3D-Printing Technology | Patent Landscape Report

This report provides a patent landscape of the advances in 3D-Printing technology. It includes the analysis of 13268 patents of various companies from 2000 to 2023.

Patent LandscapeReport

3D-Printing

Published and edited by

STIMAnalytics

Dubai

UAE

©STIMAnalytics 2023

Powered by STIM AI Service

The report can be downloaded from

stimanalytics.net/plr-3d-printing

Executive Summary

This report is the first of a series of patent landscape reports on 3D-Printing technologies by STIMAnalytics. It presents the results of patent analyses in the 3D-Printing domain, which were performed by STIMAnalytics AI-Powered service in collaboration with experts in patent knowledge and subject-matter. The aim of this report is to provide a summary of the main patent trends in 3D-Printing and related areas. Patent information is a valuable source of technical information on patented inventions that reflect the commercial expectations of the applicants. Patent information often contains technical and other information that is not available from any other source.

This report can be useful as an information source in the 3D-Printing area. The report's methodology relies on AI-Powered application developed by STIMAnalytics. This app uses advanced algorithms and models to meet the needs of various stakeholders (Inc. R&D managers, product managers, technologist, researchers and academics) in established or emerging technical fields.

The number of inventions in 3D-Printing has grown rapidly in recent years. The number of inventions in this field increased ten times over the last 10 years, which is much higher than the general growth in all fields of technology. The figure on the next page shows the number of International Patent Families in 3D-Printing and in all technical fields, as a function of the year when the inventions were first disclosed to the public.

- ## Patent Landscape Report at a Glance

In this report, 13,268 patents have been examined, of which 5,609 are active and 4,214 are pending. This shows the large number of patents requested in the last 3 years. Also, the three companies Hewlett-Packard, Signify and Xerox are the pioneers in patent registration in this field.

The highest number of patents has been registered in China with 5,537 patents, followed by the United States. It is noteworthy that most of the leading applicants in China are universities and research centers, while in the United States, large technology companies have the largest number of applications.

Also, Velo3D company has the largest number of highly-cited patents, which is a sign of the high value of this company's patents. The main themes of the patents represent the thematic focus of patents on areas such as 3D-Printing for use in the body and bones, dentistry and implants, surfaces, containers, and materials and inks used. In addition, "Technology of Data acquisition or data processing for additive manufacturing for controlling or regulating additive manufacturing processes" and "Apparatus for additive manufacturing; Details thereof or accessories thereof" are the top technology areas in this field. In addition, three main patent applicant companies were examined separately.

Content

1. Introduction

3D printing is a technology that allows you to create physical objects from digital models. 3D printing works by adding layers of material on top of each other, following the shape and design of the model. 3D printing can be used for various purposes, such as prototyping, manufacturing, art, education, and medicine. 3D printing can create complex and customized shapes that are difficult or impossible to make by other methods. 3D printing can use different types of materials, such as plastics, metals, ceramics, or even biological materials. 3D printing requires a 3D CAD model, a 3D printer, and a suitable material to print with.

The purpose of this report is to give an overview of the key patent trends in the field of 3D-Printing. For this, the report uses publicly available patent information, which is a very rich source of technical information on inventions that were patented based on the commercial expectations of the applicants. Patent information often has technical information that is not found from any other source.

This report is based on the patent information collected from various patent databases related to different countries' patent offices. The keywords and classifications were selected to cover the relevant patents in this field. The text and metadata of the patents were analyzed using descriptive statistics and artificial intelligence (natural language processing) methods.

This patent landscape report is useful for commercial companies and technology developers in this field. This report consists of four main parts. First, the Patent Outlook section provides an overview of patent application macro trends, major applicants, major owners, market coverage of patents applied for by major players, and high-value patents.

Then, in the Technology Analysis section, the technology areas of interest to the applicants are introduced at four levels, based on the technology tree aligned with IPC. The emphasized technologies in the last five years are also presented. Key patents that have the most citations are also introduced. In addition, using machine learning methods, patents are clustered into different groups and top terms are presented for each cluster. The key themes of all patents are also presented using the topic modeling method.

Next, the Technology Market Space section examines the cooperation network of the main actors, the continuation of their activities in the last 10 years, and their patenting behavior through clustering of requested patents and investigating pending patents.

Finally, the patenting behavior of three key applicants is examined individually and in detail. The patent family of these three companies, along with emphasized technologies, technology collaborations, key patents, main themes of the requested subjects and patent clustering for each of these players are presented.

Overall, this report provides a 360' view and a detailed picture of technology trends, market, and behavior of key players in this field. This valuable information can help companies in formulating technology, new product development and market entry strategies.

3D PRINTING SCIENCE ANALYTICS

3D printing technology is growing rapidly and due to its scientific nature, it is seriously related to academic research. The analysis of scientific articles can provide very important information to companies to investigate future investment possibilities as well as cooperation with universities and research centers. Currently, the report of more than 60,000 scientific articles published in scientific journals has been prepared by the STIMAnalytics and can be obtained.

This report includes descriptive reports related to the publication trends of scientific articles, active researchers and institutions, citations related to articles and other matters. Also, collaboration networks between researchers, articles, and keyword co-occurrence network are part of scientometric analysis. Finally, analyzes based on artificial intelligence including clustering, topic modeling and burst detection express the current and future trends in this field.

For more information, visit the STIMAnalytics.net website.

2. Patent Landscape Overview

2.1. Patent Family Analysis

By examining patents in the field of 3D-Printing technology, it is clear that 13268 patents have been registered between 1990 and 2022. Also, the process of applying for patent registration in this field is increasing rapidly. This growth shows the high commercialization capacity of this technology. The highest number of patent registrations is in 2018. It should be noted that 4214 patents are pending, and it is expected that an important part of them will be registered in the next 24 months and will be added to the statistics of the last two years. It should be mentioned that 5609 patents are active and 3420 patents are inactive, non-continuing and expired. This shows that this field of technology is growing and the number of patent applications is expected to increase in the coming years.
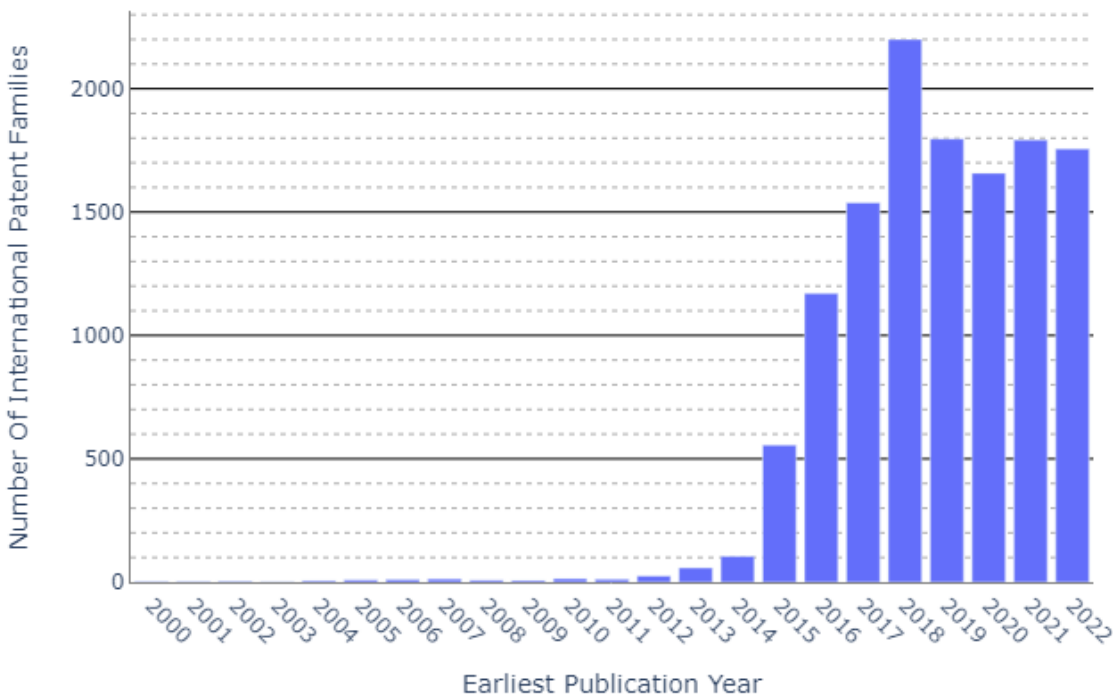
Another important point is that 80% of these patents have been registered since 2015 and this indicates that, with great probability, various products using these patents will be presented to the market in the coming years.

2.2. Patent-Market Coverage

Most of the patents in this field have been published since 2012. The largest number of patents have been registered in China and the trend has been that the registration of patents in the jurisdiction of China has continued until 2018, and since 2018 it has faced a significant decreasing trend.
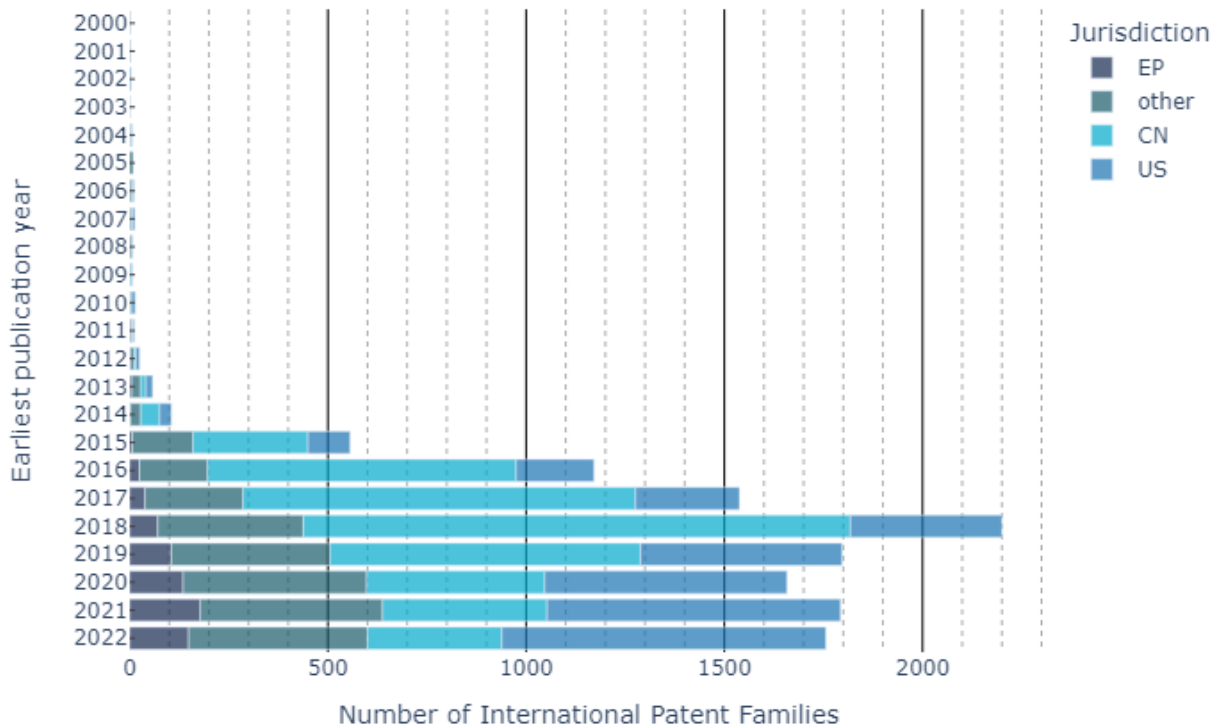
This is while patent registration in the United States has had a relatively steady growth trend since 2012, and since 2020, the number of patents registered in the USPTO has surpassed that of China, which indicates possible changes in market demand. Also, the amount of patent registration in Europe is increasing with a relatively constant growth rate. Although China still has the highest number of patents registered in this field, it seems that the tendency of companies to register patents in USA and Europe is growing faster.

Although China still has the highest number of patents registered in this field, it seems that the tendency of companies to register patents in USA and Europe is growing faster. It is also worth mentioning that South China University has the largest number of patent registrations in China. While in USA, Hewlett-Packard has the largest share of registered patents. The remarkable thing is that the top set of patent registrants in this field in China are universities, while in USA, large companies are at the top of patent applicants in USA.
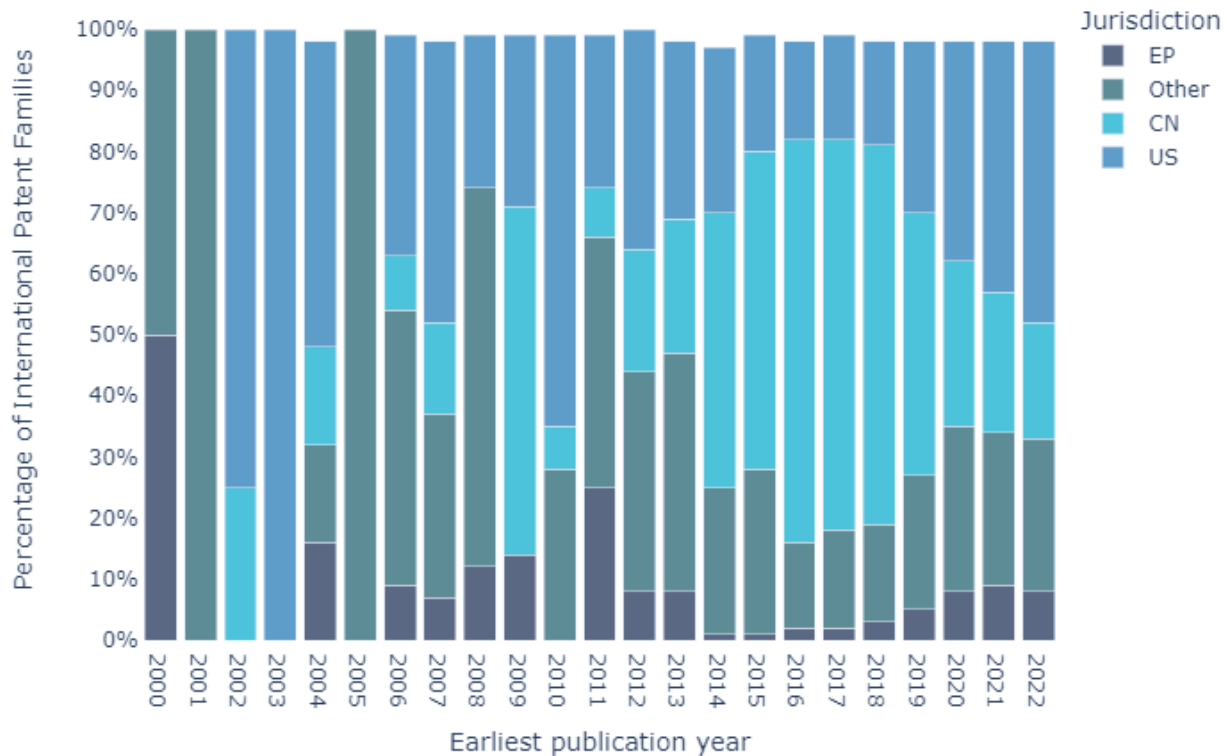
2.3. Geographical jurisdiction

The number of patents registered in different countries shows that USA and China having about 80% of the number of registered patents, are at a great distance from other countries. This issue indicates the significant growth of the future market of 3D printers in these two markets. The European market is also moving after these two main markets of 3D printer technology. Other players such as Canada, England, South Korea and Japan do not have a decisive role in the market.

It is noticeable that the main destination of international companies for patent registration is the US market. Of course, Hewlett-Packard also has a significant number of registered patents in China.

2.4. Top Applicants

Despite the high volume of patent registrations in China, the leading companies applying for patents are all large US and multinational companies. With more than 400 patent applications, Hewlett-Packard is far ahead of other competitors. After that, there are Signify Holding, Xerox, XYZPrinting and Knipo.
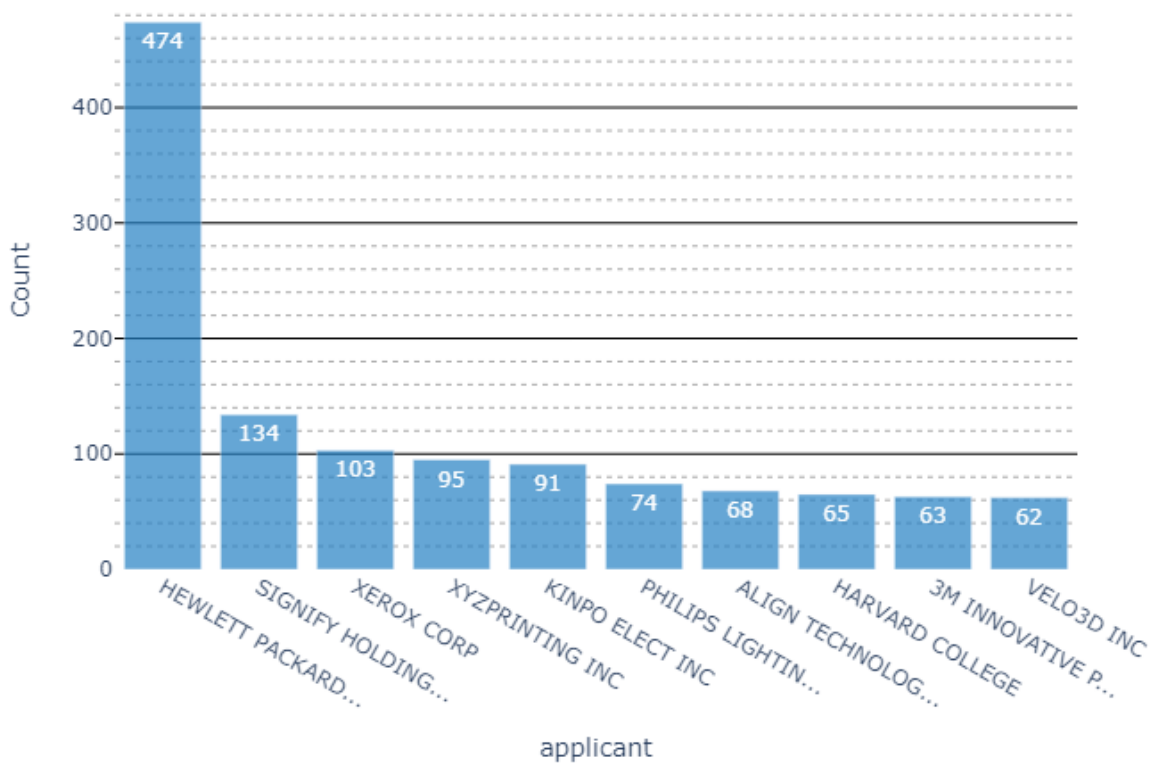

Meanwhile, the significant increase of patents registered by Hewlett-Packard company, especially between the years 2019 and 2021, is significant compared to other competitors. While during the years of the Covid-19 epidemic, most of the leading companies did not have much growth in patent applications, Hewlett-Packard Company has set new records in this field, which indicates the high investment of this company in the field of 3D printers and probably in the future, we will face a wide range of products related to 3D-Printing technology by HP.

