Electronic Systems for Cancer Diagnosis
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Lecture - 45
3D-printing: Introduction and Work Flow

Hi, welcome to this module. In this module, what we will look at we will look at how 3D-printing works. Now, what exactly 3D-printing is, and what do you mean by additive manufacturing and subtractive manufacturing. How 3D-printing can be used ah to as a casing for the electronic systems, so as to see ah working prototype for understanding the cancer there, because our silt focus is on understanding or diagnosing cancer using electronic systems. But when we design fabric or fabricate chip, we have to enclose that chip inside a casing and thus 3D-printing can be extremely important ah tool to learn.

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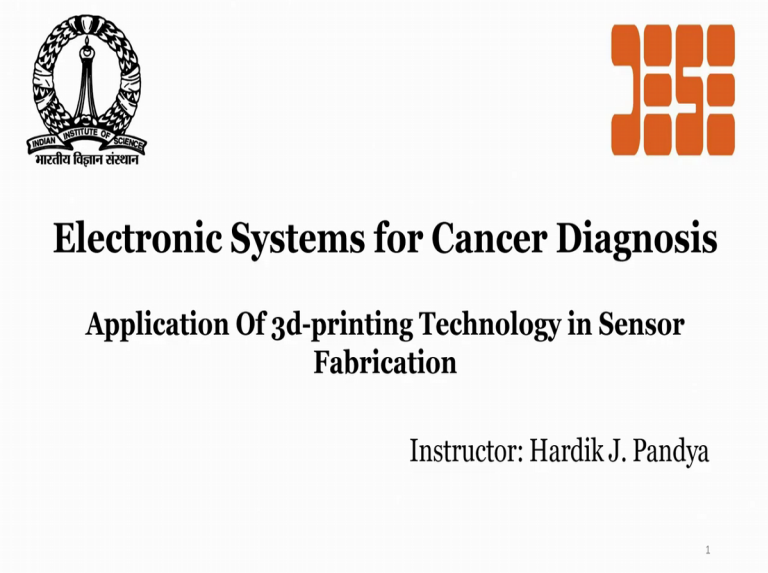

So, if you see here the, these today's focuses on application of 3D-printing technology in sensor fabrication.

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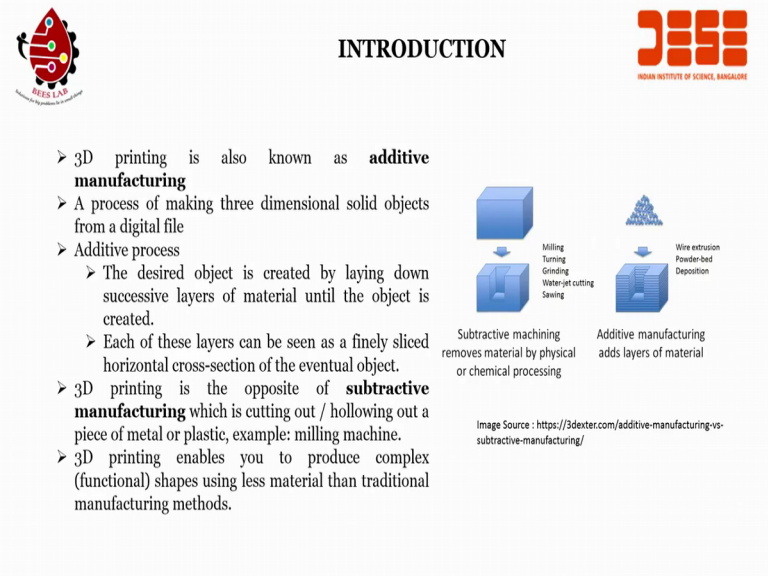

So, if you start with the introduction, the 3D-printing is defined also known as the additive manufacturing process, process for making three-dimensional solid objects from a digital file. So, what exactly additive manufacturing means right. So, if you see here in this two particular case shown in the schematic, theadd, additive manufacturing, subtractive manufacturing shown here. In subtractive manufacture, if you take a block, if you take a block and you remove a part of block by physical or chemical processing either, it can be milling, it can be turning, it can be grinding, it can be water jet cutting, it can be sawing right. So, in any way when you are cutting the things from block, it is a subtracting that material, so subtractive manufacturing.

For adding a material to a block, for example, right over here right adding manufacturing additive manufacturing adds layers of material, and that layer is deposited using the wire extrusion power bed deposition technique right, which we will also see as a 3D manufacturing process. So, when you add the material, additive manufacturing, when you remove the material subtractive manufacturing to in a very easy way to understand. So, what additive processes the desired object is created by laying down successive layers of material until the objectives created.

So, in, in this particular process, where we talk about additive manufacturing, the object is created by laying down successive materials as you can see layer by, layer in horizontal way, a layer by layer can be used in vertical way. So, we will see the

advantages of those some sometime later, but right now each of these layers can be seen as finely sliced horizontal cross section. In this particular schematic, it can be seen as a finely sliced horizontal cross section right, while repainting is the opposite of subtractive manufacturing, where the cutting or hollowing out a piece of metal or plastic, example milling or machining I just explained you.

Now, the 3D-printing enables, you to provide or produce complex functional shapes using less material than traditional manufacturing methods. That is the added advantage of 3D-printing over traditional manufacturing processes, where the material conception is less for making complex ah shapes.

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So, this is ah about the 3D, 3D printing introduction. Now, let us quickly see in a video, how exactly 3D-printing works, and it is a actually it is a the introduction to additive manufacturing.

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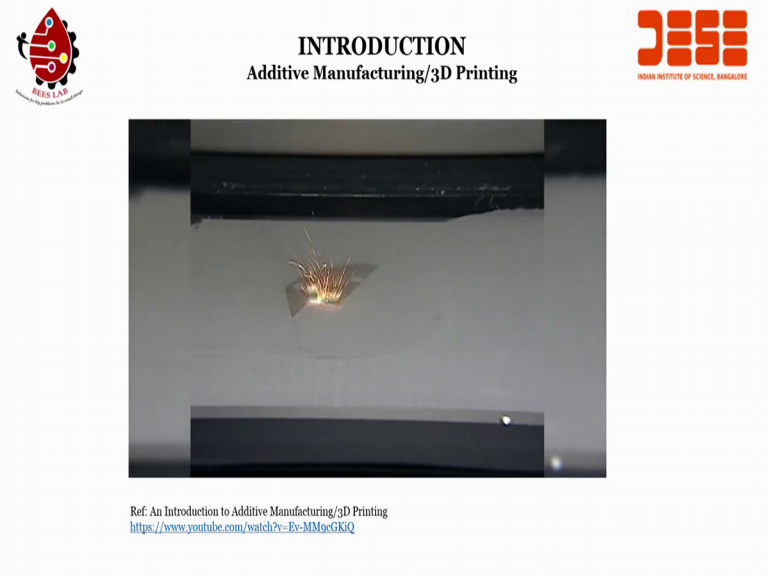

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So, let me play the video, and then we go to the next slide. Additive manufacturing in 3D-printing are general terms encompassing of variety of system, which is to create three-dimensional physical parts and models directly from digital data. These systems primarily manufactured using a layer by layer or additive means of construction.

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Additive technologies are based on the solid modeling portion of Computer Aided Design or CAD. Additive systems use this solid modeling data to build in extremely then cross sectional layers.

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This permits manufacture of intricate and complex shapes and surfaces much more simpler than by conventional methods.

