaged in such a way that the signal-to-noise will be high. So that is one of the consideration that we always take.

Then see, all these devices are prone, since these are micro devices that we are trying to implant. They are prone to environmental hazards for example, there can be corrosive media, that can be dust particles. Say these neural implants that we are talking about will be less than 50 micron in diameter, right? So, for example, we have an electrode like this for a recording. This would be less than 50 micrometer.

Now, if it is kept open in a contaminated environment, a dust particles can just fall on it. So, Professor Hardik might have already discussed with you about clean room and importance of clean room. So if a dust particle comes and falls on this, due to this very small size of dust particles, it is very difficult for us to remove it as well. And also one, say, we fabricate a neural implant, and then we observe under microscope or characterize it to see if it is functional, we assume that it is good, I mean, once we get good characterization data.

But from the characterization point to implantation, while we carry it around, if we are keeping it in a contaminated environment, it is possible that the electrode can get oxidized or the electrode can get covered by dust or some other form of contamination. Or some organic contamination or anything like that would actually damage the device. And then if we try to record the data or stimulate, we are going to get errors data, which we will be able to understand probably at a later point of time after the experiment is done.

So, to avoid errors for the long, so then comes the next part. So along with the reduction in error of measurement and getting errors data, we also need the longevity of implant. So, for acute studies, there are acute neural experiments, and then there are chronic experiments as well. So for short-term studies, probably we would not need the longevity of sensors, but if we are looking at a long-term recording, say one month or a week to start with or usually when we implant devices on the rat brain or human is a separate case altogether.

But if we are talking about animal models, we might be looking for one week of recovery period after the implantation. Recovery, one week recovery. Then followed by maybe a month of data collection, data collection. So we need the device to be intact for one month of time. So how is it possible to make sure that the device stays intact. So these are few of the considerations from the implant side, it has to perform in this, this manner.

While if we are looking at from a subject point of view or a patient or animal point of view, there are always, we are bound by ethical, we should be following them because we are using animal models for the betterment of humanity and understanding of neuroscience. At the same time, we should be very considerate about the way we do these experiments. So we should make sure the implants, when we implant them, they should be comfortable for the subject, and also it should be as painless as possible.

Anyway it says invasive process of implantation. But again, once it starts recovering, it should face minimal discomfort. And also during the implant, I mean, long-term recording, it should create minimal pain and disturbances for the subject. Then there is always a possibility that there are chances for infection, so the key being, there are bacterial contaminants and fungal contaminants everywhere. And especially in animal models, which probably would not, but there are chances that it will have its pathogen associated with itself.

So when we do a invasive process, it is highly possible that an infection can happen and the animal might die due to this infection. So a very perfectly designed package is very essential to make sure the wound is not exposed to the atmosphere and any infection might happen. So that is very important. And this is also important from neuroscience perspective that, if you think about it, some of the studies that we might plan to do would require chronic recording.

So that means a month of recording or two months of recording. So that means the animal should be alive for a longer period of time so that we can complete the experiments as we require. So we need to make sure the package can reduce chances for infection, so that we can complete our study as well. And also, many a times an improper design of a package can cause to the implant damaging the brain tissue, which again, can lead to scar formation, hemorrhage, and ultimately the death of the animal.

And also it will corrupt the data that we get. So, so many things has to be considered while designing, and not just an implantable device, but also the package associated with it.

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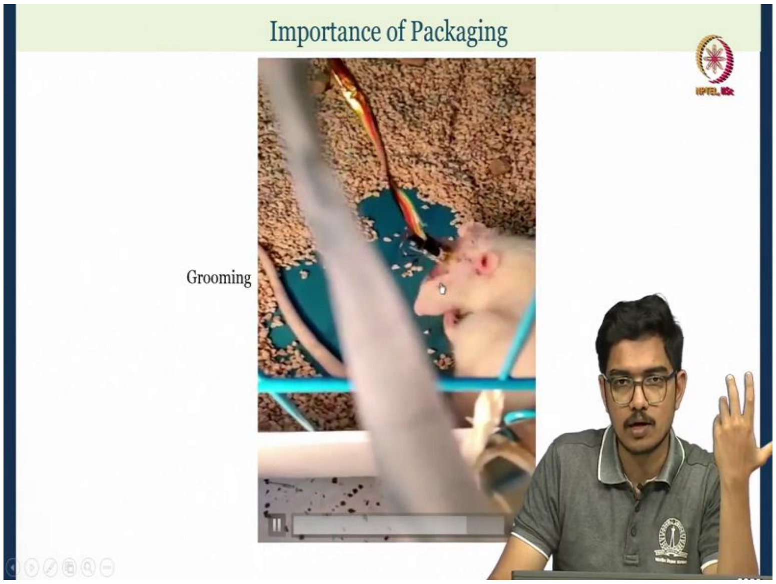

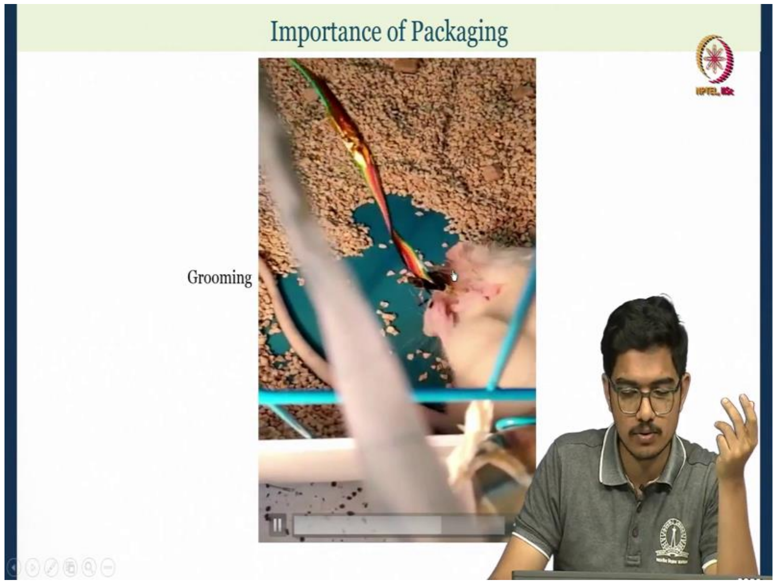

Now, there is a video here, so you can see here a rodent with an implant in its head, and the cable for data transfer. And you can see this is a very typical grooming behavior of an rodent where it will lick its four paws, and also scratch its head, face and the other parts of the body.

So if you see here, it is very evident that the animal is always restless, it is not like human beings, you instruct them and they would listen to you. But if you look here, the rodent will scratch its head where the actually the implant is there, and the four paws are so strong and sharp that it will be able to take out the implant after some period of time. So, when we design the package, we need to make sure the rodent does not cut off the cable or take off the implant from this port.

So, many a times during experiments, this is one of the key concern that we have, the implant should stay in the rat brain for a longer period of time.

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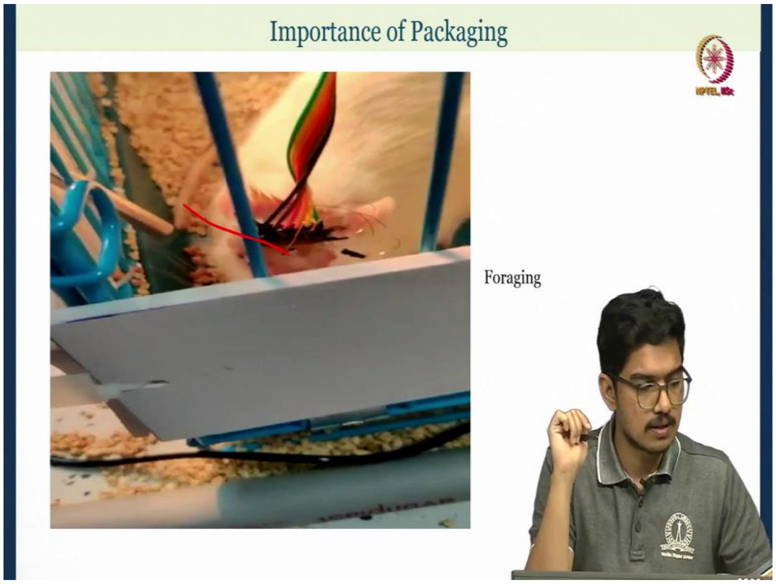

This is another example where it is not grooming, but it moves around for taking water or things like that. So when it looks around, it is a very exploratory animal, so it will walk around, it will move around, it will hit its head against different things. So we need to make sure the implant remains there.

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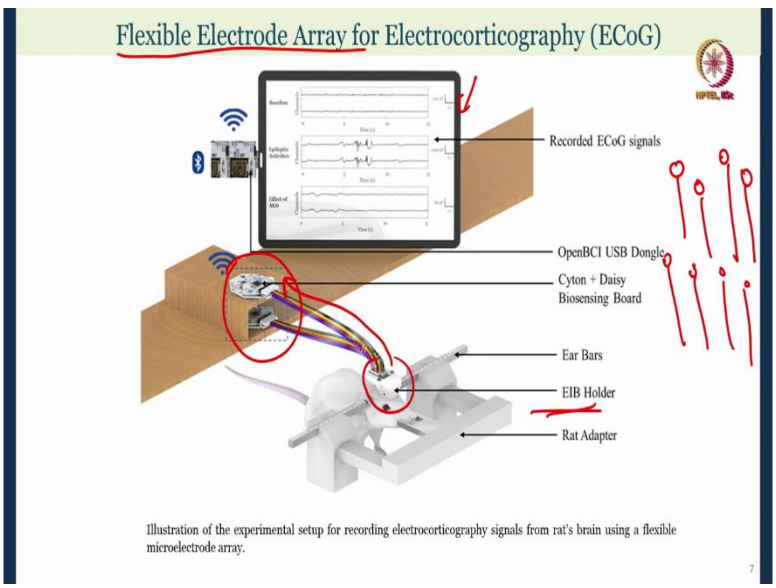

So, whenever we plan to design a package for one of the neuroscience applications, say, this is now for one of the experiments that I am trying to show. So say, we have a flexible electrode array, which I think, yeah, we will be showing the fabrication of this device during the course of this lecture. So, a flexible electrode array is something that we will be seeing. So, I have shown you the image earlier, we have recording electrodes like this, maybe 33-channel or 10-channel, and all on a flexible substrate.

So this flexible substrate has to sit in the rat brain here. Now, from the electrode, the data has to transfer all the way to the recording module. Again, we will be covering about this recording module in some other part of the lecture, course. So, the wires will take the data to this module, and this module will be transmitting the data to an accusation system that is sitting somewhere else.

Now, again, this is not a on chip processing kind of a method, because these tools sit or the chips that sit very close to the brain or near the implants, are very costly and very difficult to fabricate.

So in our studies, we mostly use a wireless transmission system, but a bit away from the rat. Now, we are working towards on chip processing recently. So, if you look at that, you can see something known as an EIB holder, which is a package that houses some amount of electronics, and also the device that will sit in the rat brain.

