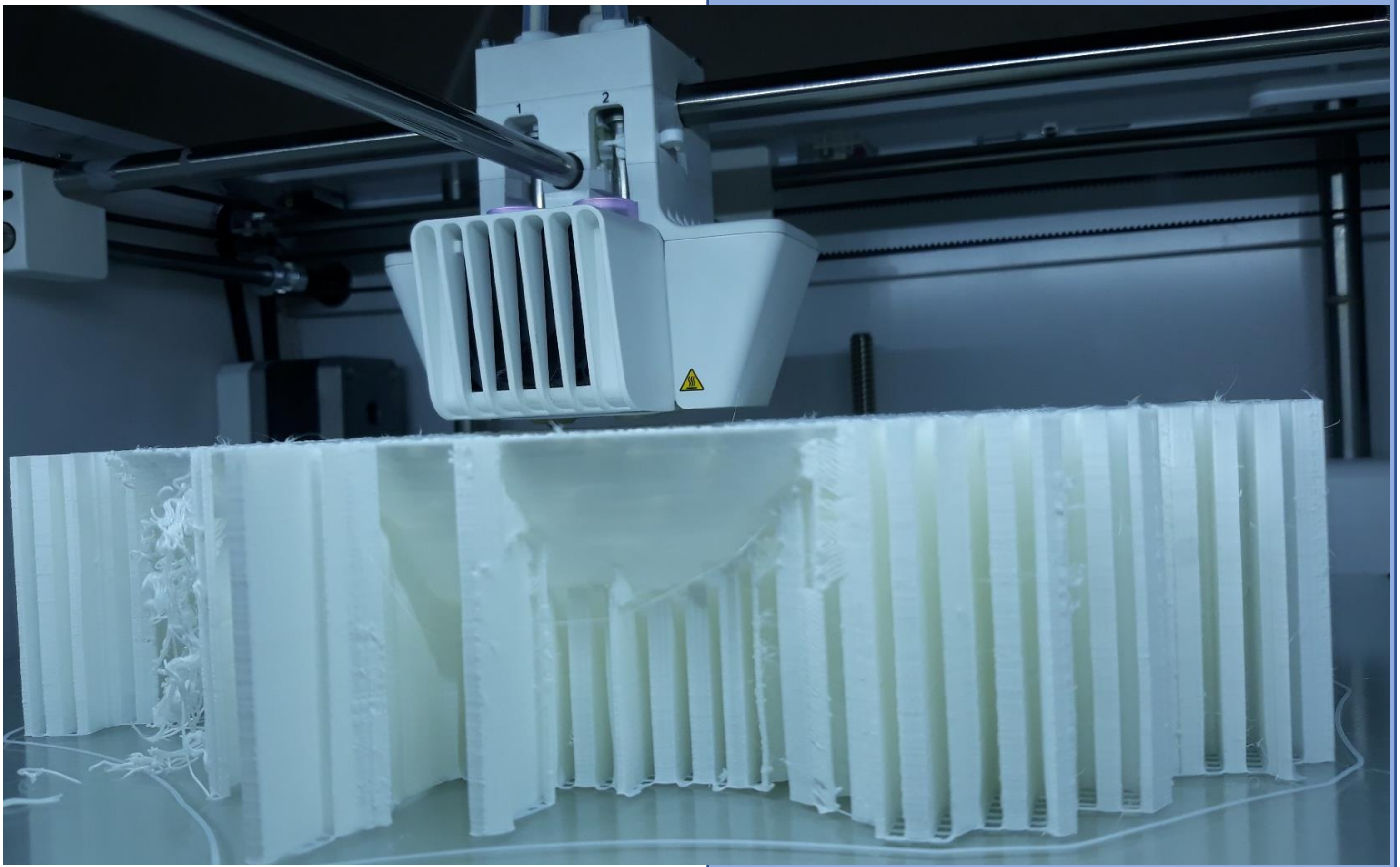
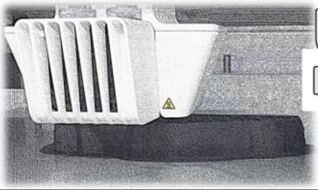
FABRICO ADITIVO E IMPRESSÃO 3D



TECNOLOGIAS DE IMPRESSÃO 3D

Carlos Relvas



Índice

Additive Manufacturing Will Change in the Next Decade

(https://www.additivemanufacturing.media/articles/6-ways-additive-manufacturing-will-change-in-the-next-decade)

When stereolithography was invented more than 30 years ago, would anyone have guessed that 3D printing technology would explode, expand and come to change the way that production parts are made? Likely not. Additive Manufacturing Media has reported on industrial uses for 3D printing over the last 10 years, and while some of the issues around AM have remained the same, the techniques, materials and applications have grown exponentially. And we predict that this growth will continue, though perhaps in different directions than it has thus far.

In the most recent edition of the AM Radio podcast, I challenged co-host and AM editor-in-chief Peter Zelinski to come up with some predictions about where additive manufacturing is headed over the next 10 years. We each shared three ideas, summarized below. Read on or listen to the episode (embedded above or anywhere you get your podcasts).

6 Predictions for Additive Manufacturing's Next 10 Years:

Service parts will lead to a re-engineering of the entire product lifecycle. 3D printing has great potential as a source of aftermarket and spare parts, but only if 3D printable files exist for those parts. In the future, we will rely less on 3D scanning and reverse engineering because those digital files will exist from the beginning, and be created as part of the product's initial development.

