

Sculpteo's 3D PRINTING MATERIALS BIBLE



2016 EDITION



INTRODUCTION

THE IDEA BEHIND THIS EBOOK

At Sculpteo we live and breathe 3D printing and we know that sometimes it can be difficult to keep up with the pace at which all these technologies are evolving. Materials for 3D printing are not lagging behind, with more and more options constantly hitting the market. In order to help you in this regard, we have put together a 3D Printing Materials Bible so you can quickly find whatever you may be looking for your next project.

AND SOME COMMENTS TOO

This e-book has been put together using both our personal knowledge and lots of different online sources. Whenever we share something we try to be as accurate as possible and we are sure that manufacturers, suppliers, 3D printing services or people on forums do the same. That being said, take this information as is and always check it with your supplier or service if you are about to 3D print something really important. Also we are more than happy to receive any feedback you can give us to make this work as comprehensive and useful as possible! If you have a photograph that depicts better one of the materials included in this e-book and you want to participate, please contact us!

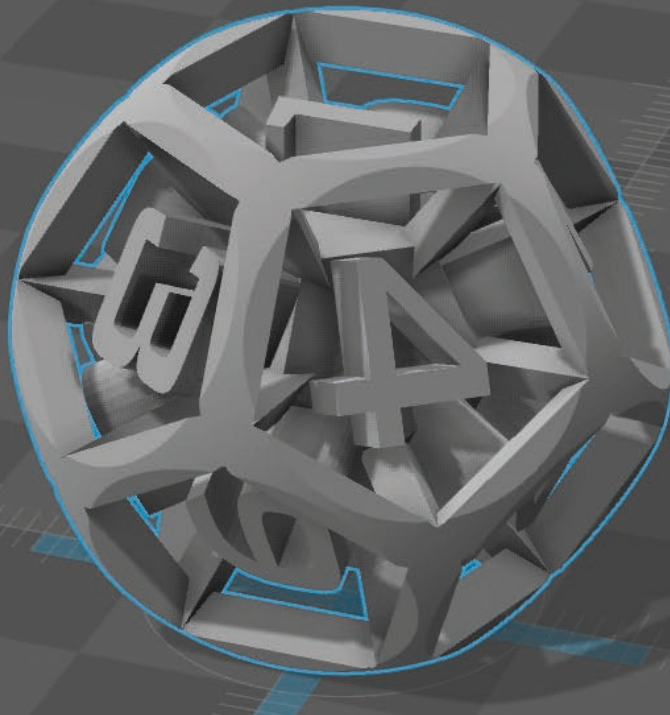
LET THE PRINTING BEGIN!

JUST SOME TEXT IS NOT ENOUGH

Although we can try our best to describe a given material, its colors, textures, etc sometimes one just needs to see it. We cannot ship a sample object for each material to every single reader out there but at least we can print and photograph an object in as many materials as possible so you can appreciate what it actually looks like.

Our test object is a 12-sided dice, on the shape of a 1” dodecahedron. The reduced size of the object and the macro shots allow you to look closely and appreciate the real texture of the print. Bear in mind that this can be slightly deceiving as any texture would look smoother at normal viewing distance. For the materials or technologies that cannot print this dice, we also printed a simplified version of the same size.


TEST OBJECT



3D PRINTING TECHNOLOGIES

PLASTICS, RESINS, METALS, MULTICOLOR, WAX, PAPER..

No single technology can print in every material. Some of them support a wide range of materials whereas some others can work with only one specific material. In the following lists you will find the most popular technologies today for both metal and non-metal 3D printing. The idea behind this seemingly arbitrary division is to minimize overlapping capabilities. Simply put, if one technology of one group is ideal for a certain job, the others in the same group may do reasonably well where as the technologies in the other group will be probably unsuitable or highly impractical.

At Sculpteo we work with many of these technologies. If you decide you want to see and feel one of these material for yourself, search for  which means that we can print one of your designs with that material and ship it to you.

MAIN NON-METAL 3D PRINTING TECHNOLOGIES

- **FDM (Fused deposition modelling):** Most common type of consumer-grade 3D printers. The material comes in filament form and is fused and deposited on the 3D space of the building box. Also referred as FFF (Fused filament fabrication).
- **SLS (Selective Laser Sintering):** One of the most popular options for large scale production. The material comes in powder form and is sintered layer by layer with an infrared laser.
- **SLA (Stereolithography):** The oldest 3D printing technology, it uses a LED or laser UV light source to solidify a liquid photocurable resin.
- **DLP (Direct Light Processing):** Similar to SLA but replacing the LED or laser with a projector. Thus it can generate a complete layer in a single step instead of scanning the layer's surface.
- **PolyJet:** Tiny photocurable resin droplets are jetted by the printer and quickly solidified with light. This technology developed by Objet (Stratasys) can mix and jet different resins during the printing process, allowing multi-material objects.
- **Multijet:** Analogous to Polyjet but developed by 3D Systems. Some differences on the cleaning process.
- **ColorJet:** This technology involves two major components, a core powder (plaster-like) and a multicolor binder. Layer by layer the binder glues and gives color to the powder particles.
- **MCor Paper 3DP:** Regular paper sheets are printed on full color, glued and stacked. The shape of each layer is also cut with a blade so the final object can be peeled away, discarding the excess paper all around.

MAIN METAL 3D PRINTING TECHNOLOGIES

- **DMLS (Direct Metal Laser Sintering):** Analogous to SLS 3D printing but using metal powder instead of plastic powder. As expected, the laser is also significantly more powerful in order to reach the sintering temperature of the metal particles.
- **SLM (Selective Laser Melting):** Similar to DMLS but reaching higher temperatures in order to melt the powder metal particles instead of just sintering them. Laser power is even higher than on DMLS, reaching the 1000W mark.
- **EBM (Electron Beam Melting):** This technology works similarly to SLM but it uses an electron beam instead of a laser. This change allows for higher energy transfer, reaching melting temperature faster and thus 3D printing (generally) faster than SLM.
- **BJ (Binder Jetting):** This is a multi-step process that starts gluing metal powder together with a jetted binder. The resulting object, still fragile, is cured in an oven, removed from the powder box and then infiltrated with bronze in a furnace.
- **LWC (Lost Wax Casting - Indirect method):** This technology is a upgraded version of a really old technique called "Lost wax casting". In this process the object is originally 3D printed on a special kind of wax from which a mold can be made. When the mold is cured the wax melts away leaving no residue behind and this mold is finally used to produce the metal object.