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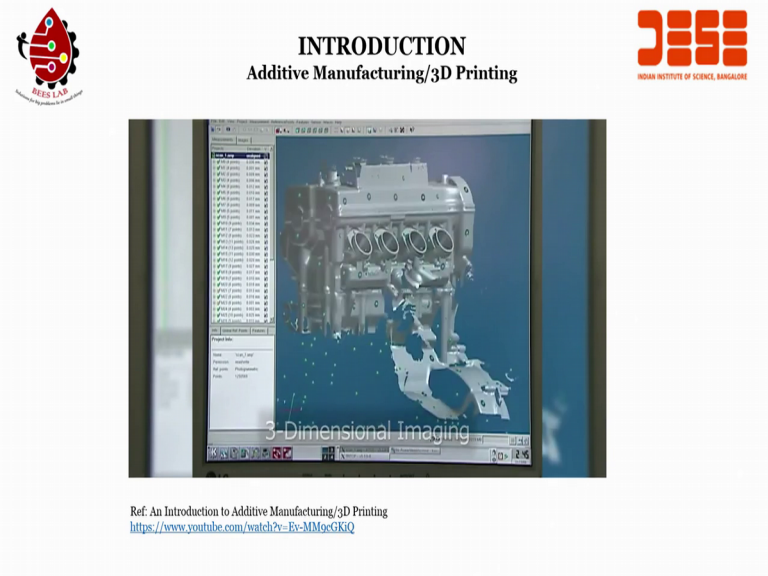

Pieces can also rebuilt from three-dimensional imaging data generated by 3D scanning or medical imaging devices.

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Materials used in additive manufacturing are broadly classified as either liquid.

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Powder.

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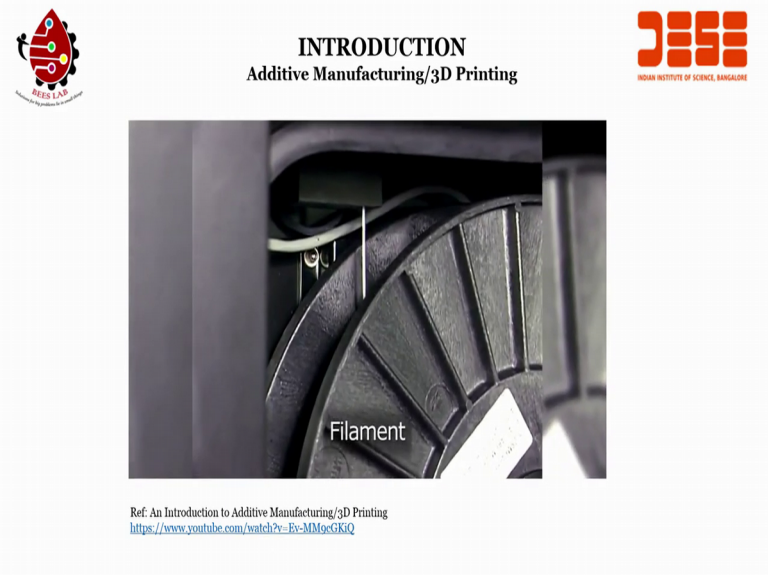

Filament.

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Or Sheets.

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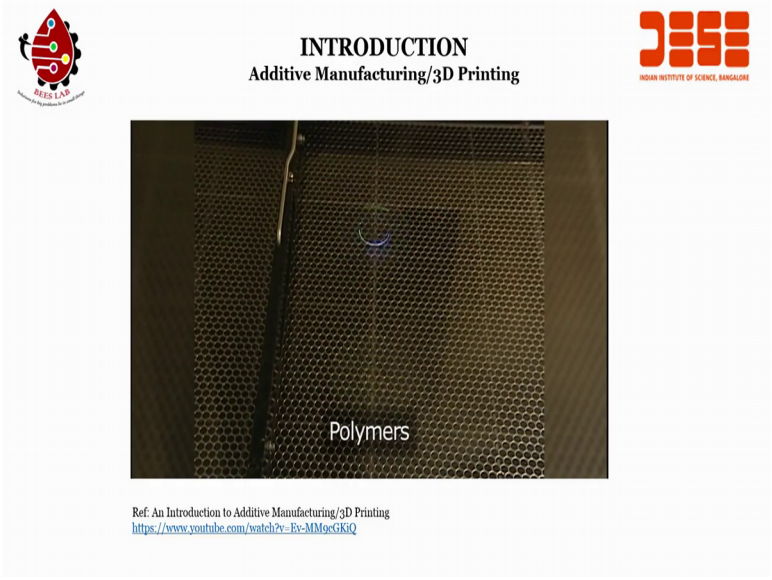

Polymers are the primary type of materials used in additive manufacturing.

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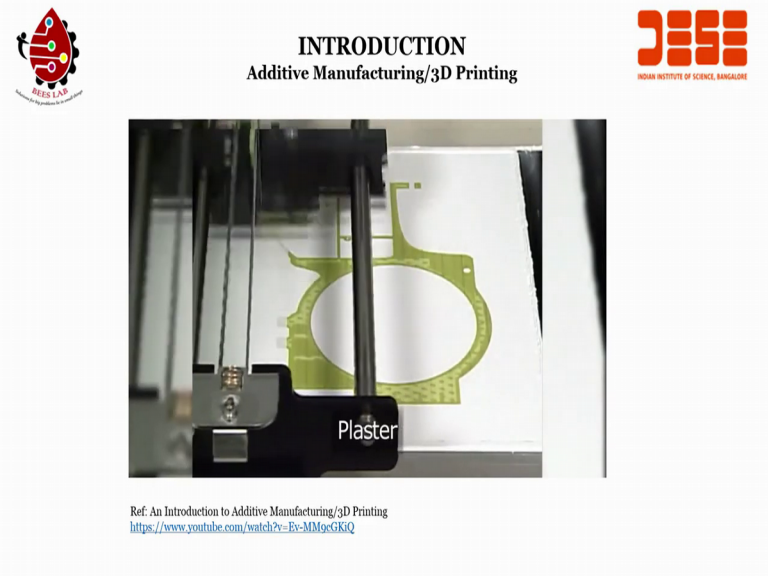

But systems are available to build with plaster.

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Metals.

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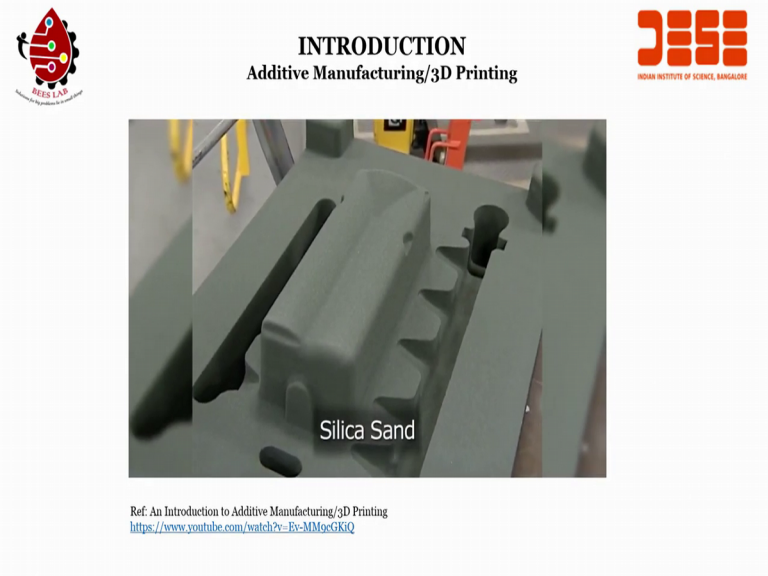

Silica Sand.

