A Dental Technician's Guide to 3D Printing

Whip Mix

DENTAL TECHNOLOGY SOLUTIONS

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Introduction: 3D Printing in Today's Dental Lab

When combined with intraoral or benchtop digital scanners, 3D printers enable the laboratory to create 3-dimensional products from a digital file quickly and efficiently. It is considered a rapid technology because it eliminates several laborious steps used in conventional dental technology techniques and it takes nearly the same amount of time to produce one object or many. Therefore, its efficiency is enhanced by printing multiple units and relying upon the economies of scale.

The objects the printer can produce for the laboratory include models (casts), crown and bridge resin burnout patterns for casting or pressing ceramics, temporary crowns, surgical guides, splints, partial denture framework patterns, custom impression trays, and more. With proper settings, it can consistently produce resin products of stunning accuracy and detail, especially when compared with subtractive milling technology. Conventional dental technology is subject to a high degree of inaccuracy, costly labor, and even more expensive materials. Making these objects not only requires a considerable amount of time, but also a highly skilled technician with a complete understanding of the process. Perhaps the greatest limitation with hand-made restorations is the lack of consistent results. It is for these and a multitude of other reasons that additive technology is a welcome addition and enhancement to dental technology.

3D printing increases the quality of the products we make, while reducing manufacturing costs. This enables the laboratory to attain a rapid ROI (return-on-investment).

With 3D Printing, reduced material costs, increased productivity, low manufacturing and labor costs = FAST ROI

CHAPTER TWO

Types of 3D Printing

Understanding Types of 3D Printers

The 3D Printing process divides the digital object is into horizontal slices desired layer thickness (affects surface and build time) and then prints sequential sliced layers of material until the complete object is formed. There are 3 main types of 3D printing: Extrusion, Granular/Powder based and Light Polymerization.

Extrusion 3D Printing

Fused Filament Fabrication (FFF) - is the process of building an object from the bottom up by heating and ejecting a thermoplastic filament layer by layer. This print style is most commonly viewed as the hobbyist's printer due to its simple form and low entry level cost. FFF can be used for creating prototypes, tools, toys, simple plastic jewelry, etc. Unfortunately, this style of printer generally does not print in a high enough accuracy and resolution for the dental industry.

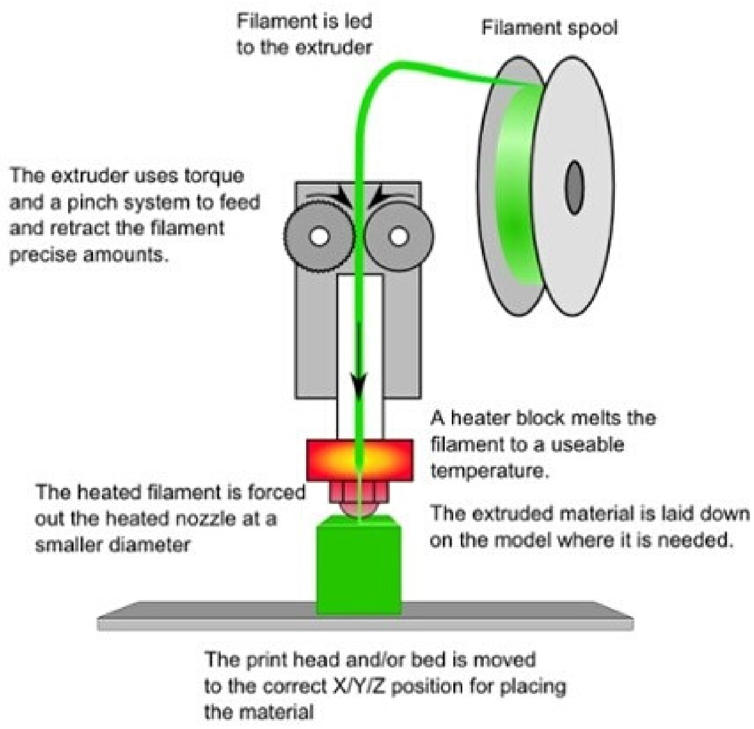


Photo Credit: http://reprap.org/wiki/Fused_filament_fabrication

Understanding Types of 3D Printers

Inkjet 3D Printing - Inkjet 3D printing is also known as PolyJet Printing, MemJet, and MultiJet Printing. This process comes from the technique of inkjet printing, but instead of printing ink the head will extrude the material to be printed. The main advantage with this 3D print style is that more than one material can be printed at a time, usually consisting of a support like material and a main material that will form the object. This style of printing is already being used within the dental industry for creating dental models and castable dental restorations. The disadvantages with inkjet printing are: wasted expenses due to the mandatory support material, difficult post processing, slower print time, and high initial purchase price.