2.5. Market Coverage of Top Applicants

As can be seen in the chart below, Hewlett-Packard has considered a wide range of markets for its technologies and related products and has filed patent applications in all major jurisdictions. Other companies have mainly considered the US and European markets at the same time.
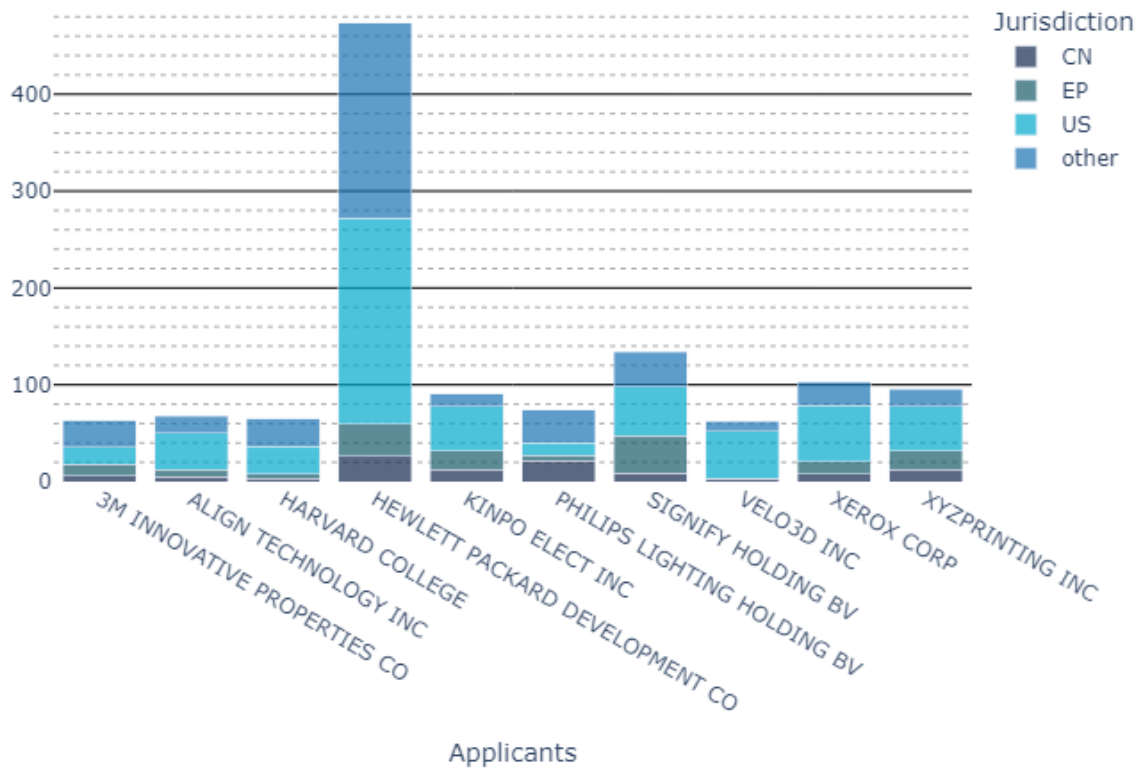

Also, the big Chinese applicants have mainly registered patents inside China, which indicates that Chinese companies are focusing on producing products inside China or - selling patents to Chinese companies. The figure below shows the distribution of patent applications by the top applicants across different jurisdictions.
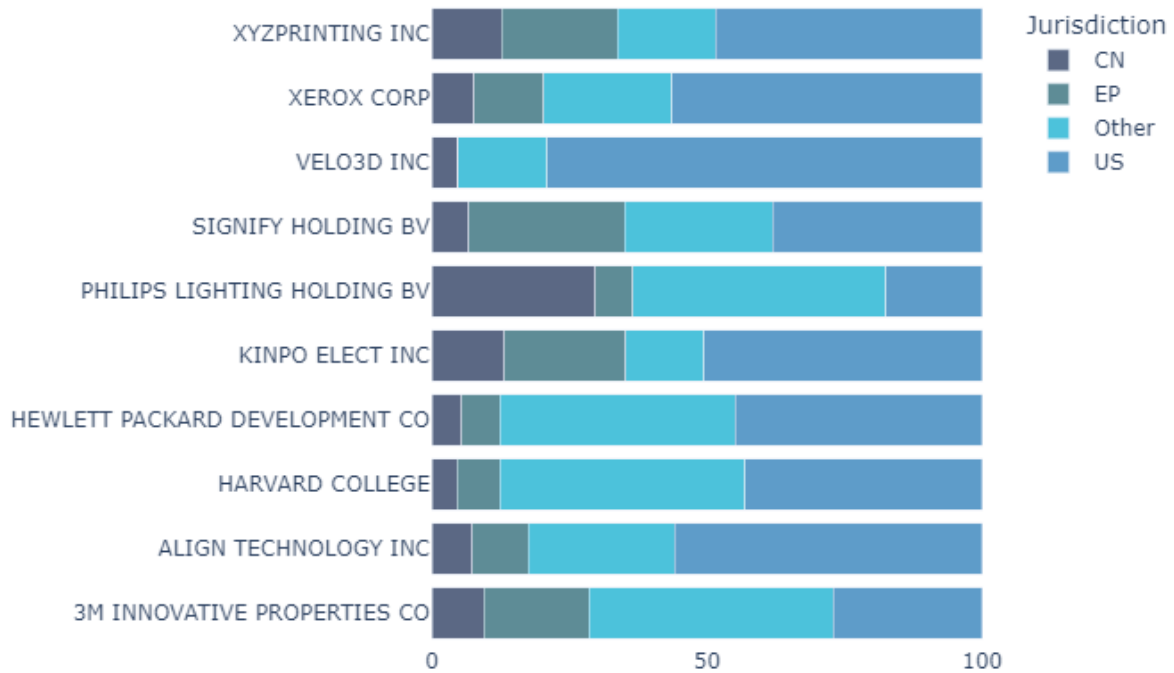
2.6. Top Owners

Patent owners are sometimes different from applicants. Basically, the owners are the main commercial users of patents. In the field of 3D-Printing technology, Hewlett-Packard owns the largest number of patents. After HP, there are Xerox, XYZ Printing.
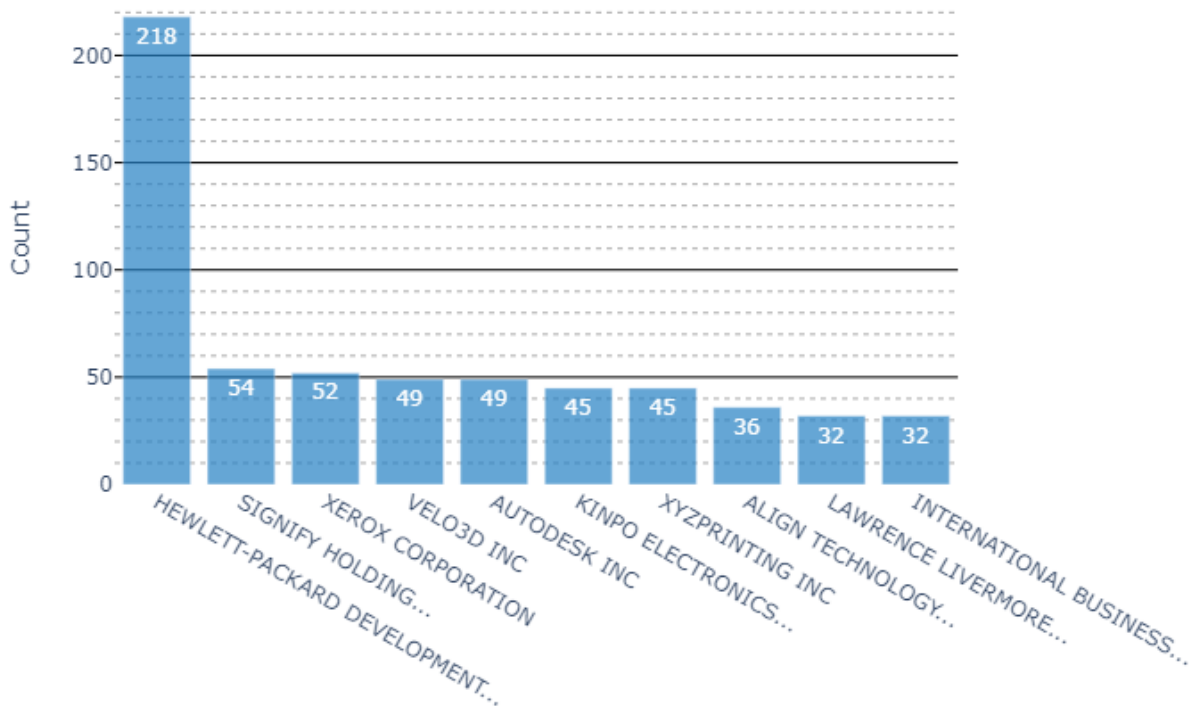
2.7. Highly-Cited Applicants

The highest number of citations is related to the patents of Velo3D Company with the number of 3017 citations. After that, the patents of Markforged, Autodesk and Harvard College. The high number of citations of Velo Trade Company indicates the high value of the registered patents of this company. Considering that most of the patents in this field have been registered since 2012, this high number of citations to active patents shows that this group is the leader in the advanced technologies of this field.
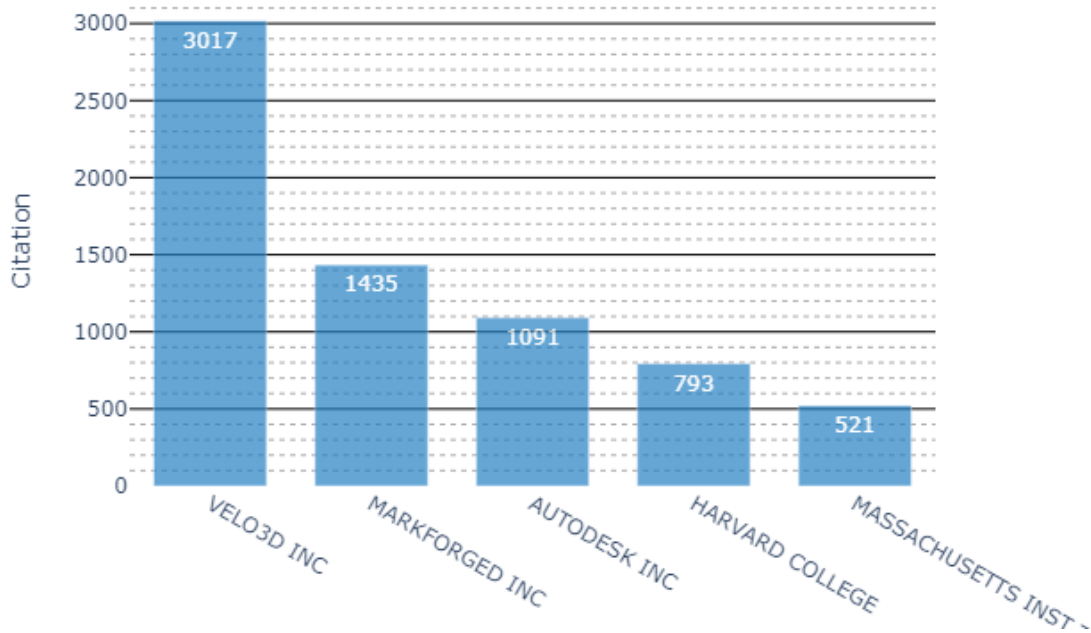
3. Technology Analysis

3.1. Top Technologies

3.1.1. Top Technologies by Class

According to the IPC[1] classification, patents can be classified in 4 levels: class, subclass, main group and subgroup, each of the components of this technology tree represents a range of technologies and their applications. The chart below shows the top classes in terms of the number of patent applications in that class.

As it is known, Additive manufacturing technology is at the top, then there is the area of Working of plastics. The attendance of health, casting and computing classes is significant among the top classes.
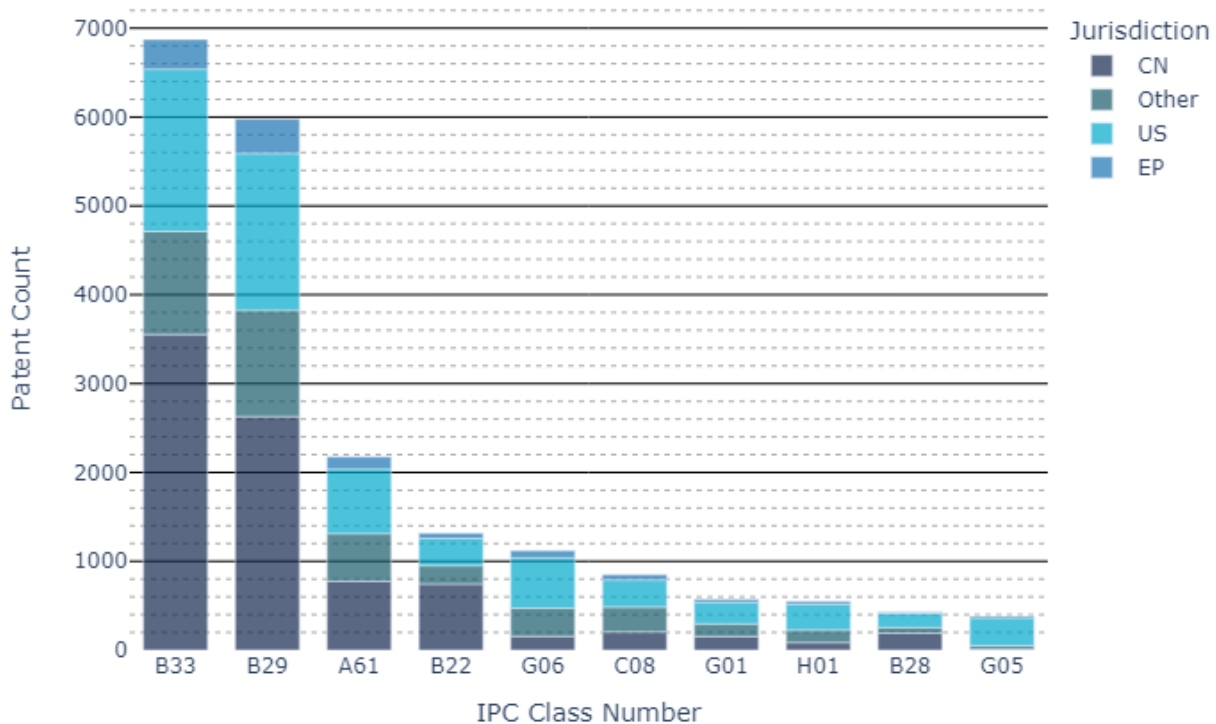
[1] - If consider an IPC for a patent like C08L23/12
C08: Class
C08L: Sub-Class
C08L23: Main-Group
C08L23/12: Sub-Group

B33	Additive manufacturing technology	C08	Organic macromolecular compounds; their preparation or chemical working-up; compositions based thereon
B29	Working of plastics; working of substances in a plastic state in general	G01	Measuring; testing
A61	Health; life-saving; amusement	H01	Electric elements
B22	Casting; powder metallurgy	B28	Working cement, clay, or stone
G06	Computing; calculating or counting	G05	Controlling; regulating