Increasingly irregular and organic designs. There is some extent to which today's designers and engineers hold back on using additive manufacturing to its full geometric capability, simply because the consumers and users of 3D printed items must feel a sense of trust and recognition of these objects. As humans become more accustomed to generative designed and topology optimized forms, the door will open to increasingly complex, asymmetric and optimized objects, whether they be aerospace brackets, automotive engine components or consumer products.

The arrival of a new category of machine shop that specializes in metal AM parts. Additively manufactured parts are unlike the stock, blanks or even castings most machine shops are accustomed to handling. A new class of machine shops staffed and equipped to fixture, locate, machine and inspect the often irregular parts possible through 3D printing is on the horizon.

More intentional material usage enabled by AM. 3D printing allows for material conservation by encouraging the use of material only where it is necessary, but it also increasingly supports the use of gradients and the joining of different materials. These capabilities will challenge the notion that one part should be made of a single material, and enable more innovative designs and better conservation of high-value materials. Expanding options for sustainable materials from bio-based or recycled sources will also support this material intentionality.

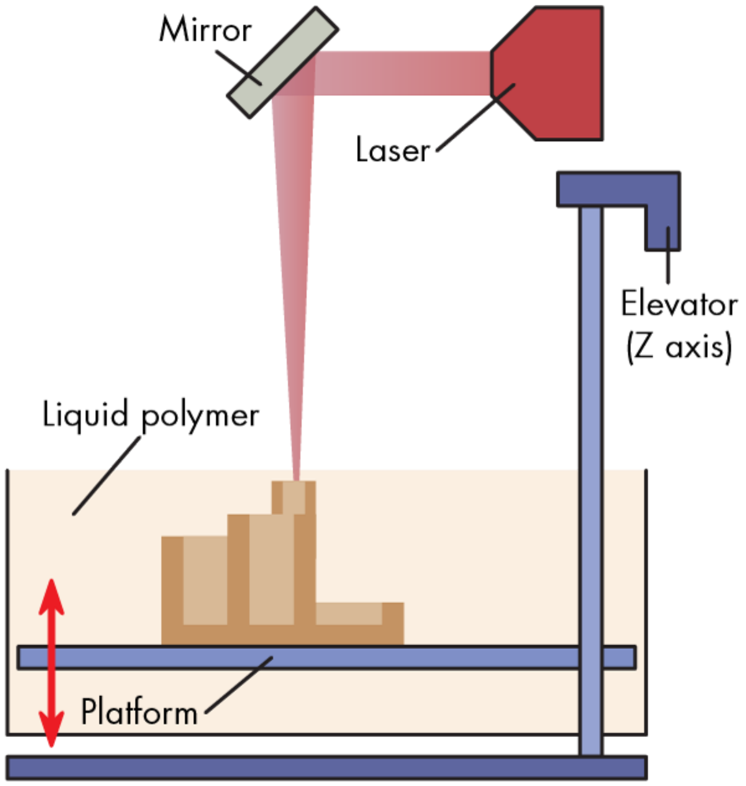
Inventors as a new category of manufacturers. There is a hard line today between product development and manufacturing, where design and ideation must stop to enable production through injection molding, machining or some other conventional method. Not so with additive manufacturing; without tooling, the design of the product can continue to change even as the item goes into production — and the inventor can continue to be involved, even to be the manufacturer through 3D printing.

New kinds of 3D printing that we have not yet imagined. The past year alone has revealed a handful of unexpected means of constructing parts layer by layer; there's no telling what the next ten might add to the available options. 3D printing methods that today are only in development, only the seed of an idea or perhaps not even in existence at all could prove to be the next important advance in AM's next decade.

TECNOLOGIAS DE IMPRESSÃO

MATERIAIS POLIMÉRICOS

Stereolithography Process



A UV laser is curing a liquid photopolymer in a vat. The part is built by lowering the build platform into the vat.

Stereolithography machines build parts out of liquid photopolymer through polymerization activated by a UV laser. Parts are built on to a build platform inside a vat filled with the liquid photopolymer. The laser is scanning the surface of the vat which is solidifying. The build platform is lowered subsequently into the vat and the part is built layer by layer.

Stereolithography requires support structures for overhangs, which are built in the same material.

(https://www.semanticscholar.org/paper/3D-PRINTING-%E2%80%93-A-REVIEW-OF-TECHNOLOGIES%2C-MARKETS%2C-Aspler-Kingsland/9046d712a5d525f58d8dce674b9480144eed98ec)

https://www.youtube.com/watch?v=jeCHKDxQQh0
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https://www.youtube.com/watch?v=V3URKrviXd8
https://www.youtube.com/watch?v=KrSTNYnJ0E0
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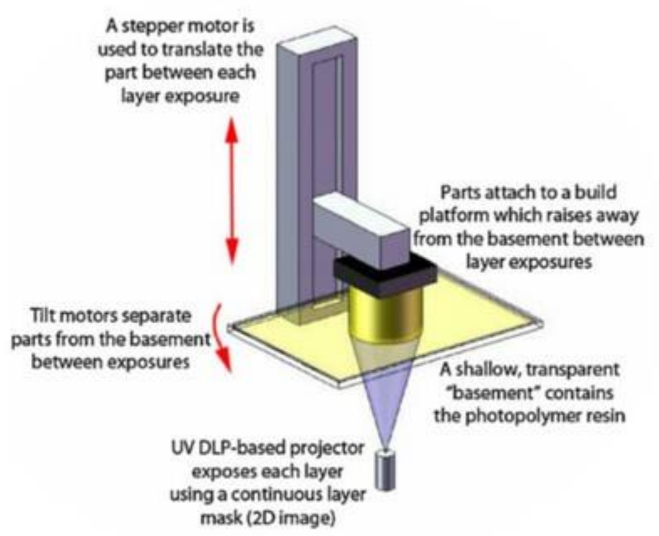
Digital Light Projection (DLP)