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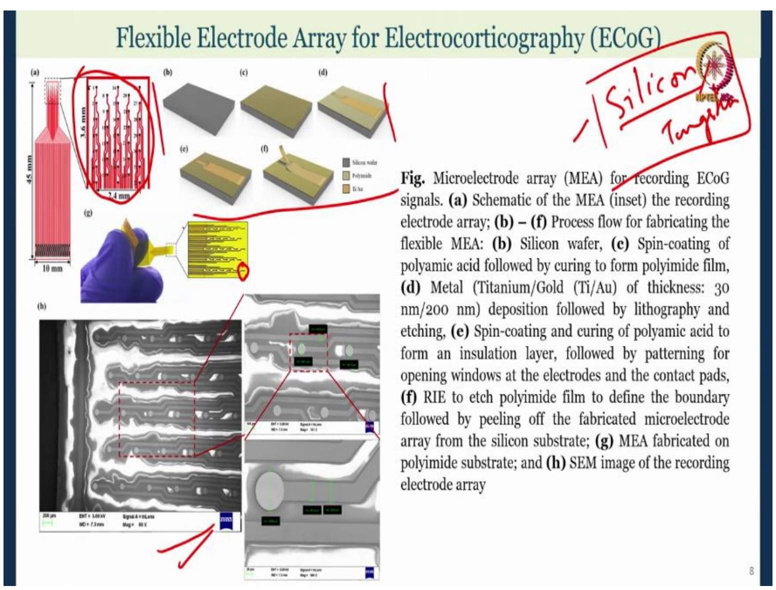

So this is the device that I was just talking about. It is a 33-channel neural implant. You can see the electrodes here, it is numbered as well. Okay, so there are 33 recording electrode which are this kind of circles here or dots that you see. Now, it is a very flexible device. Why flexible? Again, comes to the thought process of what I discussed earlier. We need longevity of recording, and also, we need minimal damage to the brain.

So this silicon based probes, which have been conventionally used for so many years are very damaging to the brain, even the wires for that fact, because the stiffness of silicon or tungsten or any of this metals or silicon. The stiffness is too high compared to that of brain tissue. So what happens is many a times slight micro motions in the brain, it still will cause this materials to damage the brain.

So that is why people have started moving towards flexible substrates or flexible material as such for long term chronic recordings for rodent models and even for human models. So what you see are the SEM images and the process flow for fabrication of the sensor. We will discuss about this later on in detail.

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Now, so this is how the device is implanted. So you can see here the device being placed on the rat brain, and then we have the package. So this is during the surgery, what the process that you are seeing. So the rat is fixed to the stereotactic apparatus, the device can be seen here. And once this is fixed, the package is fixed using dental acrylic to the rat skull. So now the rat will be able to move around without damaging the device. So this is how a package is made for very specific application to house the electronics that we need, the wires that we need, and also the device so that it stays fixed to the rat brain.

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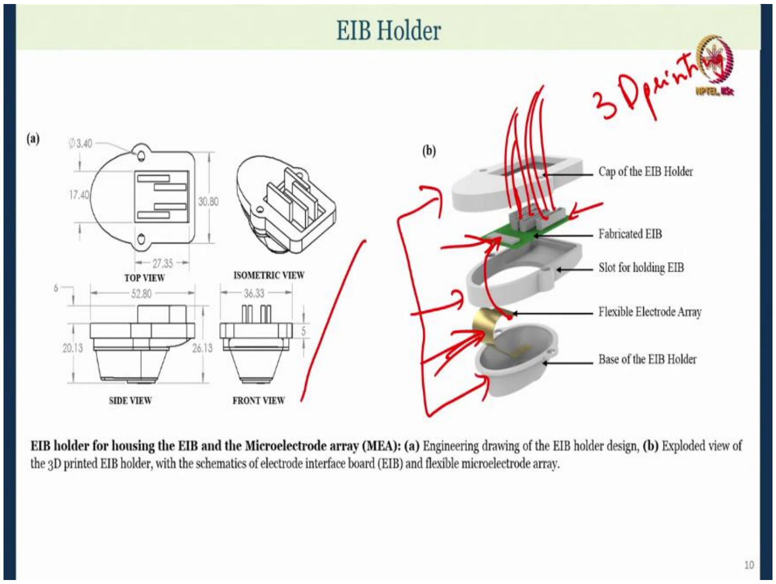

Now, what does it entail? So what all parts are there? So these are the engineering drawings for this EIB holder. So if we look at it, there are 3D printed, so what we mostly use is 3D printing for fabrication of this EIB holders. So, EIB stands for, Electronic Interfacing Boards. So, this is the EIB here, or this is the interface between the electrode here, so this is the electrode. So the electrode, this bend area will actually connect to this PCB over here, and this PCB, or the EIB will be connected to the bunch of wires that will be taking the data out.

So, there is a lot of scope in electronic packaging MEMS packaging in biomedical devices. Especially for implants, a lot of miniaturization and other things are happening over the period of time. So, for this specific sensor, and for this specific EIB, which we have designed, we would design a 3D printed casing, which encloses them all safely so that that mechanical strategy will be there, which will prevent any damage to the EIB and flexible electrode.

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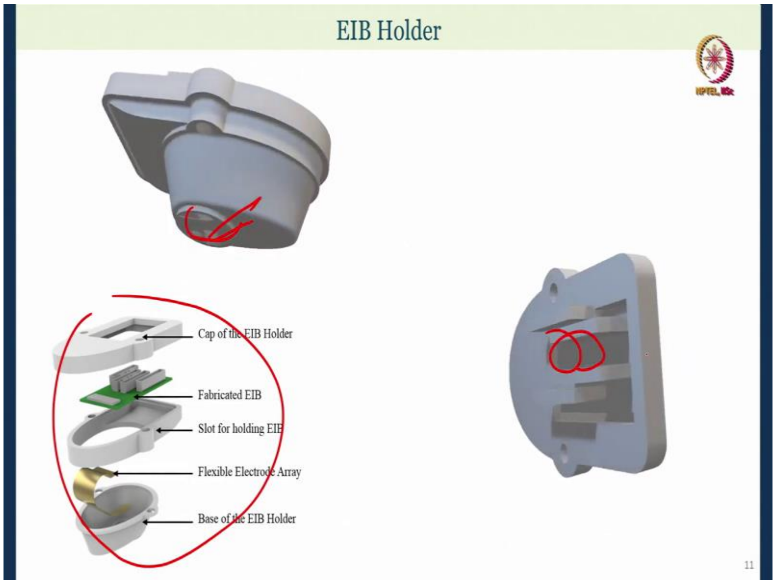

So if you see here, this is the exploded view of the EIB that we were talking about, and you can see here how the profile looks like. The surface has been made smooth in the bottom area so that the rat will not be able to catch hold of it while it scratches the head. And you can see the electrode over here, and here also, you can see very clearly. So the electrode is this that comes through a slot underneath the EIB holder. So this how the package actually looks like.

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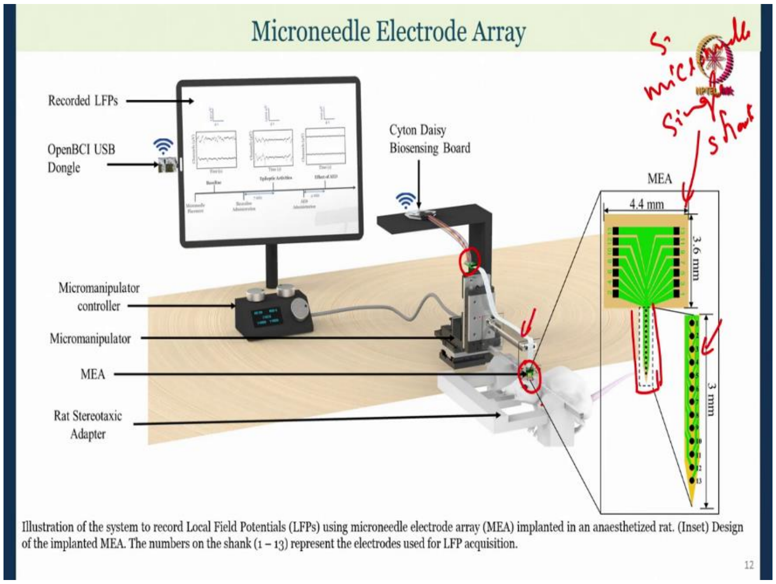

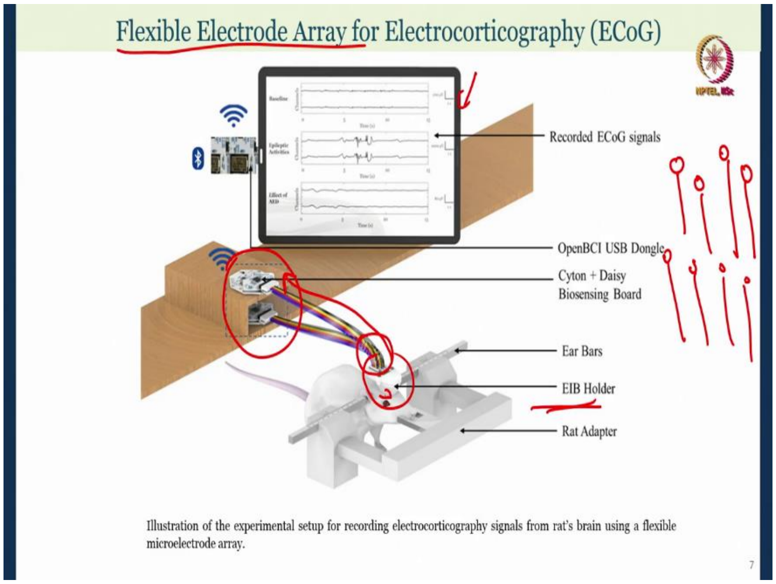

Now say we move from a flexible package to a package for a microneedle array. So now microneedle, as I said, are silicon based mostly. So this is a silicon based microneedle. A silicon based and single-shank. So, you can see a single needle with close to 13 electrodes in it. Now, once this is implanted on rat brain, then everything else remains the same. So from the previous package to the package that I am showing right now, you would see a big difference that, as the, we also started learning of how packages can be made.

Here, you can see a lot of bunch of wires used to come to the interface in module. Then from there, we moved all the way to a very thin cable or FPC cable, which actually gets connected to the EIB holder that stays way far from there. So this actually enables us to make a better package. Also, this is very essential as well, because the microneedle, as I said, is very stiff because it is made of silicon. So if it is subjected to movement, it can damage the brain as such. So, to prevent any unnecessary movement of the microneedle, we have used this FPC cable for data communication. Everything else remains the same, the configuration.

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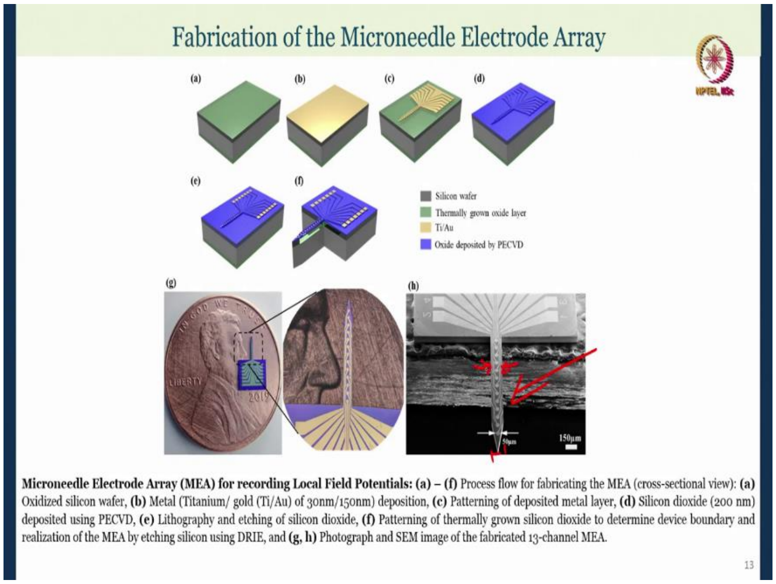

So this is the process for the fabrication of the microneedle. You can see the same image of how thin the device is, so it is a 150 micron, wide microneedle.