The figure below shows the distribution of top technology areas at first level -by class-across different jurisdictions.
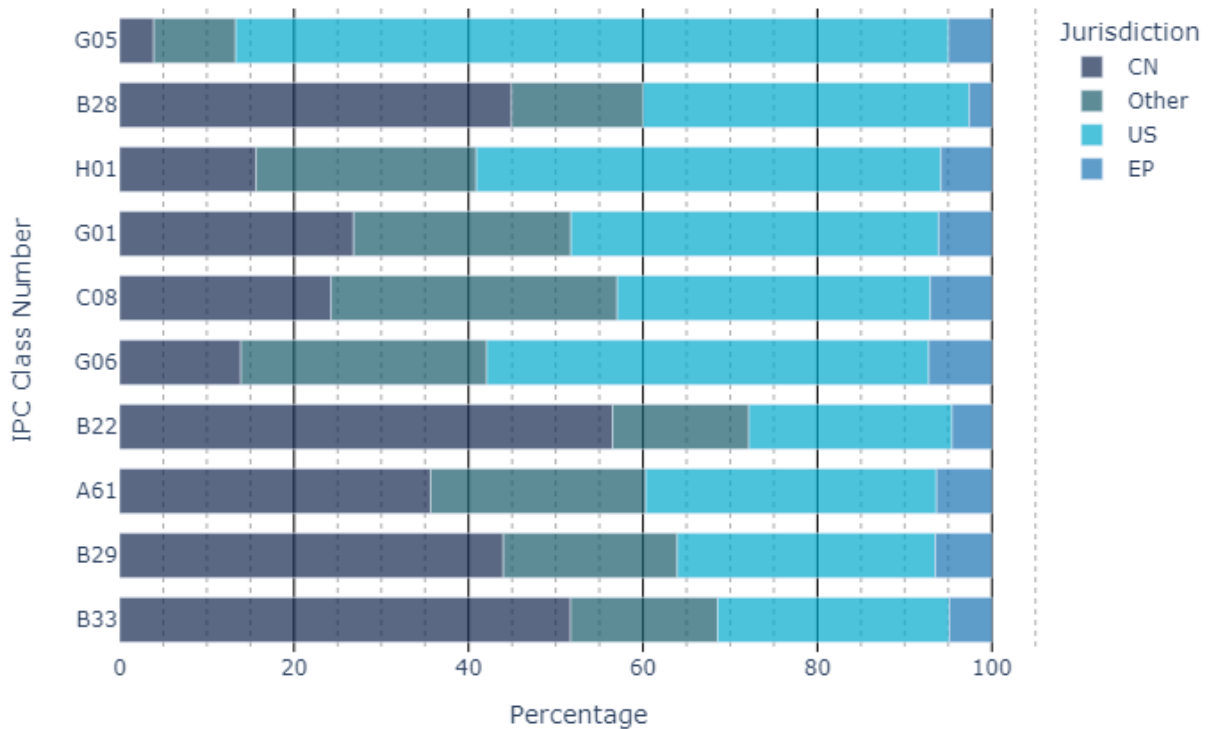
3.1.2. Top Technologies by Sub-Class

The chart below shows the top sub-classes -second level of technology tree- in terms of the number of patent applications in that sub-class. As it is known, "Additive manufacturing, i.E. Manufacturing of three-dimensional [3d] objects by additive deposition, additive agglomeration or additive layering, e.g. By 3D-Printing, stereolithography or selective laser sintering "with code B 33Y is at the top, then there is the area of Shaping or joining of plastics.
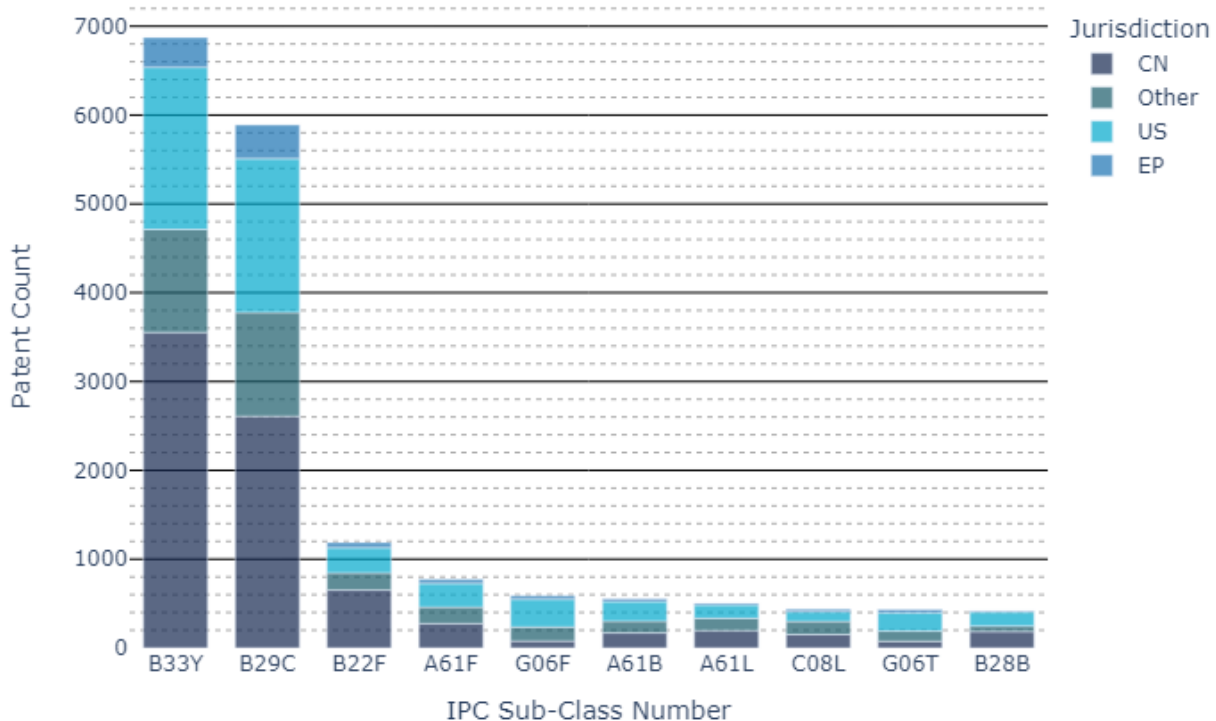
B33Y	Additive manufacturing, i.e. Manufacturing of three-dimensional [3d] objects by additive deposition, additive agglomeration or additive layering	A61B	Diagnosis; surgery; identification
B29C	Shaping or joining of plastics; shaping of material in a plastic state, not otherwise provided for; after-treatment of the shaped products	A61L	Methods or apparatus for sterilising materials or objects in general; disinfection, sterilisation or deodorisation of air; chemical aspects of bandages, …
B22F	Working metallic powder; manufacture of articles from metallic powder; making metallic powder	C08L	Compositions of macromolecular compounds

A61F	Filters implantable into blood vessels; prostheses; devices providing patency to, or preventing collapsing of, tubular structures of the body	G06T	Image data processing or generation, in general
G06F	Electric digital data processing	B28B	shaping clay or other ceramic compositions; shaping slag; shaping mixtures containing cementitious material, e.g. plaster

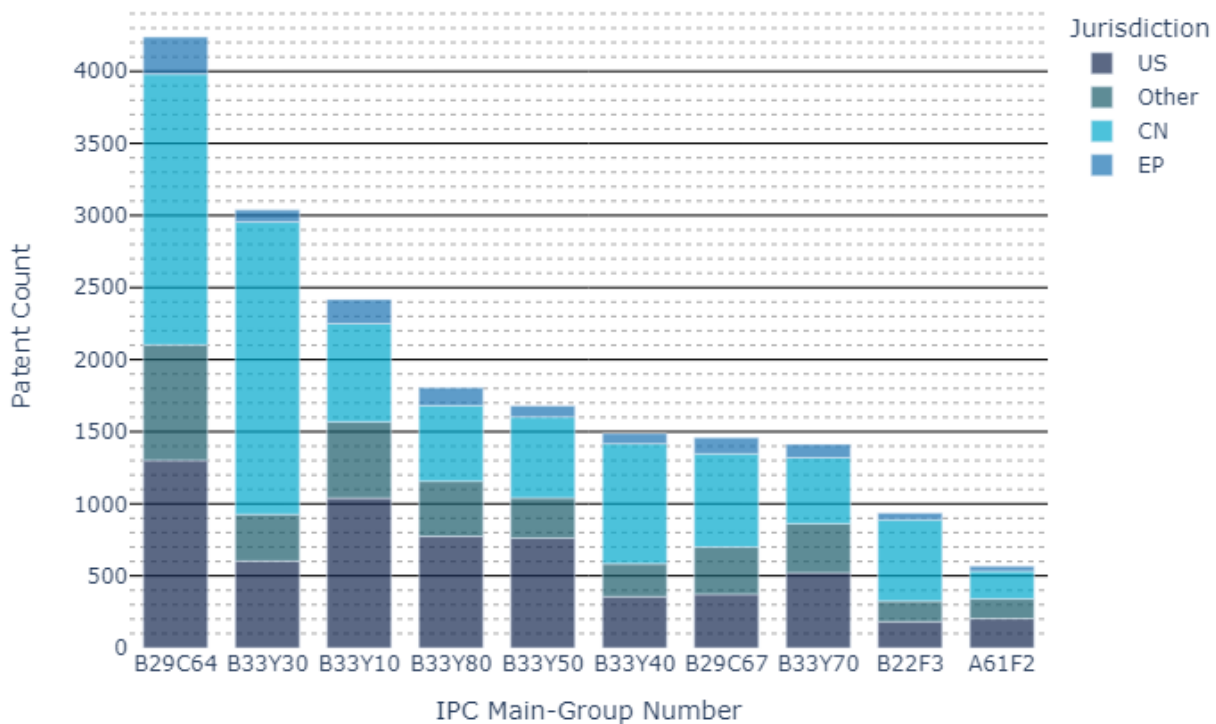Working metallic powder, then Filters implantable into blood vessels; prostheses; devices providing patency to, or preventing collapsing of, tubular structures of the body, e.g. Stents; orthopedic, nursing or contraceptive devices; fomentation treatment or protection of eyes or ears; bandages, dressings or absorbent pads; first-aid kits, , and also Electric digital data processing are among the subclasses with the highest number of registered patents.

The figure below shows the distribution of top technology areas at second level -by sub-class- across different jurisdictions.
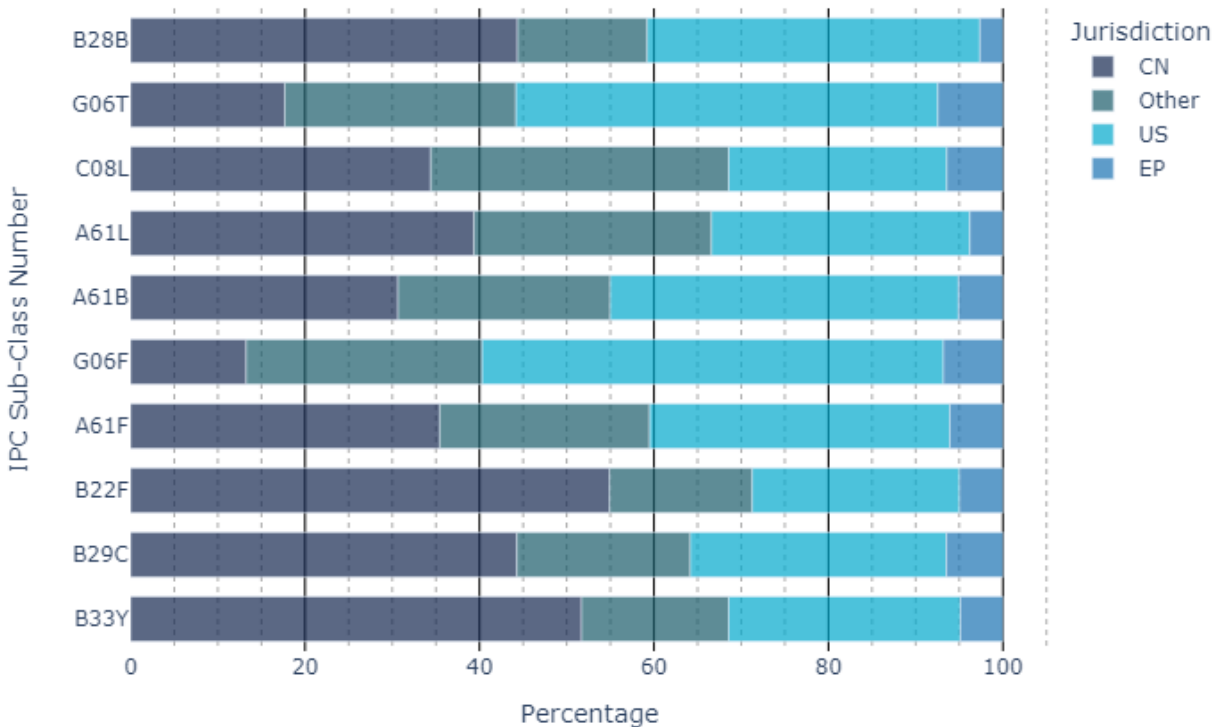
3.1.3. Top Technologies by Main-Group

The chart below shows the top main-groups in terms of the number of patent applications in that main-group. As it is known, "Additive manufacturing, i.E. Manufacturing of three-dimensional [3d] objects by additive deposition, additive agglomeration or additive layering, e.G. By 3D-Printing, stereolithography or selective laser sintering "with code B29C64 is at the top, then there is the area of Apparatus for additive manufacturing.

B29C64	Additive manufacturing, i.e. manufacturing of three-dimensional [3D] objects by additive deposition, additive agglomeration or additive layering, e.g. by 3D printing, stereolithography or selective laser sintering	B33Y40	Auxiliary operations or equipment, e.g. for material handling
B33Y30	Apparatus for additive manufacturing; Details thereof or accessories therefor	B29C67	Shaping techniques not covered by groups
B33Y10	Processes of additive manufacturing	B33Y70	Materials specially adapted for additive manufacturing

| B33Y80 | Products made by additive manufacturing | B22F3 | Manufacture of workpieces or articles from metallic powder characterised by the manner of compacting or sintering; Apparatus specially adapted therefor |
| B33Y50 | Data acquisition or data processing for additive manufacturing | A61F2 | Filters; Devices providing patency to tubular structures; Prostheses; Accessories |

Processes of additive manufacturing, Products made by additive manufacturing, and Data acquisition or data processing for additive manufacturing are among the Main-Groups with the highest number of registered patents. The figure below shows the distribution of top technology areas at third level -by main-group- across different jurisdictions.
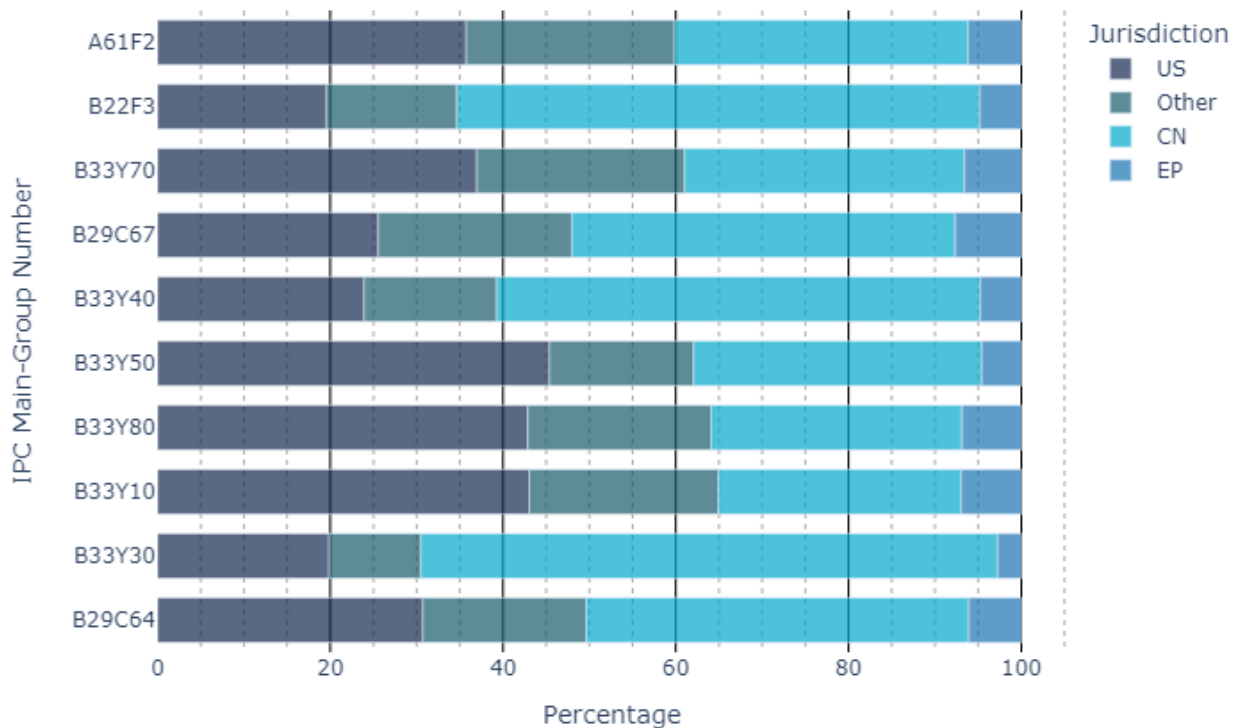
3.1.4. Top Technologies by Sub-Group