SLA vs DLP:

Photo-polymerization is another general term that, simply put, uses light to solidify a liquid polymer or resin. Examples include, but are not limited to, SLA and digital light process (DLP). These processes are both bath or vat processes with a photosensitive polymer or resin. The SLA uses a laser, and DLP uses a projector, to solidify the material. SLA can take longer, because the laser must travel the entire path of the part for each layer. A projector may expose the entire layer cross-section at the same time. This means the power of the lamp will be important to part size, and is often why DLP is performed with small parts.

Another miscommunication is that DLP is done from the bottom, whereas SLA is from the top. However, both processes can take a top-down or bottom-up approach. Right now, though, the trend is bottom-up for DLP top-down for SLA.

Barfoot explained the current trend may be due to the optics of the laser. If used in the bottom-up approach, problems could arise when traveling through the glass as refraction. Thus, reflection might be why the top-down approach is preferred for the SLA process. The top-down approach limits the travel in the Z axis to the depth of the basin, but the bottom-up approach will travel as long as the guide rails will allow. It also doesn't require the basin to be full, since it's working from the bottom. The part can lift out of the basin. As long as the working surface is submerged, the bottom-up process can continue.

https://youtu.be/d56j1ve2aDI
https://www.youtube.com/watch?v=7-2tyf7umsc
https://www.youtube.com/watch?v=8l8p62JhH6o
https://www.youtube.com/watch?v=yW4EbCWaJHE
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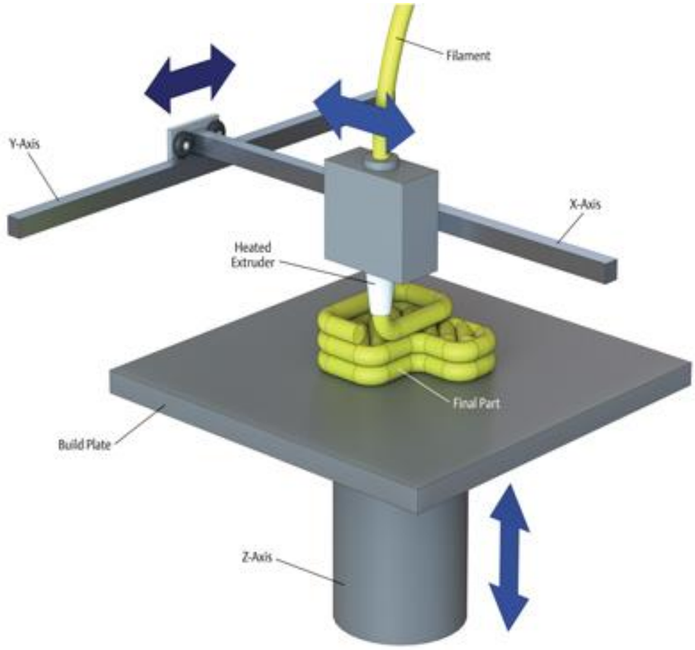
Fused Deposition Modelling (FDM)



A plastic filament is melted and extruded through a nozzle. Parts are built by laying down layer-by-layer.

A fused deposition modeling machine melts a plastic filament and extrudes it through a nozzle. The melted material is laid down on the build platform, where it cools and solidifies. By laying down layer on layer the part is built.

Fused deposition modeling requires support structures which anchors the parts on the build platform and supports overhanging structures. Through the use of a second nozzle, the support structure can be built in a different material. Several parts can be produced at the same time as long as they are all anchored on the platform

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https://www.youtube.com/watch?v=BwPgGCAseq8
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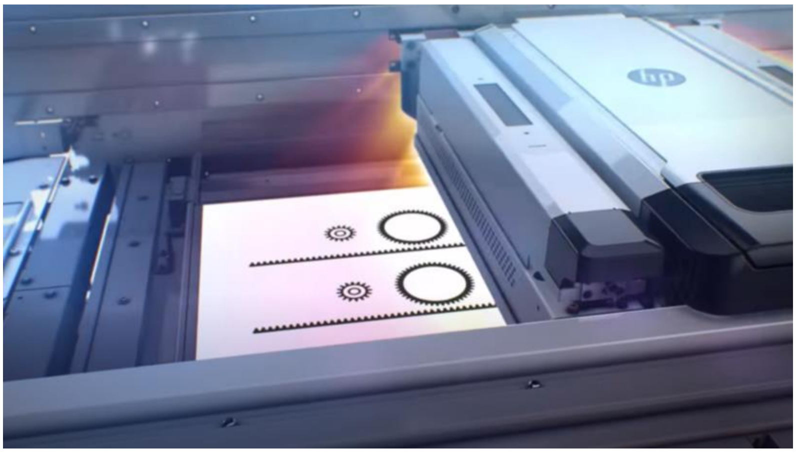
https://www.youtube.com/watch?v=J4OQQ9bA6g0

Multi Jet Fusion (MJF)



Multi-jet fusion (MJF) is a 3D printing system technology designed by HP Additive. MJF uses an inkjet array to selectively apply fusing and detailing agents across a bed of nylon powder, which are then fused by heating elements into a solid layer. This additive manufacturing system is designed for industrial additive manufacturing, and it has features that support industrial use cases. A selection of materials is available, but polyamide materials work best.