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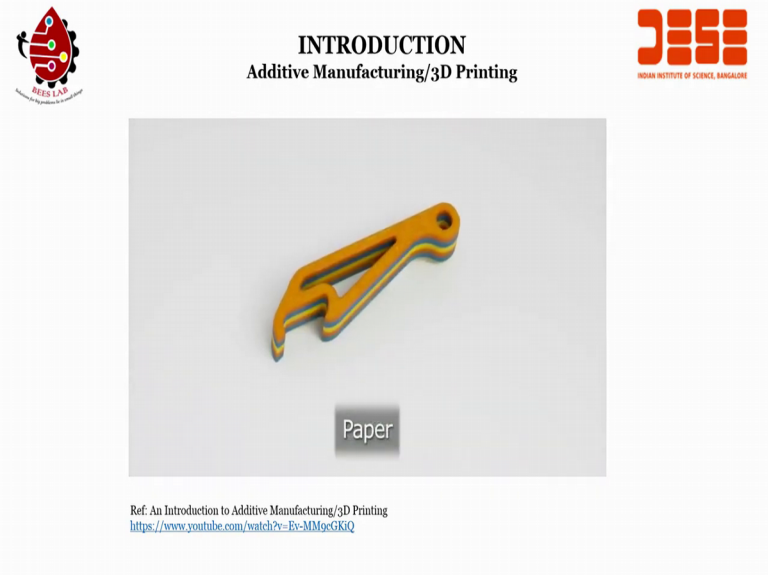

Paper.

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Ceramics.

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And even biological materials.

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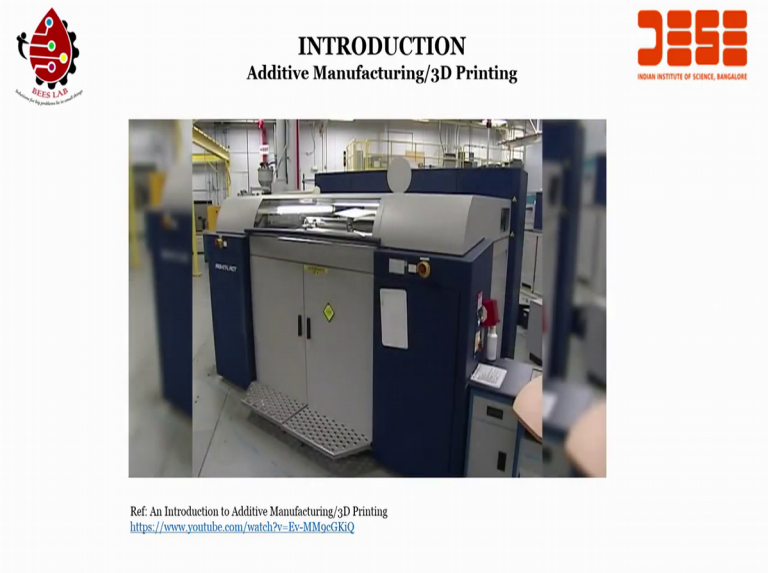

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Additive systems range from large industrial machines suitable for shop floor and laboratory environments.

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To smaller desktop printers used by consumers.

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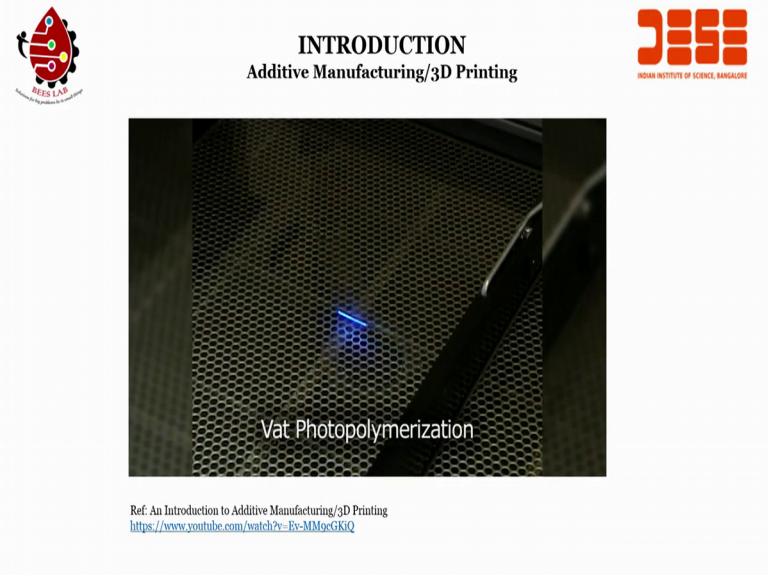

These systems utilize numerous technologies with the most popular including Vat polymerization.

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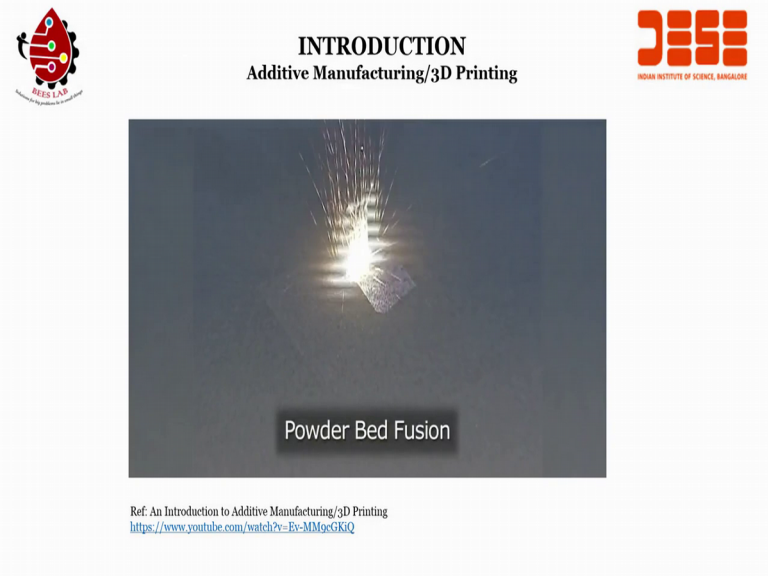

Powder bed fusion.

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Material Extrusion.

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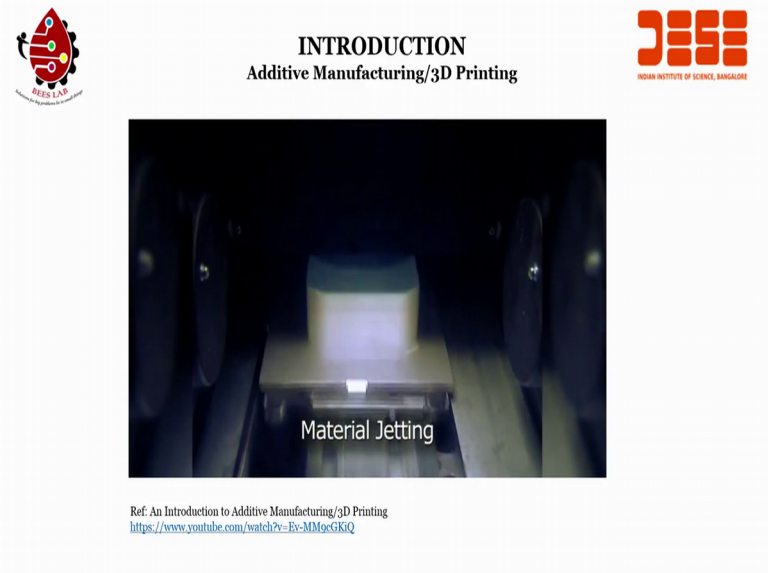

And Material Jetting.