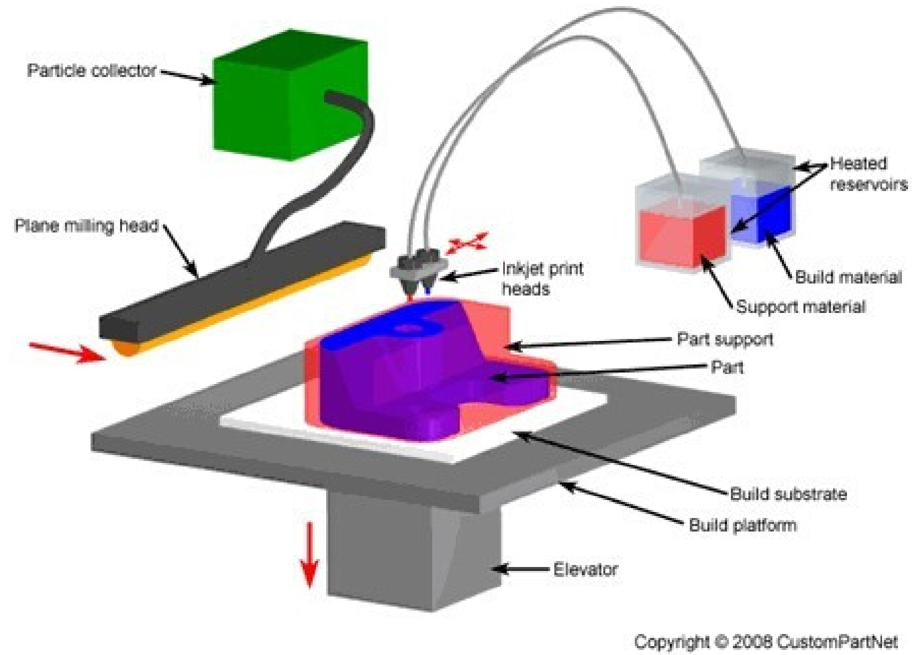


Photo Credit: http://www.custompartnet.com/wu/inl-jet-printing

Understanding Types of 3D Printers

Granular/ Powder Based 3D Printing

BinderJet - is the process of taking a powder base material and using a liquid binder to solidify the object layer by layer. This process can also infuse color into the liquid binder to provide a multicolored object. However, Binderjet printing produces a lower resolution print, which is not ideal for dental restorations, but it is ideal for creating scale prototypes and medical models.

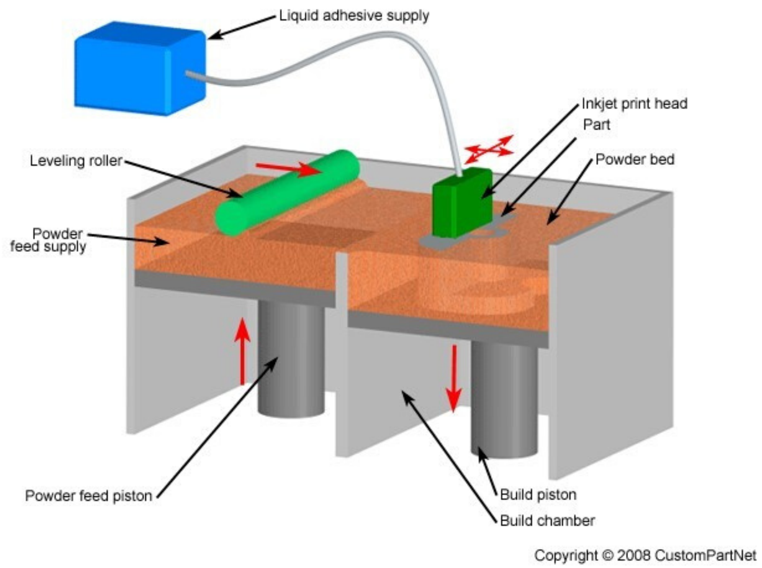


Photo Credit: http://custompartnet.com/wu/3d-printing

Selective Laser Sintering (SLS) - This process is quite similar to BinderJet in the idea of using multiple layers of powder to create the object. However, the difference being Selective Laser Sintering uses a laser to sinter and bind the material. The materials used in this type of printing can range between plastics, glass, to all types of metal. SLS is currently being used in a wide range of industries from medical, automotive, aerospace and the dental industry. Within the dental industry, SLS is being used for RPD frameworks, bridge frameworks, single copings, and even full contour restorations.