An HP Jet Fusion printer includes a build unit which looks like a rolling cart. The build unit is placed inside the printer before the process can begin. In the printing process, a material recoater carriage moves across the build area, depositing a thin layer of powder material. Next, the printing and fusing carriage moves across the build area. As the printing and fusing carriage passes over the build area, it first preheats the powder to a specific temperature to provide material consistency. Next, an array of inkjet nozzles jet fusing agents onto the powder bed in areas corresponding to the part's geometry and properties defined at that layer. The printing and fusing carriage then heats the surface of the bed to fuse the material.

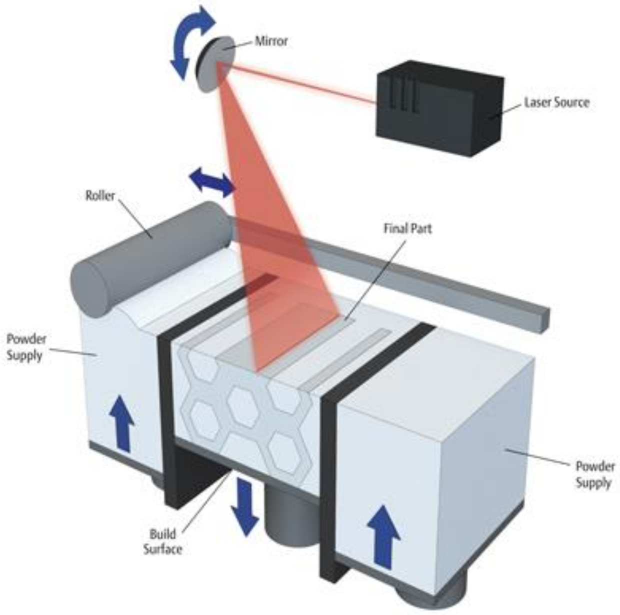
After each layer, the build unit retracts downward, creating space for the next layer of material deposition, and the process is repeated. By the end of the process, the build unit contains a three-dimensional area filled with unfused powder and the fused part or parts. An operator will remove the build unit from the printer and roll it into a separate processing machine, for cooling, unpacking the parts, and recovering unfused material powder. (https://www.hubs.com/knowledge-base/what-is-multi-jet-fusion/)

https://www.youtube.com/watch?v=VXntl3ff5tc

https://www.youtube.com/watch?v=FDlDPRszBpA

https://www.youtube.com/watch?v=GExSj17SyzE&list=PLoMwRIlUViGQsA-49cKLGZ62iX4MmWrXb

Selective Laser Sintering (SLS)



A thin layer of plastic powder is selectively melted by a laser. The parts are built up layer by layer in the powder bed.

A laser sintering machine will coat a layer of plastic powder onto a build platform, which is melted by a laser (or multiple lasers). The build platform will then be lowered and the next layer of plastic powder will be laid out on top. By repeating the process of laying out powder and melting where needed, the parts are built up in the powder bed.

Laser Sintering does not require any support structures. The built parts are sustained by the loose plastic powder. The entire build volume can therefore be filled with several parts including stacking and pyramiding of parts, which are then all produced together. The process chamber is preheated and under a protective gas environment.

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https://www.youtube.com/watch?v=ruvRijM7f50

https://www.youtube.com/watch?v=ksLiAjk8yBI

https://www.youtube.com/watch?v=oO77VKDB89I

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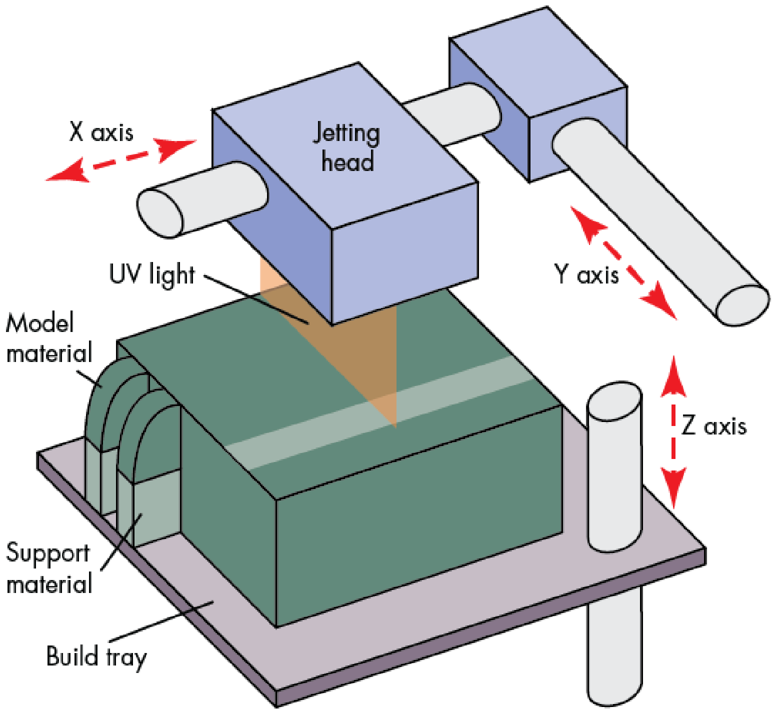
https://www.youtube.com/watch?v=y9PkFBV5138

Material Jetting Process (MJ)



Inkjet print heads are used to jet liquid photopolymers onto a build platform. The material is immediately cured by UV lamps and solidified which allows to build layers on top of each other.