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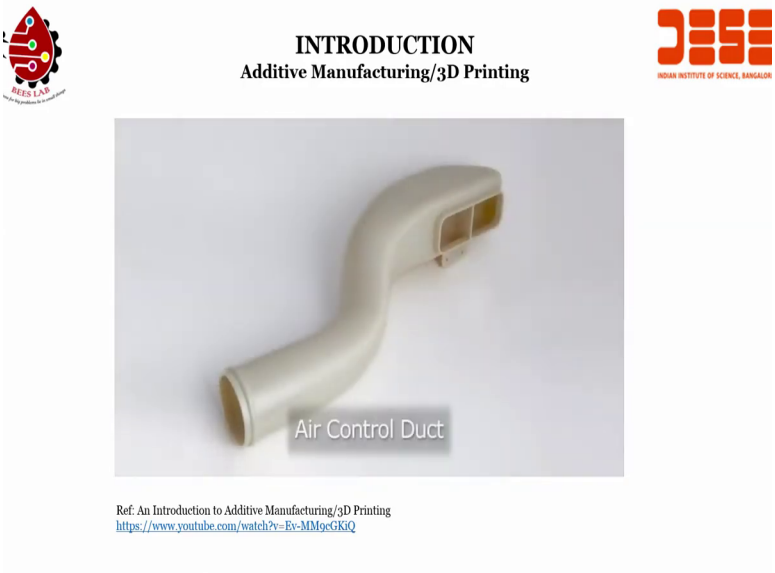

Although additive technologies have been in use for decades, new advancements and applications are being developed every day in the fields of aerospace.

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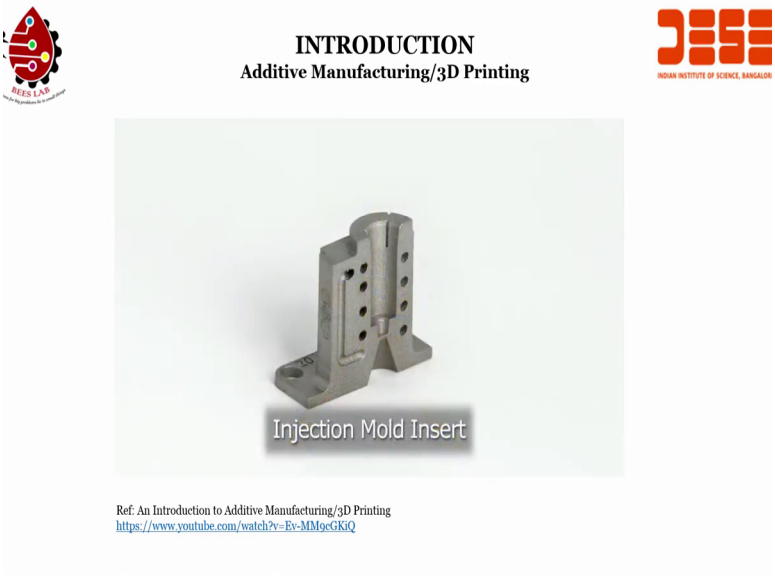

Industrial machines in tooling.

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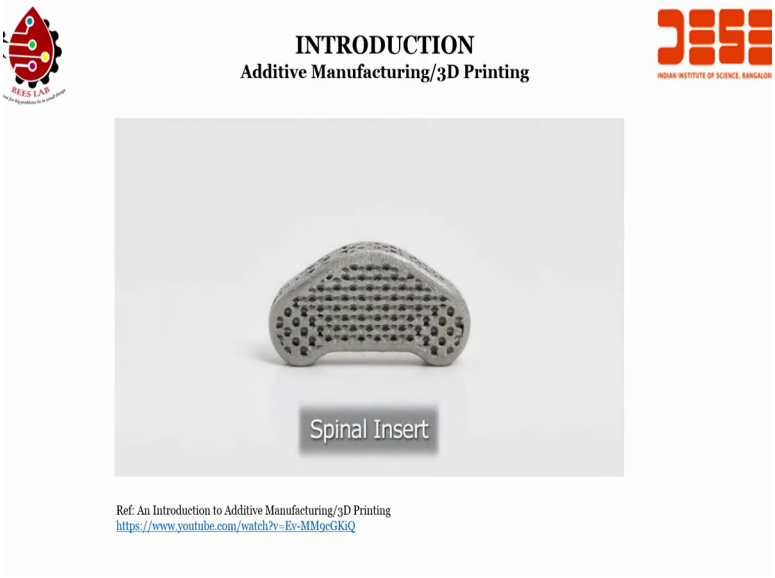

Medical implants.

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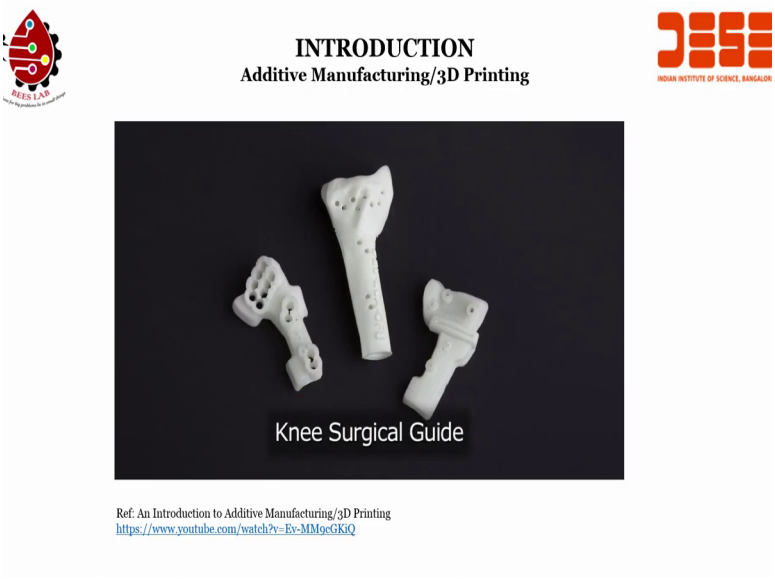

Surgical guides.