ALL 3D PRINTING MATERIALS

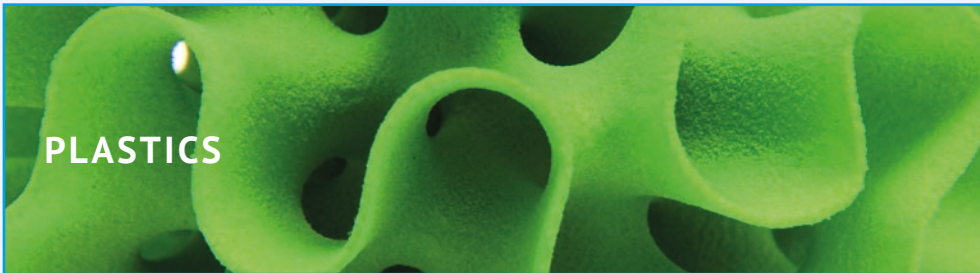
3D PRINTING MATERIALS

We have grouped all 3D printing materials into 4 categories. You can go directly to each category by clicking in the following menu.

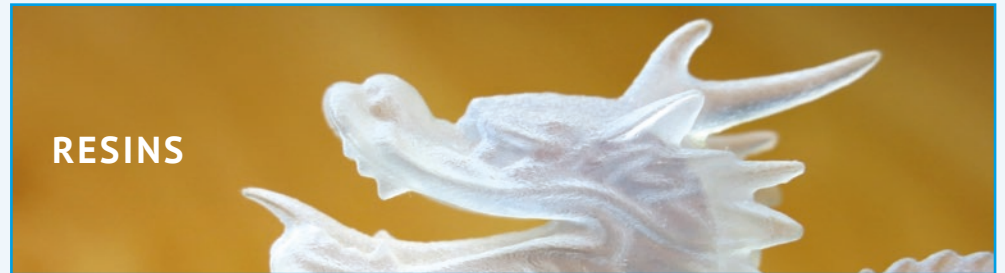


CATEGORIES

PLASTICS



RESINS



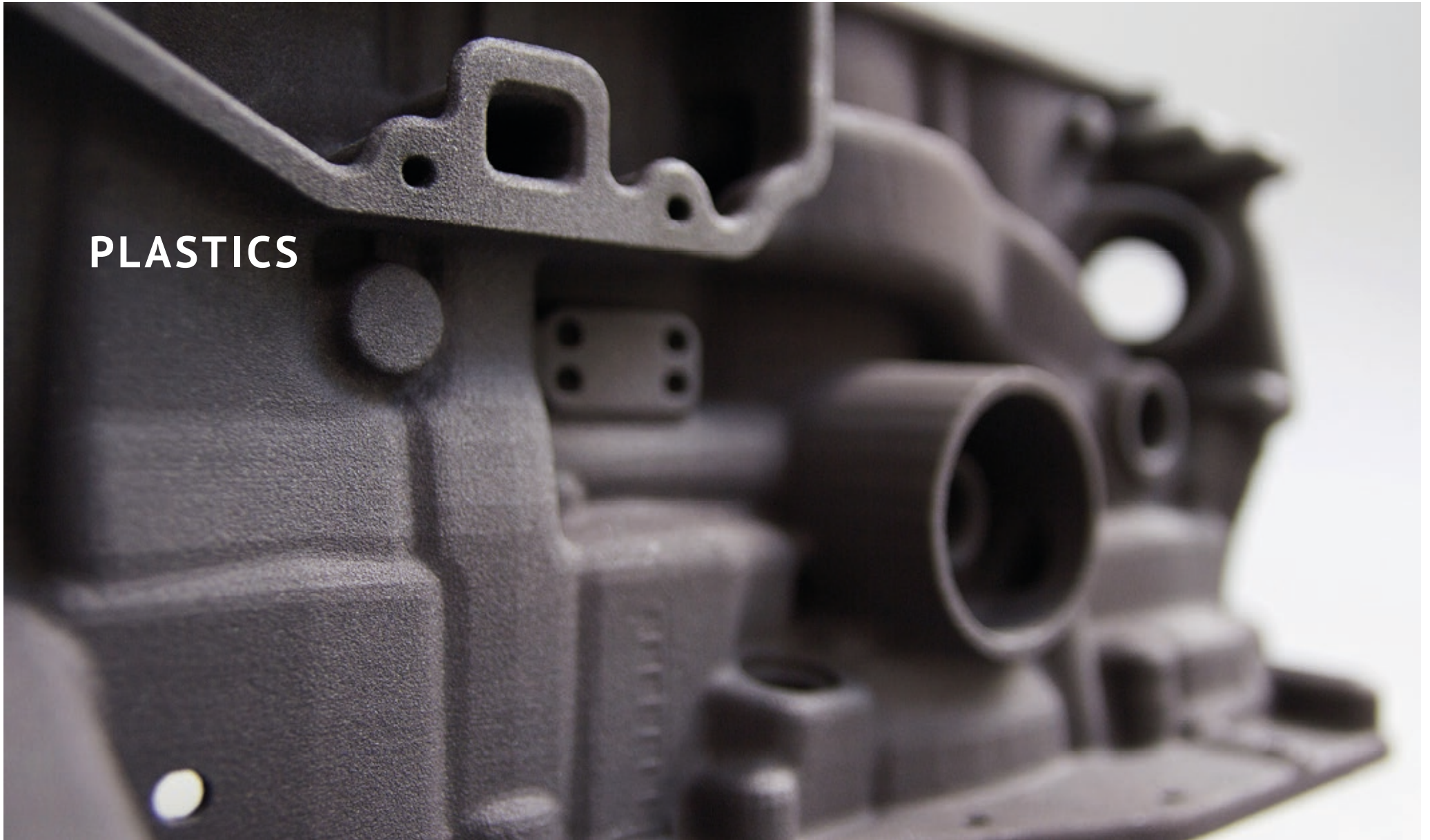
METALS



FULLCOLOR AND OTHERS



PLASTICS



PLASTICS INDEX

PLASTICS

Plastics are the most used materials in the 3D printing world. This is not coincidental, the extremely wide variety, relative low cost of the material and compatibility with even the most inexpensive printers have made of it one outstanding option for multitude of projects and the number one choice for both enthusiasts and professionals.