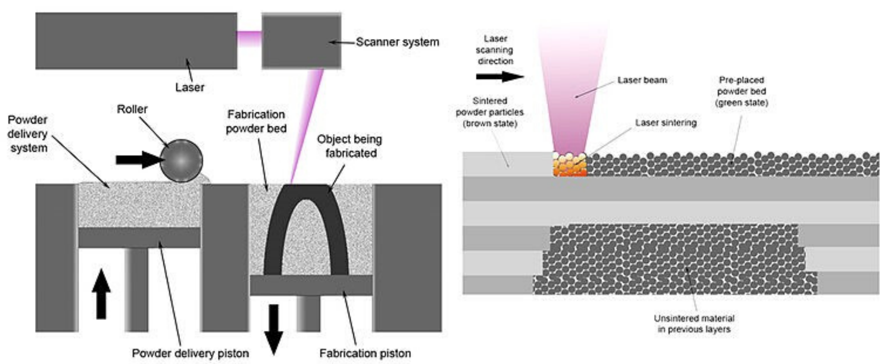


Photo Credit: http://custompartnet.com/wu/3d-printing

Understanding Types of 3D Printers

Light Polymerization 3D Printing

Stereolithography (SLA) - is the process of turning a photopolymer liquid resin into a solid object. SLA is actually the first form of 3D printing invented and it still widely used today. Within an SLA printer you will find 3 key components: a build plate, a resin tray, and a laser. During the build process the build plate will lower into the resin tray, where the liquid resin is placed, at this time the laser turns on and will draw/cure all theaspects of that current layer. After the current layer is completed, the build plate will move away from the laser the exact distance of 1-layer thickness and then the next layer will begin to be cured. SLA is a great and accurate way to 3D print any objects and it can be used in all industries due to the wide range of materials that can be used. Unfortunately, SLA printing is not a fast method for 3D Printing in a production setting.

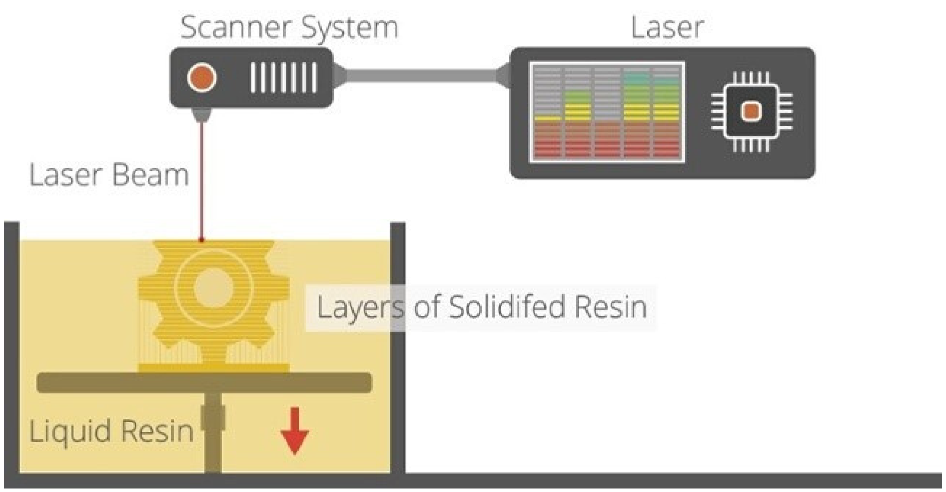
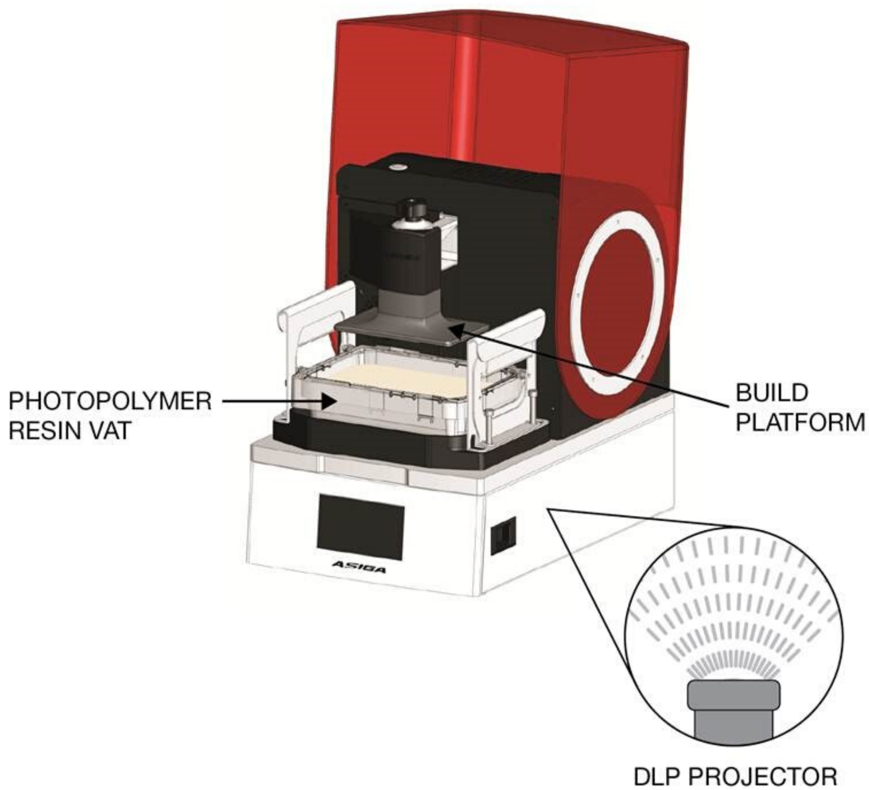