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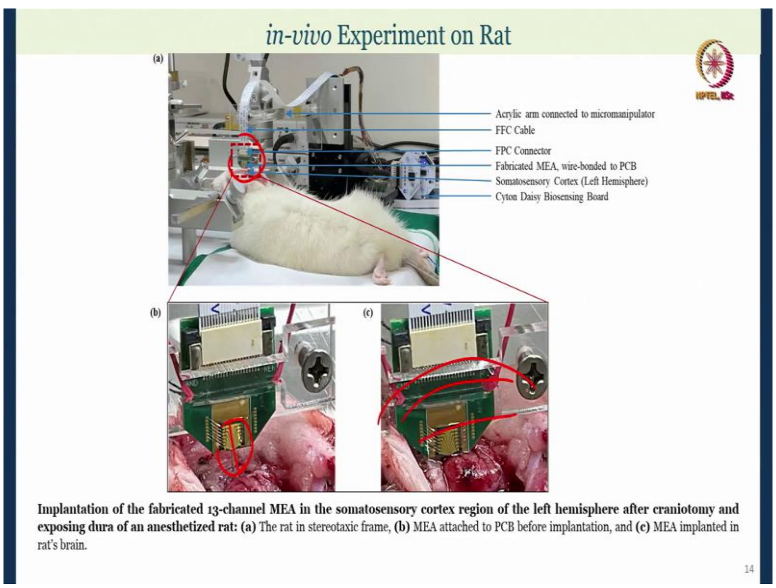

Now, and so this is how the implantation of microneedle is been done. So you can see the animal is fixed onto the stereotactic apparatus, and the microneedle is brought down using a micromanipulator, so that no error in placement of microneedle happens. And then again, this package will be covered using dental cement.

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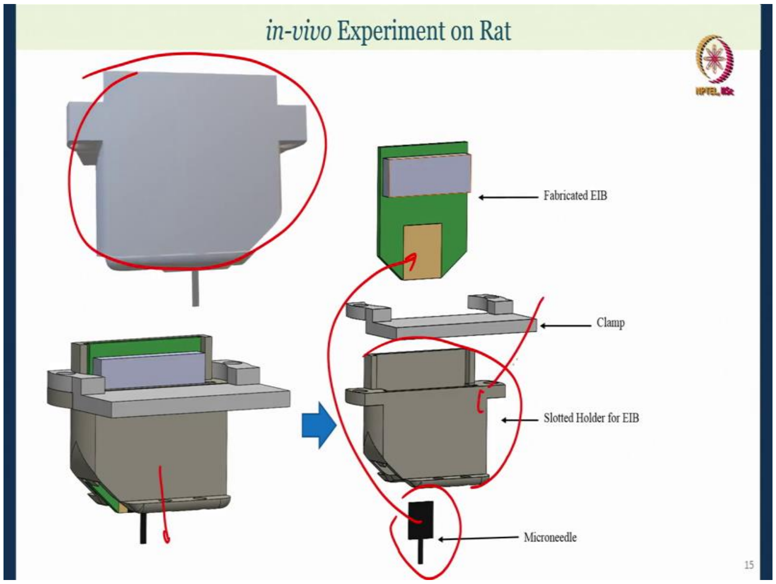

So this is the package that we had designed and implanted for microneedle implantation and packaging. So you can see this is the 3D printed casing for this specific application. You can see the microneedle here. Then, this EIB, or this is very small compared to the previous one that I have shown. So this microneedle will sit here and the implantation can be done, or it can be brought down like this or assembled like this. And these are all 3D printed again.

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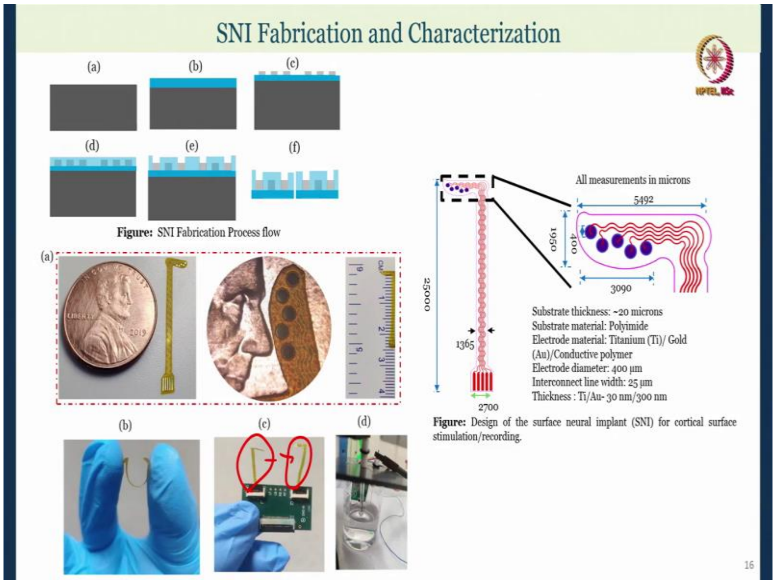

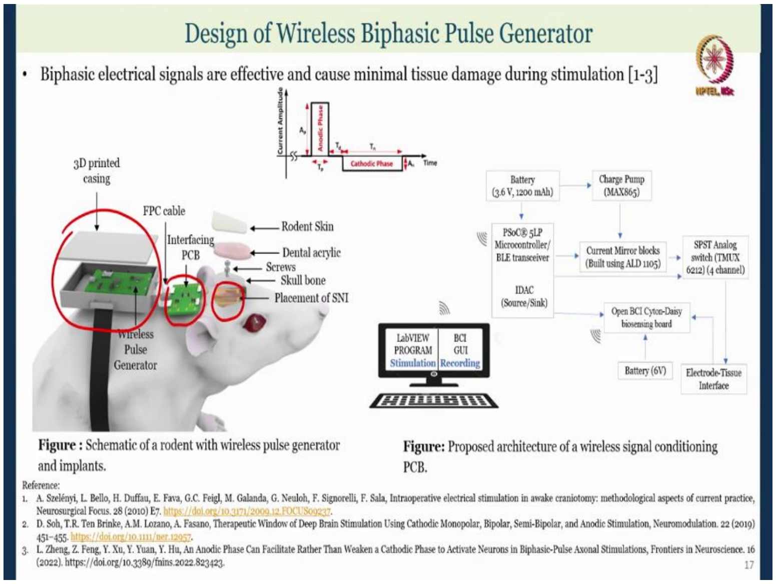

Now, say we move ahead with a different kind of neural implant. See in all the other cases we had a single microneedle or a single flexible device. Now, what if we have multiple devices like this, which has to be simultaneously implanted, so we have come up with a different kind of an approach where these are surface neural implants have, there are two of them with five electrode each.

And which can be simultaneously implanted on left and right frontal lobes of the rat brain. And in this case, we were looking at chronic implantation and recording for a longer period of time. So that is why the package has been modified, so with a backpack so that we can attach it to the rat so that we can wirelessly transmit data and long-term recording is possible. And also for long-term recording, it is very inconvenient for having a wired data transmission module.

So this is something we have developed now. So we have a preamplification circuit in the interface in PCB and then we have the implant here. So, the packaging of the devices for its specific applications have evolved over the period of time to the stage we are right now.

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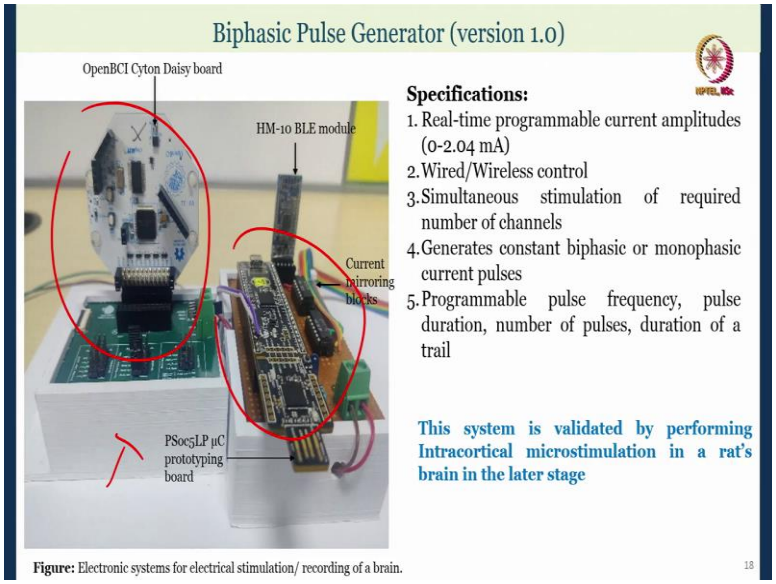

Now when we talk about packaging, it is not always just about the site closed implantation, but also when it comes to the recording modules or electronics or casing for all those units as such. So you can see here the electronic module that we use has been packaged inside of 3D printed casing, so that we can keep it very stably on top of it, thus can do the recording while we are doing the experiments.

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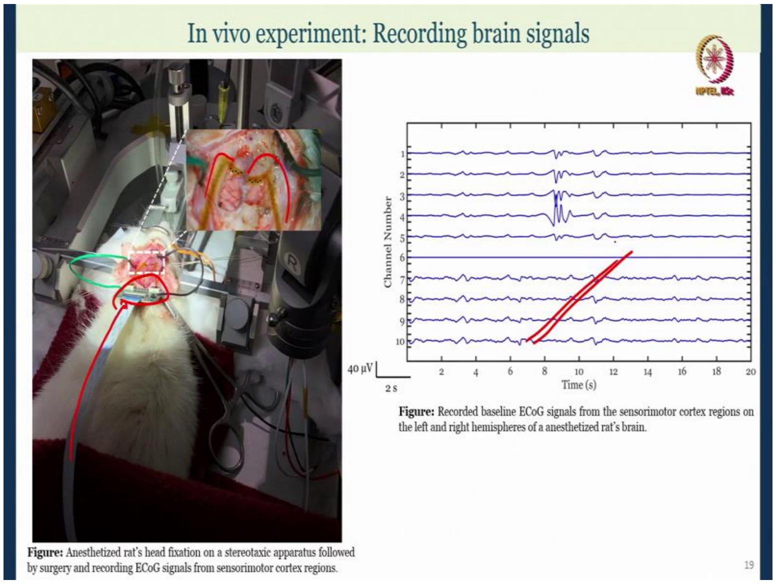

Now, you can see here, so the FPC cable comes here, the interfacing PCB is there, and the two electrodes are here, which have been implanted, and this is the signal that has been recorded from the brain.

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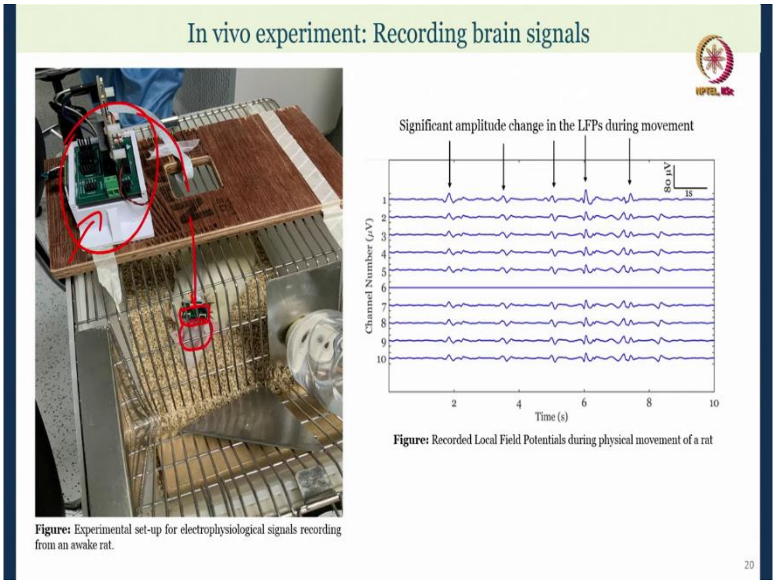

Now, this is another case where you can see the electronic module that I discussed earlier, which has been packaged inside of 3D printed casing, and then only the FPC cable will go and connect to the PCB, and it has been fixed here using dental cement.