POLYAMIDE	ALUMIDE	PLA	CARBON FIBER REINFORCED PLA
CARBON FIBER REINFORCED PLA	WOOD PLA	BAMBOO PLA	COPPER PLA
BRONZE PLA	ABS	THERMOPLASTIC POLYURETHANE (TPU)	HIPS SOLUBLE
PVA SOLUBLE	PET	PETG	POLYCARBONATE (PC)
THERMOPLASTIC ELASTOMER (TPE)			





POLYAMIDE (PA)



More commonly known as Nylon, polyamide objects are created from either an extruded filament or sintered fine powder. The material is rigid and strong but flexes under high loads. Thanks to its widespread use it is one of the cheapest materials available for 3D printing.

VARIETY

SLS: Opaque black, white or gray, Glass compound, Flame Retardant, Carbon fiber reinforced, Aluminium compound.

FDM: Multiple colors.

THINGS TO KNOW

- It is possible to polish, dye or paint polyamide objects.
- Its use with consumer-grade FDM printers is best advised for experienced users and keeping the filament dry is key to avoid problems.
- Some providers: EOS (SLS), Stratasys, Airwolf3d, Taulman3d (FDM)

PROS

- Toughest plastic material
- Bends without snapping
- Relatively inexpensive
- High chemical resistance
- Food compatible (check with supplier if it's colored Nylon!)
- High softening temperature

CONS

- Nylon filaments are prone to absorb humidity fast and need to be properly stored



ALUMIDE



Alumide is a mix of Polyamide 12 and Aluminium that comes in powder form for SLS printers. It is produced by German e-manufacturing company EOS (Electro Optic Systems).

VARIETY

This material belongs to the Polyamides family. Similar compounds would be PA-Glass and PA-Carbon Fiber.

THINGS TO KNOW

Alumide parts have a granular, slightly porous texture. When dyed, the aluminium particles don't get colored resulting in a particularly unique bicolor look.

PROS

- Stiffer than Polyamide
- Aluminium gives metallic shine to the surface
- High softening temperature

CONS

- Only comes in gray (but can be dyed)



POLYLACTIDE (PLA)

Poly lactide or Polylactic acid is one of the most popular materials for consumer-grade 3D printers. Corn-starch based, is also one of the most eco-friendly and that along with its ease of use have made it a great replacement for previously ABS users.

VARIETY

Regular, Fluorescent, Glow in the dark, Carbon Fiber Reinforced, Color changing, Wood, Bamboo, Copper, Bronze, Gold, Stainless Steel, Aluminium, Flexible, Magnetic, Photochromatic, Sparky, Conductive.. new compounds are coming out all the time.

THINGS TO KNOW

Although Polylactide itself is food safe, it's not generally advisable to print food containers with it because of possible additives, the printer's materials in contact and the resulting texture that can be difficult to clean properly. Blue tape for the printing bed is recommended.

PROS

- Odorless
- Not petroleum-based
- Biodegradable
- Inexpensive
- Wide variety

CONS

- Low temperature resistance
- Low strength
- Brittle



GLOW IN THE DARK PLA

This particular material adds a phosphorescence substance to the PLA plastic in order to absorb and re-emit light giving this unique characteristic. Great not only for fancy-looking objects but also for functional purposes.

VARIETY

Some brands that offer this type of product are ColorFabb, Makerbot, Hatchbox, Formfutura, Blackmagic3d among others.

THINGS TO KNOW

How much and how long this material will glow will depend on the intensity and type of light used to excite it, going from a few minutes to even hours in some cases.

PROS

- Seriously eye-catching on dark places
- Available on several colors

CONS

- Temperature variations during printing can slightly change the color of the layer (visible on picture on the left)



CARBON FIBER PLA

Carbon composites are always awesome and all the advantages they offer had to arrive to 3D printing at some point. This reinforced PLA material has up to 20% (by weight) of tiny carbon fibers that give structural rigidity to your prints.

VARIETY

Some brands that offer this type of product are Proto-pasta, 3dxtech and Formfutura.

THINGS TO KNOW

Bear in mind that the superior strength to weight ratio of carbon composite materials is due to the fact that the fibers that compose it are much longer than what could go through a 3D printer's nozzle. Because of this, one cannot expect to achieve the same level of overall strength.

PROS

- Increased stiffness
- Light-weight

CONS

- More brittle than regular PLA
- The fibers can lead to clogging nozzles, specially on smaller sizes.
- On the expensive-ish side



WOOD PLA

This material has up to 30% of real wood particles and fibers mixed with PLA plastic that give the characteristic color, texture and even smell that resembles a wooden object.

VARIETY

Some brands that offer this type of product are Formfutura, Colorfabb and ColiDo.