Photo Credit: http://3dprintingindustry.com/3d-printing-basics-free-beginners-guide/processes/

Understanding Types of 3D Printers

Digital Light Processing (DLP) - DLP 3D printing is a new form of SLA printing, in which the process and theory is almost identical, but Instead of a using a laser to cure the photopolymer resin, this form uses a DLP projector. This projector technology gives DLP 3D printing a huge advantage over standard SLA, as DLP 3D printing can print and cure a single layer across the total build plate in just a couple seconds, making it significantly faster. Another advantage that DLP has over SLA, and most other forms of 3d printing, is that it wastes very little material, which helps keep the cost per print to bare minimum. DLP printing is currently being utilized in the dental industry for creating Models from digital impressions, castable restorations, surgical guides, splints, and even short-term temporaries. Due to the speed and accuracy of DLP printing, this form of 3D printing will continue to grow in the dental industry.



Open vs. Closed 3D Printers

What’s the Difference and Why Should I care?

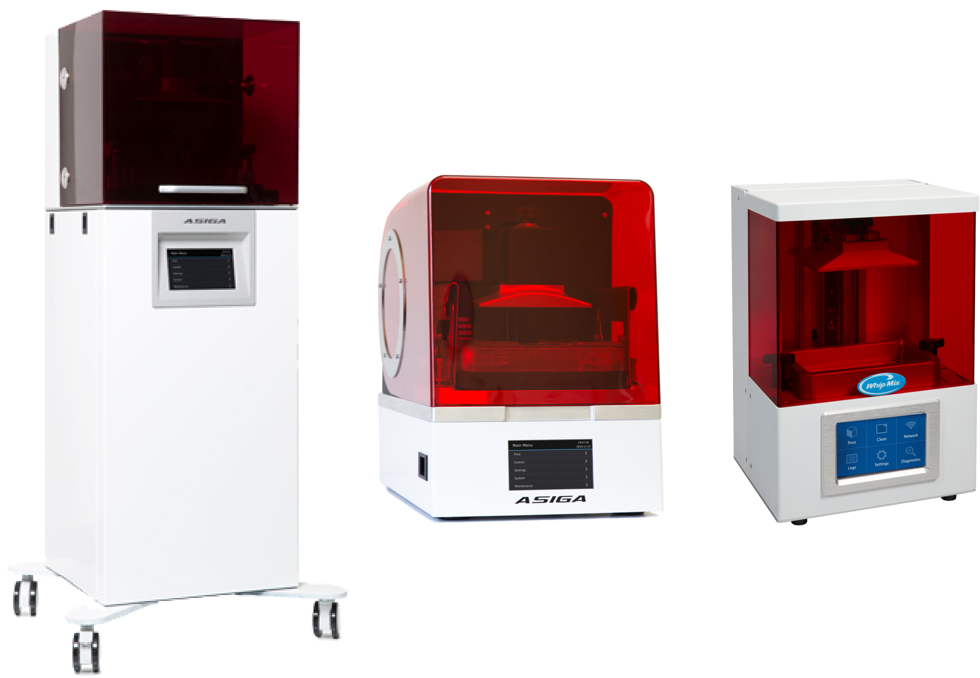
The dental lab industry is very aware of open versus closed systems when it comes to scanners and milling systems, but did you know this also applies to 3D printers?