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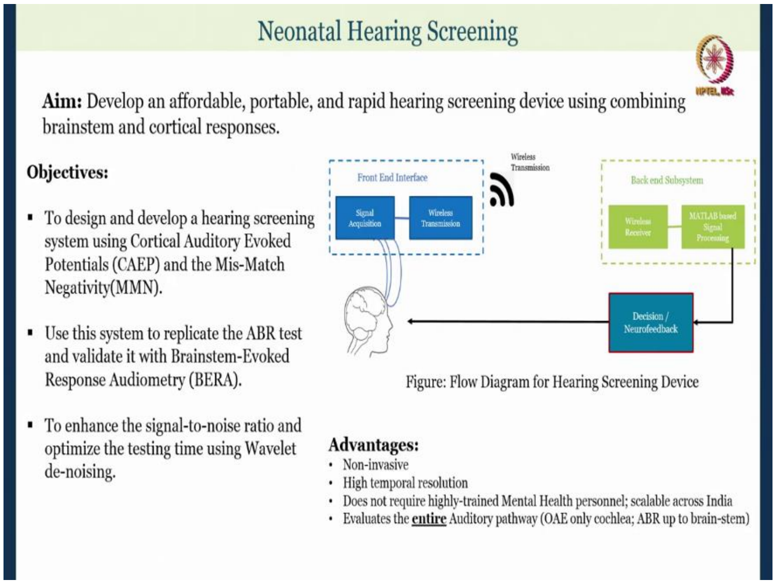

So, then we have another use case, say these are all for rodent models that we were talking about. Does packaging come into an application for actual human beings? So in one of the use cases, for neonatal hearing screening, where we are trying to understand whether there is any hearing deficit neonatal or babies.

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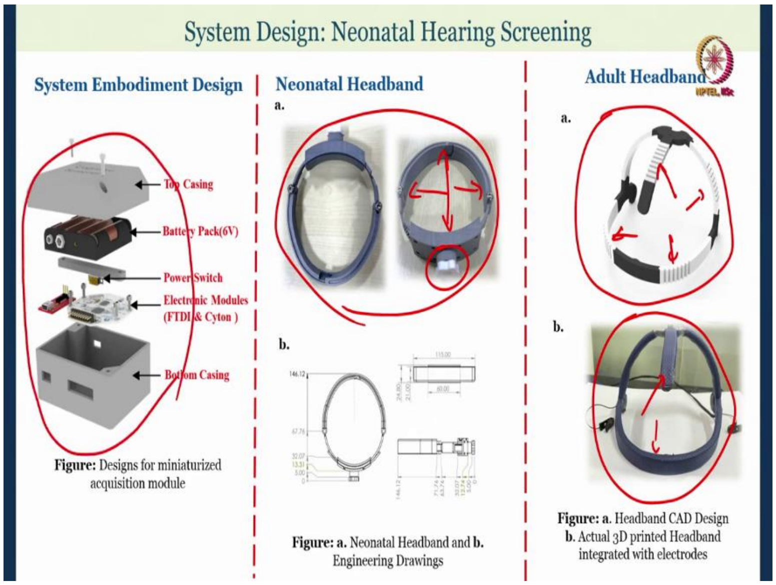

So we will be discussing about this work in another lecture probably. So here we have a headband for neonatals and adults. So based on the head size of the baby or the head size of the adult, the package can be redesigned. So you can see the notches given here, which provide flexibility for the device. And you can see also a knob here to adjust the diameter for the size of the head size.

Then you can see that the material has been made very comfortable so that they can wear it without any difficulties. And then also the electronic module for recording has been enclosed inside a package.

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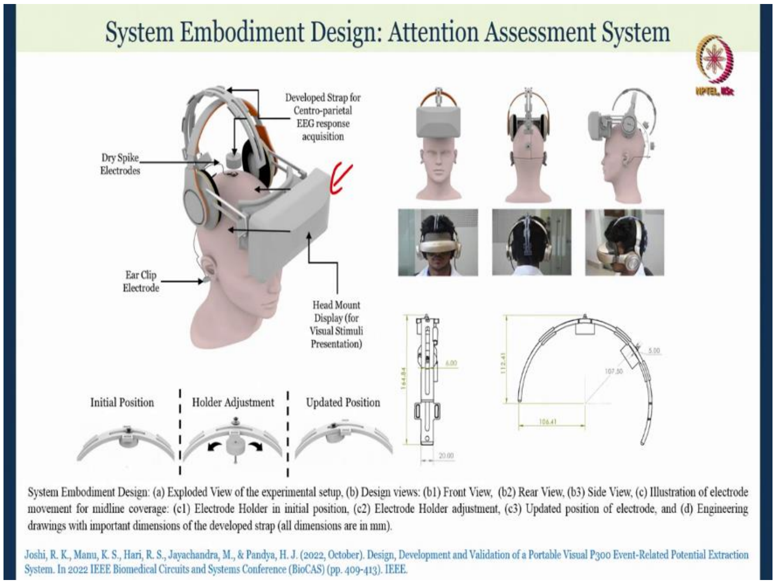

In another case, we were trying to understand the attention assessment system. So whether the person is attentive enough. So for that, we need a VR based set up like you can see. So this is also designed 3D printed, and tested. So, so many design innovations can be made, engineering design innovations can be made for specific neuroscience related applications, putting together the skillsets from mechanical engineering, biology, electronics engineering, and so many, materials engineering. So, multidisciplinary kind of research is actually very helpful.

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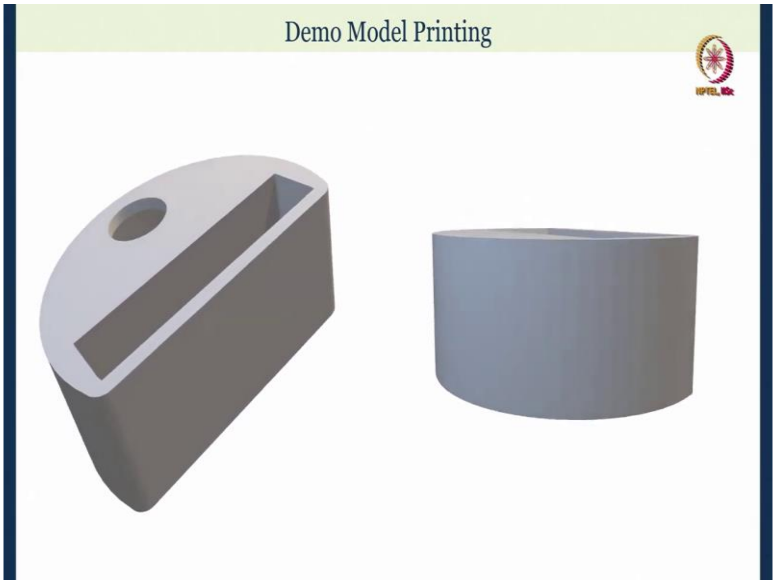

Now, as a sample, I am going to show you one model that we are going to print for the surface neural implant that I had shown earlier. So this is the model that we will be 3D printing and showing you so that you will understand how from a design we go all the way to printing and realizing the actual object. So that you will also understand how small it is, what is the scale we are talking about.

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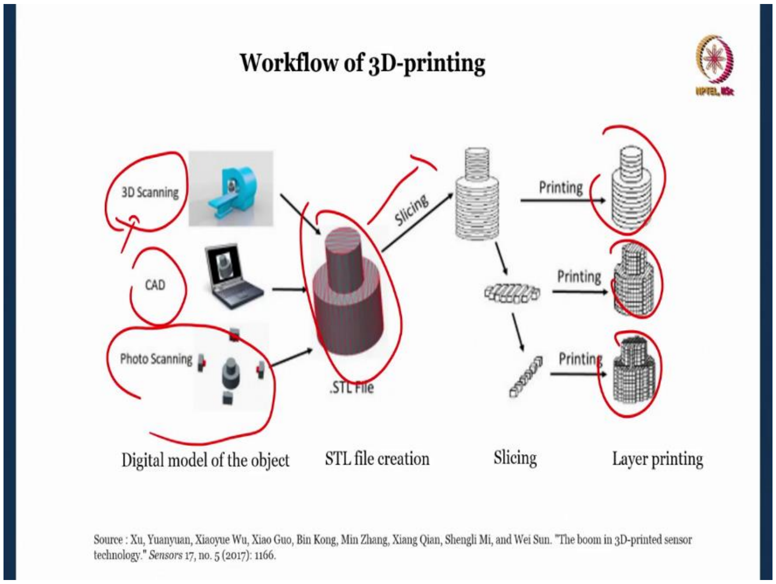

Now, just introducing you to 3D printing, which is a very, very popular tool these days, and also very effective for rapid prototyping and testing for this kind of application. Typically, for 3D printing, has been evolved, where people do 3D scanning using Lidar or some other tool to create a 3D model of a real life object. Then there is a process known as slicing, where the 3D object will be sliced into thin layers and printed. So that is one form of approach.

Now, in our cases mostly, we cannot 3D scan it because we do not have a predefined model available with this. Instead, we would design itself by ourselves using a CAD software, like SolidWorks or Inventor or software like that. And then create an STL file. There are also cases where people use photo scanning, where you take images of an object from different angles, stitch them all together to create a model, but we do not need to go into those details.

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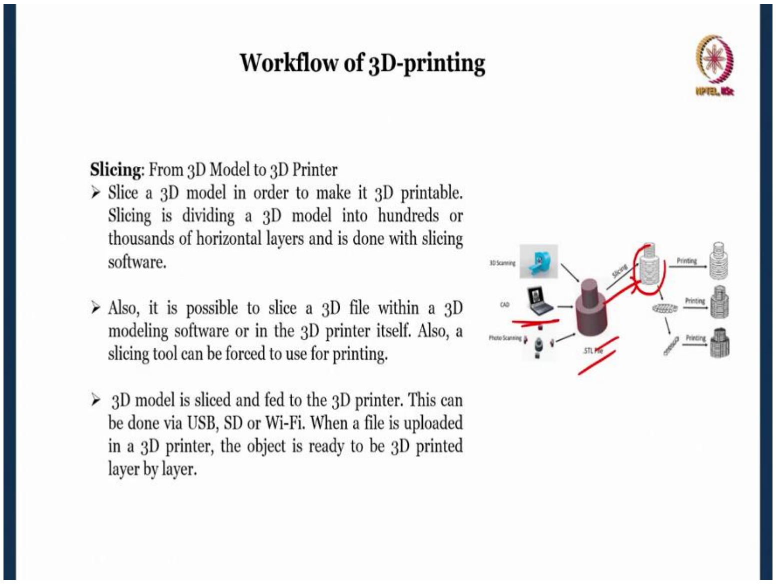

So, from the 3D model using CAD, we will generate an STL file, then we will slice it and then feed this sliced information to the printer or 3D printer, which will print it. It is very similar to the paper printer, but assume that the stacking of layers also happens than just a 2D plane.

