The Ultimate Metal 3D Printing Guide

by sculpteo.com

Table of contents

3D PRINTING INTRODUCTION & HISTORY

Introduction

We've entered the Fourth Industrial Revolution, and manufacturing is changing considerably. Additive manufacturing is now a part of the manufacturing landscape, just like CNC and injection, a complement of traditional technologies that need to be understood and used.

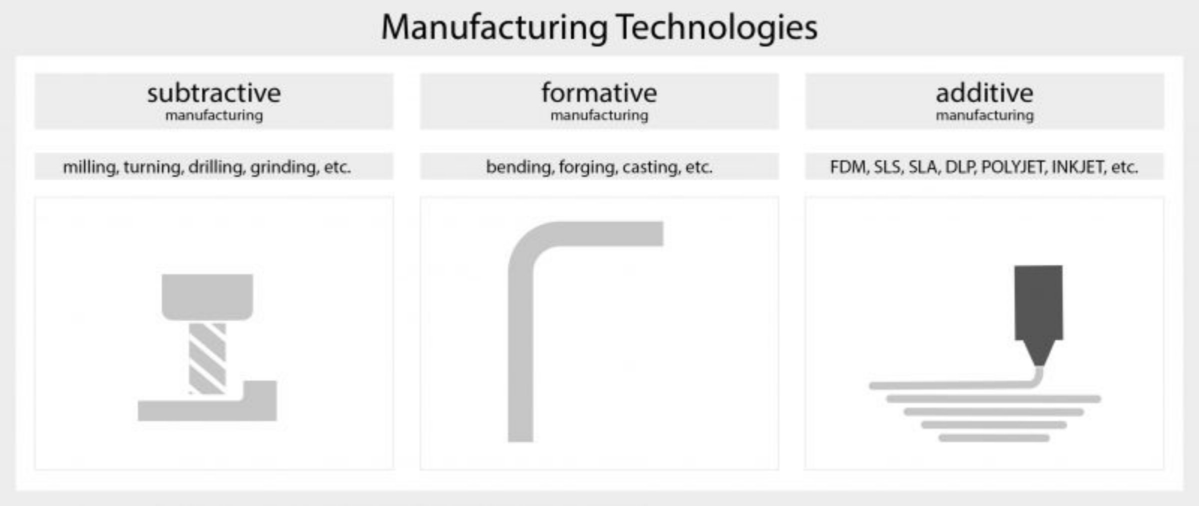


Image: 3Dprintwiki.org

Among additive manufacturing techniques, **metal 3D printing is changing the game** most particularly. It's already making its marks in fields such as aeronautics which need innovative ways to create **high-performing mechanical parts**. 3D printing brings exceptional benefits to prototyping and production, which will bring a **competitive advantage** to your business if used properly:

- Complex designs, and shapes that would be impossible without layer-by-layer production

- Speed, and reduced assembly time

- Topology optimization and weight reduction

- Cost-efficiency for short runs

- Mass customization

- Remote production when using an online 3D printing service like Sculpteo

Long story short: the history of metal 3D printing

Often considered as recent progress, additive manufacturing has actually been developing since the 1980s and regroups many techniques and patents.

First came laser-based technologies, both for metals and polymers. Binder jetting was developed later on.

Among the main developers of these technologies are the MIT and the University of Texas (SLS; Binder Jetting), 3D Systems (SLA), as well as SLM Solutions (SLM) and EOS GmbH, who were vital in the development of metal 3D printing in particular.

Another industrial has appeared in 1999: Arcam. They developed their own metal 3D printing technology called Electron Beam Melting.

In the middle of the 2000s, General Electric joined the course and started to get interested in the Metal 3D Printing opportunities. They finally decided to apply it in the production process for their aviation branch with a metal 3D printed fuel nozzle.