With a closed 3D printer system, you can only use the printer manufacturer's resins. 3D Systems and Stratasys are two examples of manufacturers that developed their systems to only print with their proprietary resins. There are other systems on the market that utilize the DLP printing capabilities that could be open, but do not publish material files or allow software access to change the print parameters. This is essentially a closed system.

Whip Mix needed to find out what the industry wants in a 3D printing system. The answer was clear. Most labs want an open system. Open material 3D printers allow you to print any suitable material from any supplier. If a resin can be UV cured at 385 or 405 nanometers, it can be printed in an open source printer. This type of printer gives a lab material options.

Whip Mix is continually developing and manufacturing its own line of resins for open material systems which are compatible with these types of 3D printers.

Whip Mix Corporation is the original North American distributor of Asiga 3D printers, (open source, of course). Additionally, Whip Mix also offers an open source VeriBuild LCD printer. As the full digital circle from clinic to lab and back is completed, this line of printers gives labs the material freedom they are used to having.



CHAPTER THREE

Choosing a 3D Printer

Which 3D Printer is Right for My Lab?

Which one is right for my lab?

By digitizing your dental laboratory's workflow, you will be able produce your crowns and bridges more efficiently and accurately for your doctors that are using an intraoral scanner (IOS). Your 3D printer will also allow you to print models in-house for those cases. In addition, 3D printing can be used for the fabrication of custom impression trays, surgical guides, splints, and patterns for partial frameworks.

According to an article by 3D Printing Industry, Scott Dunham, senior business analyst at SmarTech, stated that the dental industry "will be the most radically changed by 3D printing in the next decade when we look at where it's at today versus what it will look like thanks to 3D in the next five to ten years. Part of that is because the methods used today for fabrication of dental restorations are surprisingly primitive."

We took those words to heart and considered the future – as well as the present – when determining which 3D printer best represented Whip Mix and its vision of tomorrow.

The company that we chose several years ago is Asiga. Their printers satisfy all of the requirements for printing dental objects today and were competitively priced. Their Max UV printer covers everyone, from entry-level users to high-volume manufacturing.

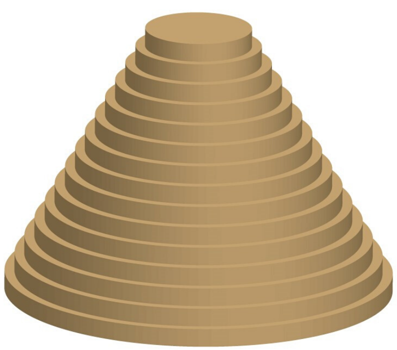
Need more volume? The Asiga PRO 4K printer features the latest DLP imaging technology offering the largest build platform in Asiga's line. It's available in both 65µm (176.5 x 99 x 200mm build volume) and 80µm (217 x 122 x 200mm build volume) resolution versions.

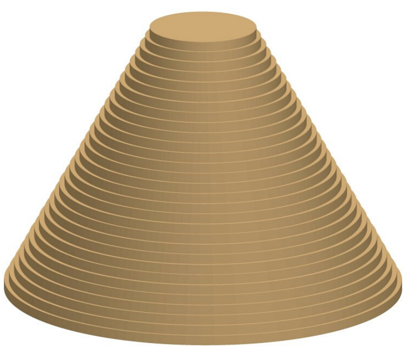
The Whip Mix VeriBuild LCD Printer fits most lab's needs at a fraction of the cost - not only today, but in the future as well. This exciting new printer features rarely seen in economically priced printers. Whether this is your first 3D printer or an add-on for increased production, you can count on consistently high print quality and high accuracy at an affordable price for any lab – big or small.

Which printer is right for your lab? They're right here for you to decide.

Understanding 3D Printer Resolution

3D printer resolution is separated into two segments; Z Resolution (vertical) and XY Resolution (horizontal). These two segments define the accuracy of the 3D printer and need to be understood when selecting which printer is going to provide the highest precision prints. Let us begin with the Z axis resolution. Z-Resolution is commonly referred to as the controllable layer height of the printed object. This will define the surface quality and detail. A high Z-resolution (thinner layers) will produce an extremely smooth finish and reach a higher level of detail. A low resolution (thicker layers) will produce a coarse finish with a “stair-step” design. By changing the Z-resolution, the user will create a compromise between surface quality and print speeds.