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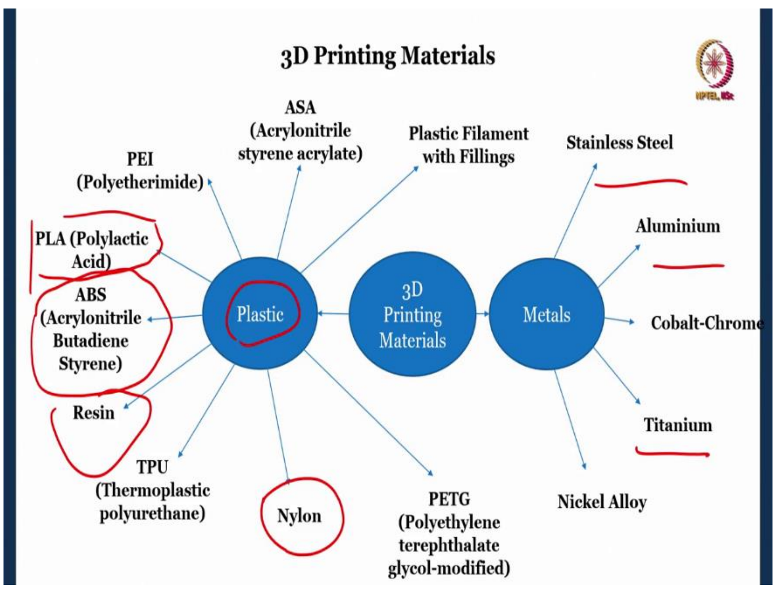

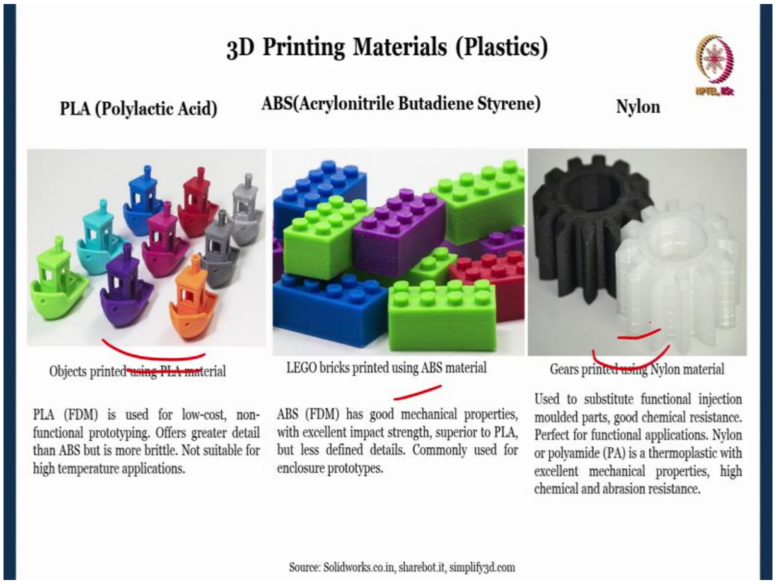

Now, one good thing about 3D printing over the years is that it supports variety of materials, which can be metals or plastics suited for our application. Say, if we are looking for a metal based say, steel or aluminum or titanium, so these are metal based printing that is possible for these materials. Now, many of these metal fabrication have been previously done using casting and other processes.

Now, many of these very intricate geometries have been now moved towards the fabrication using 3D printing. If we are looking at plastic, we have variety of materials available. We have biocompatible and biodegradable PLA material, which is very commonly used. Then we have slightly stiffer version, which is ABS. Then we have resin based materials, which are very durable for a long run. Then we have nylon, which is one of the lightest and best material. So, so many kind of materials are available these days for our applications. So these are few of the examples. This is PLA, and ABS, then nylon.

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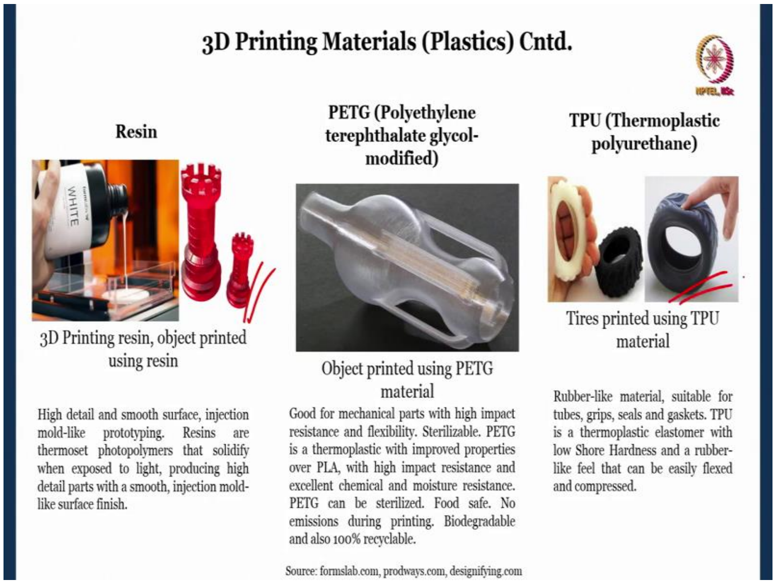

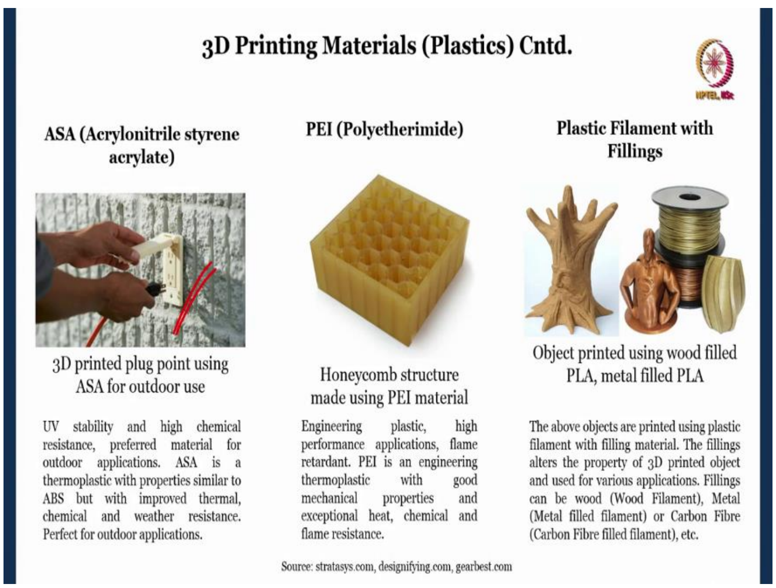

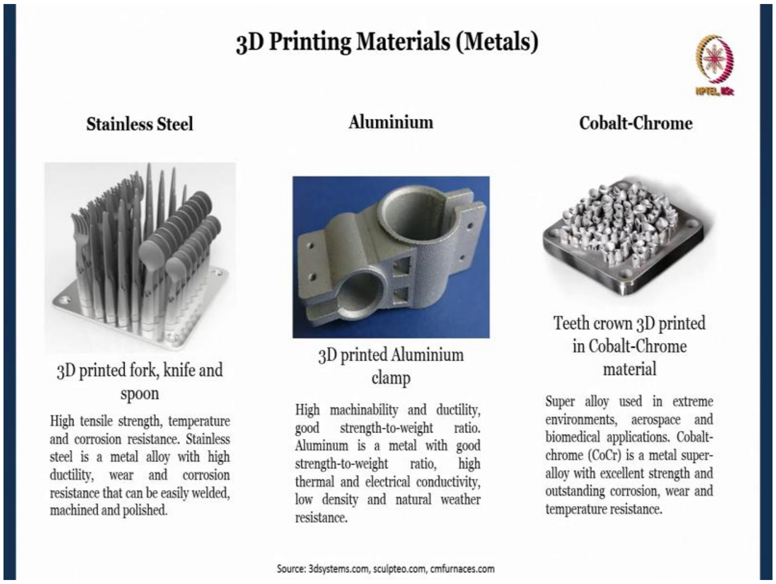

Then there are resin based printers. So TPU is flexible in the nature. So depending on our application, we choose the material. So if we have some electrical application, we can use ASA. Then, so many different applications are there. Then metal based process are also developed now.

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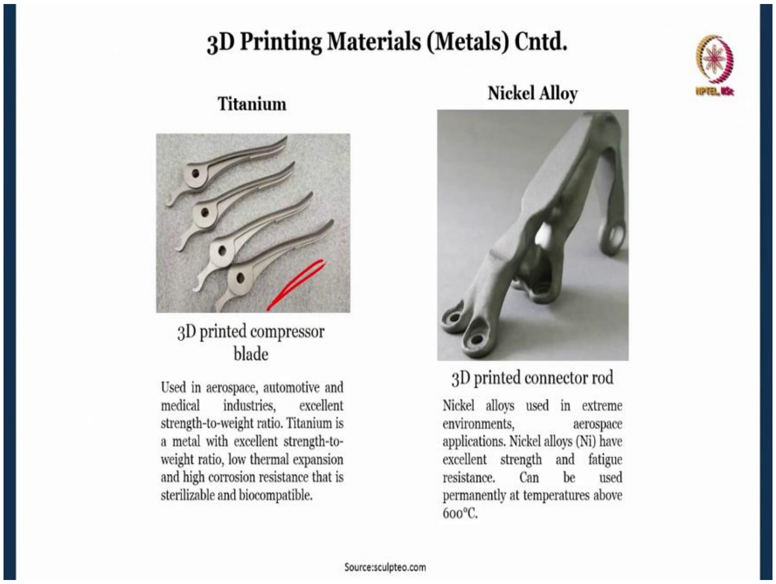

Even titanium for implants, titanium has been very popularly used as an implant material, so this can also be 3D printed.

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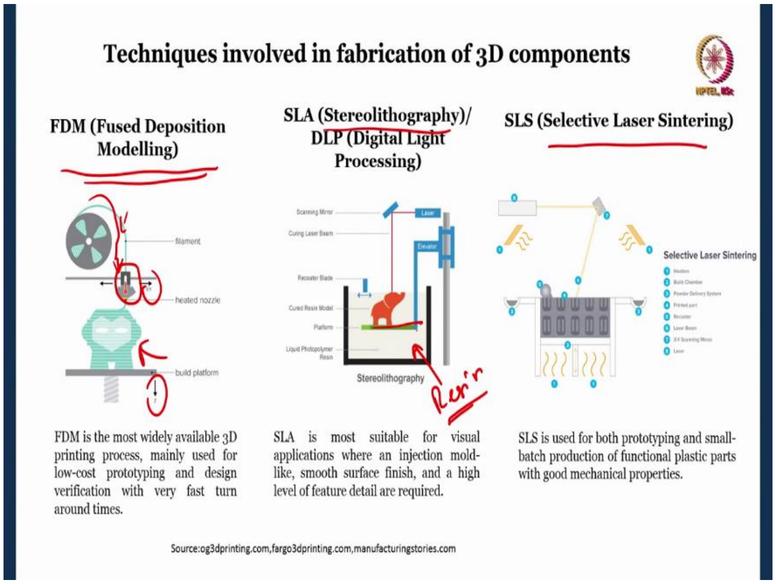

So how do we print it? So there are different technologies for 3D printing that are available in the market. Say, one of the most common one is FDM or Fuse Deposition Modeling, which most of you might have seen already. Where we have a filament and this filament will be heated by an extruder or a heater to melt it. So, if PLA is the material that being used, it melts around 180 to 200 degrees Celsius.