THINGS TO KNOW

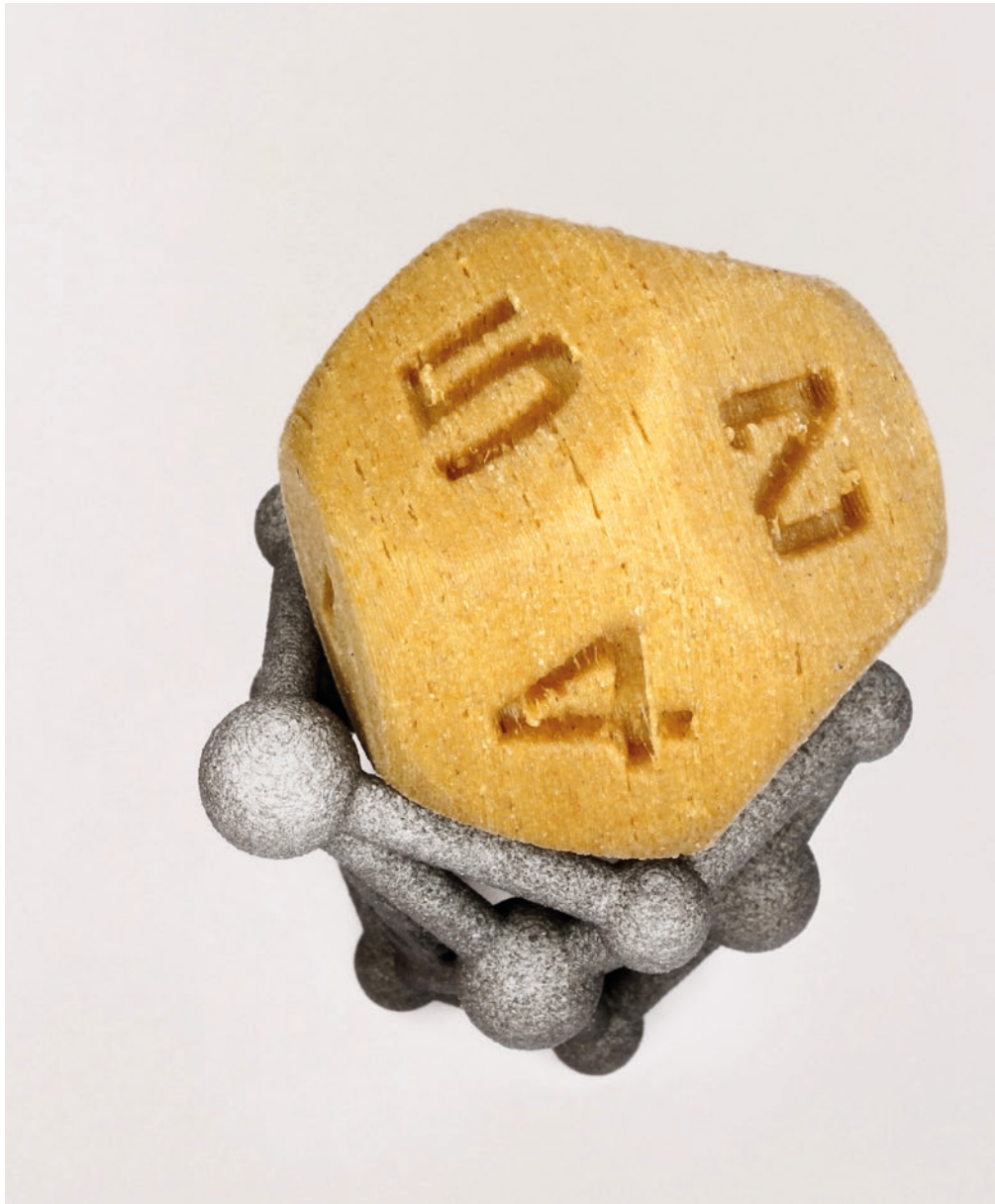
This material's color changes with the extrusion temperature, getting darker as temperature raises. This property allows the user to create a more realistic appearance by subtly increasing and decreasing the temperature during the printing process. Check with the manufacturer for more details.

PROS

- Pretty much the only option to quickly produce a convincing wood-like object

CONS

- Printing with this material can be a bit tricky
- Not the cheapest material



BAMBOO PLA

Bamboo PLA is another great example of recent development in 3D printing materials. Similar to Wood PLA but with the characteristic bamboo color.

VARIETY

Some brands that offer this type of product are Colorfabb, Alchement and Adafruit.

THINGS TO KNOW

This material's color changes with the extrusion temperature, getting darker as temperature raises. This property allows the user to create a more realistic appearance by subtly increasing and decreasing the temperature during the printing process. Check with the manufacturer for more details.

PROS

- Unique bamboo effect

CONS

- Printing with this material can be a bit tricky
- Not the cheapest material



COPPER PLA

With a genuine reddish color brought by the copper particles in the mix, this material not only looks metallic after polishing but it's also heavier than most 3D printing materials, making the metallic effect more realistic.

VARIETY

Some brands that offer this type of product are Colorfabb, Reprapper and Adafruit.

THINGS TO KNOW

Some versions of PLA-Copper also have PHA (Polyhydroxyalkanoate) which is another polyester that added to the mix makes the material stronger, less prone to crack under loads.

PROS

- Can be polished to achieve a metallic look
- Way heavier than regular PLA, feels like a real copper

CONS

- Expensive
- Best for experienced users
- After being polished it oxidizes pretty quickly, losing its shiny finish



BRONZE PLA

As one of the first metal-plastic filament materials, Bronze-PLA lead the way for more and more complex compounds designed for FDM printers. Similarly to Copper-PLA above, this material looks its best after is polished, revealing a unique metallic appearance.

VARIETY

Some brands that offer this type of product are Colorfabb, eSun, Formfutura, Reprapper and Adafruit.

THINGS TO KNOW

Some versions of PLA-Bronze also have PHA (Polyhydroxyalkanoate) which is another polyester that added to the mix makes the material stronger, less prone to crack under loads.

PROS

- Can be polished to achieve a metallic look
- Way heavier than regular PLA, feels like a real bronze

CONS

- Expensive
- Best for experienced users



ACRYLONITRILE BUTADIENE STYRENE (ABS)

ABS is an extremely common thermoplastic polymer and one of the 2 or 3 most used materials for 3D printing, as well as one of the first to be used on FDM printers. The fact that it's among the cheapest 3D printing materials and is compatible with even the most basic and affordable FDM printers, make it a good alternative for enthusiasts with a limited budget.

VARIETY

Regular, Translucent, Conductive, Biocompatible, Anti Bacterial, Glow in the dark, Temperature Sensitive

THINGS TO KNOW

This material can be post-processed with acetone to provide a smooth, glossy finish instead of the typical slightly rough, layered surface.