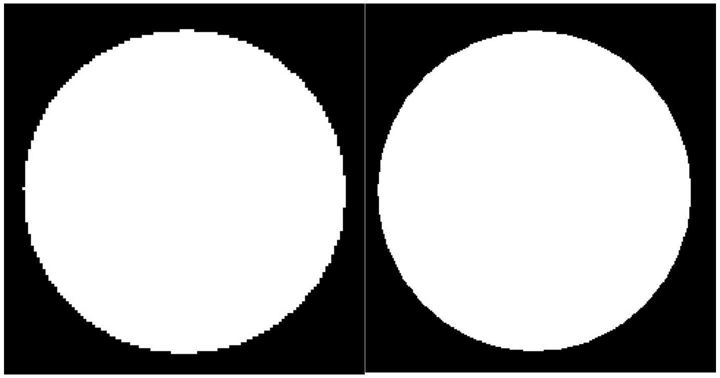


For example, the photo below shows the same model twice, but the model on the left was printed in 100 micron layers and the model on the right was printed in 50 micron layers.

It is quite obvious that the model on the right has a higher surface quality but there is a tradeoff: the 50 micron layered model took twice as long to print as the 100 micron one. When comparing printers, most specifications will only show the Z resolution and state it as representing the “accuracy” of the printer. This is misleading as the proper resolution/accuracy of the printer is not determined by the Z axis, but rather the XY axis.

Defining the XY accuracy of a 3D printer will depend on the type of 3D printing technology that you are using. Let us begin with the DLP 3D printer, which is the most common form of desktop 3D printing being used in the dental industry. The accuracy of a DLP 3D printer is defined by the size of the pixel being projected. The easiest way to understand how the pixel-size defines the accuracy is to compare it to a HD television screen. If you look closely at your TV screen you will notice

Understanding 3D Printer Resolution



75-micron 37-micron

thousands of small “squares”, or pixels, that change color to create the image being shown. Now if you were to compare a 1080p TV to a 4K resolution screen you will notice immediately that the pixels on the 4K screen are significantly smaller, creating an image with higher precision. This comparison is identical to defining DLP printer accuracy. The smaller pixel size will directly correspond to a higher accuracy in a DLP 3D printer. Notice the two images of a single projected layer below? Can you notice the difference in Pixel size? You should instantly notice that the image on the right was printed with a higher resolution 3D DLP printer with a smaller pixel size.

The size of the pixel will also define the feature size that the printer is able to print. For example, a DLP 3D printer with an XY accuracy and pixel size of 75 microns will be able to print objects as thin as 75 microns. This would produce a highly detailed object. Since DLP 3D printers have a high resolution, they are able to be used for all applications in dentistry including Crown and Bridge models, restorations, RPD frameworks, surgical guides, splints, custom impression trays, orthodontic models and even temporaries.

Stereolithography (SLA) Laser printers define their resolution by the diameter of the laser. The most common desktop SLA printer has a laser resolution of 140 microns. At this resolution the smallest printable feature size would be 140 microns making it 2-3 times less precise than a DLP 3D printer. SLA Laser printers work fine for areas where high precision, detail, and accuracy is not needed, such as custom impression trays, splints and surgical guides.

Popular Desktop 3D Printers on the Market

Let's take a closer look at some of the most popular desktop printers with regard to open source printing, build envelope size and accuracy.

Whip Mix VeriBuild LCD

Technology – Liquid Crystal Display (LCD)

Open Source Printing – Yes

Build Envelope Size *(X,Y, Z mm)* – 118 x 66 x 140

Pixel Resolution – 47ɥm

iLED Wavelength – 405nm

Popular Desktop 3D Printers on the Market

Asiga Max UV

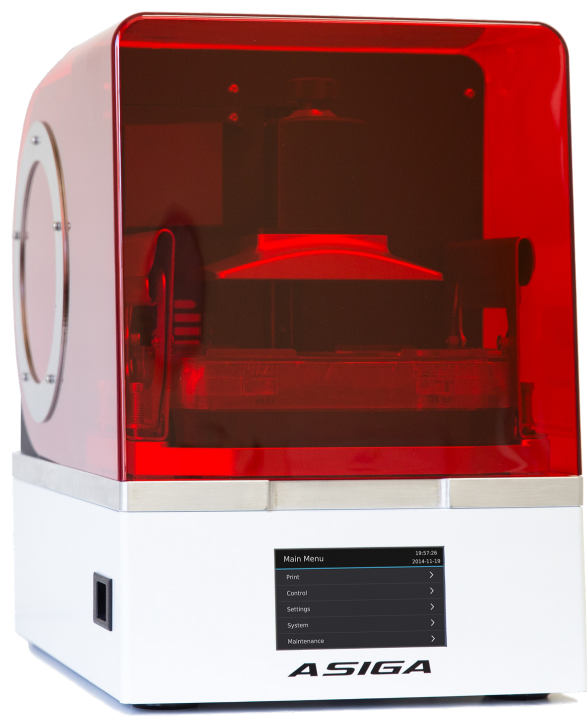
Technology – Digital Light Processing (DLP)