The chart below shows the top sub-groups in terms of the number of patent applications in that sub-group.. As it is known, "Additive manufacturing, i.E. Manufacturing of three-dimensional [3d] objects by additive deposition, additive agglomeration or additive
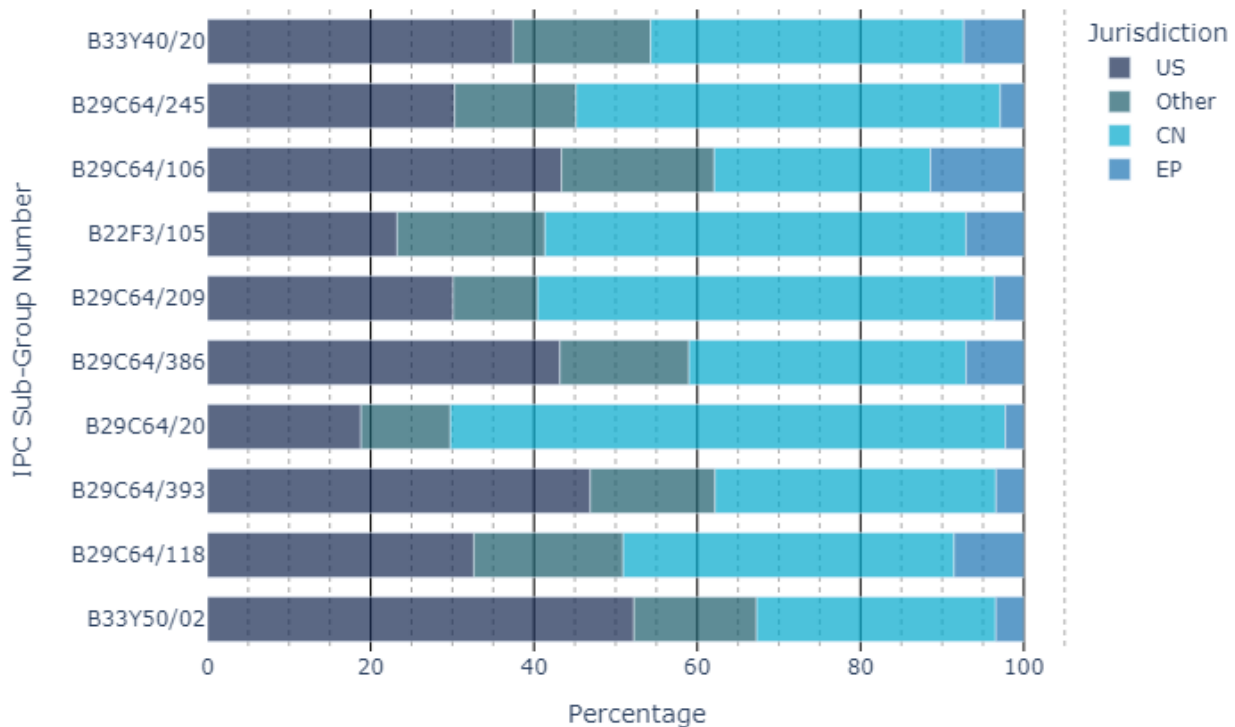
layering, e.G. By 3D-Printing, stereolithography or selective laser sintering "with code B29C64 is at the top, then there is the area of Apparatus for additive manufacturing.
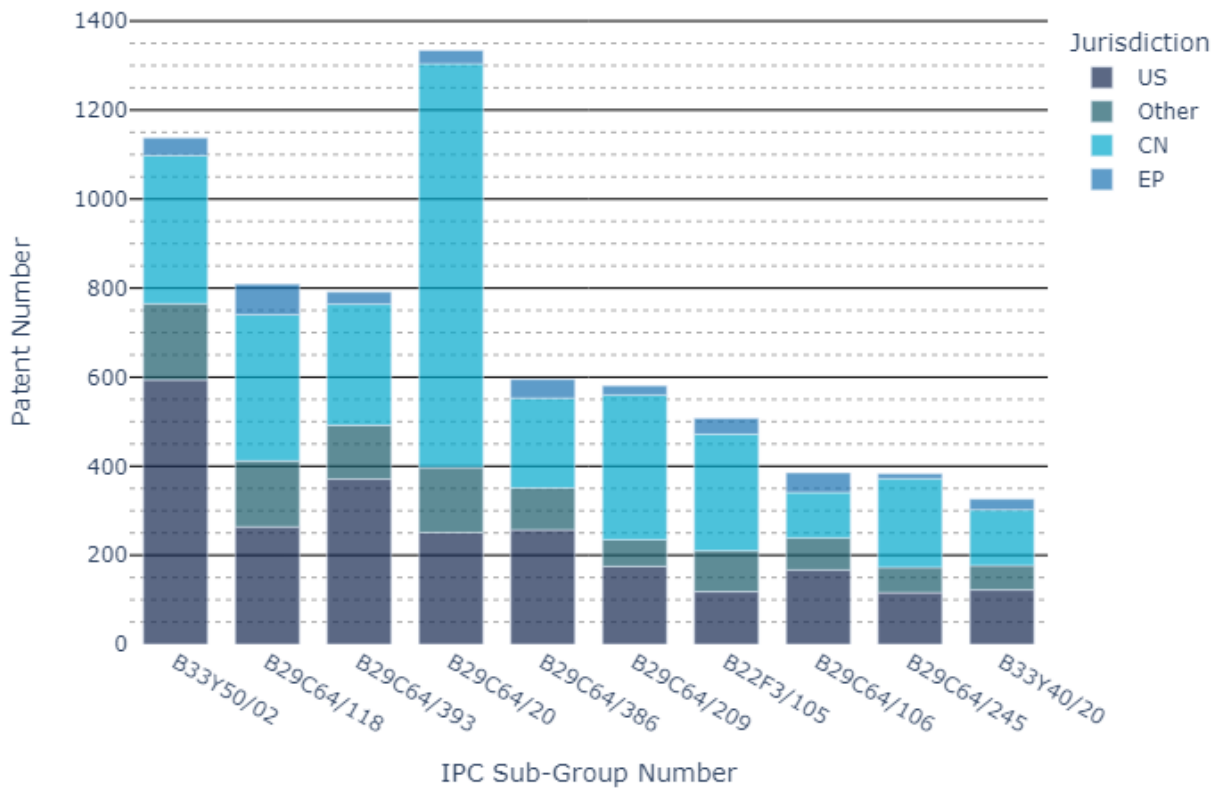
| IPC Code	Description	IPC Code	Description
B33Y50/02	for controlling or regulating additive manufacturing processes	B29C64/209	Auxiliary operations or equipment, e.g. for material handling
B29C64/118	using filamentary material being melted, e.g. fused deposition modelling [FDM]	B22F3/105	Shaping techniques not covered by groups
B29C64/393	for controlling or regulating additive manufacturing processes	B29C64/106	Materials specially adapted for additive manufacturing

B29C64/20	Apparatus for additive manufacturing; Details thereof or accessories therefor	B29C64/245	Manufacture of workpieces or articles from metallic powder characterised by the manner of compacting or sintering; Apparatus specially adapted therefor
B29C64/386	Data acquisition or data processing for additive manufacturing	B33Y40/20	Filters; Devices providing patency to tubular structures; Prostheses; Accessories

Apparatus for additive manufacturing; Details thereof or accessories therefor, Data acquisition or data processing for additive manufacturing for controlling or regulating additive manufacturing processes and using filamentary material being melted, e.g. fused deposition modelling [FDM] are among the sub-groups with the highest number of registered patents. The figure below shows the distribution of top technology areas at fourth level -by sub-group- across different jurisdictions.

3.2. Five Recent dominant technologies

The five key technology areas that have the highest number of patents in the last 5 years are presented in the figure below. The technology "Additive manufacturing, i.e. manufacturing of three-dimensional [3D] objects by additive deposition, additive agglomeration or additive layering, e.g. by 3D-Printing, stereolithography or selective laser sintering" is at the top of the technology fields with the highest number of patent registrations in the last 5 years.
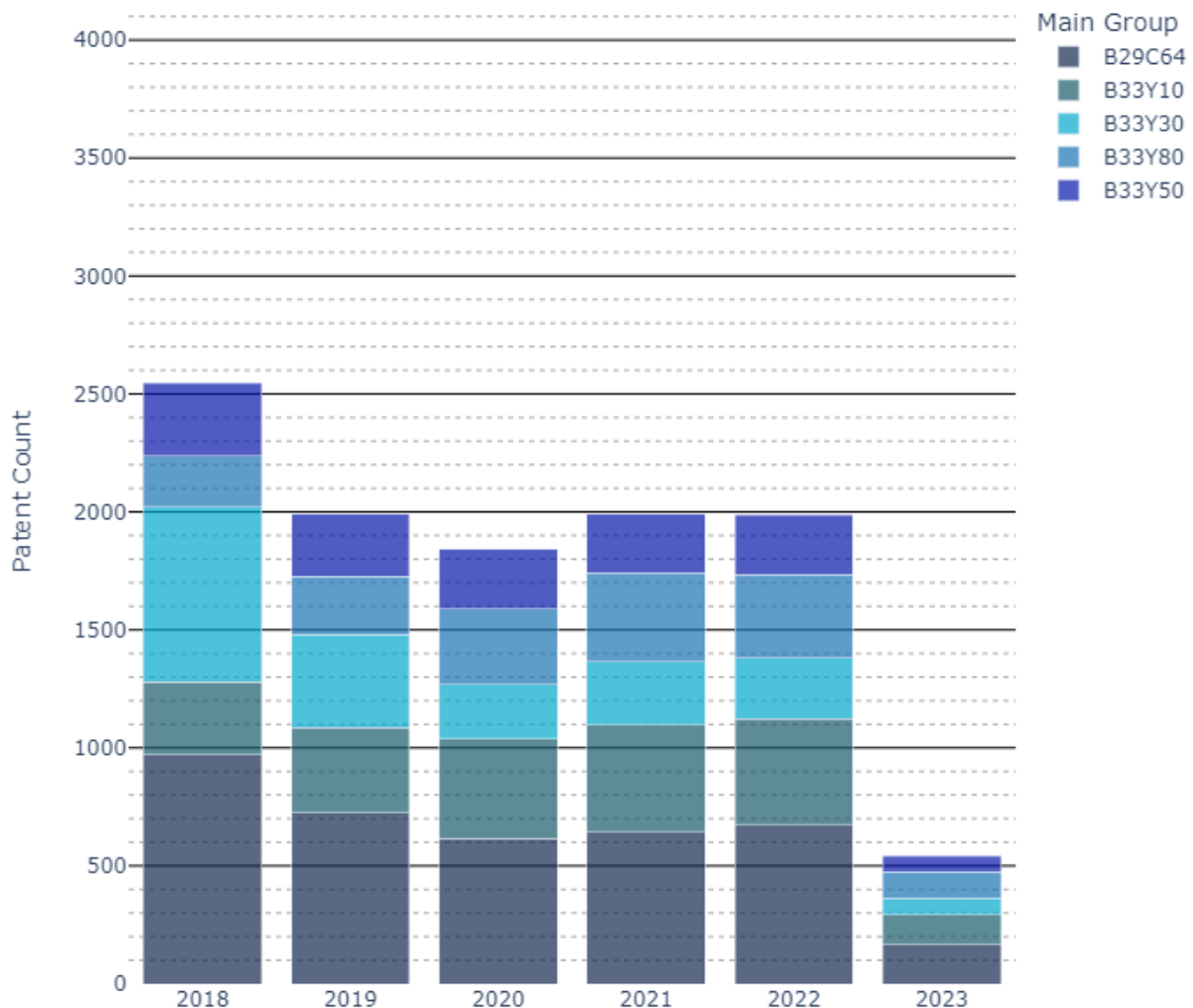
B29C64
Additive manufacturing, i.e. manufacturing of three-dimensional [3D] objects by additive deposition, additive agglomeration or additive layering, e.g. by 3D printing, stereolithography or selective laser sintering

B33Y10
Processes of additive manufacturing

B33Y30
Apparatus for additive manufacturing; Details thereof or accessories therefor

B33Y80
Products made by additive manufacturing

B33Y50
Data acquisition or data processing for additive manufacturing

Following this technology, there are "Processes of additive manufacturing", "Apparatus for additive manufacturing; Details thereof or accessories therefor", "Products made by additive manufacturing", and "Data acquisition or data processing for additive manufacturing" technologies.
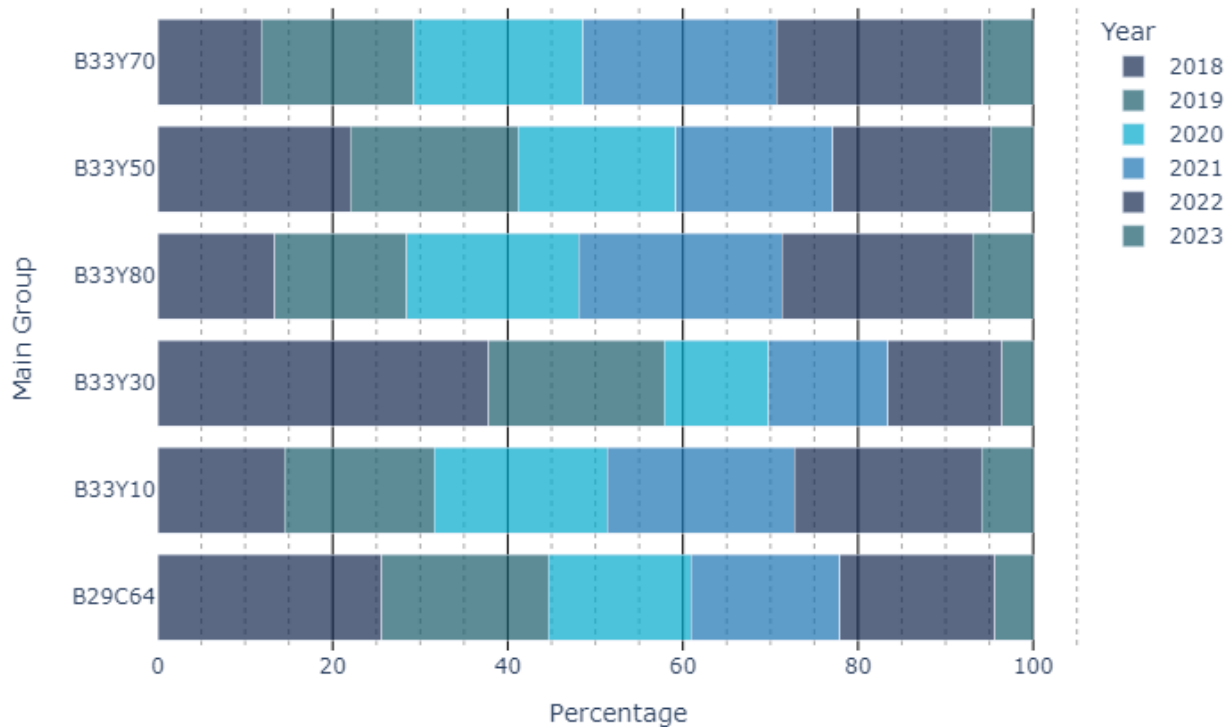
3.3. Key Patents

Key patents are patents that have received the most citations over time. These patents are expected to be the foundational patents in this field in the future.
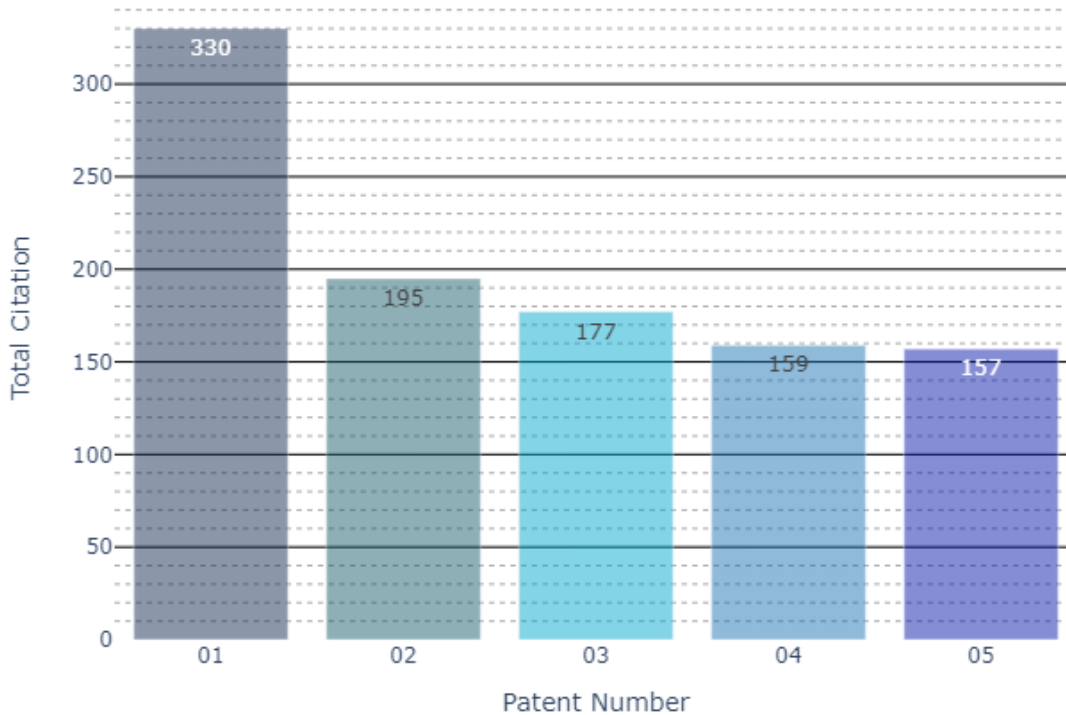
1 US 2015/0331402 A1
Intelligent 3D-Printing through optimization of 3d print parameters
Applicant: AUTODESK INC Publish year: 2015

2 US 2015/0360419 A1
3d print adhesion reduction during cure process
Applicant: AUTODESK INC Publish year: 2015

3 US 9254535 B2
Apparatuses, systems and methods for three-dimensional printing
Applicant: VELO3D INC   Publish year: 2016

4 US 2014/0156053 A1
Three-dimensional design and manufacturing systems
Applicant: Mahdavi Siavash Haroun;;Ruto Anthony;;Shayani Hooman;;Within Technologies Ltd   Publish year: 2014

