Electronic Systems for Cancer Diagnosis
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Lecture – 58
Demonstration of Cleanroom Equipments
Rapid Prototyping using 3D Printer

Hello everyone. Welcome to the course on Electronic Systems for Cancer Diagnosis. Today let us see an important part of micro fabrication, which is 3D printing. How does it become an important part of this course study is, say we fabricate devices. So, how do you translate this into a complete device? We have seen the micro fabricated chip or the bio chip what I showed previously, but how does it become a wholesome device.

So, 3D printing is a part of rapid prototyping, where the technology is used for translation research. That is the product, the bio chip what we fabricate for instance I would also be showing you a device which was used for oral cancer detection. Now, how does all of this become into a entire product. How do you; how can the ease of use becomes easier or it is comfortable to use only when the entire product is developed. So, we are very important technology that is 3D printing is greatly helpful for us to overcome and to give device the entire a product.

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So, let me show you one example here. This is the device which was used to screen the cell samples in the oral cavity. For example, this is the oral cytology brush where the clinicians use this brush to smear through the oral cavity and extract cells, which are in the cheek or the tongue area. So, this forms the cytology brush. And there are a few disadvantages with just smearing using this brush that is, it is not really in order to have a comfortable this has to be rotated throughout the portion where the sample has to be taken.

In order to have this automated there is a device that is fabricated in our lab. So, this is the device, this outer casing has been entirely made using 3D printing. We will see into we will get into the details about the choice of materials the kind of design which has to be made and how the electronic modules can be incorporated to get a complete device like this. So, this is one part of the device on which the cytology brush sits in. And here there is a knob which will automatically rotate the brush.

So, what happens is, this is handheld device, where when you rotate this, the entire sample rotates and then the smearing happens smoothly. Let us see what goes into the device.

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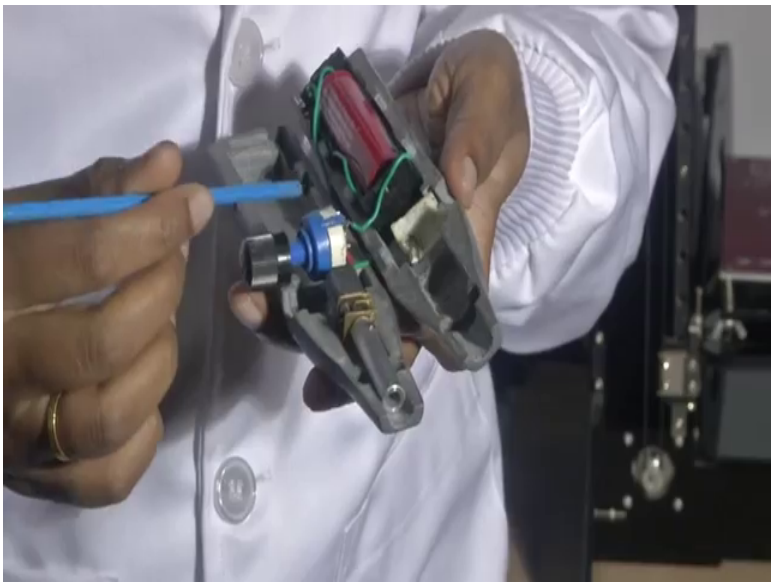

As you can see the different electronic modules here the battery in order to support the device the power what is required by the entire device, the motor which is used to rotate the cytology brush and then the other fixtures, All of this together are integrated and then

in order to have a complete device or wholesome device we have the 3D printing technology here.

So, this is rapid prototyping. In case you have various ideas or devices which have to be fabricated and how do you translate them into a device; 3D printing is what helps you in achieving this. Let us get into the details about handling the different parts of the 3D printer what goes into making the printer and what are the different software technologies what are used. So, let us get into the details of the 3D printer machine here.

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So, this is the 3D printer machine here in our lab. This here connected the thin wire if you can see is the PLA. PLA is the material which is used for 3D printing. There are really huge options regarding the choice of material for your 3D printed device and more into details will be taken to you by professor Hardik. And this is the black wire and they are available in different color combination, here the one which is right beside is the one in white.

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Now, that we have the material which goes into the tube here. So, here we have another material, which is white in color. Again the type of material is again PLA, there could be other, there could be plastic, there could be many other choices, but here what we have we are using is PLA. And each of this has a fixed cost for this material it is around cost around 1500.