PROS

- Stronger than PLA
- Long lifespan
- Inexpensive
- Wide variety
- LEGO® uses this plastic so it must be good

CONS

- Warping can be an issue
- Not biodegradable
- It can shrink significantly when it cools down
- Unpleasant and toxic fumes when printing



THERMOPLASTIC POLYURETHANE (TPU)



TPU is another material that found its way into multiple 3D printing technologies as is one of the favorite options for flexible prints. On FDM printers the surface will have a more shiny, layered texture whereas SLS prints will have a more homogeneous and granular texture. It is the perfect material to give some movement to your designs and prototypes.

VARIETY

As a filament, TPU can be found in several colors as well as translucent, almost transparent. There is even a electrically conductive variation of this material. Some suppliers: SainSmart, Yasin3d, Airwolf3d, WolfBend, CreativeTools, Rubber3dprinting.

THINGS TO KNOW

Not all TPUs are created equal and its flexibility can vary significantly. Its Shore hardness typically ranges between 65A and 65D, the former being more flexible than the latter.

PROS

- Flexible
- Abrasion resistant

CONS

- Not the best for tiny details

MORE PLASTICS...

HIGH IMPACT POLYSTYRENE (HIPS) - DISSOLVABLE

FDM SLS SLA DLP PolyJet MultiJet ColorJet DMLS SLM EBM LWC BJ

HIPS is a mix of polystyrene and polybutadiene that has become particularly interesting not because of its mechanical properties but because it can be dissolved in Limonene solution. This combination allows for its use as support material, which can be easily removed without having to cut, force, sand or break parts of the print, resulting a cleaner and better looking object. It's easy to print, inexpensive and it comes in a wide range of colors.

POLY VINYL ALCOHOL (PVA) - DISSOLVABLE

FDM SLS SLA DLP PolyJet MultiJet ColorJet DMLS SLM EBM LWC BJ

PVA is another widely used filament, mainly as support material since it can be dissolved using just water. Just as with HIPS, to make the most of this material, a dual extruder FDM printer is necessary.

POLYETHYLENE TEREPHTHALATE (PET)

FDM SLS SLA DLP PolyJet MultiJet ColorJet DMLS SLM EBM LWC BJ

PET is another popular material that found its way to 3D printing. Commonly used for plastic bottles, objects printed with this material will be stiff, lightweight and colorless. It's also really strong and, as you can guess, food compatible (double check if it's colored). Printing PET can be a bit tricky for beginners. Some supplier even offer bottles-based recycled material.

MORE AND MORE PLASTICS...

GLYCOL MODIFIED PET (PETG)

FDM SLS SLA DLP PolyJet MultiJet ColorJet DMLS SLM EBM LWC BJ

PETG is an inexpensive, naturally transparent, flexible and durable material that has found its way to FDM 3D printers aiming to match the strength of ABS plastic with the ease of use of PLA plastic. Its low shrinkage makes prints less prone to warp and detach from the printing bed. Although PETG filament is pretty new in the market it is already gathering a lot of attention. Some suppliers of this material are Taulman3D, eSun and Airwolf3d.

POLYCARBONATE (PC)

FDM SLS SLA DLP PolyJet MultiJet ColorJet DMLS SLM EBM LWC BJ

Polycarbonate is another type of thermoplastics that is widely used in all sort of objects from water bottles to CDs and safety goggles. It is really strong, impact and temperature resistant and has recently started to be used in consumer grade 3D printers. Several colors are already available but it's still recommended only for experienced users that have high-temperature extruders. Some suppliers of this material are Polymaker, Gizmodorks and Ultimachine.

THERMOPLASTIC ELASTOMER (TPE)

FDM SLS SLA DLP PolyJet MultiJet ColorJet DMLS SLM EBM LWC BJ

TPE or Thermoplastic elastomer is a rubber-like material with good abrasion resistance ideal to print any kind of flexible object. It is usually not as flexible as other materials like TPU. Available in several colors for FDM printers and just natural color for SLS printers. Some suppliers of this material are Verbatim, NinjaFlex(FDM), EOS and 3DSystems(SLS).

RESINS



RESINS INDEX

RESINS

After plastics, resins are used extensively for 3D printing. When Additive Manufacturing was born, a resin was the first material to be there creating stuff for us. Today, several 3D printing technologies use resins and they are mostly used to achieve superior printing quality and maximum resolution. More often than not, this requires paying a premium but the results are likely to be worth it. For some specific applications, they can even be the only way to go. There are lots of resin suppliers and resin compositions, and similar looking resins may be really different at a chemical level so the following categorisation is just a way to present resins in a simplified form.

When working with resins some precautions must be taken as they can be irritating, or even toxic. Always wear gloves and eye protection.