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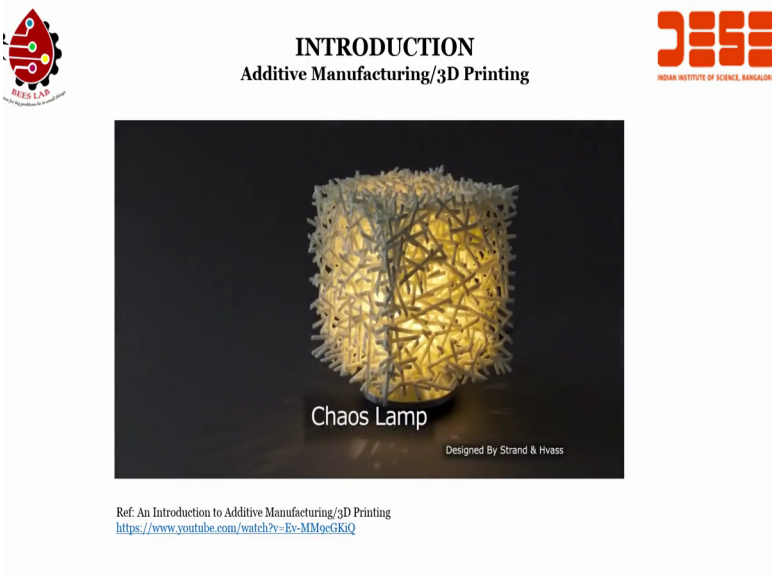

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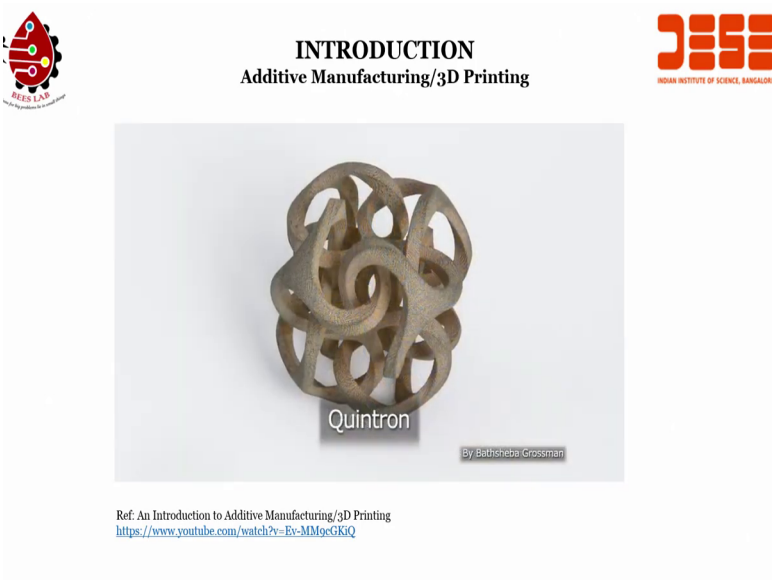

Home decor art and so much more..

So, as you have seen in the video right, ah how the additive manufacturing works.

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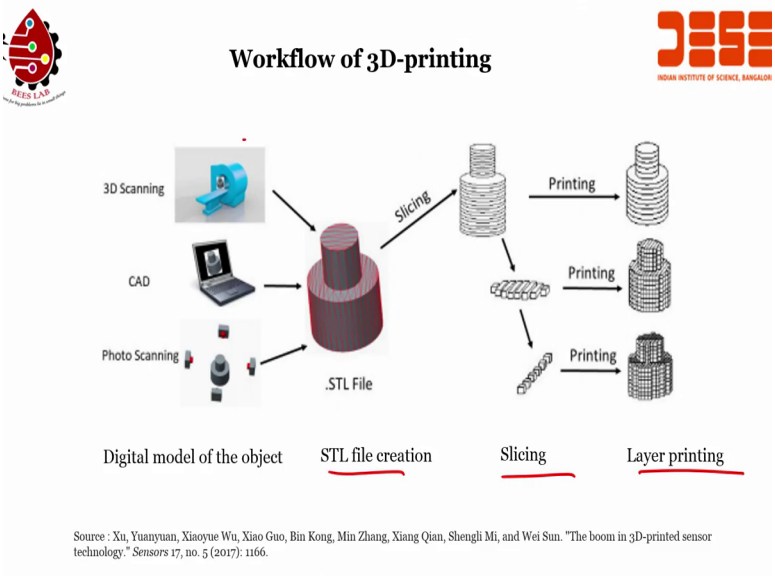

Let us also understand what is a workflow of 3D-printing. If you see here in the slide, what do you see that you have, if you want to have then there are multiple ways of you know generating STL file, either you use photo scanning technique or you use CAD tool or you can use 3D scanning. When you one of this digital model of a object is there, you

can convert it to STL file, and then you can use as a for a slicer for the printing ah you know a , in the finally, there is a layer printing.

So, it goes from digital mode to STL file to slicing and finally, layer printing. These are the steps to that when one is to follow. And you can see details about this particular slicing process and designing the 3D printed part in a paper by Zoe Chile, which is on the boom in the 3D printed sensor technology. So, if you read this article further, you will understand ah the workflow of 3D-printing in detail.

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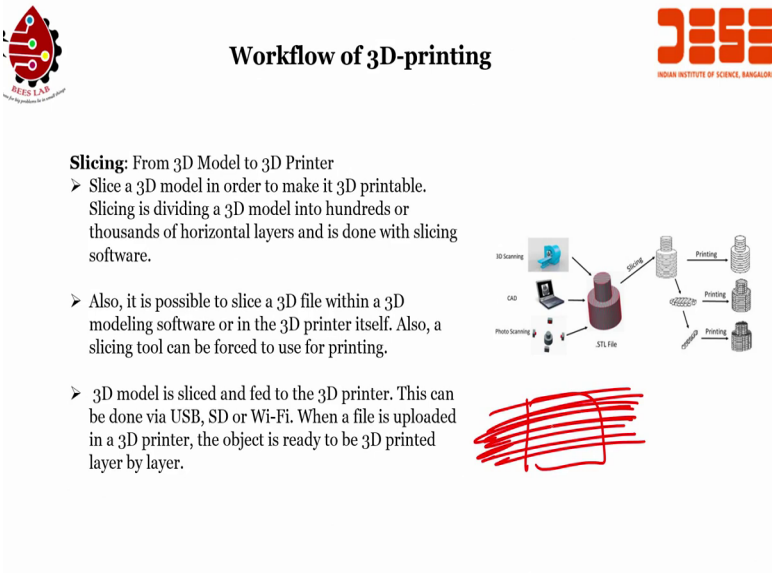

It is always good habit to read as many articles as you can, because that is how you improve your knowledge and understand what is going on in the area of science and research. So, now, with continuing the workflow of 3D-printing, what exactly slicing? Slicing is from 3D model to 3D printer. Slice is a 3D model in order to make it a 3D printable version. Now, the slicing in particular is divided or is a process where it or you can say the slicing is dividing 3D model into hundreds or thousands of horizontal layers and is done with slicing software.

So, you take a do you take a block, and then you keep on slicing it right as many layers as you can get right and that is done by the software. Also it is possible to slice a 3D file with a 3D modeling software or in the 3D printer itself. Also, a slicing tool can be forced to use for 3D-printing. 3D model is sliced and fed to 3D printer. This can be done via

USB, SD card or Wi-Fi. When a file is uploaded in the 3D printer, the object is ready to be 3D printed layer by layer.

This whole process how it happens is in this particular text.