So, depending upon the choice of material and the amount of material what would be required to achieve the device depending on that the choice could be made. Now that we have seen the two type of material they are available in different colors as well. So, here we have the black PLA which is connected into the tube and here is the head portion connected to this here is the extruder. So, what happens is the material here gets heated and then melts through the extruder which comes here. The melt portion is what forms the layer by layer for in order to form the entire device.

The layers get deposited one above the other. The entire mechanism starting from how software is used and then how the device can be fabricated will be explained. But let us just see what how does the 3D printer looks like and what are the different parts of the machine. Now, that we have seen the material and the extruder. Here this is a stage and the entire machine can move in all the 3 axis that is x, y and z plane. So, you can see the levers here, which facilitates the xyz motion of this stage.

Once we operate you will see how the stage moves to the home location that is the 0th position and then as the process the printing process begins and during the stage and during the entire process you will see how the stage moves down once the process gets completed. Now this space what you can see, this gives the entire volume like if this entire space is also calif there in their software, which is to indicate the volume of material and the size of the object which can be printed using this type of machine.

In case the object printed is much larger than what this machine can accommodate, you also can have it printed in different parts and then assemble them into one object. This is one such small tabletop 3D printer; however, the industrial machines are really huge and you can print a huge volume of the entire device in one stretch. And now, you can see the display here which talks about the temperature. The material here melts at around 200 degree Celsius. So, once it is set you can see at 200, how the material melts and starts depositing. Now this is the initial room temperature what is being displayed here.

And then you can see now that the is not an operation it says stepper disabled. And then the other options what is also connected here is a camera. The purpose of using a camera attached to this is the entire real time operation can be monitored and controlled while you sit in a remote location. So, this also facilitates a remote operation or remote control. This is connected through a LAN network here; however, it can also be connected through a Wi-Fi or the VPN and operated remotely. Now, that we have seen the stage the extruder and the material which are the important parts of the machine.

This is connected to the PC just beside it the software. So, the here if you can see the host it is the repetier host. So, what this does is now say we have, so you have an idea in mind and you want; to rapidly get prototype of it. What is done in the first stage is a software like the CAD is used to design the model. Once the 3D design is done, the 3D design is then converted into an STL file. The STL file is given to this the host the repetier host which I have showed in order to slice them. When it is sliced, each layer of this is what gets deposited. Now how do we know what is the slicing rate and how do you control how long does it take for the entire device to fabricate.

All of that options will be given in the software. Let us get into the details about how the slicing tool here is used. Otherwise there are other softwares there are huge and multi variants of software which will again be discussed in detail by professor Hardik in the

lecture videos. So, the CAD file assume we have a drawing and the CAD file has been sent and then the STL file is loaded into this. Let us get into the step wise procedure how do we proceed further from the STL file what we have.

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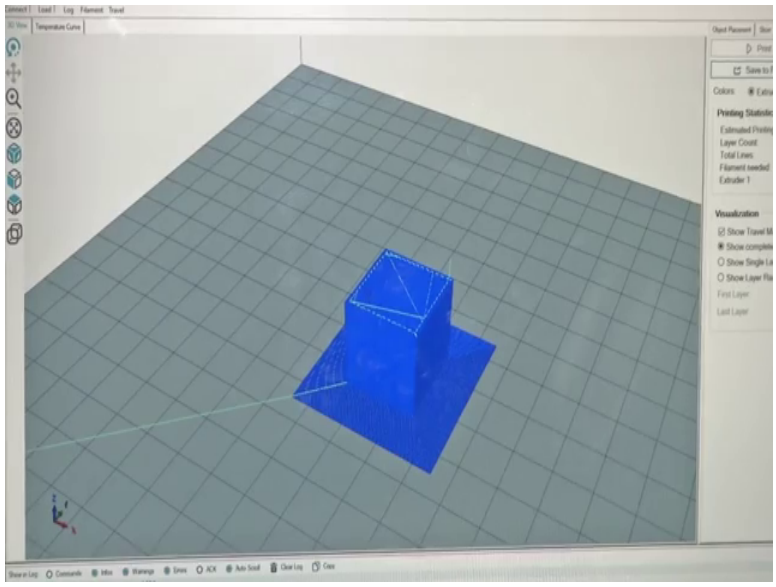

This here is the host console there, once we have the CAD file the STL file will be can be imported here. So, this is how the console looks like. Let us see the option there the plus sign which says add object is used to import the file. Now, the dot STL file as you can see on the display. So, this is the console what we have here. The repetier host console and the dot STL file what you can see here will be imported.