OPAQUE

TRANSLUCENT

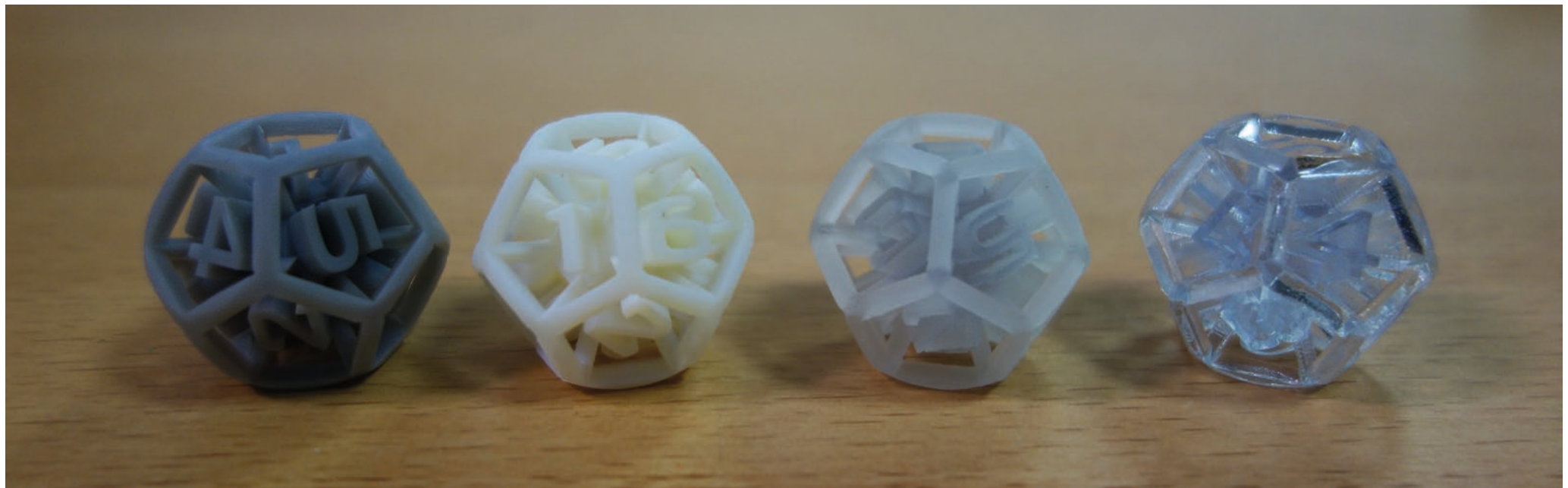
TRANSPARENT

FLEXIBLE

**HIGH
STRENGTH**

**HIGH
TEMPERATURE**

CASTABLE





RESIN



Resins are definitely among the coolest materials for 3D printing. The technologies that evolved around resins are today the ones that offer the highest quality and this make it a great choice for professional applications, important product presentations, small objects, etc.

VARIETY

Opaque, Translucent, Transparent, Flexible, Casting, High Temp, High Strength. Most of these types can also be printed in multiple colors, even on the same print using PolyJet technology.

THINGS TO KNOW

Although originally resin prints were kind of too stiff and brittle, modern developments in the field have resulted in newer compounds that can withstand a lot more punishment than before. May not be as much as some plastics as Polyamides or PC but enough to make prototypes a bit more functional.

PROS

- Suitable for high resolution prints
- Can achieve smooth textures without post-processing
- Wide variety of colors and properties
- Multi-technology

CONS

- On the expensive side
- Liquid resin can be irritating and/or toxic
- Requires cleaning on SLA and DLP which can be messy
- Intricate shapes will require a support structure or material



TRANSLUCENT RESIN



Translucent resins offer a similar transparency to what could be obtained with plastic printing but with the typical superior quality of resin-printing technologies. It has a “frosted” appearance that is difficult to replicate with any other material without some sort of postprocessing. This is a wonderful material to create objects that will interact with light as an skilled designer can play and control the way light propagates within the material but is scattered in the surface. Translucent objects lighten up with LEDs looks phenomenal in the dark.

VARIETY

This material can be mixed with pigments before printing resulting in an attractive looking translucent color object. Also this can have functional purposes, for example, to let an LED to light through an Arduino case.

THINGS TO KNOW

This is a fairly hard material which will not bend but break under excessive loads. It is not particularly delicate but with that consideration in mind, avoiding impacts or too much pressure is a good idea.

PROS

- Unique appearance
- Suitable for high resolution prints
- Color variety
- Multi-technology
- Can be polished to obtain a glossy surface

CONS

- More expensive than regular resin and most plastics
- Liquid resin can be irritating and/or toxic
- Requires cleaning on SLA and DLP which can be messy
- Intricate shapes will require a support structure or material



TRANSPARENT RESIN

This kind of resins are the only 3D printing materials that can print objects that are transparent enough and with a smooth enough surface to manufacture optical devices. From a simple magnifier glass to waveguide to a see-through mechanism or virtually unlimited decorative objects, this material will look amazing. Just as with translucent resins, if you add some lights to your project printed with this material you will definitely grab people's attention.

VARIETY

This material can be mixed with pigments before printing resulting in an attractive looking transparent color object.

THINGS TO KNOW

As a common precaution for this and many other resins, prints in this material must be handled with care as it can chip or even shatter if you drop it.

MORE RESINS..

FLEXIBLE

FDM SLS **SLA DLP PolyJet** MultiJet ColorJet DMLS SLM EBM LWC BJ

Flexible materials have been developed for almost every non-metal technology and the ones using resins could not be the exception. Relatively new in the market these materials expand the horizon of what's possible to create with high-quality resin prints. Different manufacturer offer different hardness ranging from really soft and rubbery ~25A Shore hardness to a more intermediate flexibility of 90A. Stratasys PolyJet technology even allows for gradual flexibility variations within the same print. When designing for flexible resins remember that flexible does not necessarily mean stretchable. Some suppliers of flexible resins are: Formlabs, Stratasys, PeachyJuice and Makerjuice.

HIGH STRENGTH

FDM SLS **SLA DLP PolyJet** MultiJet ColorJet DMLS SLM EBM LWC BJ

Until not long ago one of the weakest points of high resolution resin 3D printing was that most materials available were too rigid making them brittle as well. This was a limiting factor when highly functional objects were required, forcing the user to choose other materials like plastic even if they cannot offer the same level of resolution. Today, thanks to recent resin developments of the last few years, several brands offer at least one type of "tough" resin to handle all those applications that involve a little bit of punishment or real life usage for the object. Some suppliers of tougher resins: Formlabs, Makerjuice, Madesolid and Stratasys.

HIGH TEMPERATURE

FDM SLS **SLA DLP PolyJet** MultiJet ColorJet DMLS SLM EBM LWC BJ

When heat-resistant objects need to be 3D printed there are not a lot of options out there without recurring metal 3D printing. Thankfully there are a few advanced resins developed for high-end applications, that can handle up to 140°C with major deformations, according to the manufacturers. Being able to handle those high temperatures make these materials a viable alternative to create molds that were previously made with cnc machinery, saving valuable production time. Some suppliers of high temperature resins are Envisiontec, Rapidshape and Stratasys.