Open Source Printing – Yes

Build Envelope Size *(X,Y, Z mm)* – 119 x 67 x 75

Pixel Resolution – 62ųm

iLED Wavelength – 385nm



Popular Desktop 3D Printers on the Market

Asiga Pro 4K

Technology – Digital Light Processing (DLP)

Open Source Printing – Yes

Build Envelope Size *(X,Y, Z mm)* – 176.5 x 99 x 200
Pixel Resolution – 65ųm

Build Envelope Size (X,Y, Z mm) – 217 x 122 x 200
Pixel Resolution – 80ųm

iLED Wavelength – 385nm

CHAPTER FOUR

How 3D Printing Affects Productivity

Time Savings and Volume

"I'm Concerned About the Time it Takes To Print."

There is no question that print speed can affect a lab's productivity. The good news is that speed can be adjusted by pre-setting the layer thickness. Production time is also decreased by adding economies of scale with a DLP printer. Multiple units cure in virtually the same time that it takes to print a single unit. Adding units increases productivity while maintaining the same per-unit build time.

"How Many Models Can I Print in One Run?"

That depends on several factors. The build plate size affects the number of print objects you can fit horizontally (X and Y axis), but in some cases, you can increase the volume of printed units by building vertical layers (Z axis).

As an example, in the Asiga Max or Whip Mix VeriBuild printers, you can fit approximately 3 - 4 full arch models or 8 – 10 quadrants lying horizontally. With the Z axis height being 200mm, you could potentially stack up to 4 rows high allowing you to print 12 – 14 full arch models or 32 – 40 quadrants in one print run. Larger printers offer a larger print volume.

Expense

Aren't Resins Expensive? What is the Per Unit Cost?

The material, on a per-unit basis, is not very expensive. It is even less of a financial consideration when you compare the costs of a conventionally produced unit with one that is printed. With conventional technology, the labor cost is higher. When printing, the actual "touch time" is less, so labor costs are as well. Overall, a printed crown is lower in cost than one that is hand waxed.

Here are examples of material costs. Using the Asiga Max UV with Whip Mix resins, you could expect to pay the following:

Print Item Approximate Cost

Fit Check Model *(usually 3 teeth)* ~ $2
Quadrant *with articulator attachment* ~ $2 - $3
Full arch *with articulator attachment* ~ $5 - $6
Ortho Model *(over 18mm in height)* ~ $9
Surgical Guide ~ $4
Single Coping ~ $0.05
Single Full Cast Crown ~ $0.10
Custom Tray ~ $3.00
Partial Framework ~ $1.25
Splint ~ $3.11
Denture ~ $15.30

CHAPTER FIVE

Printing Materials

Changing Materials Between Print Jobs

"I've Heard it's Difficult to Change Materials. True?"

That is true with some printers. In some cases just switching the printer from one material to another takes a long time and is quite labor intensive. Some require a wasteful purge of materials used in the last run before placing the next one.

With the Asiga, changing materials is very quick. You store your build tray filled with resin in a covered box. It is ideal to have a tray designated for each resin material you use for ease of use and minimal clean up. When you are ready to swap out the material, lift up the spring loaded clamps, remove the tray and replace with another tray already loaded with your resin of choice. Simply wipe down the build plate and you are ready for your next print run. The whole process is fast, with no waste since there is no need to purge the system. The whole process takes approximately 30 seconds or less.

Post Processing

The post processing of printed resins vary from printer to printer. Many require time-consuming waterjetting to remove support structures, some require a baking process to melt away those supports and some require several cleaning agents to arrive at an acceptable ready-to-use resin object.

The Asiga printers offer the fastest and easiest processing available. To make a just-printed piece ready to use, you simply squirt the printed objects with isopropyl alcohol, scrape the printed parts off of the build plate, soak in an ultrasonic isopropyl bath for 5 minutes, then place into a UV light-cure box for ten minutes.

Whip Mix 3D Printer Resins

3D Printers are only as good as the resins they print.

Whip Mix resins are ideal for every printing application.

3D Printers vary in many ways. Some are faster than others. Some are more accurate than others. Some produce better detail than others, but it's the resin materials that give any printer its value. Dimensionally accurate models and dies, drill guides, retainers, burnout patterns for pressed ceramics or casting, custom impression trays are some of the applications that Whip Mix's resins satisfy with the highest integrity.