Now, this was the image what was imported from the CAD. So, you use any kind of software here we have used the CAD software in order to get the 3 dimensional image object. And now, once the image is imported next the option says slicer. So, the main objective of using the tool the repetier host console here is to slice the object into multiple layers.

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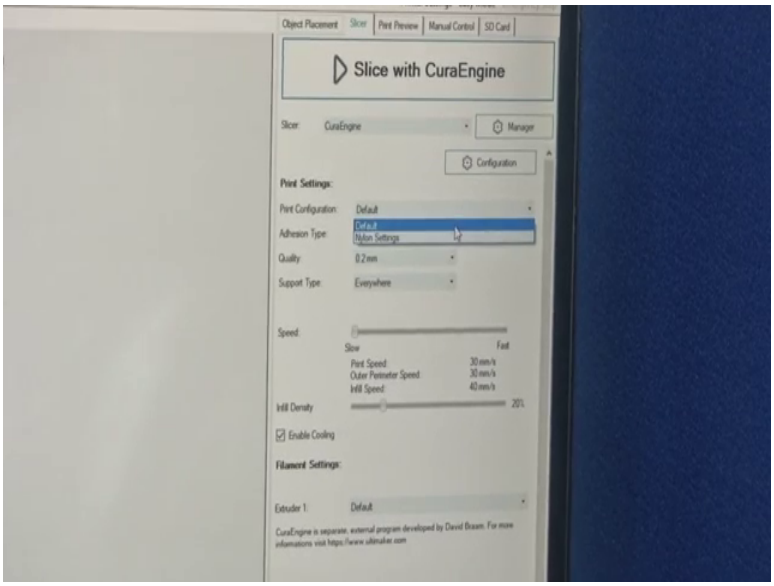

So, here the first option says print configuration which is which by here is set to default, but let us see what are the other options. So, there are other options depending on the type of material you choose you can choose the type of configuration adhesion type. So, one you will also see that once third deposition starts on the platform, it sticks to the platform.

Here this is the platform and once the material starts forming layers on this it sticks to this platform here. So, the type of adhesion also depends on the geometry and the shape of the object. Here it says brim the details are given here and the other options are raft. So, you could choose depending on your the dimensional and geometry of your object.

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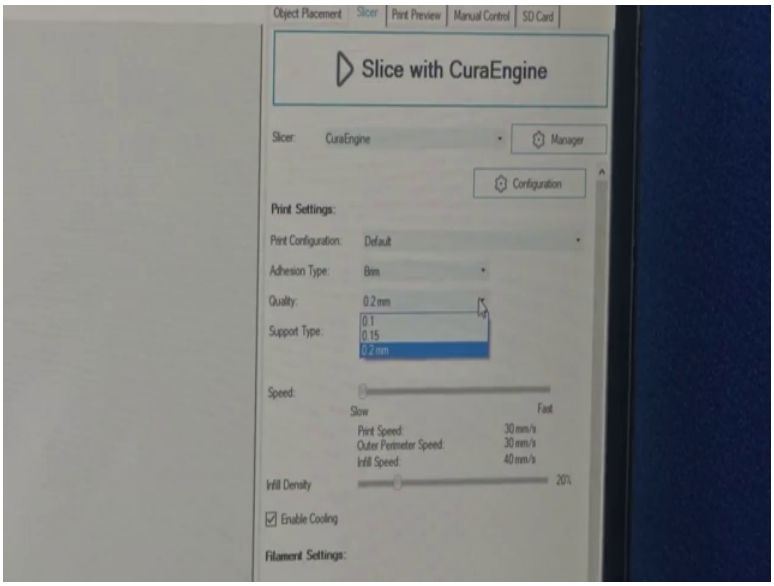

Quality here is 0.2 mm there multiple options 0.1 mm is of high precision. So, this is very small and dimension 0.1 mm layers would be formed. If you need a prototype which is required with a very high precise dimensions, then you could choose 0.1 mm. So, each of this layer will be precisely formed with very small layer width, but it takes a lot of time.