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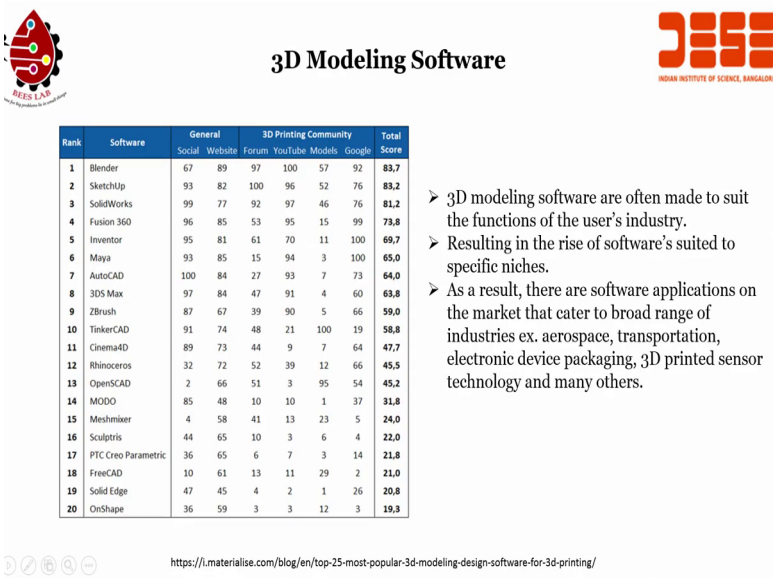

Rank	Software	General		3D Printing Community				Total Score
		Social	Website	Forum	YouTube	Models	Google	
1	Blender	67	89	97	100	57	92	83,7
2	SketchUp	93	82	100	96	52	76	83,2
3	SolidWorks	99	77	92	97	46	76	81,2
4	Fusion 360	96	85	53	95	15	99	73,8
5	Inventor	95	81	61	70	11	100	69,7
6	Maya	93	85	15	94	3	100	65,0
7	AutoCAD	100	84	27	93	7	73	64,0
8	3DS Max	97	84	47	91	4	60	63,8
9	ZBrush	87	67	39	90	5	66	59,0
10	TinkerCAD	91	74	48	21	100	19	58,8
11	Cinema4D	89	73	44	9	7	64	47,7
12	Rhinoceros	32	72	52	39	12	66	45,5
13	OpenSCAD	2	66	51	3	95	54	45,2
14	MODO	85	48	10	10	1	37	31,8
15	Meshmixer	4	58	41	13	23	5	24,0
16	Sculptris	44	65	10	3	6	4	22,0
17	PTC Creo Parametric	36	65	6	7	3	14	21,8
18	FreeCAD	10	61	13	11	29	2	21,0
19	Solid Edge	47	45	4	2	1	26	20,8
20	OnShape	36	59	3	3	12	3	19,3

If we go to the next slide, what we see is there are several 3D model, 3D modeling software. 3D modeling software are often made to suit the functions of the user industry. Resulting in the rise of software suited to specific niches or niche. We, we see that as a result there are software applications on the market that cater to broad range of applications for industries, where we can take a example of aerospace industry, or you can say a packaging industry for electronics, or transportation industry, it can be a sensor printing technology using 3D-printing and so on and so forth. While when you talk about different software that are available for the 3D modeling, those are listed here, where the blender is the blender is ranked 1 by with a total score of 83.

Now, how you can get this total score? This is again based on the vocalized-noise] social website forum YouTube models, Google and so from social forum website forum, YouTube models, Google everything in general the total score comes to 83.7. Where you go down you can have different other software for example, Sketchup, SolidWorks, Fusion, Inventor, Maya, AutoCAD, 3DS Max, ZBrush right and TinkerCAD. So, lot of softwares you are already using, the most common software, we generally we use are the first three, where you are using a Blender or the Sketchup or SolidWorks. Now if you if

you have a mechanical engineering friend, you can ask those people they generally rely on solid works or Pro E to design this as a software of course, lot of things, you need to worry on is on how to convert that particular file to a STL file. So, you can use the existing software for 3D mode modeling.

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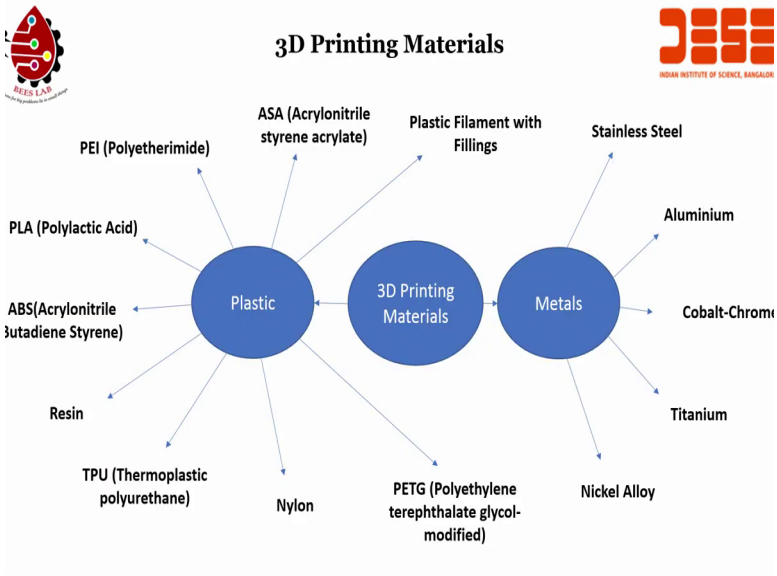

Now, if I go further what I see is that when you talk about 3D-printing materials see one is to convert your design using a particular software, but then what kind of material you want as a 3D-printing, on the 3D-printing product. So, for that, there are several materials available. When you talk about plastic then you can have setting from thermoplastic to Resin to ABS to PLA right to PEI, ASA, Plastic Filament with Fillings, lot of materials a including Nylon, PTG right. So, in terms of polymer or plastic, there are lot of options. When you talk about metals, there is a 3D-printing metal based 3D printer with where, where it prints the metal. And what kind of metals we can print? We can pin nickel, we can print Titanium, we can print cobalt, we can print Aluminum, and we can print Stainless Steel.

So, excuse me, when you talk about 3D-printing materials it can be either plastic or it can be metals. Now, as you see that in plastic there are several options available; same way in metal also there are several options available. The3D printer that uses plastic as a material is cheaper compared to the one which prints the metal.

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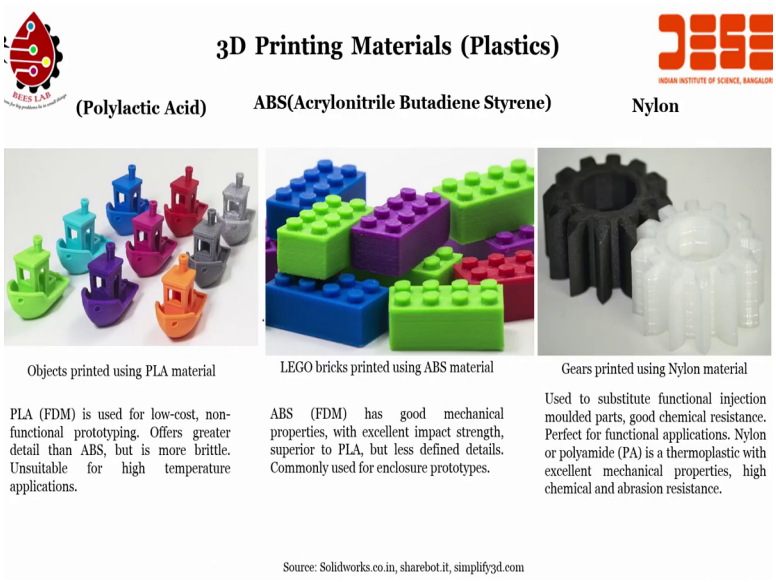

So, let us understand further. When you talk about plastics right, so you can see here objects printed using a PLA material beautiful boat. So, this is a PLA is used for low cost non-functional prototyping. Offers greater details than ABS, but it is more brittle, so unsuitable for high temperature applications.