5 US 2016/0311165 A1
Multiaxis fiber reinforcement for 3D-Printing
Applicant: MARKFORGED INC   Publish year: 2016

3.4. The main themes of patents

In this section, using the topic modeling method, the most important topics mentioned in the patents of this field are presented in the figure below. Topic modeling is a way of finding the main themes or topics in a collection of the patents. It is a type of unsupervised machine learning, which means it does not need any human input or labels to group the words together. The counted themes represent the thematic focus of patents on areas such as 3D-Printing for use in the body and bones, dentistry and implants, surfaces, containers, and materials and inks used.
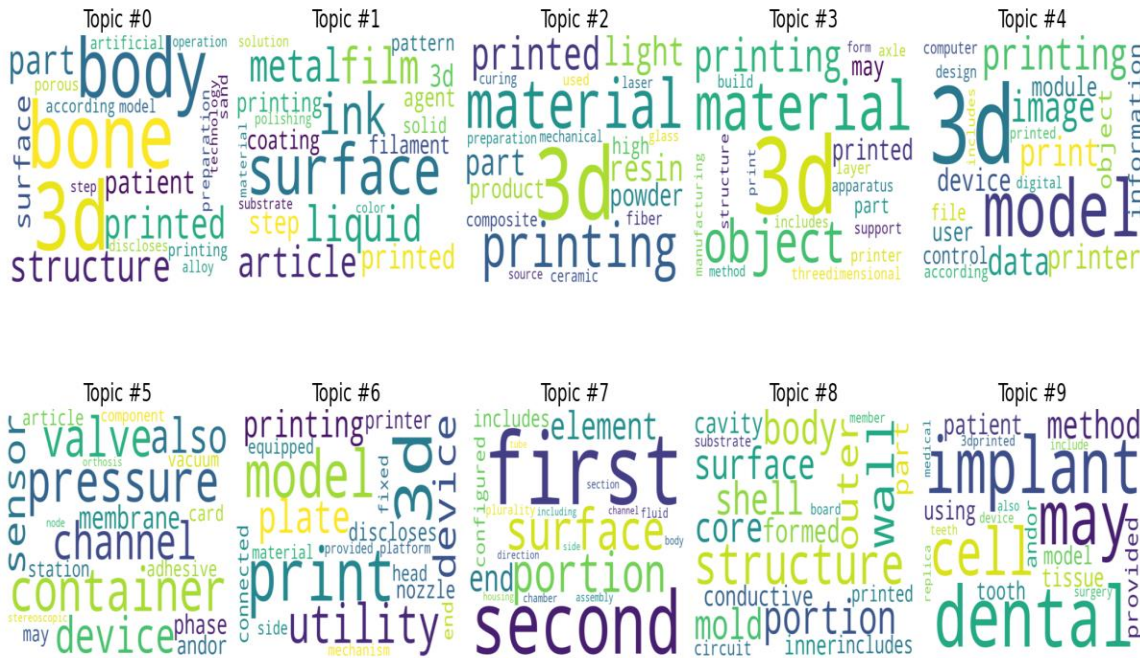
3.5. Technology clustering

The main goal in this section is to group patents in the form of different semantic groups. In this section, 3D-Printing patents are grouped into 5 main clusters and the top terms are determined in each cluster. In addition to being able to provide a good view of the focus points of patents, clustering also provides the possibility of a targeted study of patents.
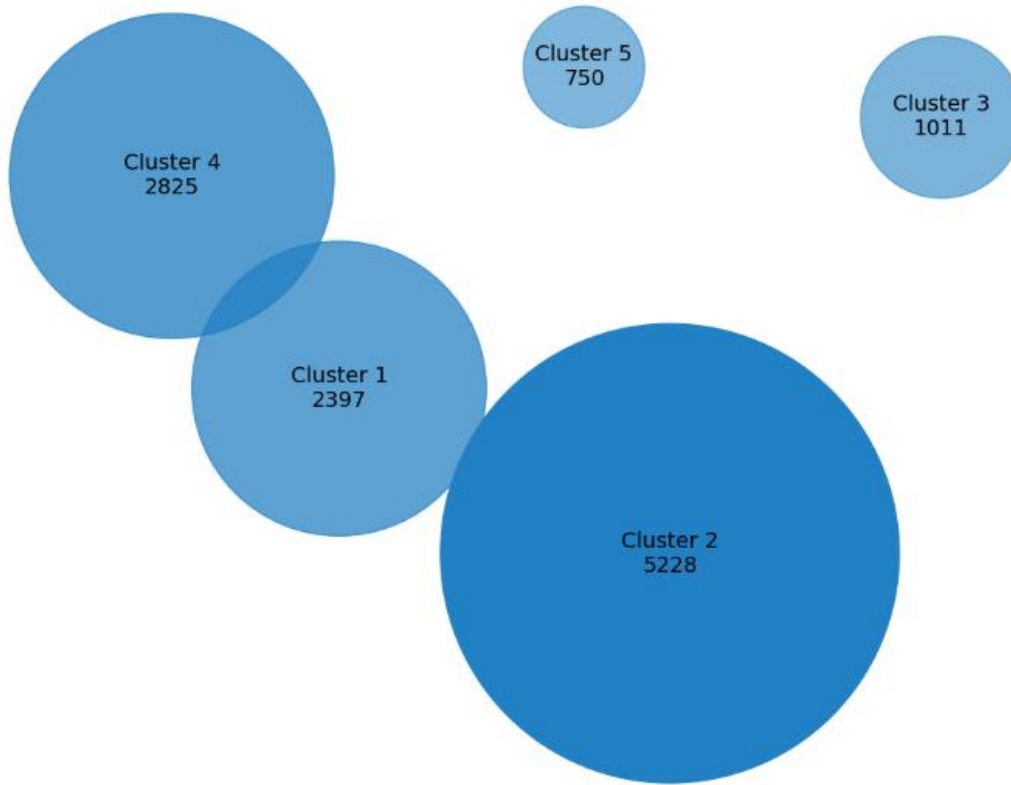
As shown above, cluster one with 2397 patents, focusing on surface and body, is the largest cluster in this field. Then the number of patents in the clusters with focus points of plate and nozzle, model and data, material and resin are considerable.

01
Top terms: nozzle, plate, print, utility, model
The number of Patents: 2397

02
Top terms: print, may, model, system, one
The number of Patents: 5228

03
Top terms: first, second, layer, material, least
The number of Patents: 1011

04
Top terms: material, print, layer, method, invention
The number of Patents: 2825

05
Top terms: object, print, dimensional, three, disclosure
The number of Patents: 750

3.6. Top inventors

An inventor in patent documents is the person or persons who contribute to the claims of a patent. The claims are the part of the patent document that define the scope and boundaries of the legal protection granted by the patent. The inventor is not necessarily the same as the applicant or the owner of the patent, who may be different entities or individuals. This analysis can be beneficial to know the main scientist and technologist in this field for next technological collaborations.
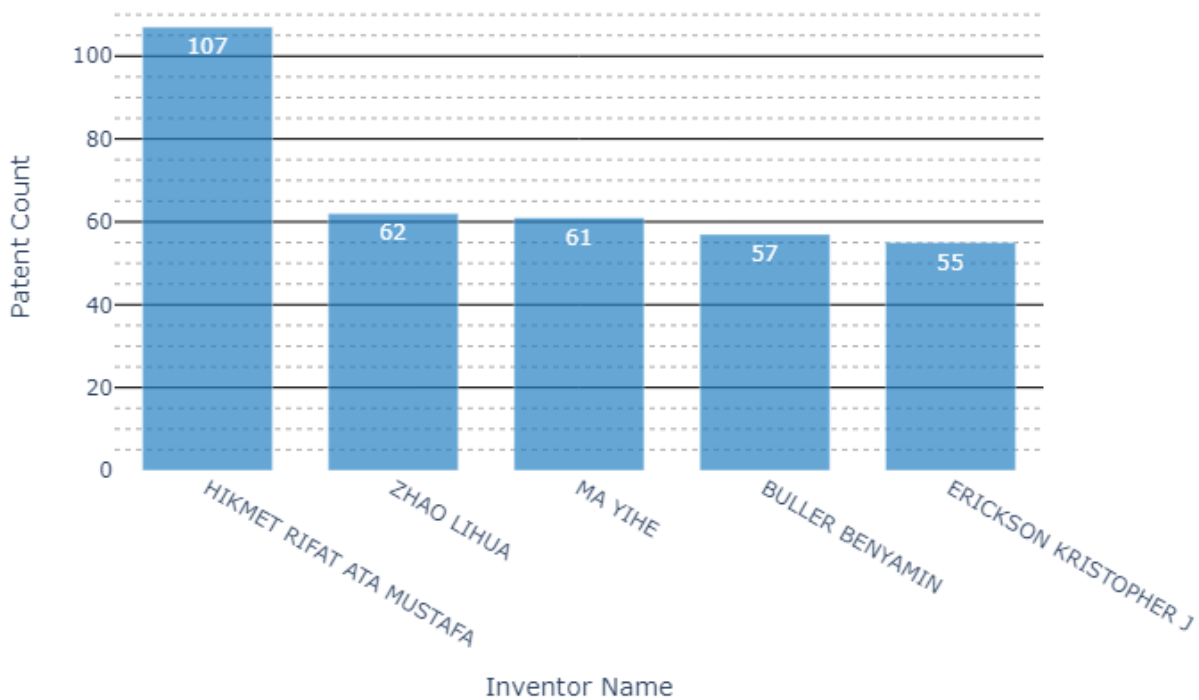
4. Market and Competitor Analysis

4.1. Collaboration

4.1.1. Top Ten Applicants' collaborations

Technological development and innovation occur in a network of cooperation between actors. Understanding the cooperation network of leading companies in the field of patent application can indicate the policies of different companies in the field of technology development and innovation. Also, the precise understanding of these networks can help to find new partners in the path of technology development. In the figure below, the collaborations of the 10 main patent applicant companies are presented.
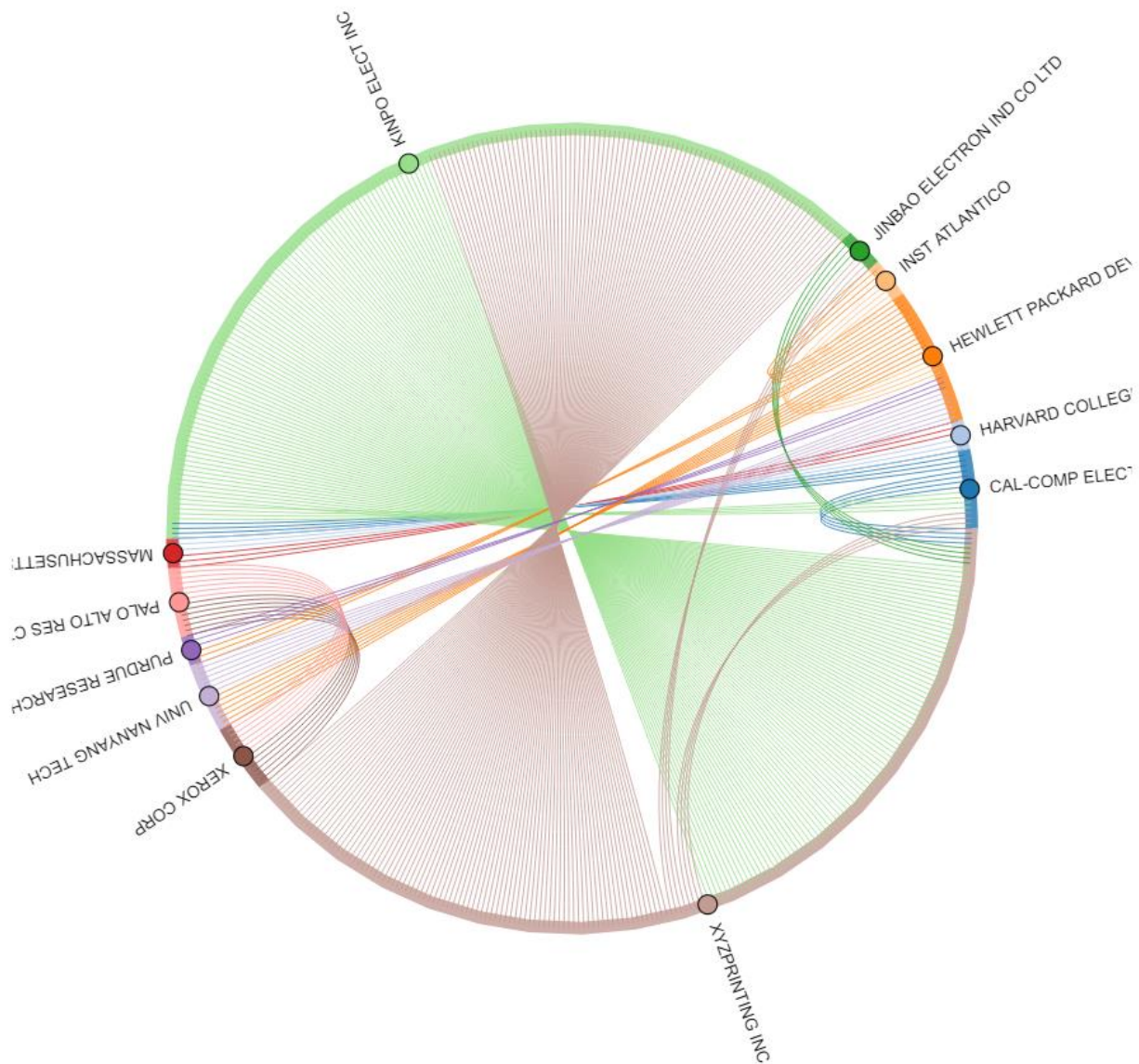
## 4.1.2. The strongest cooperation networks

In this section, the cooperation between different actors has been investigated, and among them, the cases of cooperation that have led to the highest application for patents have been counted. The identification of these cooperation networks can be used to analyze the future trends of technology development and cooperation between actors. Various help a lot in it.
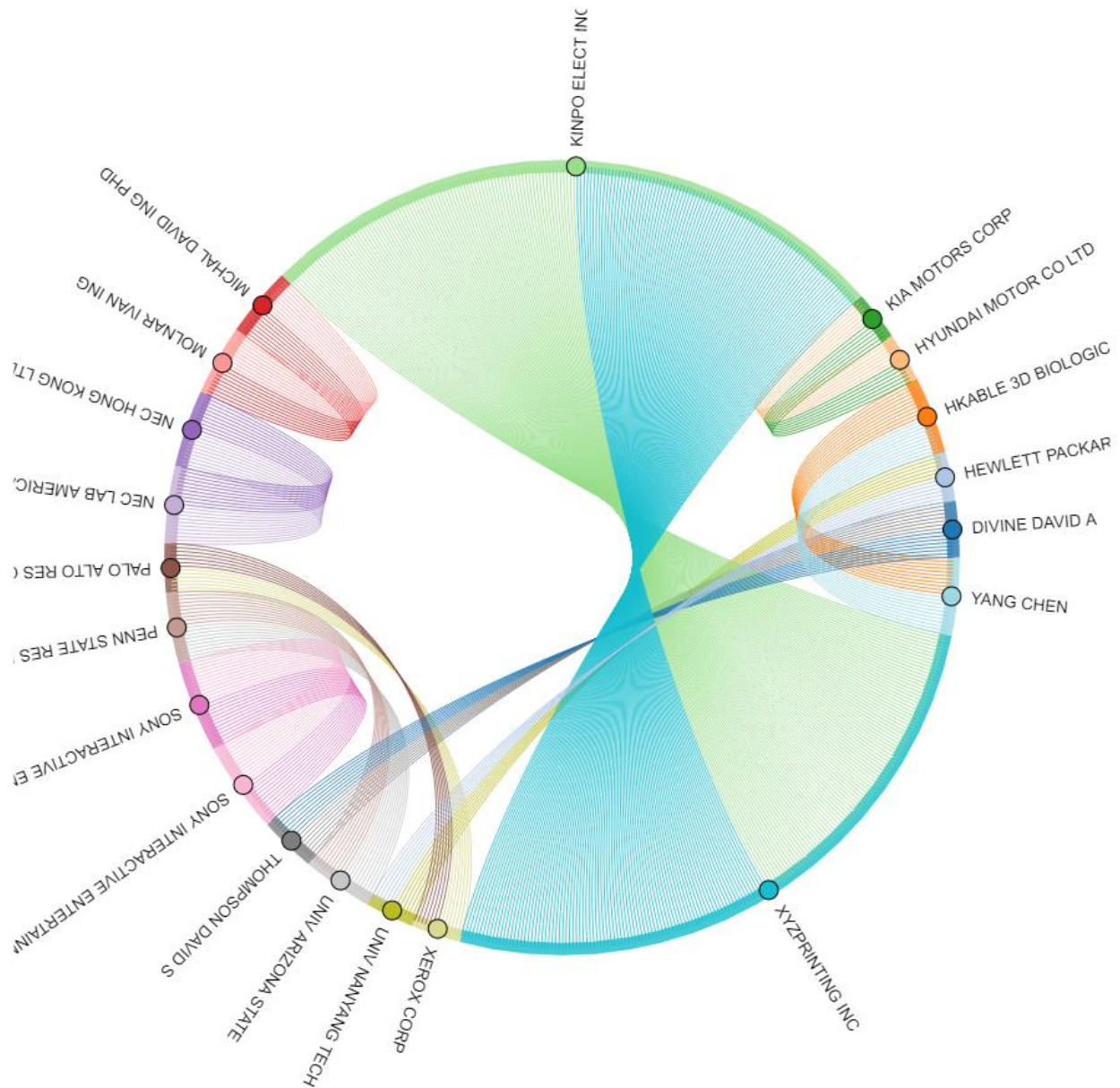
4.2. Top applicant activity