Considering time constraint and the type of device what you require if, if it requires very fine quality you can go with the type of precision here which is here in the quality. For now, we will choose 0.2 mm and the support type. Here is the speed slow to fast. Like I mentioned if you are choosing very fine precision you could choose the automatically the speed would be slow. However, if the width of each layer that gets deposited is thick then it would the entire product can be prototype very quickly relatively at a faster rate than the option where you choose a very fine quality.

Now, all of these configurations depending on your choice can be made and the type of extruder. Here we have just one extruder that is the material one type of material gets the melts and then forms layers and deposits; however, you also have options to choose multiple extruders. So, the when you have multiple there is they you could use different materials and start depositing. So, you could even use multiple color combinations and you can fabricate your entire device. In our case we have one extruder which I had shown you.

Now, that we have seen the different options under the slicer. Let us click on the slice and then you see the 3D; three-dimension object here. Now, this the green line shows the beginning of the axis the grid formation here. And the CAD file which has been imported here has a few, this is a simple cube what you can see here. And then this talks about the axis from the origin the light green line here.

Like I already mentioned the entire volume of the object what you can print can be seen in the image here. You cannot exceed the, and the length of the, volume of the entire object which can be printed. Otherwise you could choose to divide them into multiple objects and then integrate all of them to form one single object.

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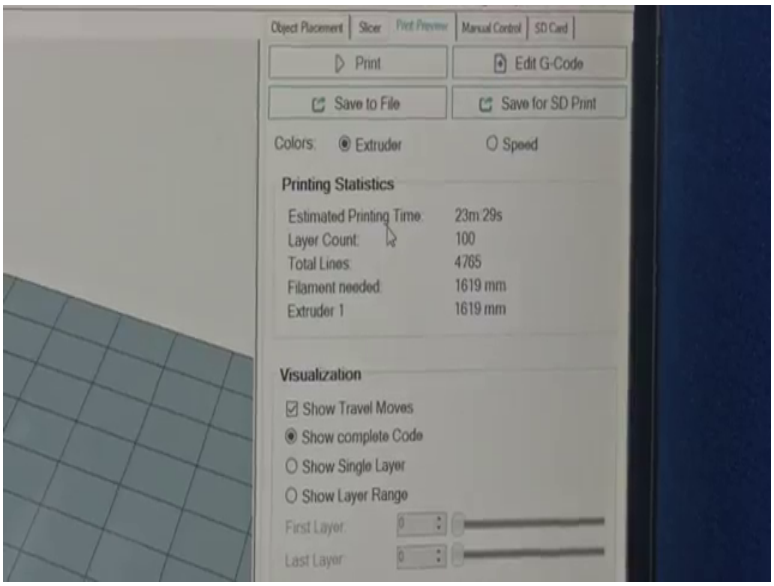

Here for the given dimensions for the object what we have here the printing statistics here shows the estimated printing time is around 23 minutes and 29 seconds. The number of layers which are required to form this object is 100. So, 100 layers, each layer of the thickness what we had given mentioned will be formed. The filament needed like here we have an entire roll, but otherwise always take care of the ama, the length of the element which will be required to print the complete object.

So, the filament needed indicates the amount of the length of the PLA or the type of material of your choice which will be required, which will be melted and then deposited in layers. So, these are the different options. Once we have configured let us save them to the file. So, here you can see the file extension says gcode. So, this when you say gcode

it is this, the now the software converts this into the language where is your firmware the hardware understands. So now, we have the gcode. Just like the assembly code the gcode converts it into a language like the zeros and ones the low level language. The g-code is the code where the firmware understands the software were the object dimensions and the other features which are configured here through the software.