So, it is better than ABS for a certain reason, how about from in terms of detailing, but is more brittle and also not useful for high temperature. While if you understand the ABS material, then ABS has a good mechanical properties with excellent impact strength, superior to PLA, but less defined details. Commonly used for enclosure prototypes. If you see this one is as a less defined details compared to this finishing product. The advantage here is that in case of ABS, we have a higher mechanical, you know properties and thus the strength.

Now, people also have started using the gears using Nylon materials. So, you, you use to substitute functional injection mold parts, good chemical resistance, advantage of Nylon is it can be a good chemical resistance, perfect for functional applications. Nylon or polyamide which is PA with the thermoplastic with excellent mechanical properties, high chemical and abrasion resistance. And thus if you use nylon over for when, when there are the when you have to use this material further in any kind of chemical or you know whether is a more mechanical properties that you need to study, for example, you are applying lot of force or you are stretching the material, then compared to ABS and PLA,

nylon can work as an alternative material. Again you can understand this, the details from the source that is given in this particular link.

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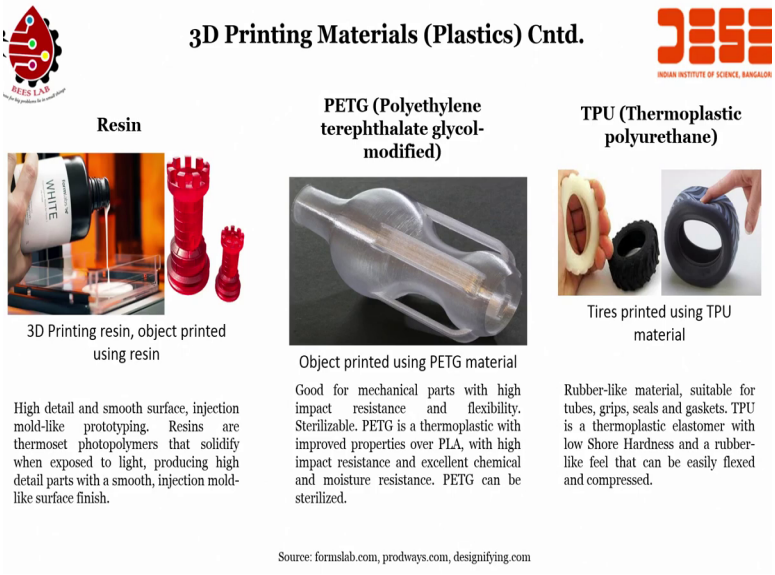

So, further if I go I see that other materials are Resin, a PETG with which stands for Polyethylene terephthalate glycol modified and as well as we have TPU, which is Thermoplastic polyurethane. So, the 3D-printing resin object printed using resin, we see here right, and here the high detail and smooth surface, injection mold-like prototyping. So, it is really good, because injection molding is where you can exactly get the working prototype. Not only working prototype, it looks like a product. Resins are thermo state photo polymer say solidifies solidify when exposed to light producing high detail paths with smooth injection more like surface finish.

So, if you use resin you will have a better surface finish. But if you go for object printed using PETG material, what you see is that it has a good mechanical parts with high impact resistance and flexibility. It can be sterilizable, and thus it can be used further is a robots that are used for operating a patient. PETG is a thermoplastic with improved properties over PLA with high impact resistant excellent, chemical and moisture resistance. Also the biggest advantage of using PETG is that it can be sterilized. Thus it can be used in the medical domain.

If you move to TPU, then rubber like material mostly suitable for tubes, grips, seals and gaskets. TPU is a thermoplastic elastomer with low shore hardness and a rubber-like feel

that can be easily flexed and compressed. Thus you can see here image where you can press it and it, it is compressible and thus it can be more like for a gripper. For example, I will give you an example where you want to pick a object, and if you make a hand using rubber right the, the way to pick a object becomes easier or you can say a gripper you can design with the help of TPU.

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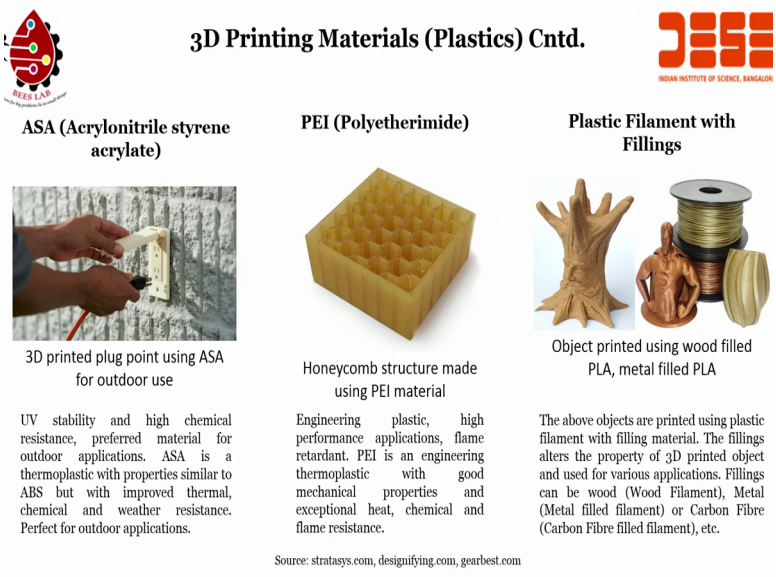

So, if I go to the next one, I still have some more materials to show it to you. The first one is ASA, which stands for Acrylonitrile styrene acrylate. And this is UV stability and has a high chemical resistance. It is preferred material for outdoor applications. You can right over see here, so this is one of the application. ASA is thermo plastic with property similar to ABS, but with improved thermal chemical and whether resistance, perfect for outdoor applications. When we talk about PEI, which is Polyetherimide, you can use it as an engineering plastic, high performance application,. It can be used as a flame retardant. PEI is a engineering thermoplastic with good mechanical properties and exceptional heat, chemical and flame resistance all right. So, if you want to use in, in certain application, where you, your temperature is little bit higher or there is a lot of chemical reaction, then you can use this particular material called PEI.

While the Plastic Filament with Fillings,. That is object printer using wood field PLA metal field PLA. And here the above objects are printed using plastic filament with filling materials. The filling alters the properties of 3D printed objects and useful various

applications. Filling can be wood, can be metal or can be carbon fiber. Soo that is the, that is how the plastic filament can be used as a filling.