VeriModel OS

- Prints accurate dental models and removable dies
- Provides high detail resolution, sharp margins, low shrinkage and long-lasting toughness
- Golden Brown, Ivory, Grey, and White colors cover lab preferences

VeriSplint OS

- 510K cleared print resin
- Cost effective
- Biocompatible
- Clear when polished

Whip Mix 3D Printer Resins

VeriGuide OS

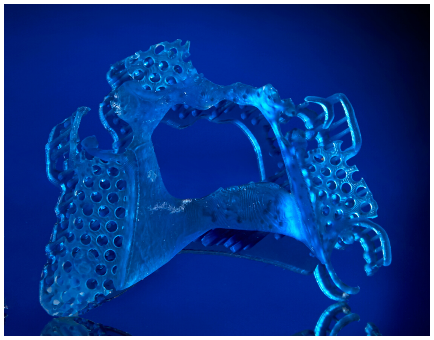
- Perfect printing resin for drill guides and retainers
- Clear, biocompatible, and cures fast
- Durable and tough
- Easy to clean

VeriTray

- Great for creating custom impression trays
- Works well with all types of impression materials
- Cool neon green color
- Prints rigid trays fast

VeriCast

- Ideal for crowns, bridges, and partial denture framework burnout patterns
- Prints and cures fast with smooth surfaces
- Works well with ResinVest and Formula One investments



Dentca Digital Denture Resin

- The first 510K-cleared Digital Denture material
- Strength and performance are the same as conventional denture acrylics
- Tooth material in Vita A1, A2, A3, A3.5, B1 & B2
- Denture base in Original Pink, Light Pink, Reddish Pink & Dark Pink shades
- Predictable fit and less technique sensitivity than conventional dentures

CHAPTER SIX

The Future of 3D Printing

The Future of 3D Printing

LITHOZ
Zirconium Oxide

LithaCon 3Y 210 and LithaCon 3Y 230 are a 3 mol% yttria stabilized zirconia. They are used for applications with extreme demands on the material. High-end metal forming, valves, bearings and cutting tools are some of the applications which benefit from the mechanical properties of zirconia. The biocompatibility of zirconia facilitates its use in medical applications, such as dental applications and as part of permanent implants.

3DCeram

3DCERAM leverages a unique technology that makes it possible to manufacture ceramic components by 3D printing.

The upstream work on laser stereolithography developed by Thierry Chartier, director of the Science of Ceramic Processes and Surface Treatments (SPCTS) in Limoges, have contributed decisively to the development of the additive manufacturing technology for ceramic parts that 3DCERAM has transformed into production technology.

This technology enables to produce ceramic components by successive layers using a laser which polymerizes a paste composed of photosensitive resin and ceramic. The parts are then subjected to a heat treatment (debinding followed by sintering) which eliminates the resin and densifies the ceramic.

The Future of 3D Printing

Antimicrobial Plastic

Dutch researchers at the University of Groningen are working on the creation of a 3D printed tooth made of an antimicrobial plastic that kills the bacteria responsible for tooth decay on contact. Imagine a restoration that kills more than 99% of all bacteria!

BioPrinting

And, last but not least, researchers at Wake Forest University in North Carolina say they have created a 3D printer that can produce organs, tissues, and bones that could theoretically be implanted into living humans. Using some of the same methods we are using to print today these researchers are laying down layers of human cells. They have printed out an ear-shaped piece of cartilage, a muscle, and a piece of a jawbone. BioPrinting is truly ground breaking.

We may be a few years from printing the final restoration and even farther than that from printing a replacement jaw, but as the above research suggests we may be there sooner than we think.

Gain Expert Advice on How to Integrate 3D Printing into Your Dental Lab

Still have questions about which 3D printer is right for your lab?

Request a free consultation from one of our Sales Representatives.

Request a Call

Resources:

1. http://reprap.org/mediawiki/images/2/22/FFF.png
2. https://kylestetzrp.wordpress.com/2009/05/20/inkjet-and-multijet-printing/
3. http://3dprinting.com/what-is-3d-printing/#whatitis
4. https://en.wikipedia.org/wiki/Selective_laser_sintering#/media/File:Selective_laser_melting_system_schematic.jpg
5. http://3dprintingindustry.com/3d-printing-basics-free-beginners-guide/processes/
6. http://www.reuters.com/article/us-health-biotech-3d-printers-idUSKCN0VO28X
7. https://3dprint.com/98211/z3dlab-zti-powder-composite/
8. https://www.washingtonpost.com/news/innovations/wp/2015/10/20/how-bacteria-fighting-3d-printed-teeth-could-impact-dentistry

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