Photopolymer jetting machines utilize inkjet print heads to jet a liquid photopolymer which is immediately cured by a UV lamp. By adding layer on layer, the part is built. Several materials can be jetted at the same time. Photopolymer jetting requires support structures for overhangs, which is usually built in a different material.

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https://youtu.be/Hx-ETs5FT_I
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https://www.youtube.com/watch?v=Som3CddHfZE
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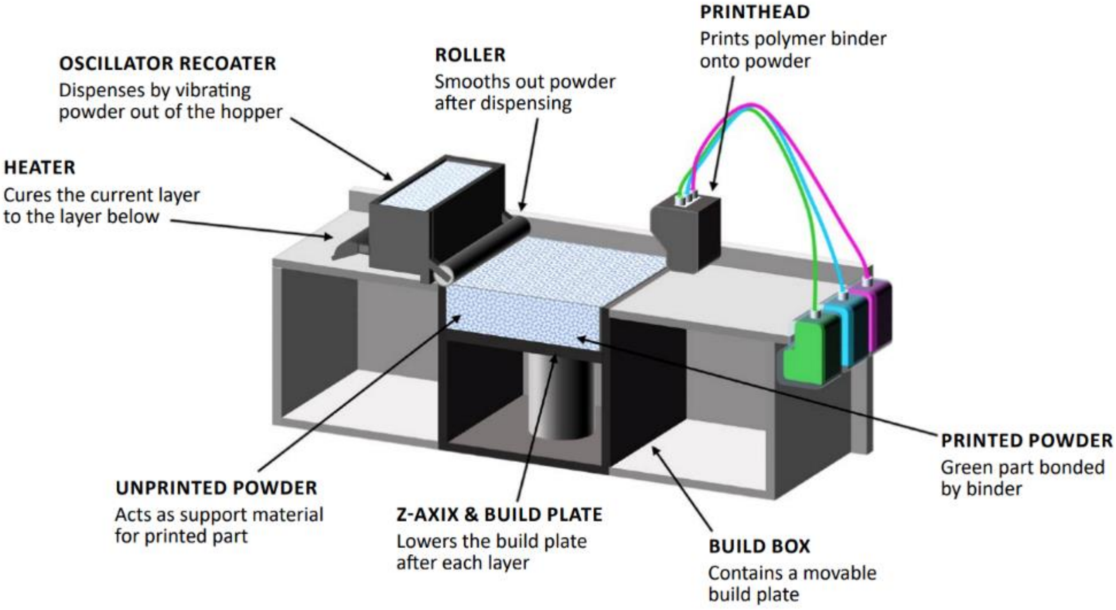
Binder Jetting Printing Process (BJ)



Inkjet print heads apply a liquid bonding agent onto thin layers of powder. By gluing the particles together, the part is built up layer by layer.

A binder jetting machine will distribute a layer of powder onto a build platform. A liquid bonding agent is applied through inkjet print heads bonding the particles together. The build platform will be lowered and the next layer of powder will be laid out on top. By repeating the process of laying out powder and bonding, the parts are built up in the powder bed.

Binder Jetting does not require any support structures. The built parts lie in the bed of not bonded powder. The entire build volume can therefore be filled with several parts, including stacking and pyramiding of parts. These are then all produced together. Binder Jetting works with almost any material that is available in powder form

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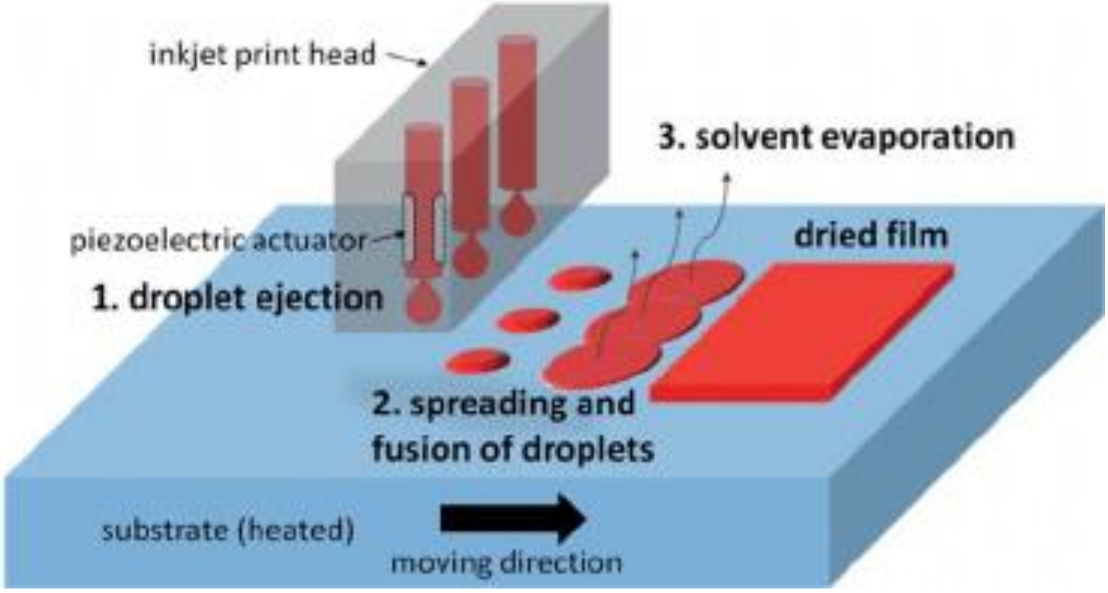
https://www.youtube.com/watch?v=ONMYx1yhJuo

https://www.youtube.com/watch?v=ps0WEZbDjHE

drop-on-demand inkjet printing system (DoD)



Inkjet print heads are used to jet melted wax materials onto a build platform. The material cools and solidifies which allows to build layers on top of each other.