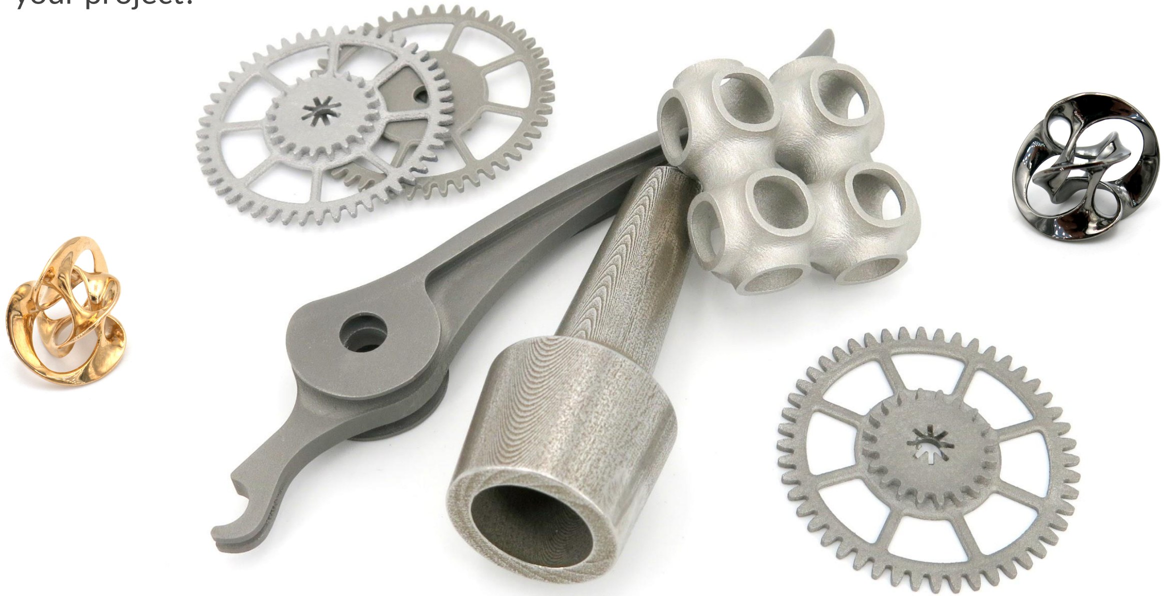
METAL 3D PRINTING: TECHNOLOGIES & MATERIALS

2. Metal 3D printing technologies: introduction

There are 3 leading technologies when it comes to metal 3D printing. They differ in methods of manufacturing and materials, and also applications. In this chapter, we will go over the manufacturing process, advantages, and utilizations of each one. Let's see which one is the best for your project!

Metal 3D printing technologies:

1. **DMLS/ SLM**
2. **Binder Jetting**
3. **Wax Casting**



2.1 DMLS/ SLM: technology and materials

Direct Melting Laser Sintering and Selective Laser Melting are Additive Manufacturing techniques developed especially for 3D printing metal alloys. The 3D printer **spreads a layer of metal powder** and then **fuses the particles with a laser beam**. When it comes to SLM, the powder is fully melted. DMLS melts the material only partly (at a temperature around between 1510°C and 1600°C).

You can use those technologies with the following materials:

Aluminum AlSi7Mg0,6: aluminum (90%), silicon (7%) and magnesium (0.6%)

- Good mechanical properties, can be subjected to high voltage

Stainless Steel 316L: iron (66-70%), chrome (16-18%), nickel (11-14%), molybdenum (2-3%)

- Strong corrosion resistance, high ductility

Titanium 6Al-4V: titanium (88-90%), aluminium (5.5-6.5%), vanadium (3.5-4.5%)

- Highly resistant to oxidation and acid, low toxicity, biocompatible

2.1 DMLS/ SLM: applications

- **Aerospace**

  Thanks to the possibility to produce **highly complex and lightweight shapes**, fixtures and mountings holding specific aeronautic tools, fully functional parts (see the 3D printed engine components by NASA)

- **Manufacturing:**

  Metal 3D printing technologies can be very beneficial for niche markets for **low volumes at competitive lead time and costs**

- **Medical**

  3D printing enables the production of **complicated and customized tool**s, matching precisely the needs of a specific study, patients of procedure

- **Prototyping**

  Fast production allows us to **develop new solutions and test them in no time,** for example implementing cooling channels into tools

- **Automotive:**

  One of the benefits of 3D printing for the automotive industry is **lightweight structures,** which leads to **lower production costs** and **less material wastage**. One example is [3D printed breaks by Ford.]