So the PLA filament will be molten and the printer head, or it is like a nozzle that moves around in x, y direction, and the stage can maybe move up and down in x, y direction to pour this molten material at specific locations so that we will get the designed shape when it cools down. Then we have SLA or Stereolithography printer or DLP or Digital Lights Processing, which is the printer that we will be showing today for demonstration.

Here, instead of a filament that being used here it say a resin bath. So this resin is a material that is photo sensitive, so what happens is there will be a bed here, and the bed will touch the resin and a laser source or a projector source will be used to shine light on specific areas that we are targeting and the resin hardens. So, this is a different approach. So layer by layer, the resin is being hardened to get the final designed shape.

Then Selective Laser Sintering is very commonly used even for metal and plastic, where we have powder, which will be sintered using a laser source.

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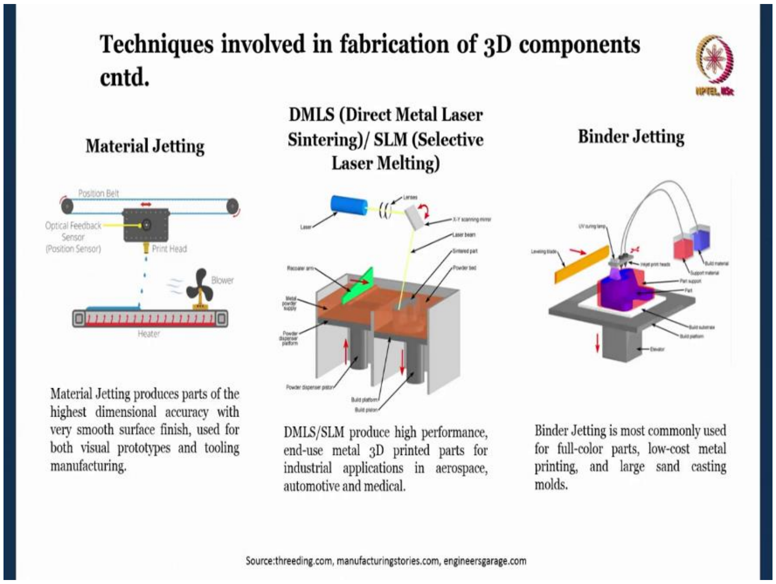

So there are different, different techniques available, like Material Jetting, and DMLS, and Binder Jetting, and I think, we would not go to the details of it.

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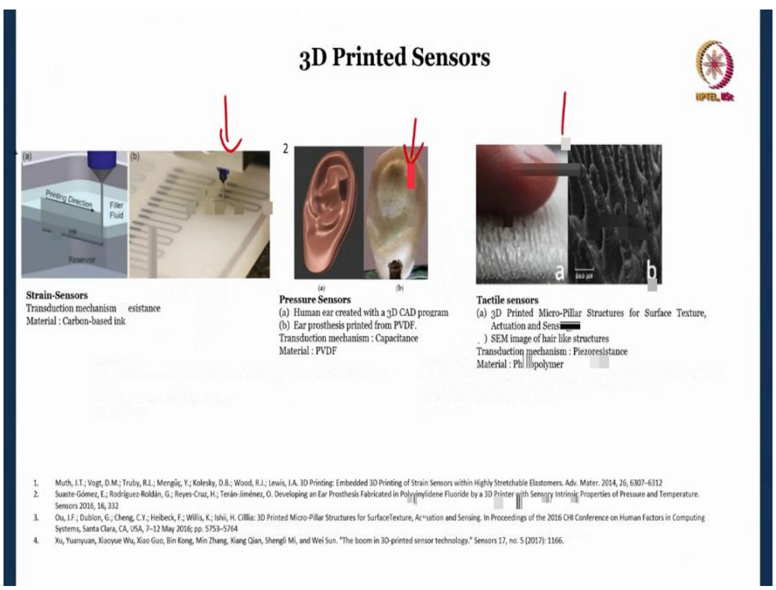

So apart from the use of 3D printing for packaging, people have used it for different sensing applications as well. For example, strain sensors. So these kind of sensors are usually put on your skin or hand to see how much stress is taken by the skin and things like that. So, so many research and physiological relevant applications have been demonstrated so far. Then pressure sensors for ear prosthesis have been 3D printed now, then there are Tactile sensors.

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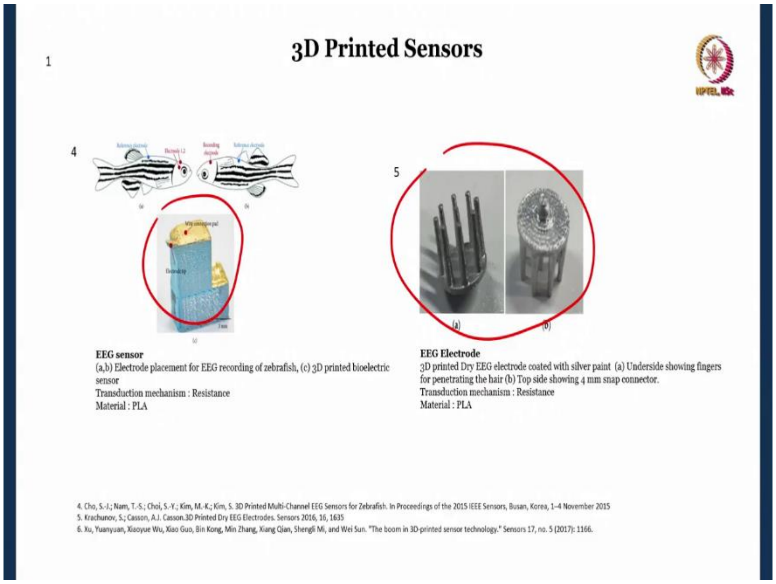

So, so many different applications and innovations have happened with 3D printing over the period of time. Then there are definitely neural implants, which are 3D printed. Then there are also EEG spike electrodes, which are printed using conductive material. So, so many different things are already available.

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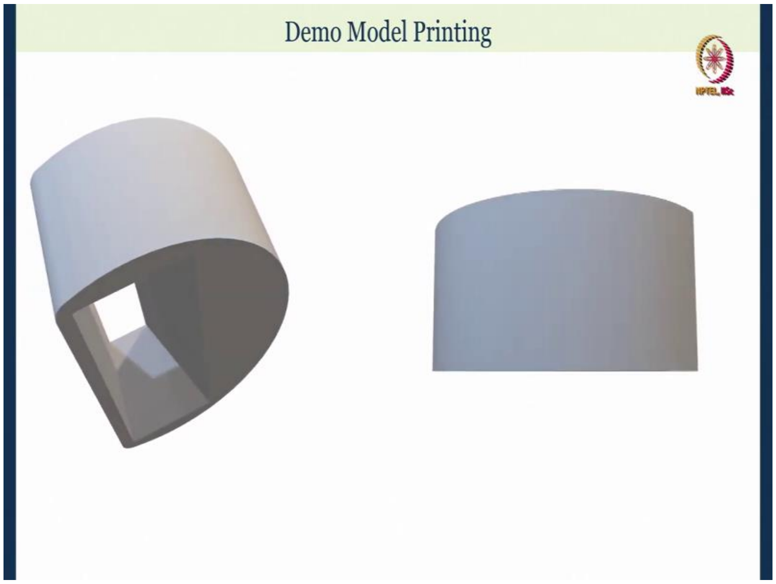

So, now we would move ahead to see how the printing of the demo model has been done, so that you will get a full on idea from how to design a package for a neural recording and also how to print it and try to use it for some implantation.

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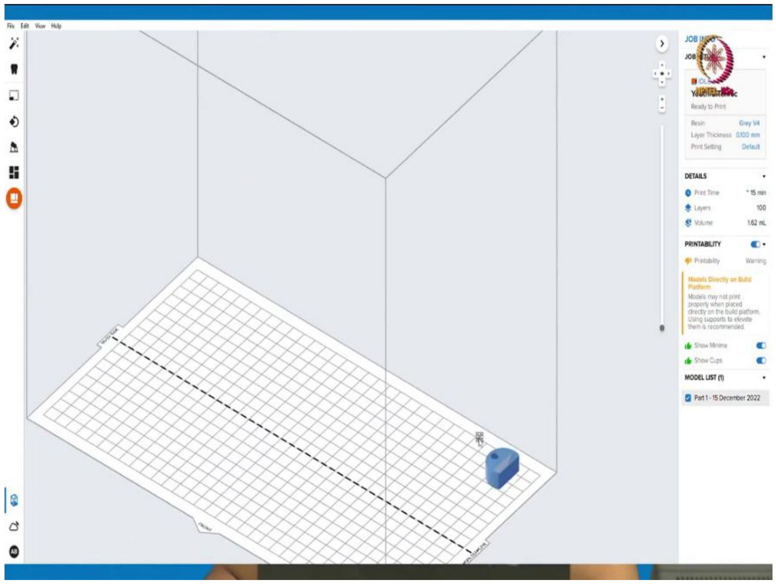

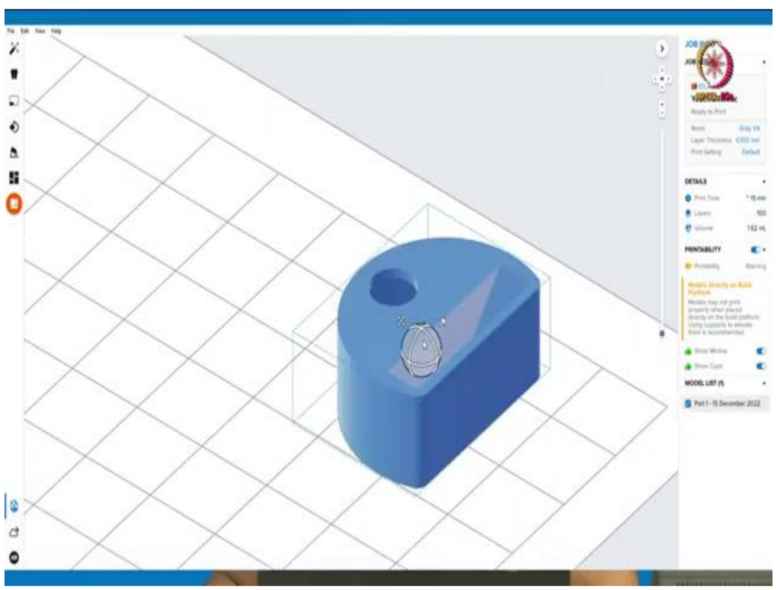

So what we have here is the preformed software, which we use for 3D printing. So it is a software that is provided by Formlabs. So the 3D printer that we have is Formlabs 3BL, which is compatible for biocompatible material printing. So I am just dragging, you can drag and drop the part that you want to print in an STL format. So this is the software width, and this is the bed size that the printer has, so you can arrange the model wherever you want. And you can zoom in, and have a look whether everything is fine, the way you want.

Now, you need to orient the print, so that it comes out well for the application that you are looking at. So for me, this seems to be a good orientation in which I can print the material, so I can keep it, look around to see if it is fine. Then what we have is, if you want to scale it up, which we would not be doing right now, but you can always scale the model and if you want to print a bigger replica and see if it is working and things like that, then also.