Material jetting machines utilize inkjet print heads to jet melted materials, which then cool and solidify. By adding layer on layer, the part is built. Wax materials are used with this technology. Material jetting requires support structures for overhangs, which is usually built in a different material.

(https://www.semanticscholar.org/paper/3D-PRINTING-%E2%80%93-A-REVIEW-OF-TECHNOLOGIES%2C-MARKETS%2C-Aspler-Kingsland/9046d712a5d525f58d8dce674b9480144eed98ec)

https://www.youtube.com/watch?v=gM86qxW7vP8

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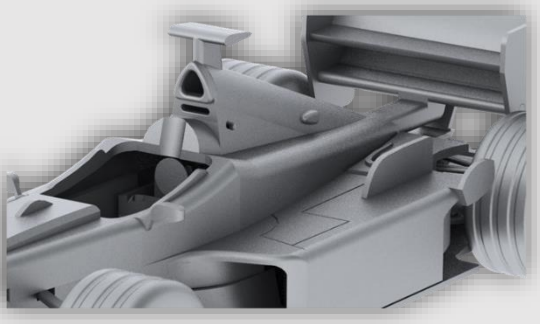
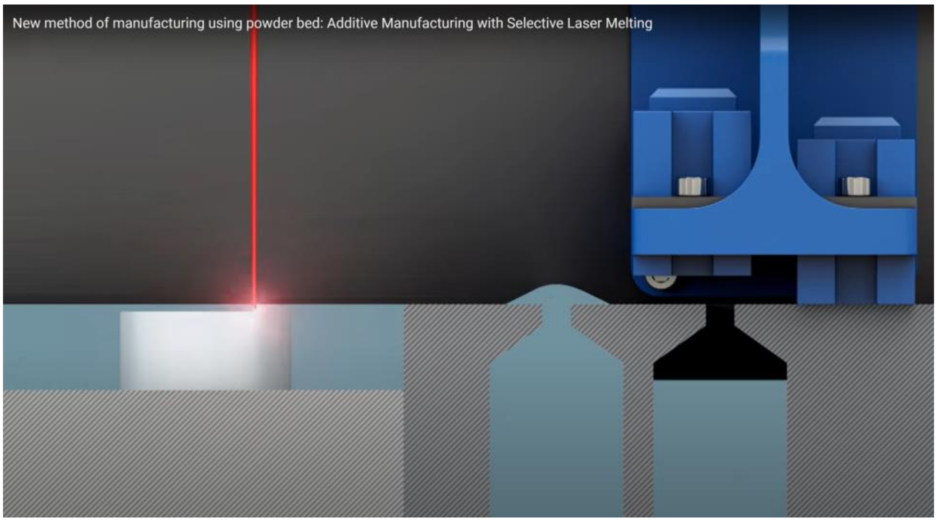
TECNOLOGIAS DE IMPRESSÃO

MATERIAIS METÁLICOS



Selective Laser Melting (SLM)



A thin layer of metal powder is selectively melted by a laser. The parts are built up layer by layer in the powder bed.

A laser melting machine distributes a layer of metal powder onto a build platform, which is melted by a laser (or multiple lasers). The build platform will then be lowered and the next layer of metal powder will be coated on top. By repeating the process of coating powder and melting where needed, the parts are built up layer by layer in the powder bed.

Laser melting requires support structures, which anchor parts and overhanging structures to the build platform. This enables the heat transfer away where the laser is melting the powder. Therefore it reduces thermal stresses and prevents wrapping. The build envelope can be filled by several parts being built in parallel as long as they are all attached to the build platform.

(https://www.semanticscholar.org/paper/3D-PRINTING-%E2%80%93-A-REVIEW-OF-TECHNOLOGIES%2C-MARKETS%2C-Aspler-Kingsland/9046d712a5d525f58d8dce674b9480144eed98ec)

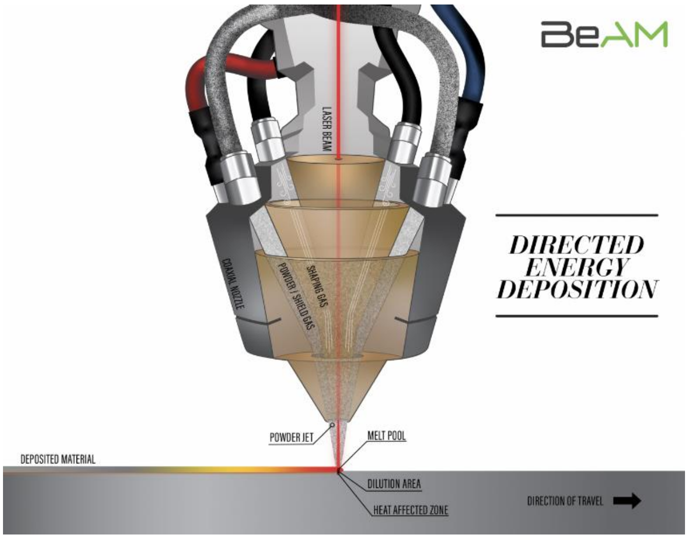
https://www.youtube.com/watch?v=te9OaSZ0kf8

https://www.youtube.com/watch?v=Mjf6oaMVWr8

https://www.youtube.com/watch?v=9MGWtpXwseU

https://www.youtube.com/watch?v=K30kLiW8EUs

Direct Energy Deposition – CLADDING process (DED)