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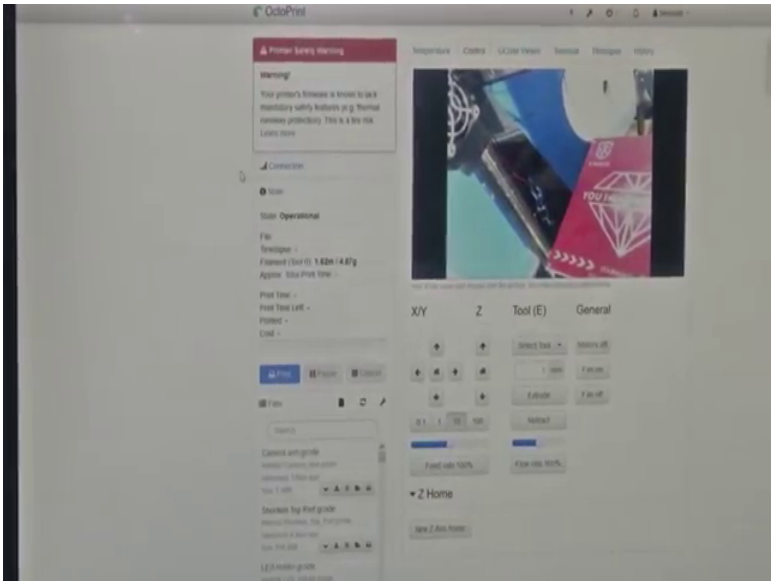

So, once we have the g code file which gets dumped into the 3D printer here this entire console. Now that we have dumped the software here, this console like I mentioned the entire operation can be remotely controlled or operated. Here as you can see the IP address, we have connected this through the to the local area network. Now that is the IP address and then the features over here, the x y and z. Here shows how you could adjust the entire the stage the x y and z plane, the home location and the other options here.

You can see how the head moves with the like you can see every time the right of the right button is pressed the extruder moves. So, you could accordingly remotely adjust your extruder instead of you your physical presence with the entire machine here this can be operated. Now, the entire thing is being replicated in the camera, which is which helps you visualize the end the machine remotely.

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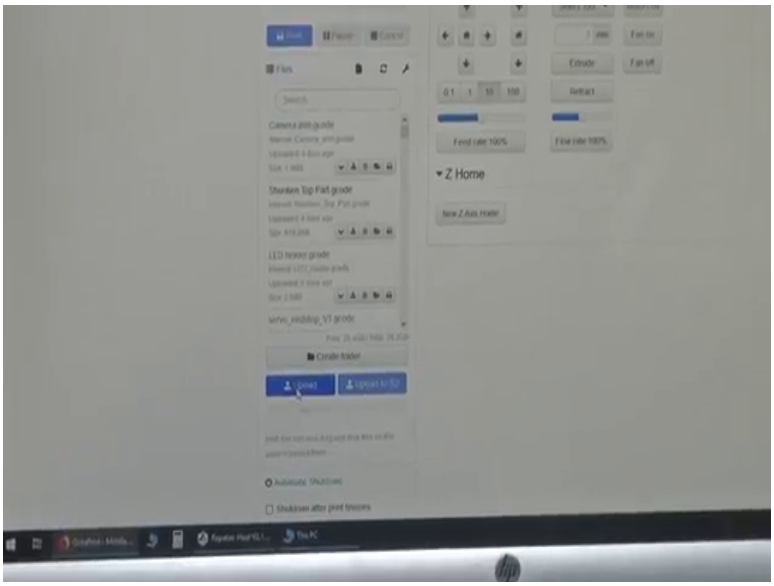

Now, that we have seen the feed rate and the other options here. Let us upload the file now. The gcode file what was for what has been done previously is being uploaded. As you can see the current details it reads the gcode, the filename which is given as test cube. The filament the PLA material what we have connected and the approximate time It also shows the cost, now this is again estimated depending on the length and the choice of material.

Now, that now is a final step where we give the print. Yeah let us focus on the machine as you can see the stage moves up. So this is the, it moves to the home location, where the once the code is done it starts from the beginning. So, this is the home location the xyz remains at 0th position. Here as you can see the display gradually there is an increase in temperature.