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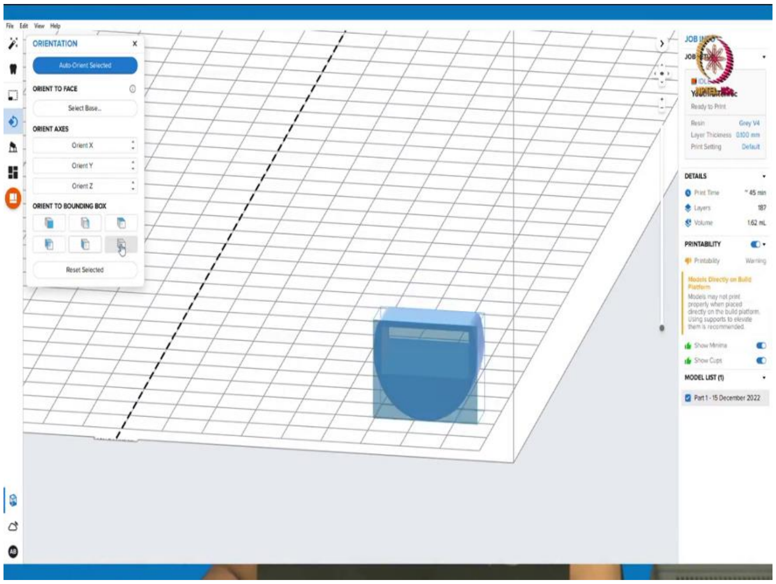

So, right now you can see this gimbal kind of option to rotate the model as such. Now, alternatively you can orient into the model, you know, what do you call it, the Cartesian coordinates as well, that is always an option to the planes of the model. But you can also orient in the way that you want in using, you can just drag and keep it like that. Then we will move ahead with generation of supports.

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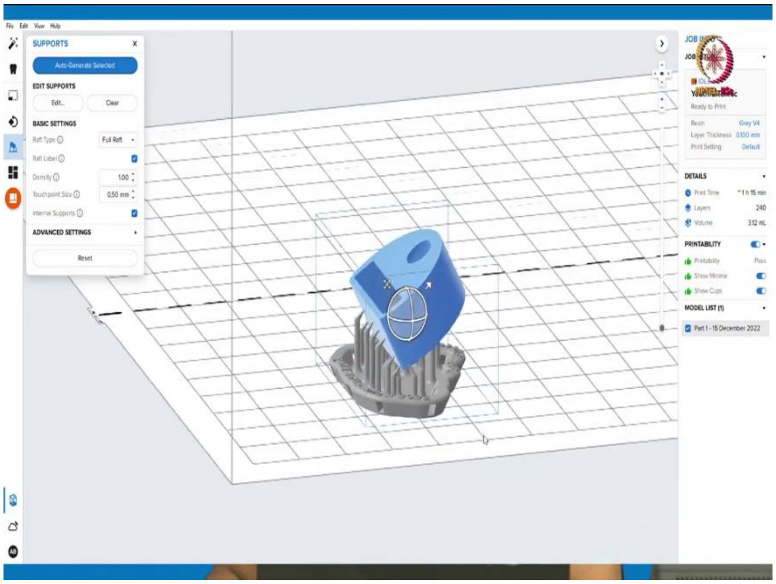

So 3D printing always, of complex shapes usually demands supporting structures to be used. So for example, I will tell you, so right now, if we are keeping it like this, there will be definitely, you know, this is an overhanging feature which has to be supported through some materials. So the software itself has the provision to create supporting structures. So if you just rotate the model in a different way, like this, then it will automatically generate supports for other things.

So basically the software itself is already optimized for giving out the best structure possible. So, I am just rotating it back to the way it was.

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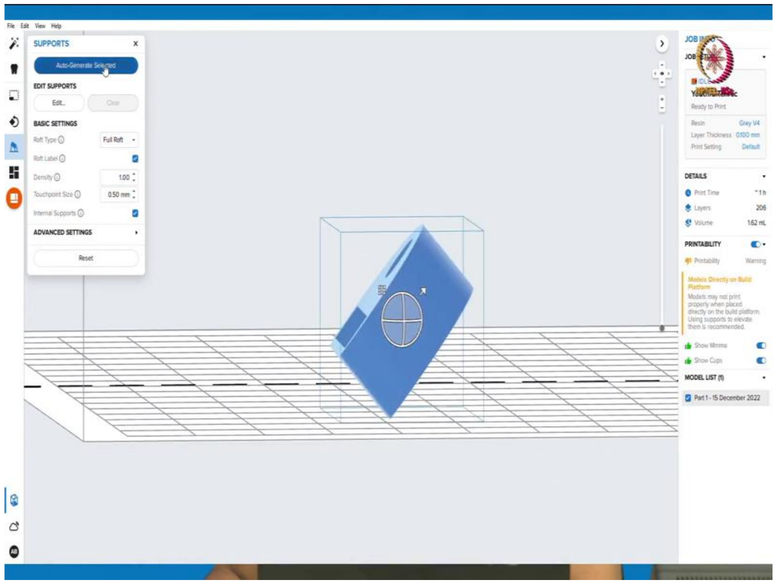

Now for improving the addition of the path to the build plate, or the deepening bed that we have here. We can create a different types of rafts. So for example, if you do not keep a raft, so this is the raft structure. This is, okay. So this is no raft. So this will give minimum addition.

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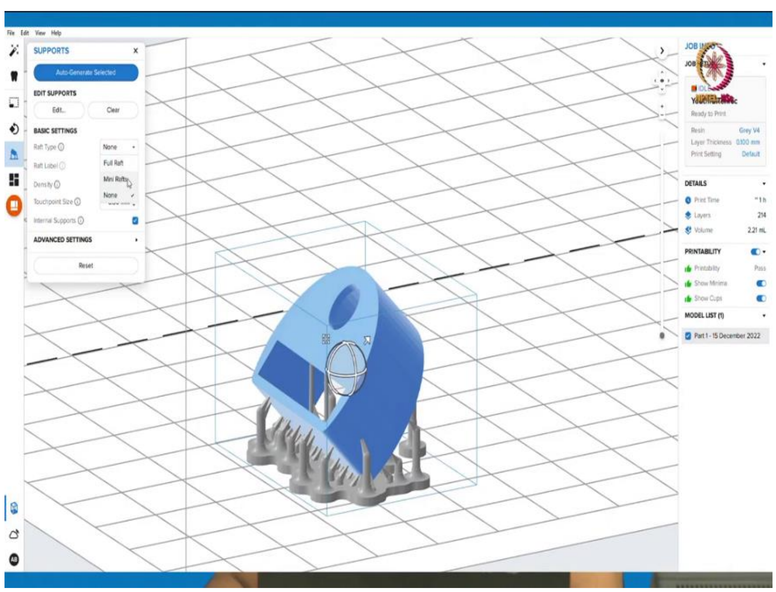

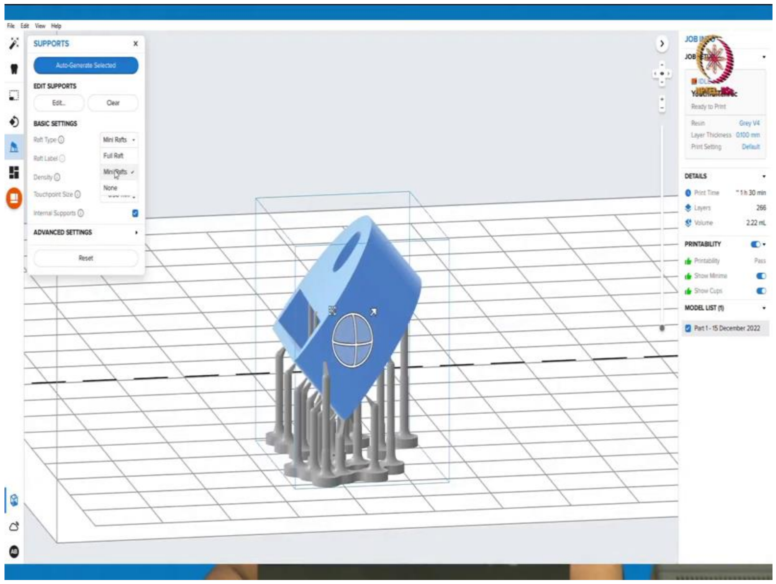

For small parts these are fine or else you can go for mini rafts, which are slightly bigger than this for better support, or we can go for full rafts, which provides better adhesion and also better print quality as such. Then that is another thing. And you can see how much approximate print time it takes. For example, here, it shows one and a half hours to print this structure. Also, how many layers are there?

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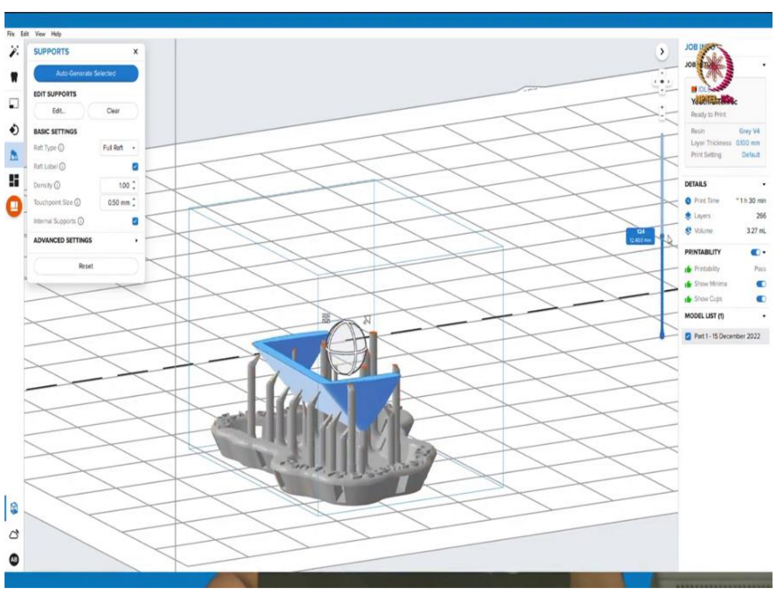

When you talk about what layers are, so this model, I told you we will slice it once the STL file is prepared, we will slice it. So this is the slicing actually that you see. So this is how the print will progress. Finally we will get this blue part that we want, but when it starts off, it starts from, from here.