CASTABLE

FDM SLS **SLA DLP PolyJet** MultiJet ColorJet DMLS SLM EBM LWC BJ

Castable resins are the modern replacement of wax to manufacture typically small and extremely detailed objects using Investment casting. This process, analogous to lost-wax casting, requires a copy of the desired object to create the mold and melt out afterwards. These resins do precisely that and that why are perfect for jewelry or any other small-sized high-quality metal objects. Some suppliers of castable resins are: Envisiontec, Stratasys, Rapidshape and Formlabs.

METALS



METALS INDEX

METALS

One could say that metal 3D printing is a world by itself. And one which is evolving faster than ever pushed by humongous industries like aeronautics, space and the military. It is also a very complex one as handling, mixing and building with metals is significantly more challenging and expensive than doing so with plastics or resins. On the bright side, the outcome of all this investment of resources is also huge and not only for 3D printing users like engineers, artists or enthusiasts but also for people that travel by airplane or need a prosthesis among many other indirect beneficiaries.

SILVER

GOLD

STAINLESS
STEEL

BRASS

BRONZE

TITANIUM





SILVER



Silver 3D printing is one of those materials that is pretty much focused on one type of application which is jewelry. This is not to say that it can be used for other purposes but the metal cost itself plus the indirect production process that requires a good amount of manual labour make this material best suited for small precious objects. Considering that silver objects were never particularly cheap, having the ability to personalize or even design a unique piece of jewelry from scratch can result in a truly astonishing gift.

THINGS TO KNOW

Although silver objects usually have small amounts of other metals to make it stronger, it is still a relatively malleable alloy and therefore it is important to consider this when designing the object as well as treat it with care after being printed.

PROS

- It simply looks amazing
- Safe to wear
- Can be polished to a mirror-like surface

CONS

- Price
- LWC process imposes some design limitations



GOLD

Unsurprisingly for some people metals like silver are not premium enough and they feel like stepping up the game. For them, there is gold 3D printing. Needless to say, when you decide to print something in gold you know it probably won't be cheap, but that's kind of the idea. At least you can feel confident that a personalized 3D printed gold gift will definitely be remembered.

THINGS TO KNOW

Similarly to silver objects, gold is a very malleable metal so in jewelry it is mixed with metals like copper, silver and others giving place to 10K, 14K or 18 karat gold. The purest it gets, the softer the object will be and the sooner it will show wear marks.

PROS

- Even more exclusive than silver
- Safe to wear
- Can be polished to a mirror-like surface

CONS

- Even more expensive than silver



STAINLESS STEEL

Stainless steel 3D printing would be the entry level alternative for metal printing. Because its mechanical properties and chemical resistance are greatly surpassed by other metals, it is mostly used for decorative elements.

VARIETY

Steel, Stainless steel, Maraging steel

THINGS TO KNOW

When stainless steel is 3D printed using Binder Jetting technology the resulting material is a heterogeneous mix of steel and up to 40% bronze. This is not the case when printing with DMLS, SLM and EBM.

PROS

- Inexpensive raw material
- Can be post-processed with a thin coating of several other metals completely changing its appearance.
- Can be polished
- Heat resistant

CONS

- Depending on the technology the surface quality may not be that good
- BJ technology impose some important design limitations
- Not all types are food safe



BRASS



Brass is an alloy of copper and zinc has been used extensively in objects like musical instruments, coins and jewelry among many others. Today with 3D printing this material is mostly used for the jewelry since the typical since in this field is something than most 3D printers can handle. This metal can be a great substitute for those who don't want to spend a lot more for gold, or perhaps to run a test print before 3D printing in gold.

THINGS TO KNOW

If you are planning to 3D print brass jewelry for someone else you may want to check the lucky recipient is not allergic to brass or copper as some people's skin may react to these materials. Even if there is no serious risk, it could spoil your gift.

PROS

- Gold-like appearance, specially when polished
- Cheaper than both gold and silver

CONS

- LWC process imposes some design limitations



BRONZE

Bronze is an alloy that consists primarily of copper and about a 10% of tin. Thanks to this relatively small addition the new material is stronger than copper alone making it more suitable for a wide range of applications. When it comes to 3D printing this material is most commonly used for jewelry, miniatures and small decorative items.

THINGS TO KNOW

If you are planning to 3D print bronze jewelry for someone else you may want to check the lucky recipient is not allergic to bronze or copper as some people's skin may react to these materials. Even if there is no serious risk, it could spoil your gift.

PROS

- Cheaper than both gold and silver

CONS

- LWC process imposes some design limitations



TITANIUM

Among all the metals that current technologies are able to 3D print, Titanium is the first choice by some of the biggest players using metal 3D printing: aeronautic, space, automotive, military and medical industries. Although one could 3D print a cool ring or a miniature, most importantly this material is currently being used to 3D print rockets, jet engines, medical implants, F1 car parts and many other key elements for the most advanced technology in existence.

VARIETY

There is a wide range of titanium alloys classified in several categories and grades specifically optimized for different applications.

THINGS TO KNOW

Although this is one of the most expensive materials to 3D print with (leaving precious metals aside) one needs to consider that traditionally, handling titanium has always been expensive. Although we cannot yet replace every other manufacturing method, such as CNC machining, 3D printing is already the cheapest option to produce titanium parts in many cases. On top of that, there are designs that can only be produced by additive manufacturing methods.

PROS

- Highest strength to density ratio of any metallic element
- Highly resistant to corrosion
- Biocompatible
- Strongest material you can currently 3D print.

CONS

- Not cheap although it is cost-effective in many areas
- Support structures are frequently needed, sometimes leaving marks in the surface after being removed

OTHERS



OTHER MATERIALS

OTHER MATERIALS

Most people's first thought when it comes to 3D printing materials is plastic or resin and that would have been almost right 15 or 10 years, when metal 3D printing was almost exclusively used by big industries and there was not much else. The picture today has changed dramatically and now we are trying to 3D print with any material we find useful, interesting, pretty or just tasty!

COLOR

CERAMIC

WAX





MULTICOLOR



Arguably the biggest difference between common everyday objects and 3D printed objects is that most printed objects have just one or two colors and common items around us are neither monochromatic nor bichromatic. That's why multicolor material is the only option to 3D print realistic color objects using literally hundreds of thousands of different colors. ColorJet technology uses glue, ink and a white powder to produce unique colorful, grainy textures. It's best suited for figurines, avatars, 3D-scans, digital pottery, building models, sculptures and many many others..