2.2 Binder Jetting: technology & materials

Binder Jetting 3D printers apply a layer of metal powder over the printing bed and then drop binding agent in the shape of your object. Between each layer, the powder is lightly cured to achieve solidification. When the 3D printing process is completed, the build box is removed. The parts are finished after additional curing in the oven.

This process can be used with materials:

Steel/ Bronze 420SS/BR: 60% stainless steel, 40% bronze

- Fairly good mechanical properties, well suited for ornamental purposes and small objects

Stainless Steel 316

- Strong resistance against corrosion and high temperature, good for small, complex objects, tooling, and molding

2.2 Binder Jetting: applications

Compared to DMLS & SLM, Binder Jetting technology is cheaper and can be a good competitor for the **production of medium batch production and prototyping**.

Production with *Steel/ Bronze 420SS/BR* will be undoubtedly beneficial for **jewelry** and other **decorative applications**, thanks to the **excellent design freedom of 3D printing and plating options**.

Stainless Steel 316 can also be used in those sectors, as after polished, silver color and smooth, shiny surface can be achieved. But those are not the only applications of this material. It can also be used in the **consumer goods** industry, to produce **tooling**, **molds,** and for **injection molding**.

2.3 Wax Casting: technology & materials

Wax Casting combines both additive and subtractive manufacturing methods. Firstly, a master model is 3D printed in wax. Additive Manufacturing is the perfect solution at this stage thanks to **high precision** and **accuracy**, as well as a **wide range of materials** that can be used for 3D printing.

A plaster mold is created around the 3D printed master model. The wax model is then pushed out of the mold through a tree-like structure by liquid metal.

There are 3 materials used for Wax Casting:

Silver: 92.5% sterling silver, 7.5% metal alloy

Brass: 80% copper, 15% zinc, 5% tin

Bronze: 90% copper, 10% tin

Find out more about Wax Casting with our [dedicated ebook].

2.3 Wax Casting: applications

Wax Casting can offer amazing advantages for **jewelry making**. It can produce **sharp edges** and **smooth surface**, as well as very **delightful aesthetics** as there are several plating options available.

Thanks to 3D printing, you can discover totally **new design solutions**, which are impossible to reach with traditional manufacturing methods. Wax Casting materials give you **beautiful solutions** to manufacturing **complex shapes**, at a **short time** and a **good price**.

Get free Wax Casting guide to dig deeper into this technology!

DESIGN GUIDELINES

	Aluminum AlSi7Mg0,6	Stainless Steel 316L	Titanium 6Al-4V	Steel / Bronze 420SS/BR	Stainless Steel 316	Silver	Brass	Bronze
Layer Thickness	150 µm	40 µm	30 µm	100 µm	100 µm	25 µm	25 µm	25 µm
Minimum wall thickness	0.5 mm	2 mm	2 mm	1.1 to 3.2 mm	1.1 to 3.2 mm	0.8 mm	0.8 mm	0.8 mm
Minimum space between fixed walls		0.2 mm	0.2 mm			0.3 mm	0.3 mm	0.3 mm
Minimum size (mm)	325 x 250 x 250	325 x 250 x 250	325 x 250 x 250	Unpolished: 400 x 250 x 250 Unpolished plated: 177.8 x 177.8 x 177.8 Polished: 152.4 x 152.4 x 152.4	120 x 50 x 50	60 x 80 x 100	120 x 88 x 88	120 x 88 x 88
Maximum size (mm)				Unpolished: 0.3 x 1.27 x 0.8 Polished: 15 x 15 x 15	Polished: 15 x 15 x 15	2.4 x 2.4 x 0.8	0.6 x 2.4 x 2.4	
Minimum visible detail	1 mm	1 mm	1 mm	0.8 mm	0.8 mm	0.4 mm	0.4 mm	0.4 mm