The continuation of technological activities in the main patent applicant companies over time shows the level of attention and concentration of companies in the field of their technological activities. As can be seen in the diagram below, the continuity of patenting activities of ten main patent applicant companies in the field of 3D-Printing is presented.
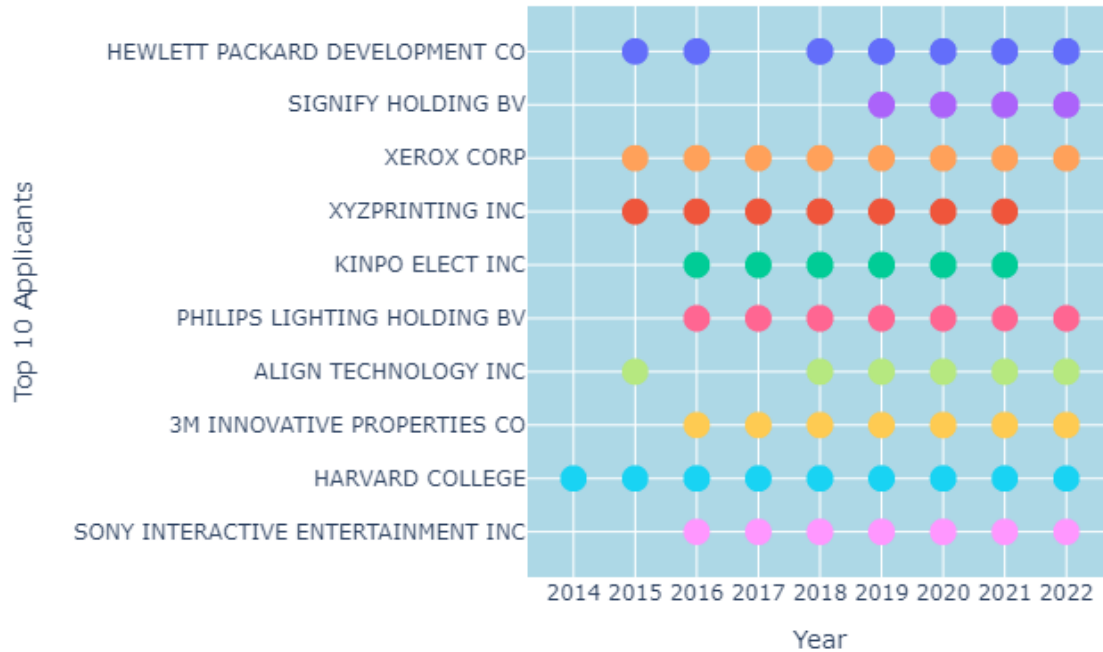

4.3. Pioneer companies in the last 5 years

The amount of patent registration of companies in the last 5 years can indicate the possible business strategies of these companies in the coming years. As you can see in the figure below, HEWLETT PACKARD DEVELOPMENT CO. is by far the leader in patent registration in this field. After this company, there are SIGNIFY HOLDING BV and XYZPRINTING INC.
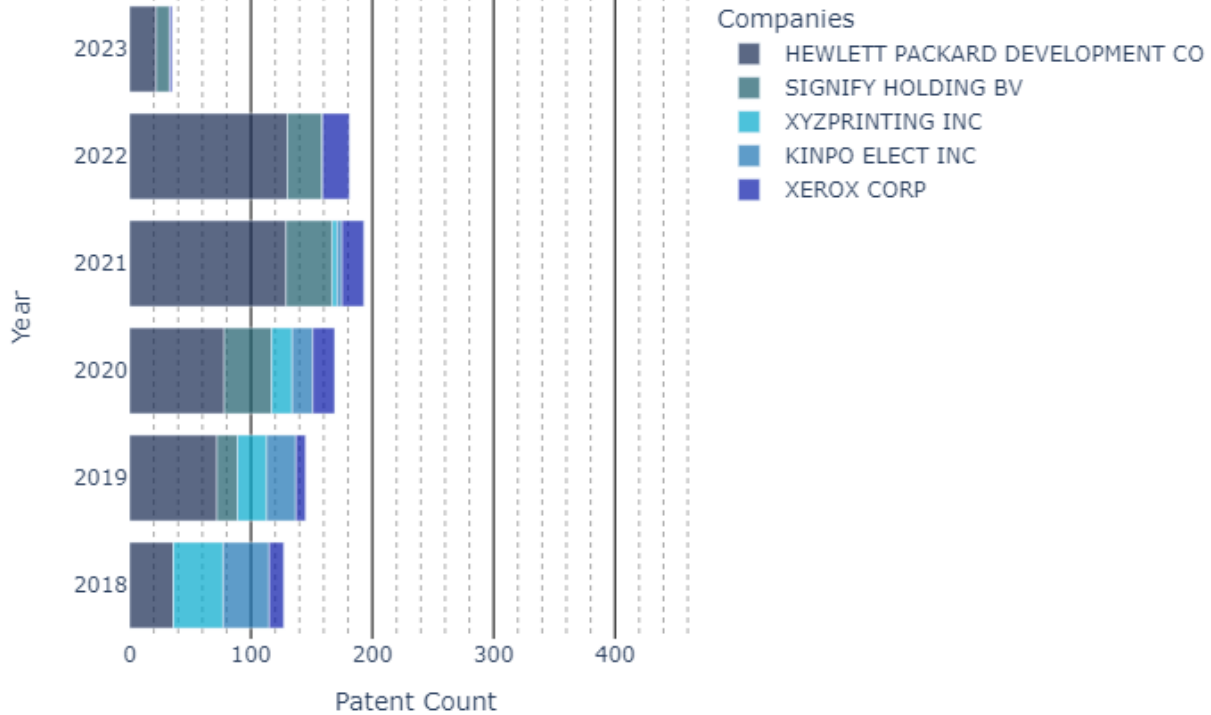
1 HEWLETT PACKARD
Total Patents: 467

2 SIGNIFY HOLDING
Total Patents: 134

3 XYZPRINTING
Total Patents: 86

4 KINPO ELECT
Total Patents: 83

5 XEROX CORP
Total Patents: 80

4.4. Top applicant clustering

Besides knowing the focus areas of companies in the 3D-Printing technologies field, it is also very important to examine the top 10 patent applicant companies. The patenting activities of these companies, as leaders in this field, can have a direct impact on the market and other players' behavior. As it is clear below, cluster number 1 with top terms "print, part, component, base" has the largest number of registered patents. Next, there are cluster number 7 with top terms "build, material, agent, powder, selectively" and cluster number 2 with top terms "object, print, surface, system, support".
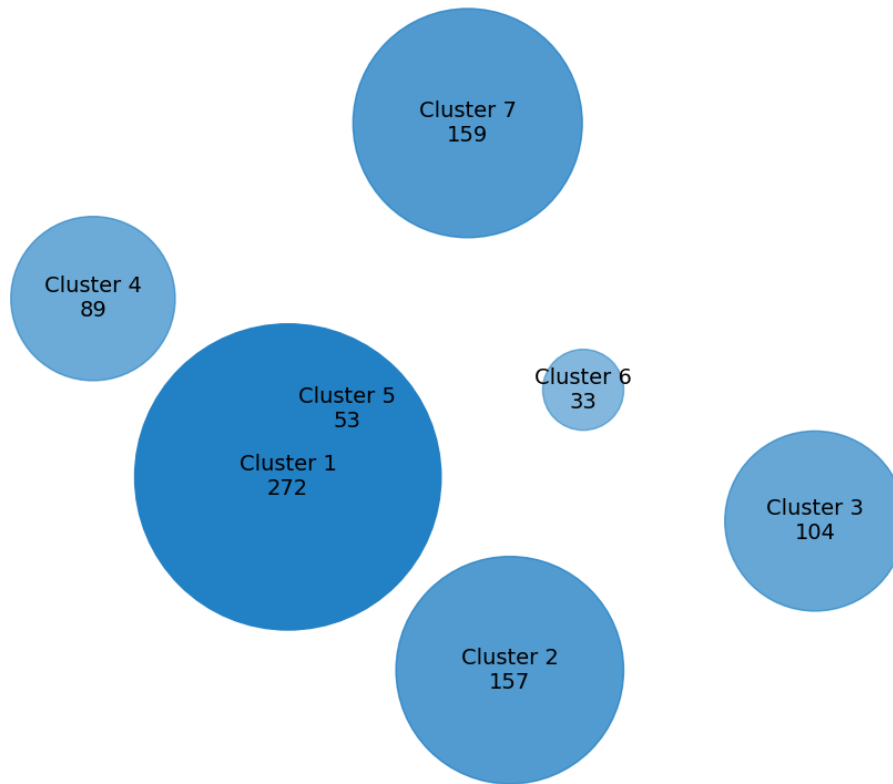
01 Top terms: print, part, component, base
The number of Patents: 272

02 Top terms: object, print, surface, system, support
The number of Patents: 157

03 Top terms: material, wherein, printable, item, print
The number of Patents: 104

04 Top terms: layer, substrate, mold
The number of Patents: 89

05 Top terms: disclosure, present, printing, reduce, dimensional
The number of Patents: 53

06 Top terms: conductive, electrically, functional, electronic, least
The number of Patents: 33

07 Top terms: build, material, agent, powder, selectively
The number of Patents: 159

4.5. Pending patents

The patent examination process is a time-consuming process and sometimes lasts up to 5 years. However, a significant number of these applications will be granted. Therefore, the analysis of pending patents is very important in predicting the future paths of technology. As can be seen, Hewlett-Packard is at the top of the companies with 330 pending patents, and this indicates that this company will most likely maintain its technological superiority for the next 5 years.
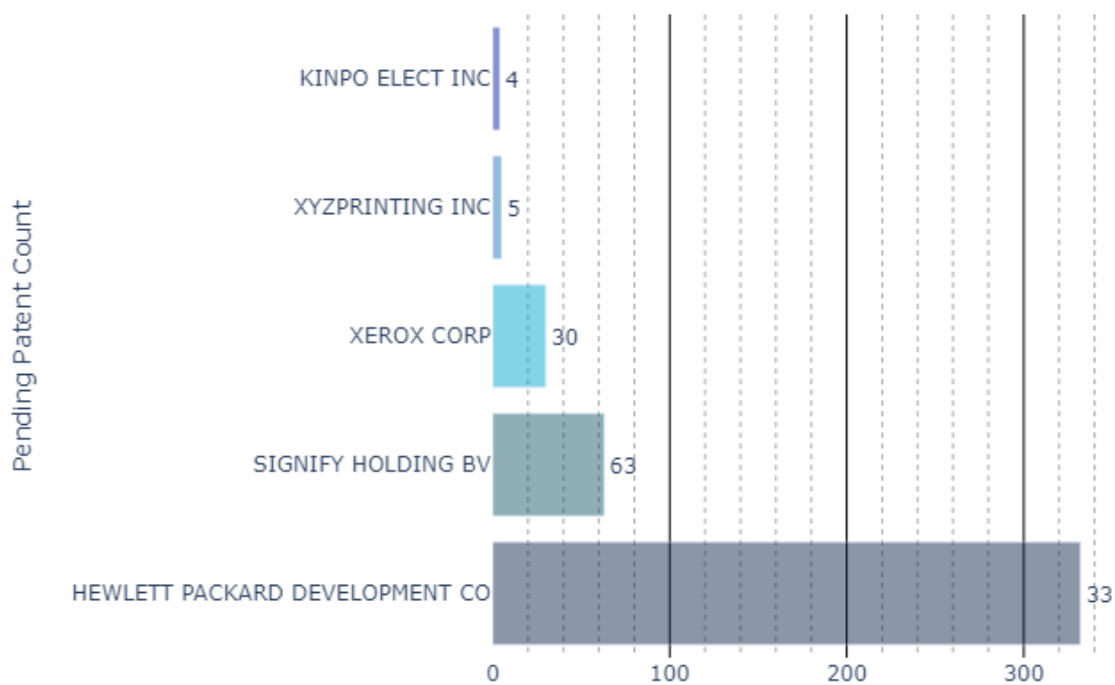
5. Key Players' Patent Profile
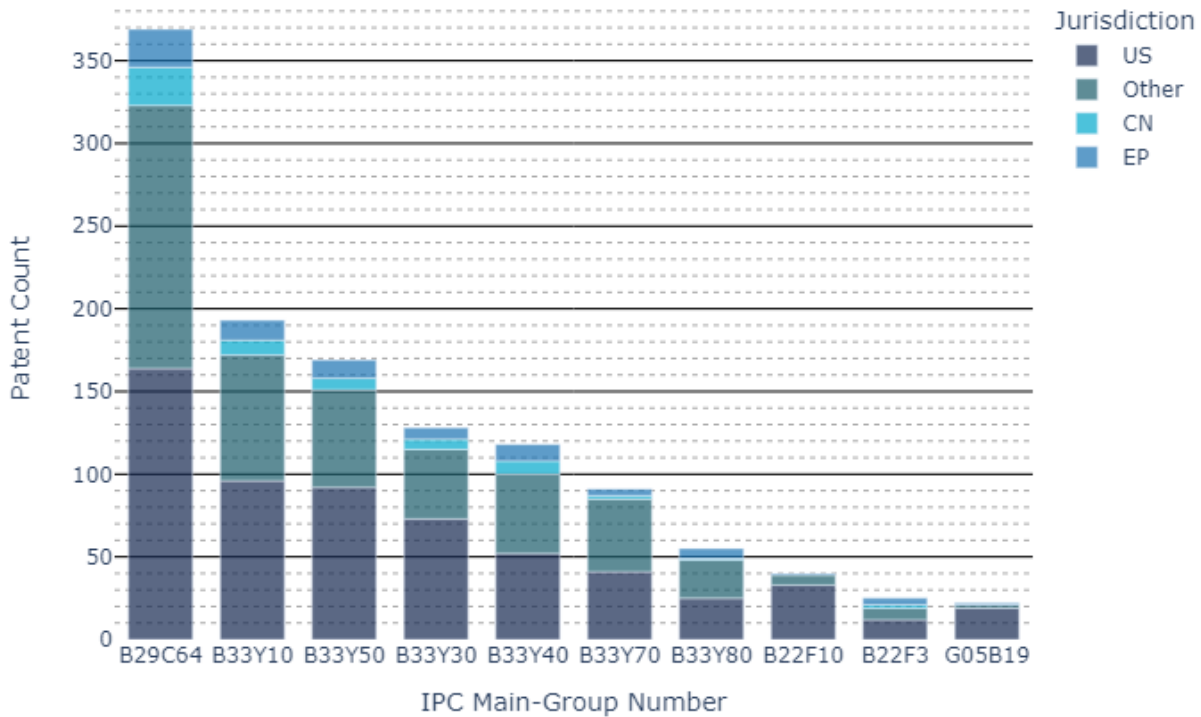
5.1. Hewlett-Packard Co

5.1.1. Patent family analysis

By examining patenting activities of Hewlett-Packard Co in the field of 3D-Printing technology, it is clear that 474 patents have been registered between 2000 and 2022. Also, the process of applying for patent registration in this field is increasing rapidly. This increase will probably be reflected in the company's future products. The highest number of patent registrations by HP is in 2021. It should be noted that 330 patents are pending, and it is expected that an important part of them will be registered in the next 24 months and will be added to the statistics of the last two years.
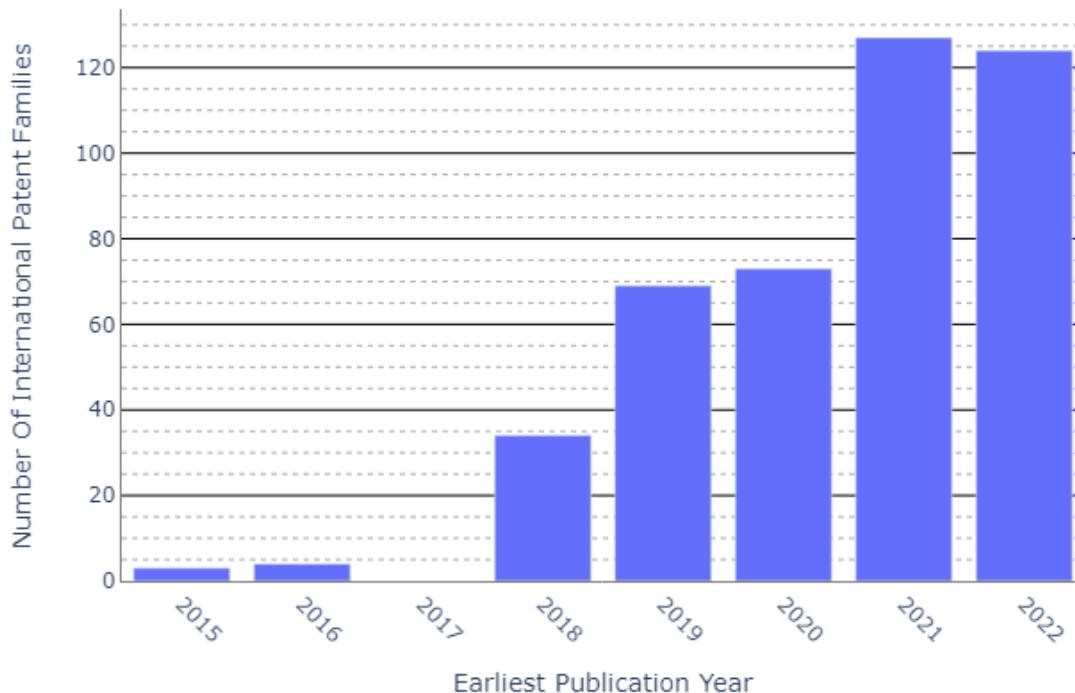
5.1.2. Top Technologies

The chart below shows the main technology fields that HP has been focusing in terms of the number of patent applications in that main-group. As it is showed, "Additive manufacturing, i.E. Manufacturing of three-dimensional [3d] objects by additive deposition, additive agglomeration or additive layering, e.G. By 3D-Printing, stereolithography or selective laser sintering "with code B29C64 is at the top, then there are the areas of "Processes of additive manufacturing" and "Data acquisition or data processing for additive manufacturing".