Powder DED

Powder-fed systems, such as Laser Metal Deposition (LMD) and Laser Engineered Net Shaping (LENS), blow powder through a nozzle, which is melted by a laser beam on the surface of the part. Therefore, for the purposes of this study, we will also reference this method as a “blown powder” AM process. This process itself is highly precise and is based on an automated deposition of a layer of material with a thickness varying between 0.1 mm and a few millimeters. The metallurgical bonding of the cladding material with the base material and the absence of undercutting are some features of this process. The process is dissimilar to other welding techniques in that a low heat input penetrates the substrate.

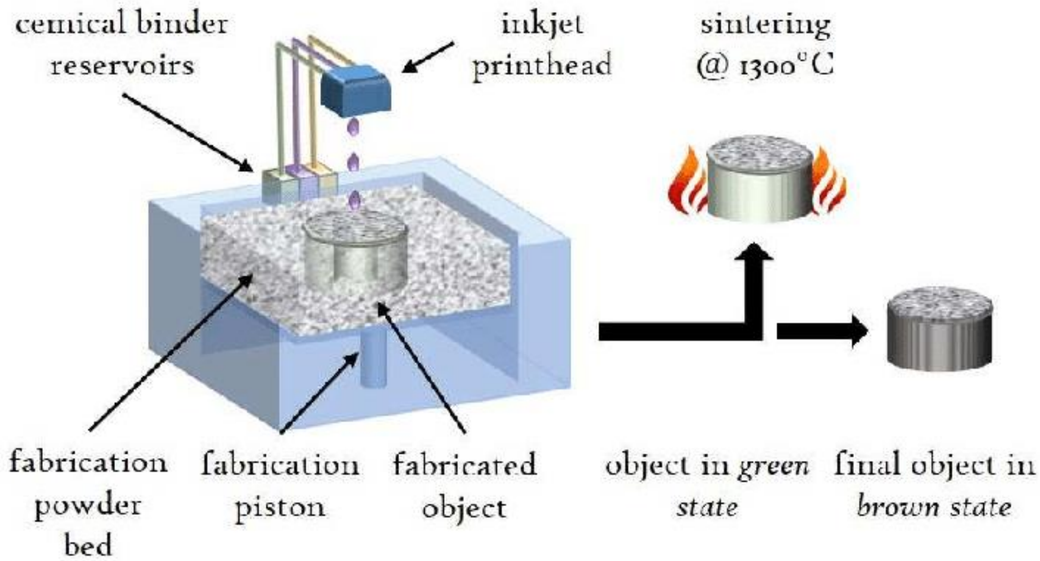
Wire DED

Laser-based wirefeed systems, such as Laser Metal Deposition-wire (LMD-w), feed wire through a nozzle that is melted by a laser, which incorporates inert gas shielding in either an open environment (gas surrounding the laser), or in a sealed gas enclosure or chamber. This process provides higher deposition rates as compared with powder bed and blown powder DED.

https://www.youtube.com/watch?v=Pjqysyy1ySs

https://www.youtube.com/watch?v=_ODyHutfxkI

Metal Binder Jetting (metal BJ)



Binder Jetting is a flexible technology with diverse applications, ranging from low-cost metal 3D printing, to full-color prototyping and large sand casting mold production. (https://www.hubs.com/knowledge-base/introduction-binder-jetting-3d-printing/)

In Binder Jetting, a thin layer of powder particles (metal, acrylic or sandstone) is first deposited onto the build platform. Then droplets of adhesive are ejected by a inkjet printhead to selectively bind the powder particles together and build a part layer-by-layer. After the print is complete, the part is removed from the powder and cleaned. At this stage it is very brittle and additional post-processing is required.

For metal parts this involves thermal sintering (similar to Metal Injection Molding) or infiltration with a low melting-point metal (for example, bronze), while for full-color parts are infiltrated with cyanoacrylate adhesive.

Binder Jetting can produce metal parts and full-color prototypes at a fraction of the cost of DMLS/SLM or Material Jetting respectively. Very large sandstone parts can also be manufactured with Binder Jetting, as the process is not limited by thermal effects (for example, warping). Since no support structures are needed during printing, metal Binder Jetting parts can have very complex geometries and, like SLS, low-to-medium batch production is possible by filling up the whole build volume. Metal Binder Jetting parts have lower mechanical properties than the bulk material though, due to their porosity.

Due to the special post-processing requirements of Binder Jetting, special design restrictions apply. Very small details, for example, cannot be printed, as the parts are very brittle out of the printer and may break. Metal parts might also deform during the sintering or infiltration step if not supported properly.