	Aluminum AlSi7 Mg0,6	Stainless Steel 316L	Titanium 6Al-4V	Steel / Bronze 420SS/BR	Stainless Steel 316	Silver	Brass	Bronze
Minimum clearance	0.2 mm	0.2 mm	0.2 mm	0.5 mm	0.5 mm	0.3 mm	0.3 mm	0.3 mm
Minimum size of text	1 mm	1 mm	1 mm	0.76 mm	0.76 mm	Width: 0.5 mm Height 1.5 mm	Width: 0.5 mm Height 1.5 mm	Width: 0.5 mm Height 1.5 mm
Engraving	1 mm	1 mm	1 mm	0.76 mm	0.76 mm	0.4 mm	0.4 mm	0.4 mm
Embossing	1 mm	1 mm	1 mm	0.76 mm	0.76 mm	0.5 mm	0.5 mm	0.5 mm
Interlocking parts	No	Not recommended	Not recommended	No	No	No	No	No
Hollowing	No	No	No	No	No	No	No	No
Enclosed parts	No	Not recommended	Not recommended	No	No	No	No	No

METAL 3D PRINTING ON THE MARKET

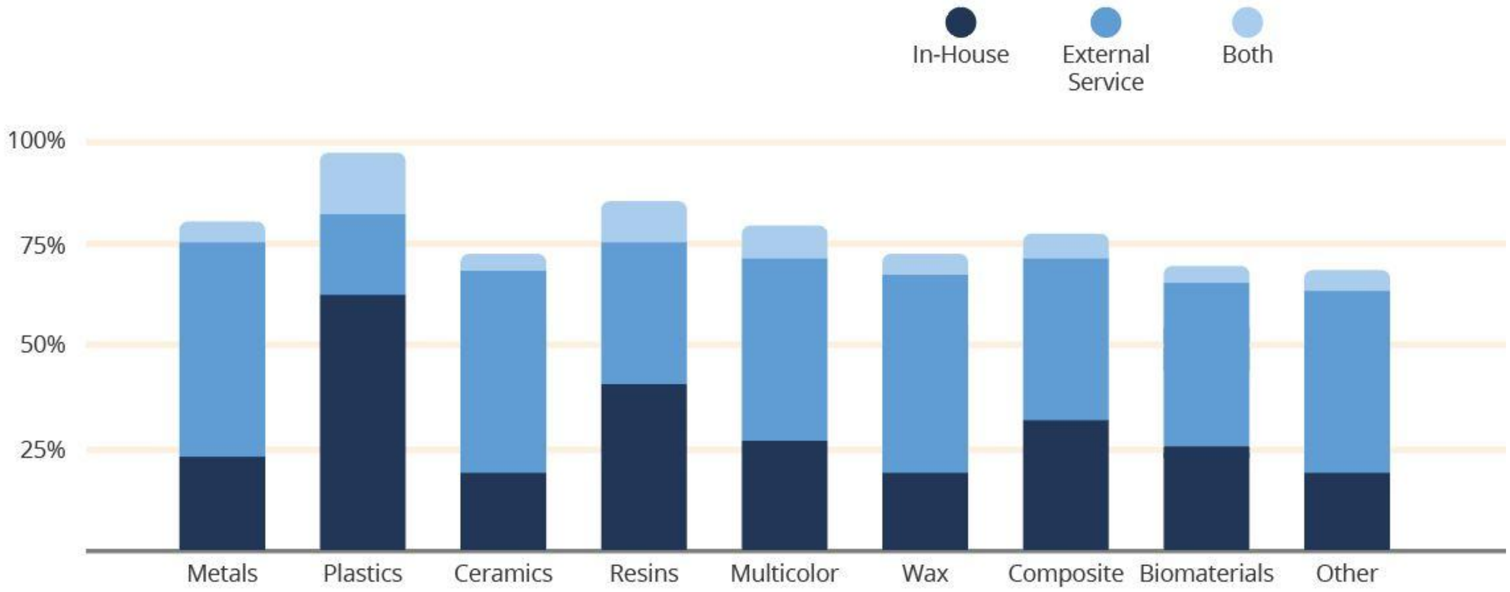
The State of 3D Printing 2019

Each year, Sculpteo launches its annual survey to collect data about the additive manufacturing world. From beginners to experts, professionals from every sector answered this survey, making it the biggest study you will find about the additive manufacturing industry. Let’s take a closer look at the state of metal 3D printing on the market!