IPC	Description	IPC	Description
B29C64	Additive manufacturing, i.e. manufacturing of three-dimensional [3D] objects by additive deposition, additive agglomeration or additive layering, e.g. by 3D printing, stereolithography or selective laser sintering	B33Y70	Materials specially adapted for additive manufacturing
B33Y10	Processes of additive manufacturing	B33Y80	Products made by additive manufacturing
B33Y50	Data acquisition or data processing for additive manufacturing	B22F10	Additive manufacturing of workpieces or articles from metallic powder
B33Y30	Apparatus for additive manufacturing; Details thereof or accessories therefor	B22F3	Manufacture of workpieces or articles from metallic powder characterised by the manner of compacting or sintering; Apparatus specially adapted therefor
B33Y40	Auxiliary operations or equipment, e.g. for material handling	G05B19	Programme-control systems

The main patenting activities of Hewlett-Packard Company in a deeper layer of the technology tree are related to two aspects of additive manufacturing: using a combination of solid and fluid materials, e.g. a powder selectively bound by a liquid binder, catalyst, inhibitor or energy absorber ,and Data acquisition or data processing for additive manufacturing for controlling or regulating additive manufacturing processes . These codes indicate that this company focuses on the convergence of data management and the operational process of 3D-Printing.
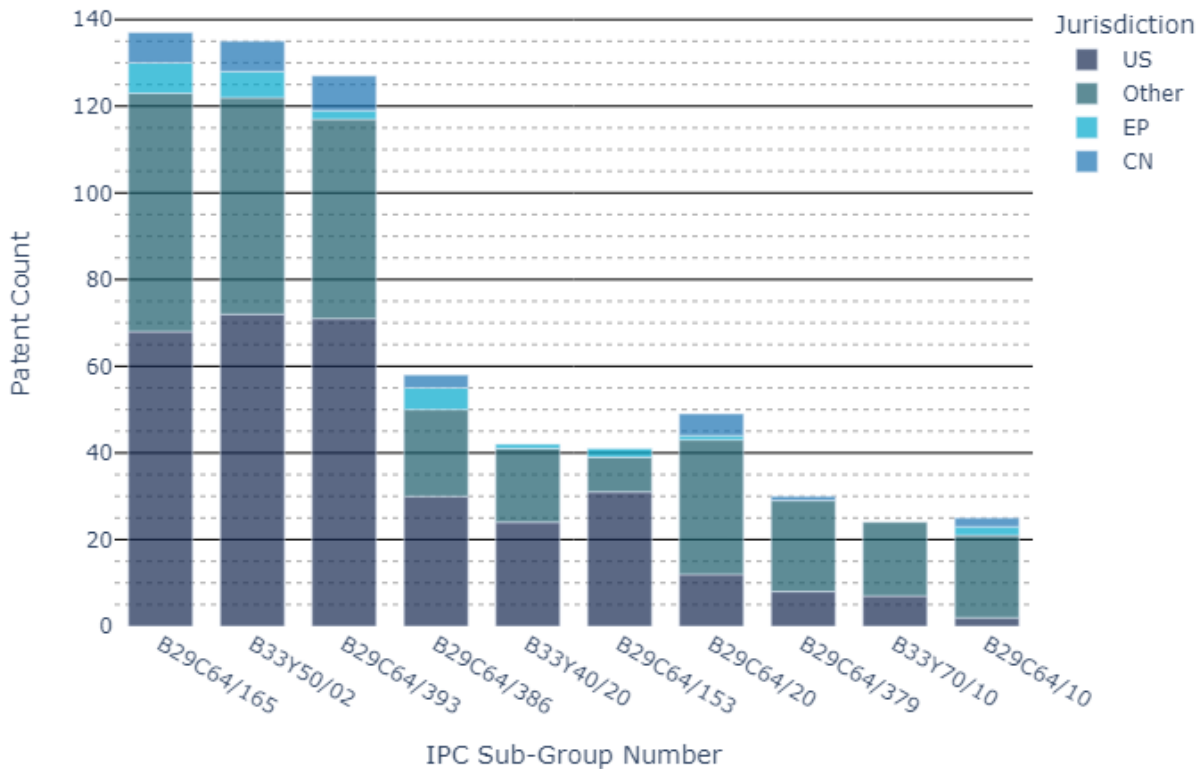
B29C64/165	additive manufacturing: using a combination of solid and fluid materials, e.g. a powder selectively bound by a liquid binder, catalyst, inhibitor or energy absorber	B29C64/153	Additive manufacturing using layers of powder being selectively joined, e.g. by selective laser sintering or melting
B33Y50/02	for controlling or regulating additive manufacturing processes	B29C64/20	Apparatus for additive manufacturing; Details thereof or accessories therefor

| B29C64/393	for controlling or regulating additive manufacturing processes	B29C64/379	Handling of additively manufactured objects, e.g. using robots
B29C64/386	Data acquisition or data processing for additive manufacturing	B33Y70/10	Composites of different types of material, e.g. mixtures of ceramics and polymers or mixtures of metals and biomaterials
B33Y40/20	Filters; Devices providing patency to tubular structures; Prostheses; Accessories	B29C64/10	Processes of additive manufacturing

5.1.3. Collaboration

The figure below shows that Hewlett Packard's most cooperation is with University of Nanyang Tech and Institute of Atlántico and Purdue Research Foundation. The composition of the type of these partners is mainly of the university/research center type.

The extensive cooperation with the University of Nanyang Tech group is remarkable with the number of participations in patent applications at the top of Hewlett-Packard's technology partners.

5.1.4. Key patents

The key patents of Hewlett-Packard Company, which have the highest number of citations, can be seen in the figure below.
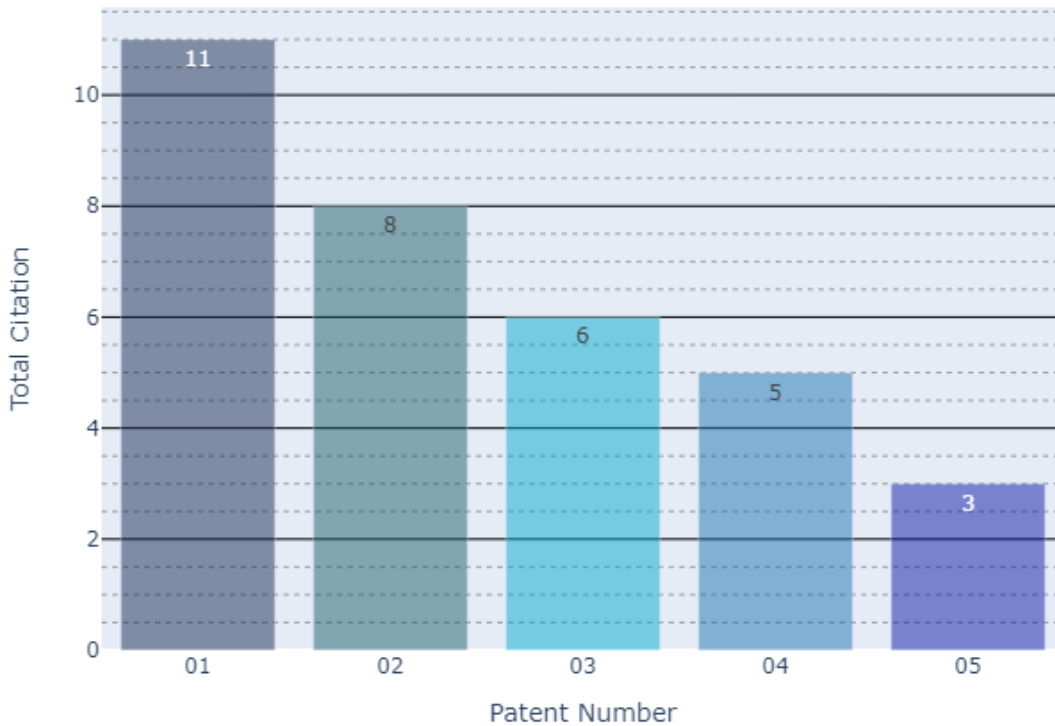
1 US 2019/0039368 A1
3D Print Selection Based On Voxel Property Association and Conflict Resolution
Publish year: 2019

2 US 2019/0126347 A1
COOLING OF BUILD MATERIAL IN 3D PRINTING SYSTEM
Publish year: 2019

3 US 2018/0321658 A1
IDENTIFY A MODEL THAT MATCHES A 3D OBJECT
Publish year: 2018

4 US 2019/0337231 A1
PROCESSING 3D OBJECTS
Publish year: 2019

5 US 2019/0054697 A1
CONTAINER FOR 3D PRINTED OBJECTS AND METHOD OF COOLING AND
UNPACKING A MANUFACTURED OBJECT FROM A 3D PRINTER USING THAT
CONTAINER
Publish year: 2016

5.1.5. Topic modeling

Patents registered by Hewlett-Packard can be classified in terms of content in the following three groups. As can be seen, the main focus of this company's patents is in the fields of materials and process of building.
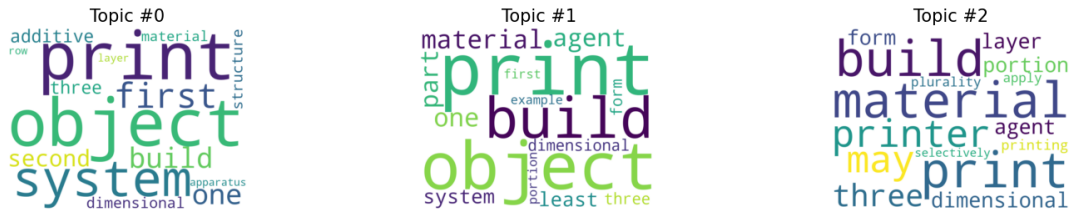
5.1.6. Patents clustering

The number of 474 patents registered by Hewlett-Packard can be classified in the following 7 clusters. The top terms of each cluster are also presented below. As can be seen, the largest number of patents of this company is in cluster number 2 with 117 patents and top terms of "object, print, processor, surface, model". After this cluster, there is cluster number 4 with 73 patents and top terms of "support, plurality, print, form, material".
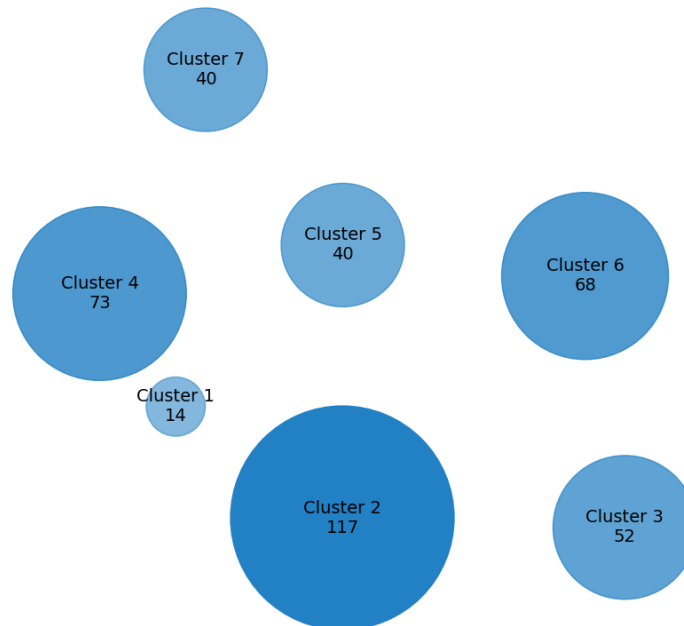
01 Top terms: cartridge, printer, material, receiver, available
The number of Patents: 14

02 Top terms: object, print, processor, surface, model
The number of Patents: 117

03 Top terms: system, additive, object, print, controller
The number of Patents: 52

04 Top terms: support, plurality, print, form, material
The number of Patents: 73

05 Top terms: agent, material, polymeric, polymer, range
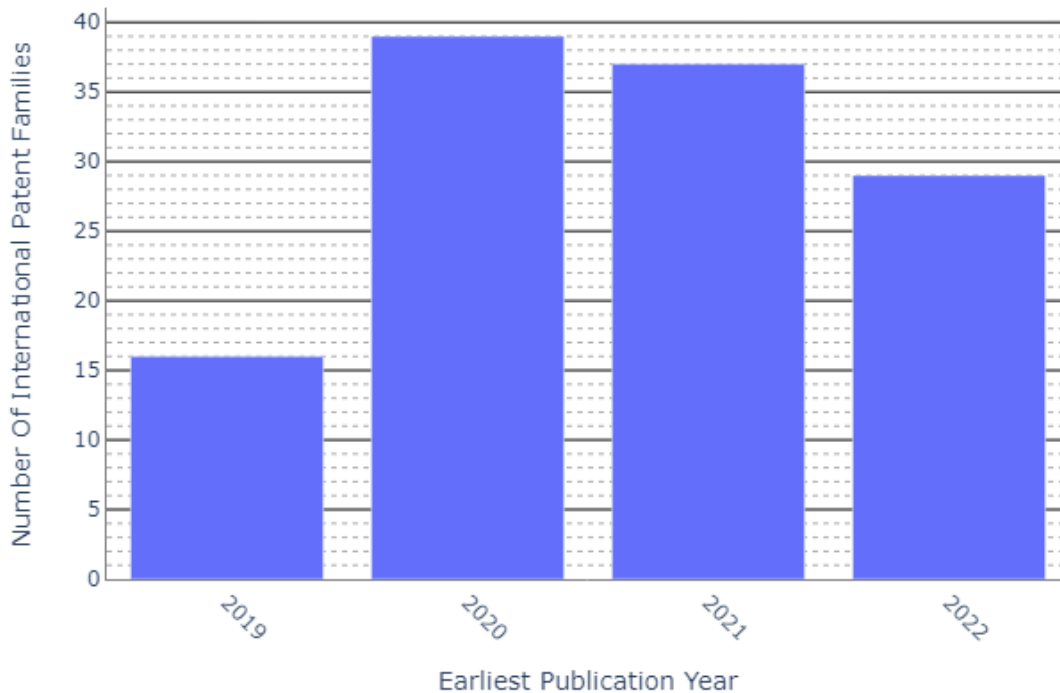The number of Patents: 40

06 Top terms: build, first, material, platform, second
The number of Patents: 68

07 Top terms: material, agent, metal, build, least
The number of Patents: 40
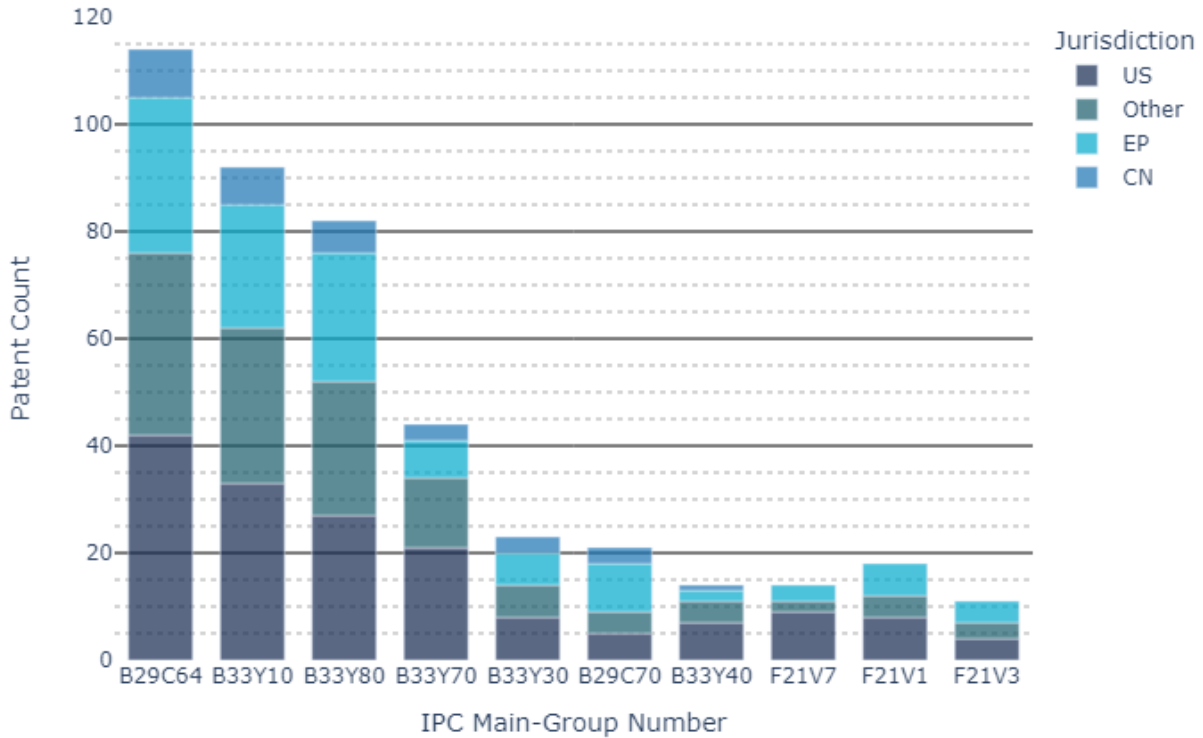
5.2. SIGNIFY Co

5.2.1. Patent family analysis

By examining patenting activities of SIGNIFY Co in the field of 3D-Printing technology, it is clear that 134 patents have been registered between 2000 and 2022. Also, the process of applying for patent registration in this field is increasing rapidly. This increase will probably be reflected in the company's future products. The highest number of patent registrations by HP is in 2020. It should be noted that 63 patents are pending, and it is expected that an important part of them will be registered in the next 24 months and will be added to the statistics of the last two years.