THINGS TO KNOW

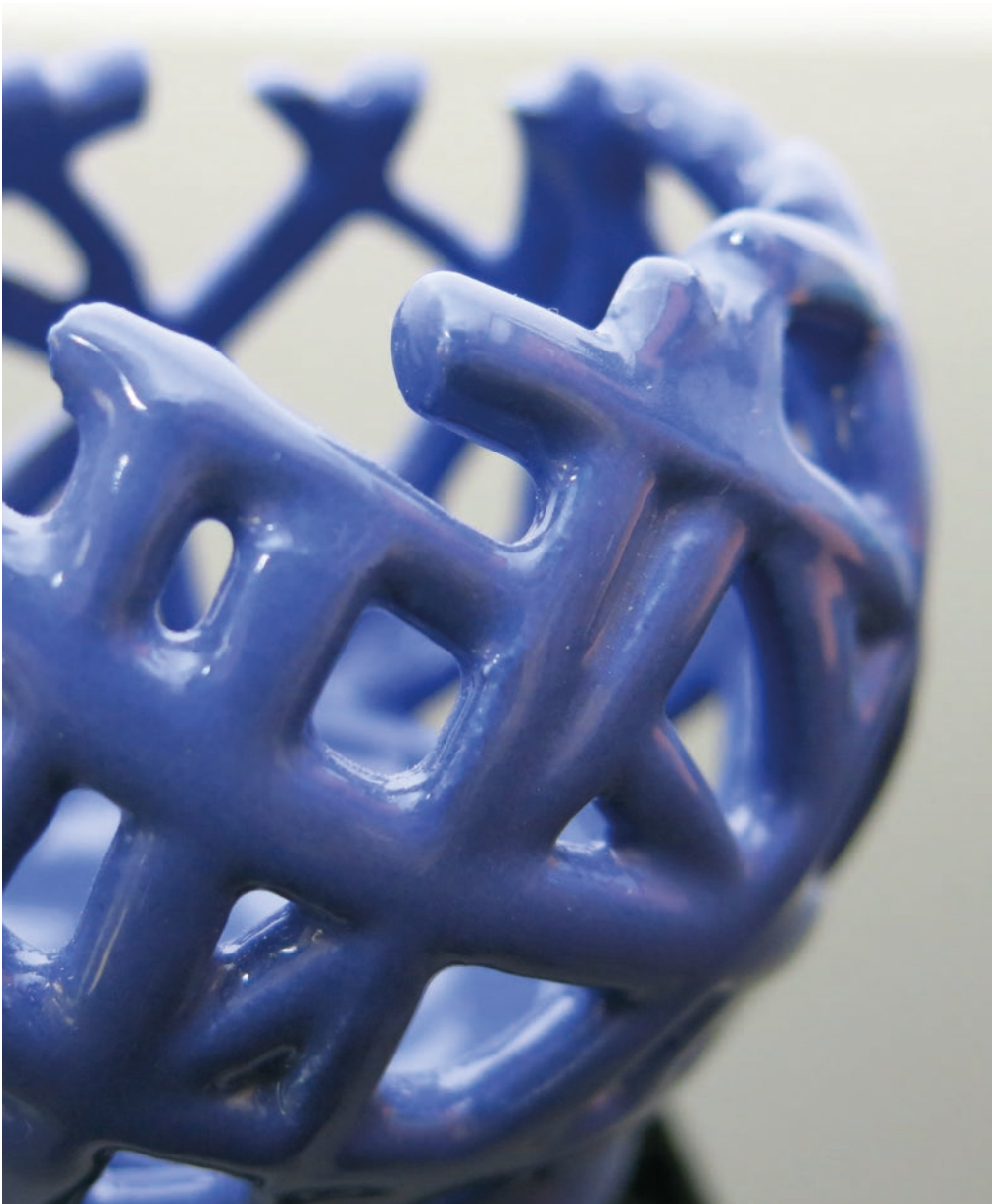
This material feels a bit like ceramic, both because of its weight and texture. Another characteristic shared by these two materials is that they are fairly fragile and must be handled carefully.

PROS

- Inexpensive
- Only material capable of full color 3D printing
- Can be varnished to get a more glossy and smooth surface

CONS

- Somewhat fragile
- Cannot be polished
- Not water resistant



CERAMIC

3D printing ceramic is a pretty complex multi-step process that impose several limitations to the design process. Despite its modest use, this material has a few great uses: 3D printing the coolest personalized coffee cups and mugs, tableware items and pottery designs.

VARIETY

Once the core object is 3D printed, there are multiple glazing color options.

THINGS TO KNOW

On the last few steps of the production process, the still colorless object is coated with the glazing material and then put into an oven at $\sim 1800^{\circ}\text{F}$ (1000°C) where this layer melts adding $\sim 0.04''$ (1mm) over the object's surface. Unfortunately when this happens any small detail on the surface will be smoothed out by the glazing and therefore it's better to avoid them altogether.

PROS

- Practically the only way to manufacture complex shapes in ceramic in small quantities
- Food compatible
- Heat resistant

CONS

- Fragile (but just as regular ceramic)
- Reduced resolution due to the glazing process
- The base of the object cannot be glazed



CASTABLE WAX

This material has been designed to manufacture small metal objects with exceptional precision using the lost-wax casting process. This is essentially a middle step to 3D print metals such as silver, gold, bronze or brass, among many other metals. Wax prints are used to create the mold that will later hold the molten casting material.

THINGS TO KNOW

Even using modern 3D printing technology for the first step of the process, lost-wax casting is a very ancient and manual method that requires a lot of time to prepare the mold and do the casting. It may not be rocket science but it will demand a good deal of time for unexperienced creators.

PROS

- Gives brave enthusiast and professionals the chance to create sophisticated metal objects in the most affordable way

CONS

- Requires some additional skills and knowledge and equipment to cast an object with the wax print
- Wax prints are very fragile and temperature sensitive



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