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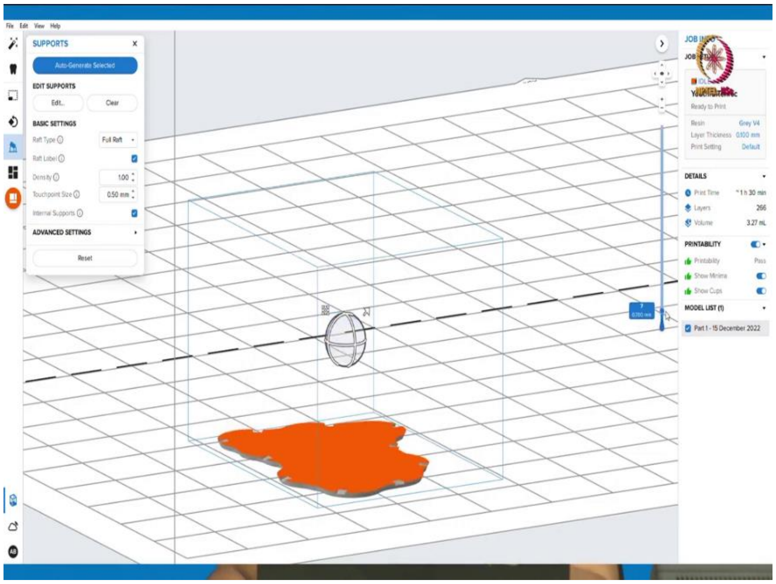

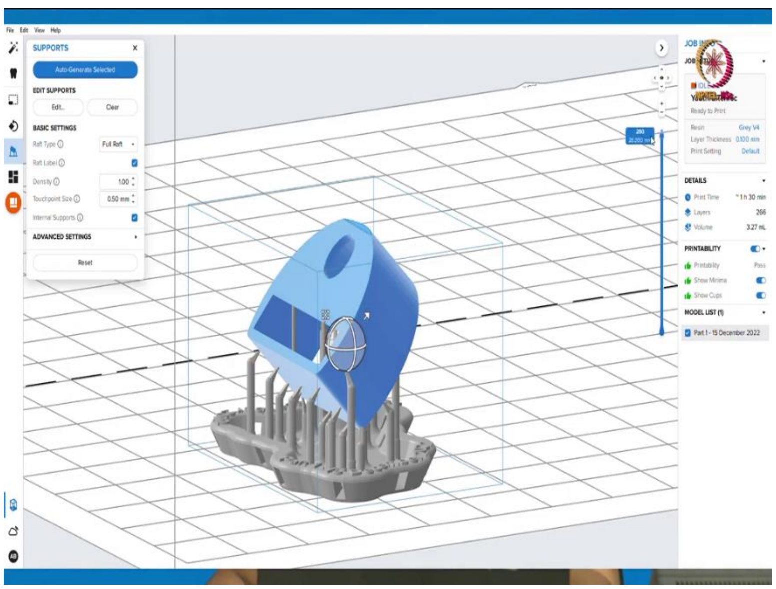

So first laser will shine on this much area, so that resin will get cured. Eventually, it will start forming structure like this, like this, like this. Now the part has formed.

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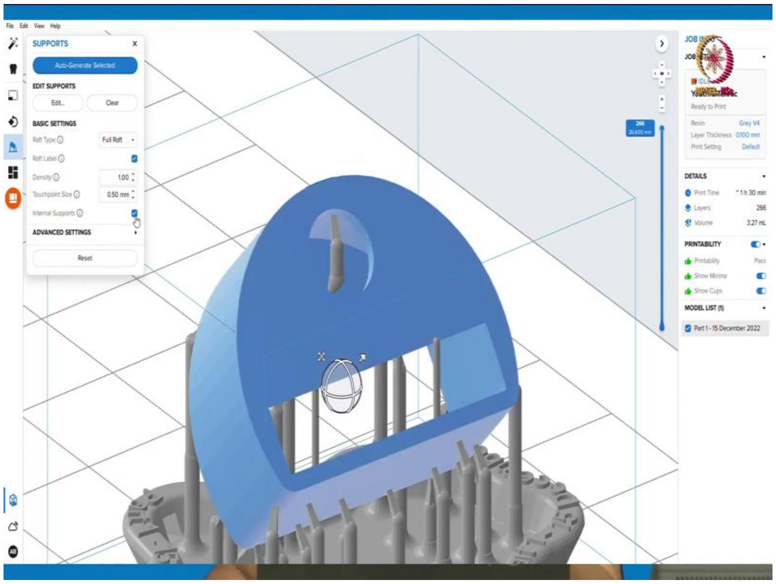

See, now it finally completes like this. Now if you see here, there are some support inside here as well, so, which may not be desirable for some application. So you can untick this internal support option. Then you will not have the internal support in the actual file. But you have to look for, you know, if there are no internal support, you need to make sure that, if there are any overhanging features, which definitely requires support and it is not being provided, there will be a red marking in that area. Right now, this model looks fine, so it should be fine to print.

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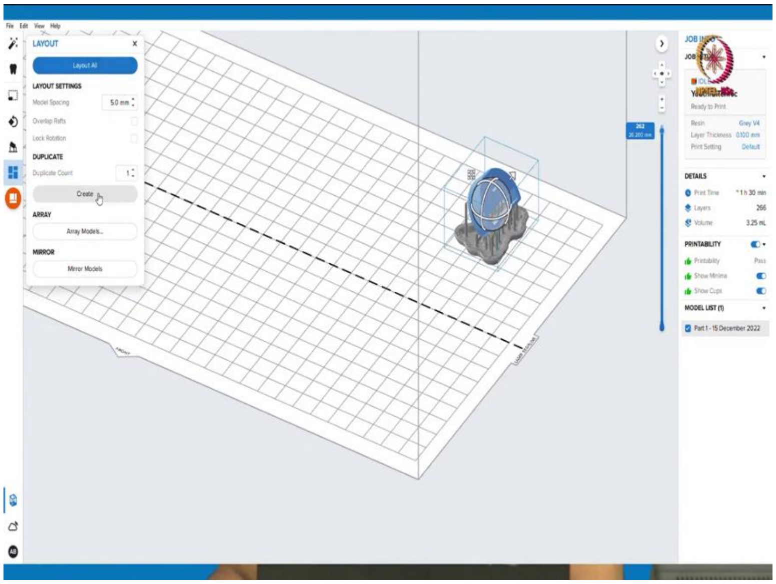

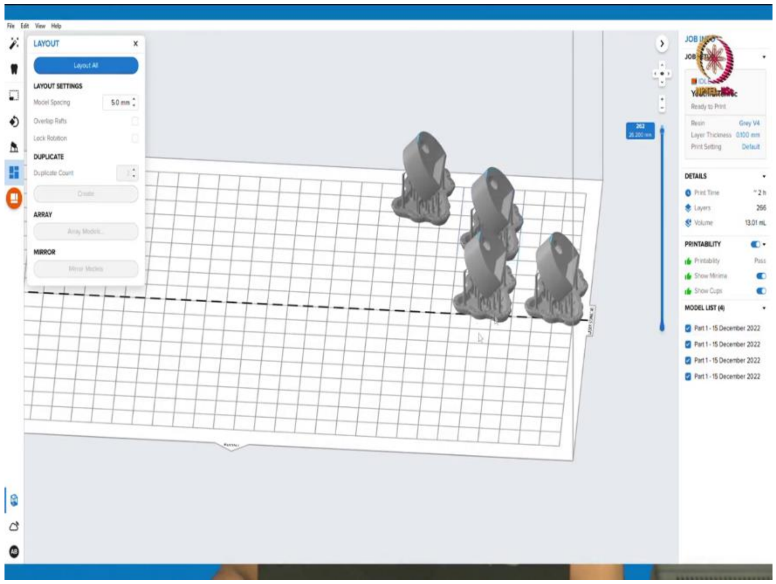

Then we can see, if we need multiple models then you can always duplicate multiple models. You need two models, you can always do that. So once you arrange one unit, you can always multiply them, but we only need one, so I am just deleting the other ones. Then even the entire model now can be moved around the way we want after creating the support structure.

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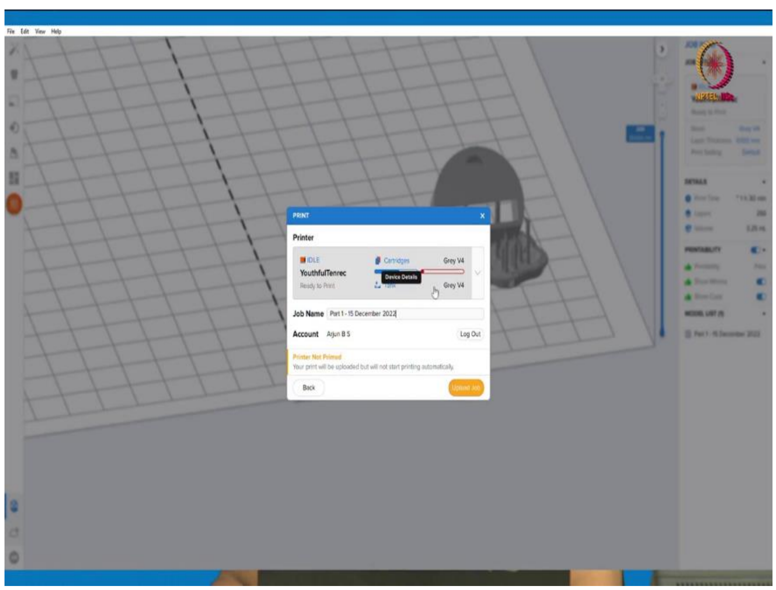

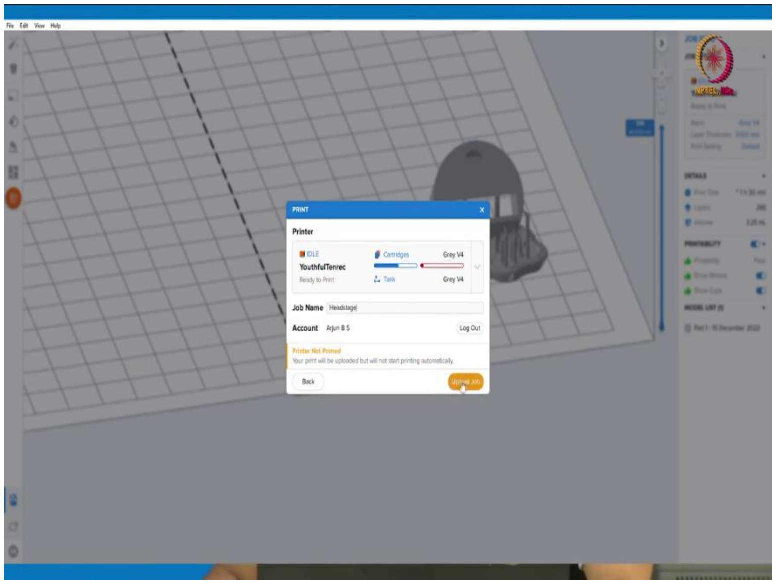

Then we select the printer, so this is the 3D printer that we have right now. So you can connect to this printer, and then you can always upload the job. So this is the job. So I will just rename it as Headstage and you can upload the job. So once you upload the job, this printer that is connected to my laptop through LAN, now the model will go there and then we will go to the place where we have kept the printer and we will do it.

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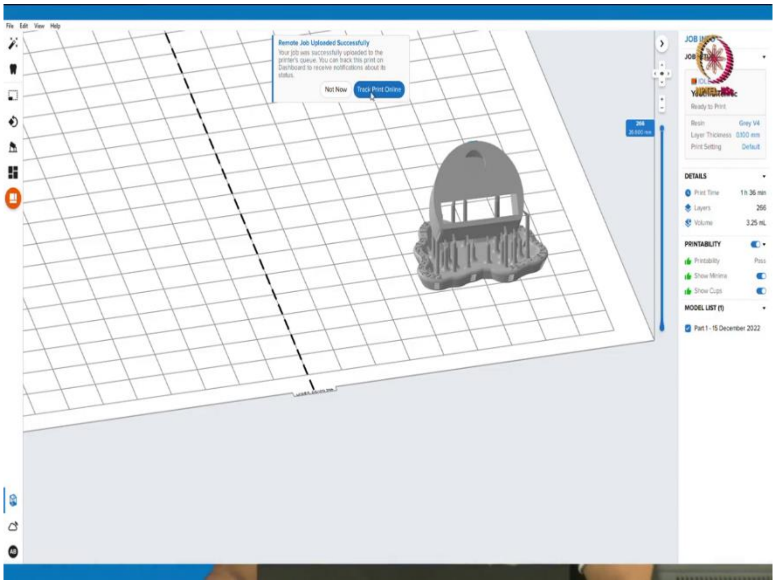

So now you can see that the remote jobs uploaded successfully. Yeah, so you can see that now the file has been uploaded. Now we can go and see the printer. Thank you.