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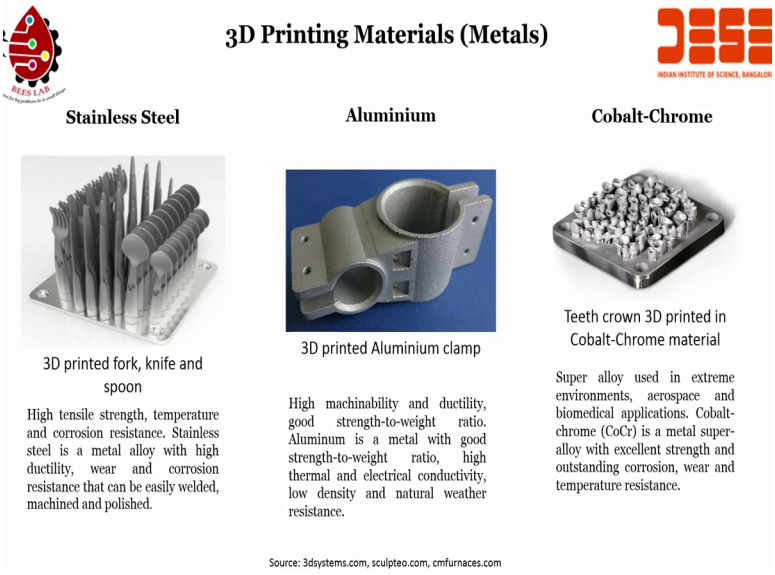

Further, when we go for other materials, now, this all the above where all plastic right. But if we talk about metals and 3D-printing materials using metals, then first one is that comes to our mind is Stainless Steel. And with Stainless Steel, we can print fork, knife and spoon, high tensile strength , temperature and corrosion resistance. You know that stainless steel is a metal alloy with high ductility where and corrosion resistance there can be easily welded machined and polished. So, this is about steel.

When you talk about Aluminium, the advantage of Aluminium generally is its lighter weight. So, high mechanical ability and ductility, good strength-to-weight ratio, Aluminium is a metal with a good strength-to-weight, ratio high thermal and electrical conductivity, low density and natural weather resistance. So, that is a, this is a 3D printed aluminium clamp, while you talk about Cobalt-Chrome, then what you see here is that Teeth crown 3D printed in Cobalt-Chrome material is right shown in the schematic by super alloy used in extreme environments, aerospace and biomedical applications ah this material is used. Cobalt-Chrome also called as CoCr is a metal super alloy with excellent strength and outstanding corrosion, wear and temperature resistance. So, depending on a type of metal that you choose the application also changes.

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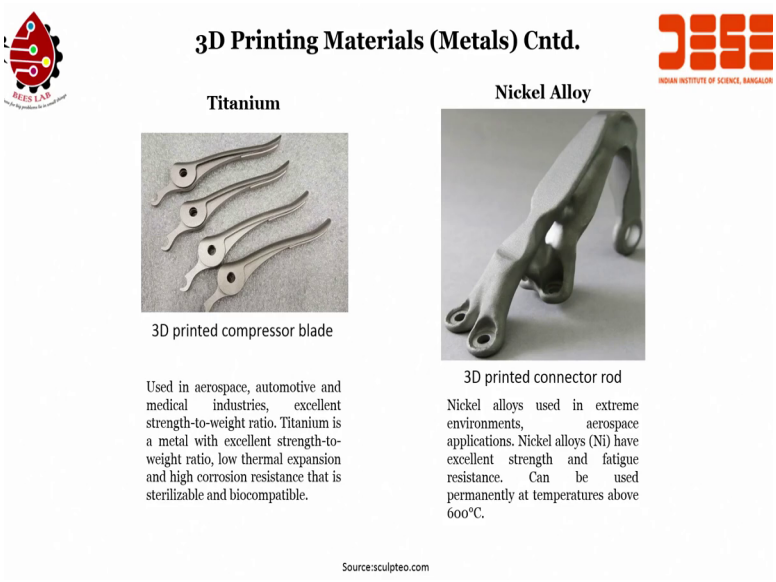

Finally, if we talk about Titanium and nickel, you, you are extremely familiar, I am hoping that you are extremely familiar with Titanium, where you can make lot of it can be used in lot of application including aerospace, automotive, medical industries, excellent strength-to-weight ratio is the advantage of Titanium. Titanium is a metal with excellence strength-to-weight ratio, lower thermal expansion, higher corrosion resistance. Also it is sterilizable and it is a biocompatible material that is can be used as an implant. So, for the implant we can use Titanium.

If you go to the next one, which is Nickel Alloy, what you find is this is a 3D printer connected rod. Nickel Alloys, is used in extreme environments. The examples are aerospace applications. Nickel alloys have excellent strength and fatigue resistance. Can be used permanently at temperatures about 600 degree Centigrade. That is the advantage of nickel alloy.

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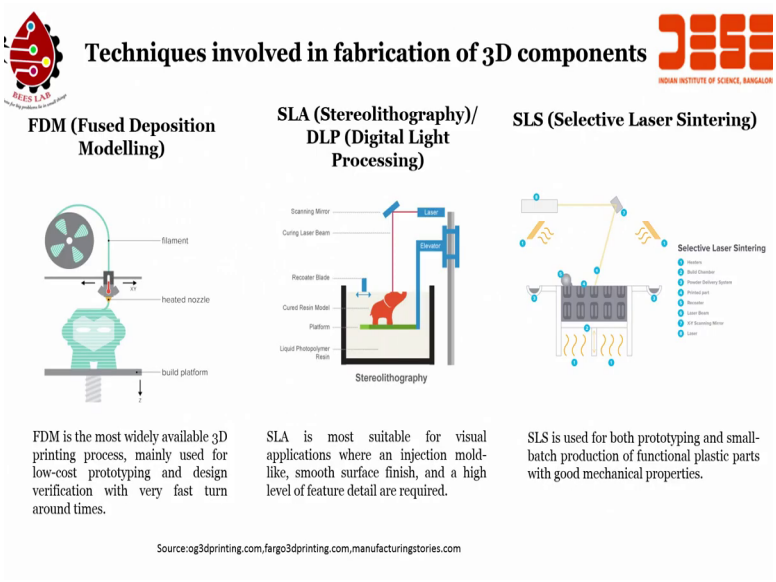

Thus these are the metals that are generally used for 3D-printing right.

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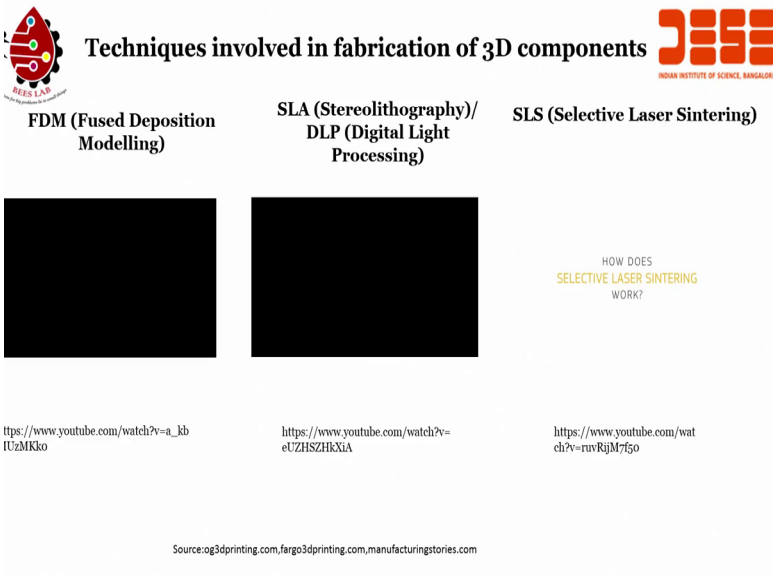

But if I talk about the ah techniques involved in fabrication 3D components, then you will see that how 3D how different techniques can be used for, for printing 3D for, for pinning different materials using 3D printer. So, we will talk about techniques in the next module. For this module let us just end it right over here that what are the different materials that are used in 3D-printing technology, what exactly 3D-printing is, what is

additive manufacturing what is subtractive manufacturing ok. So, in the next module, we will see the techniques for 3D-printing.

Till then you take care, I will see you next class. Bye.