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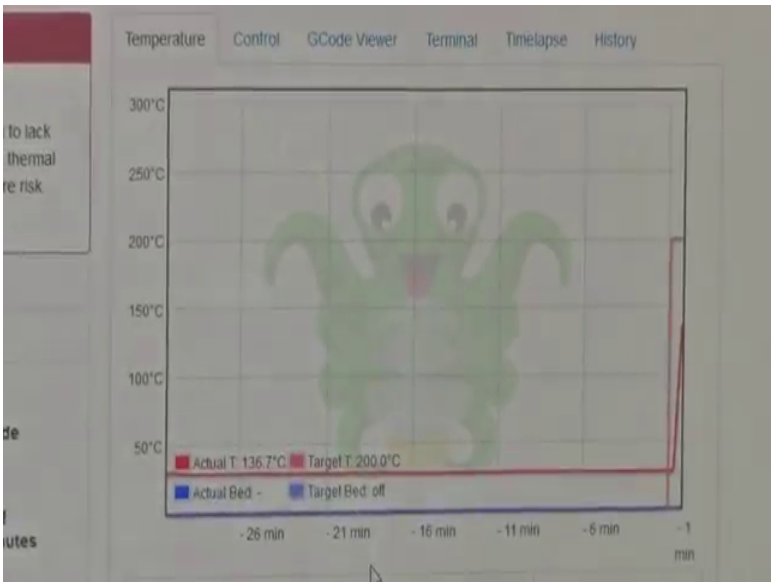

So, the initial temperature was around 28 degrees and now the temperature gradually rises and the set temperature here on the console, the actual temperature here if you see the one in red and the target temperature. So, the actual temperature is gradually increasing in order to reach the target temperature. The target here is set to 200 degree Celsius which is optimal for the type of material what we have chosen to melt.

So, the graph here indicates the gradual increase in temperature. Once it sets to 200 you will see how the printing would automatically start. Now, it has reached 197, 198 degree Celsius. Yes, now that is close to 200 degree Celsius, you can see how the extruder moves and the stage if you can see how the stage moves depending on the dimensions. So, in real time you could actually monitor how each layer of this material gets deposited.

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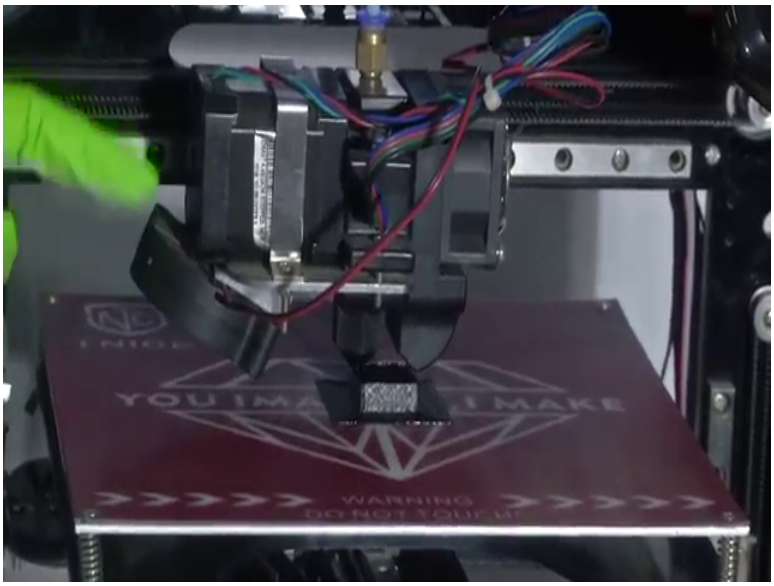

So, we have divided; so, 100 such layers will be formed with the precision of material what we have chosen and each of that deposition can be seen here where in case you have connected the system remotely. So, depending on the entire geometry your stage the firm that decides how the stage moves in the xy and z direction.

So, here on the console you can see the estimated time. So, here is just one percent the time taken for the entire the device geometry what is given in order to achieve the entire 3D object will take an estimated time of around 18 minutes as of now. So, it is just one percent complete. As you can see it is the whole object so, each layer is being deposited otherwise they are formed in the deposition can also be in the form of mesh, where enough strength; when enough strength of the material is not really a constraint then mesh like structures can be formed in order to save material.

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For example, the one in my hand is a 3D printed object. Now this is one part of a drone. So, as you can see the 4 hands here the structures which are here does not really go into they do not integrate any other system into this, but just that you could either have filling structure hole filling like this the entire material can be filled or you could even have structures like this in order to save material.

So, this is still robust, yet it saves a lot of material. So, this was one such structure which was designed and fabricated here using the 3D machine, the 3D printing machine what you see here. So, this is one layer what is formed now. So, there is 5 percent. So, this is the entire this is the process how the deposition is taking place.