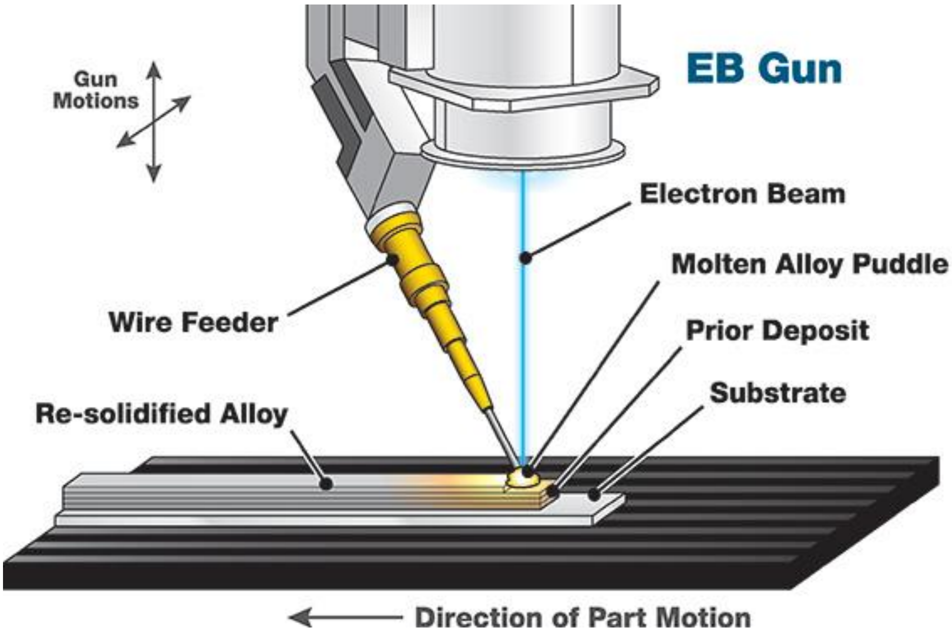
https://www.youtube.com/watch?v=L6Rd9dilkrs

https://www.youtube.com/watch?v=wRj44e8D-xk

https://www.youtube.com/watch?v=h0YVh_TPBRY

https://youtu.be/i6Px6RSL9Ac

HYBRID process



While “hybrid” can be used to describe many combinations of subtractive and additive manufacturing (AM), “hybrid manufacturing” most often refers to the combination of machining and 3D printing, typically metal.

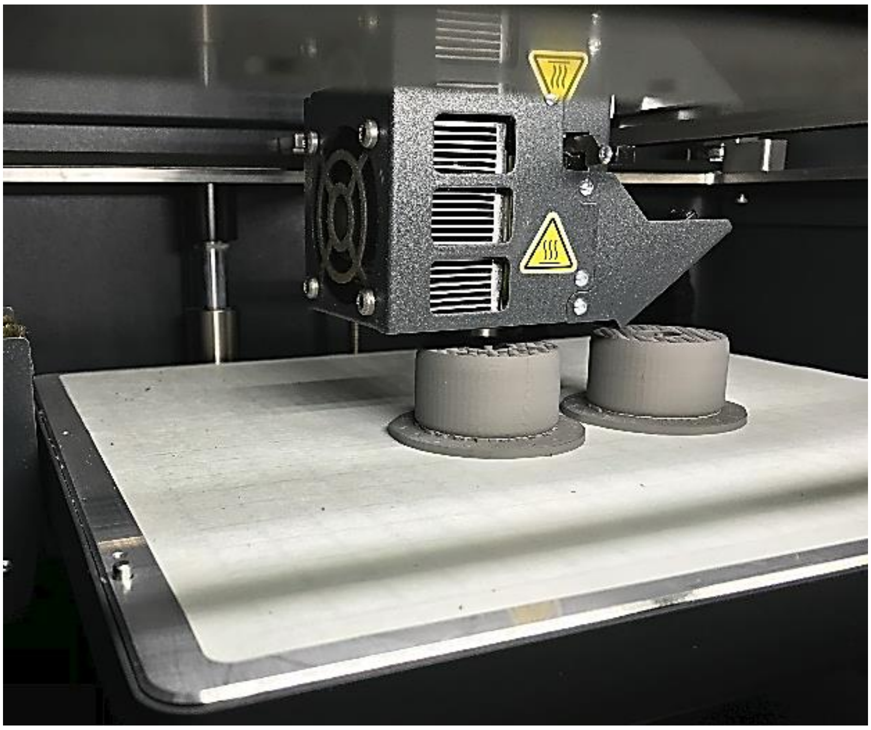
Hybrid systems most often consist of a machine tool such as a mill or lathe, or a robot arm, that is equipped with a directed energy deposition (DED) head for depositing metal powder or wire. Other systems are available that combine machining with powder-bed fusion (PBF). There are also hybrid systems for processing polymers, typically using material extrusion as the additive process.

(https://www.sciencedirect.com/science/article/pii/S2666912921000027#:~:text=Introduction,advantages%20(Chu%2C%202014).)

https://www.youtube.com/watch?v=wOrUahat-K0

https://www.youtube.com/watch?v=oaIOrQi2HLM

Bound Metal Deposition (BMD)



Bound Metal Deposition, is an extrusion-based metal additive manufacturing (AM) process where metal components are created by extrusion of a powder-filled thermoplastic media. Metal powder that is sustained together by both wax and polymer binder. They are then heated and extruded onto the build plate. This shapes the part layer by layer. The binder is later removed by the debind process and then sintered directly after printing. This causes the metal particles to densify.

Common metal AM technologies often include melting powder, or wire feedstock using lasers or electron beams. Many facilities require the accommodation of power and safety. Furthermore, support removal often calls for machining because of localized melting and rapid solidification. This creates complex stress fields within parts, with necessary rigid support structures to aid heat dissipation and resist shrinkage.

(https://proto3000.com/3d-printing/metal-3d-printing/deep-dive-bound-metal-deposition/)

https://www.youtube.com/watch?v=knd92DzMyOs

https://www.youtube.com/watch?v=EQsapD2bmDA

https://www.youtube.com/watch?v=UdiwBiw5dyo