If you’re interested in finding out more about the whole Additive Manufacturing industry, download the full report.

The use of 3D printing materials

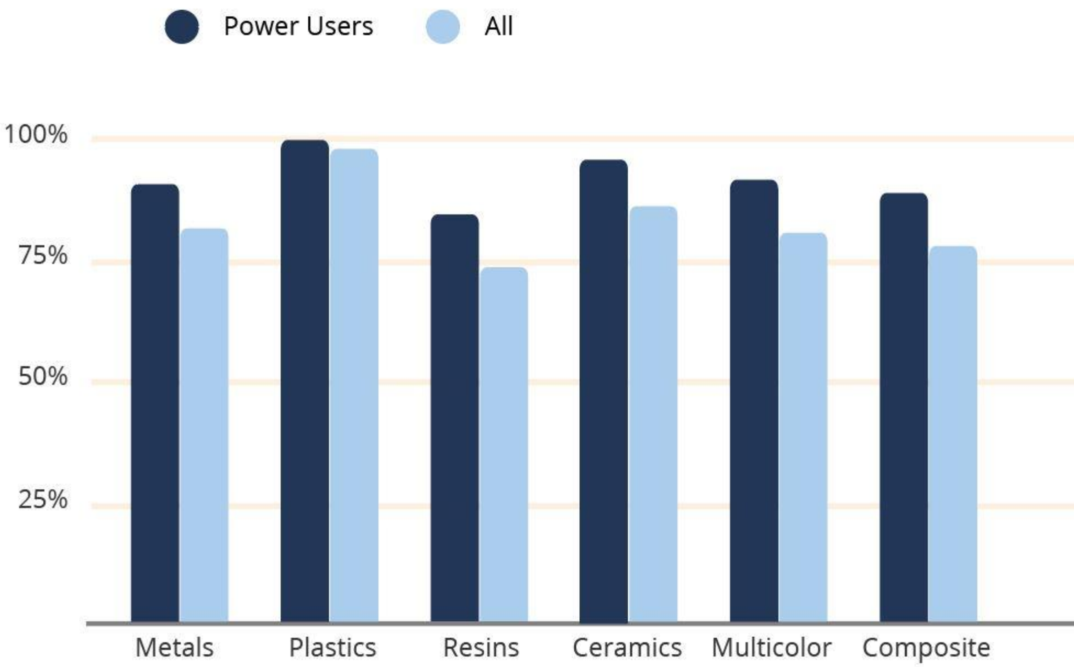
Applications of metal 3D printing constantly grow, however, metal 3D printers can be expensive. This is why we can notice grown of external service metal 3D printing. Actually, **50% of metal 3D printing is fulfilled by external services**.



Power Users vs All

Who are Power Users? This is a special group of 3D printing users, using additive manufacturing in the context of work for more than two years. Their use of 3D printing is significant, and they invested at least $10k in 3D printing last year. This section focuses on their views and uses of this technology.

They certainly invest more into metal 3D printing than other users. 89.8% of Power users declared utilizing metal 3D printing technologies, whereas it was 80.9% of all users. Those numbers are quite close and show that **metal Additive Manufacturing is definitely growing in many industries**.



sculpteo.com

Additive. Manufacturing at your scale