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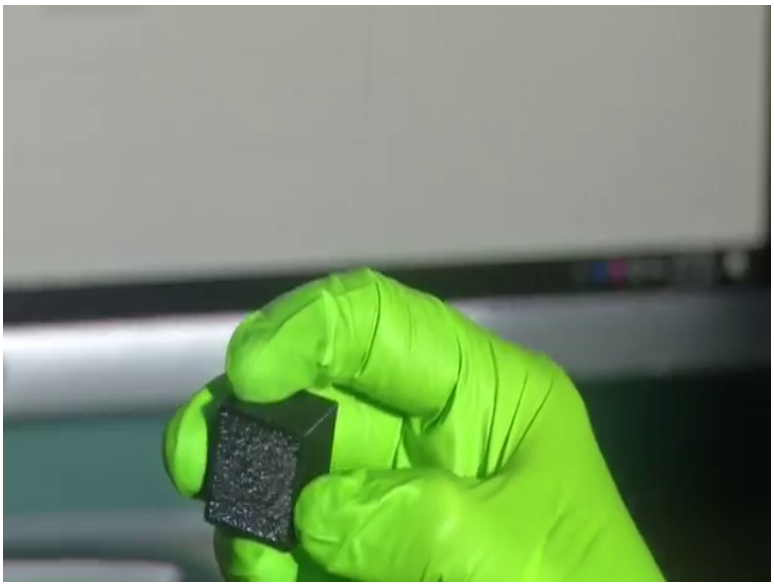

Now, the similar structure what is happening what is being printed there is in my hand here the cube. So, this is a whole cube that is the material each of this has been deposited as you can see the fine structures here. So, each of these forms like this is repeated 100 times that is 100 different layers will be repeated and a complete object like this is formed.

Yeah, like you can see the entire stage how it moves in xy and z direction. The pattern, if you can closely observe the kind of pattern so, is small rhombus a honeycomb like structure, which is being which is getting formed here. So, this saves the material, instead of depositing a solid layer, you could have patterns like this which will still give enough strength to the entire object. So, structurally it is really strong; however and also it also helps you achieve the get the entire product. This as you see the process when you closely observe you can see how the layers get deposited one above the other.

And each of this can be seen in real time without any time lapse. So, the end the precision the entire; so, you could adjust your camera in such a way that they as that layer deposition oh gets progressed, the entire stage from the beginning to the last can be clearly observed using their camera which facilitates remote monitoring. Let us say we will, let us assume the object is now complete and we would stop. So, it would actually automatically stop, but now that it takes really like 20 minutes of time. Let us say, let us

assume the product is now finished and it is and the time that is set is now completed and then what happens when we stop printing.

So, the material continuously is melted and then deposited at the extruder the point here. Now, assume the entire process has stopped and the object, if you observed how the drop dropping of the entire stage has happened. Once it is completed the software automatically ensures that the stage falls down and then you have the entire object printed here. So, this like I mentioned the adhesion the type of property which can be mentioned is there in the software. So, this is stuck to the platform which is here. Now that we have seen how it sticks to the platform and once you remove it this is this structure.

The honeycomb like structure the main idea behind using a structure like this is just to save your material. Because it really does not compromise on the strength of the entire object or the device what has been fabricated. This more or less looks exactly similar to the object what we had given in the CAD file. So, you seen the multiple layers and in case very fine precision if you really need a smooth surface across this, then you could decide on how each layer the thickness of each layer that gets deposited.

So, this was a brief introduction on how rapid prototyping can be achieved using 3D printing and how this forms this plays a major role in a micro fabrication lab. And, how you can get an entire device for the biochip what we fabricate how could you integrate them with different electronic modules and then have an entire product.

So, this was the details about how the 3D printing machine can be used the choice of material, the type of machine, the volume of the product which can be achieved, how you can split them in 2 parts and integrate the choice of software models, here we have used the CAD file to design and then the console what I had shown earlier was to do the slicing all of this are very specific to the type of products what you want to develop. However, there are multiple options you can go with variants which are they are all available you could even check for the different types of software which can be compatible based on your application.

And how all of this can be remotely controlled using the platform like the one we have used here, how you remotely this can be controlled using the LAN and then how a camera can help you visually see the different stage of the object which is being printed.

So, this is how we could leverage the use of 3D printing machine in a micro fabrication lab like ours.

Thank you.