5.2.2. Top Technologies

The chart below shows the main technology fields that SIGNIFY CO has been focusing in terms of the number of patent applications in that main-group. As it is showed, "Additive manufacturing, i.E. Manufacturing of three-dimensional [3d] objects by additive deposition, additive agglomeration or additive layering, e.G. By 3D-Printing, stereolithography or selective laser sintering "with code B29C64 is at the top, then there are the areas of "Processes of additive manufacturing" and "Data acquisition or data processing for additive manufacturing".

|			
B29C64	Additive manufacturing, i.e. manufacturing of three-dimensional [3D] objects by additive deposition, additive agglomeration or additive layering, e.g. by 3D printing, stereolithography or selective laser sintering	B29C70	Shaping composites, i.e. plastics material comprising reinforcements, fillers or preformed parts, e.g. inserts
B33Y10	Processes of additive manufacturing	B33Y40	Auxiliary operations or equipment, e.g. for material handling
B33Y80	Products made by additive manufacturing	F21V7	Reflectors for light sources
B33Y70	Materials specially adapted for additive manufacturing	F21V1	Shades for light sources
B33Y30	Apparatus for additive manufacturing; Details thereof or accessories therefor	F21V3	Globes; Bowls; Cover glasses

The main patenting activities of SIGNIFY Company in a deeper layer of the technology tree are related to two aspects of additive manufacturing: using filamentary material being melted, e.g. fused deposition modelling, and Heads; Nozzles. These priorities indicate that this company focuses on materials and advances devices.
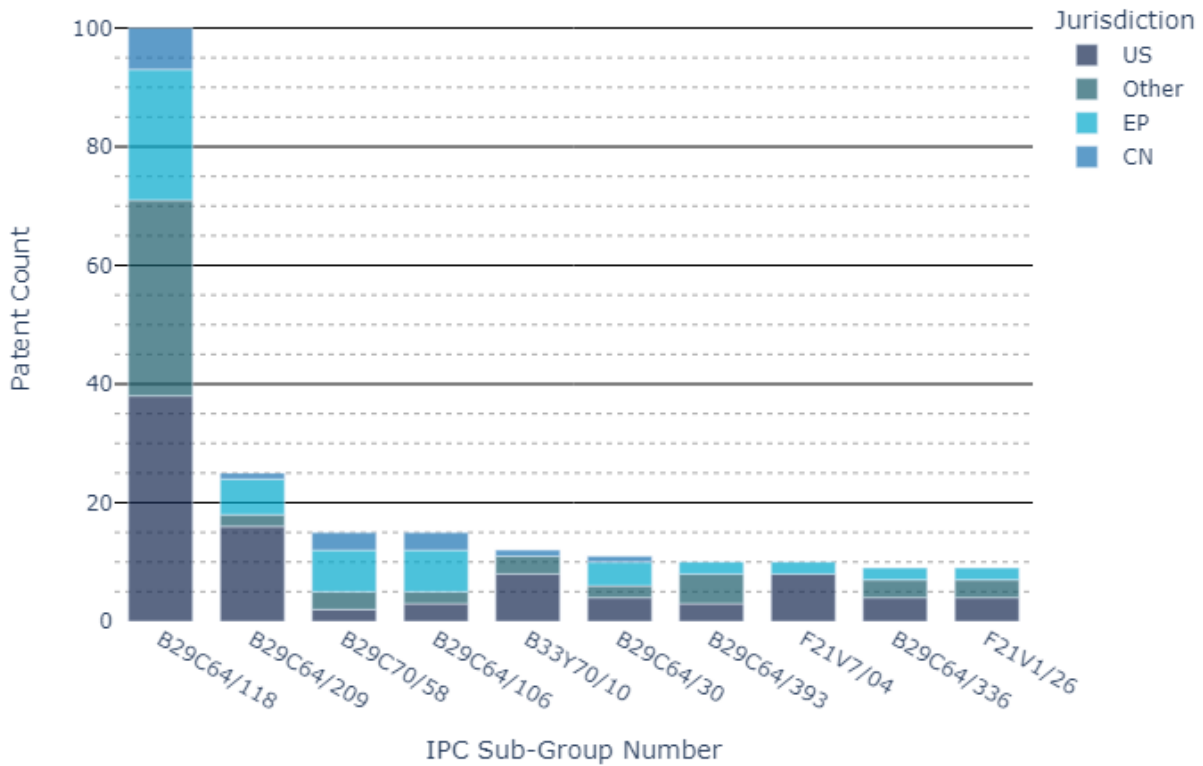
| B29C64/118	Additive manufacturing using filamentary material being melted, e.g. fused deposition modelling	B29C64/30	Auxiliary operations or equipment
B29C64/209	Heads; Nozzles	B29C64/393	for controlling or regulating additive manufacturing processes
B29C70/58	Additive manufacturing comprising fillers only	F21V7/04	Optical design
B29C64/106	Additive manufacturing using only liquids or viscous materials, e.g. depositing a continuous bead of viscous material	B29C64/336	Additive manufacturing of two or more materials

| B33Y70/10	Composites of different types of material, e.g. mixtures of ceramics and polymers or mixtures of metals and biomaterials	F21V1/26	Manufacturing shades

5.2.3. Collaboration

The figure below shows SIGNIFY's most cooperation is with Philips Lighting.
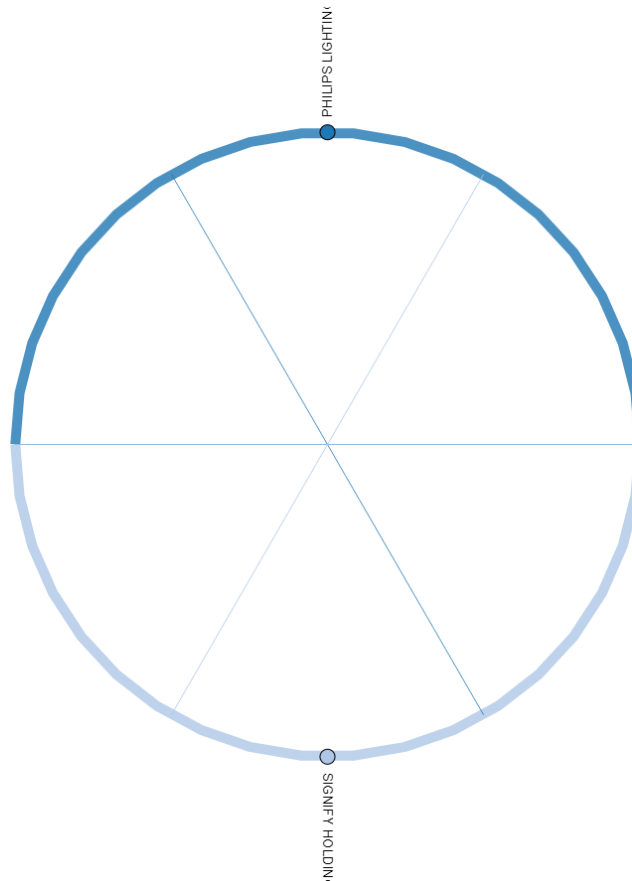
5.2.4. Key patents

The key patents of Signify Company, which have the highest number of citations, can be seen in the figure below.
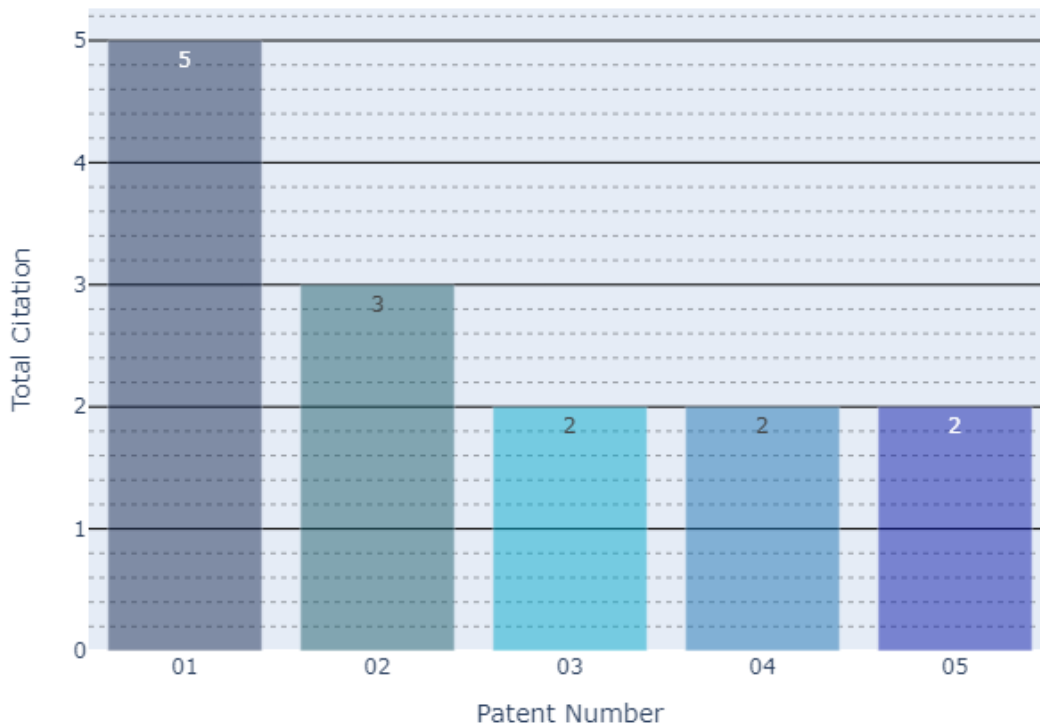
1 US 2019/0210278 A1
METHOD OF USING FDM TO OBTAIN SPECULARLY REFLECTIVE SURFACES
Publish year: 2019

2 US 2020/0361138 A1
METHOD FOR MANUFACTURING A 3D ITEM HAVING AN ELECTRICALLY CONDUCTIVE COIL
Publish year: 2020

3 CN 110520275 A
Method for 3D printing 3D item
Publish year: 2019

4 US 2020/0003395 A1
HIGH VISUAL COMFORT ROAD AND URBAN LED LIGHTING
Publish year: 2020

5 US 11007707 B2
Method for manufacturing a 3D item
Publish year: 2021

5.2.5. Topic modeling

Patents registered by SIGNIFY CO can be classified in terms of content in the following 7 groups. As can be seen, the main focus of this company's patents is in the fields of Luminaire, Light and material.
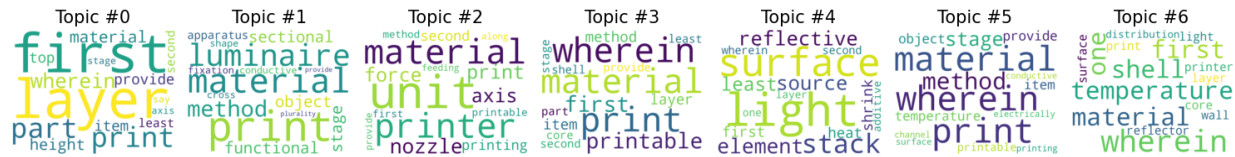
5.2.6. Patents clustering

The number of 134 patents registered by SIGNIFY can be classified in the following 7 clusters. The top terms of each cluster are also presented below. As can be seen, the largest number of patents of this company is in cluster number 5 with 32 patents and top terms of "layer, print, material". After this cluster, there is cluster number 2 with 14 patents and top terms of "printer, nozzle, distribution, material".
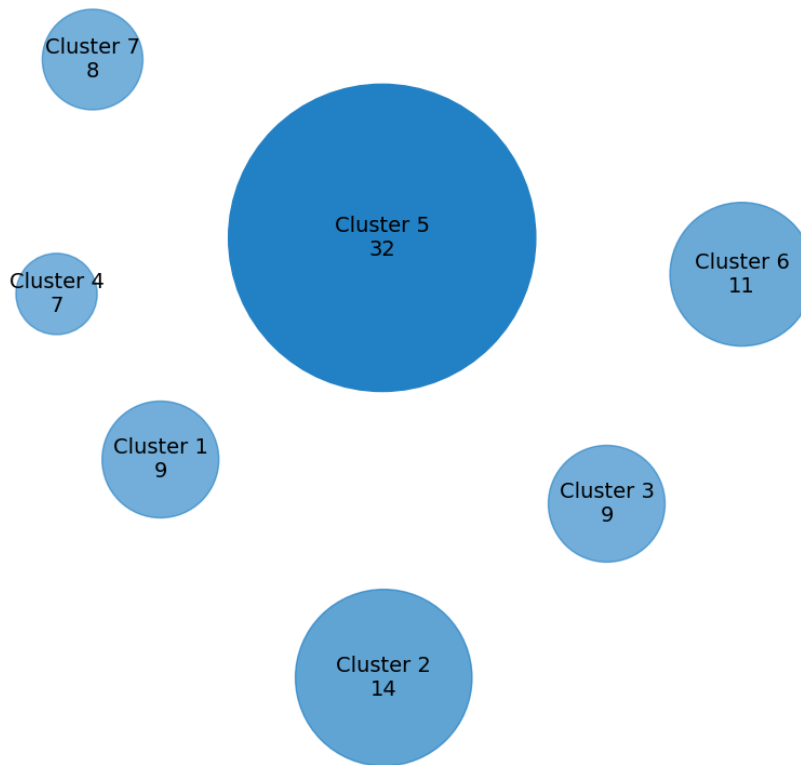
01 Top terms: shell, core, material, wherein, layer
The number of Patents: 9

02 Top terms: printer, nozzle, distribution, material
The number of Patents: 14

03 Top terms: length, particle, dimension, material, ratio
The number of Patents: 9

04 Top terms: conductive, heat, electrically, stack, shrink
The number of Patents: 7

05 Top terms: layer, print, material
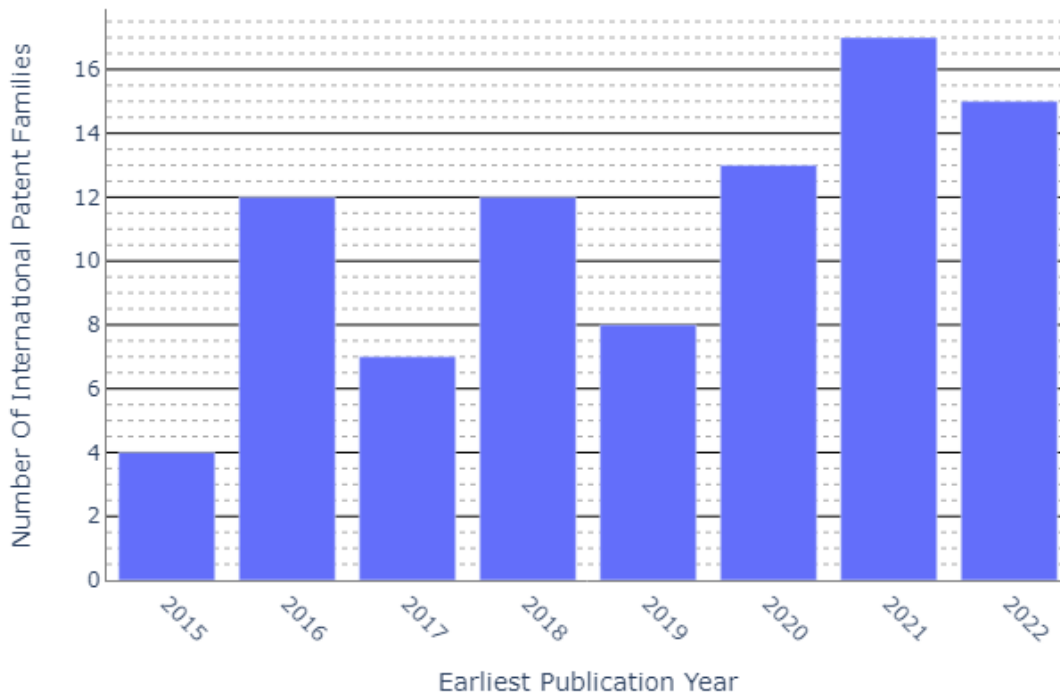The number of Patents: 32

06 Top terms: material, print, printable, heat
The number of Patents: 11

07 Top terms: temperature, material, glass, shell, core
The number of Patents: 8

5.3. Xerox Co

5.3.1. Patent family analysis

By examining patenting activities of Xerox Co in the field of 3D-Printing technology, it is clear that 103 patents have been registered between 2000 and 2022. Also, the process of applying for patent registration in this field is increasing rapidly. This increase will probably be reflected in the company's future products. The highest number of patent registrations by Xerox is in 2020. It should be noted that 30 patents are pending, and it is expected that an important part of them will be registered in the next 24 months and will be added to the statistics of the last two years.

5.3.2. Top Technologies

The chart below shows the main technology fields that Xerox CO has been focusing in terms of the number of patent applications in that main-group. As it is showed, "Additive manufacturing, i.E. Manufacturing of three-dimensional [3d] objects by additive deposition, additive agglomeration or additive layering, e.G. By 3D-Printing, stereolithography or selective laser sintering "with code B29C64 is at the top, then there are the areas of "Processes of additive manufacturing" and "Shaping techniques".
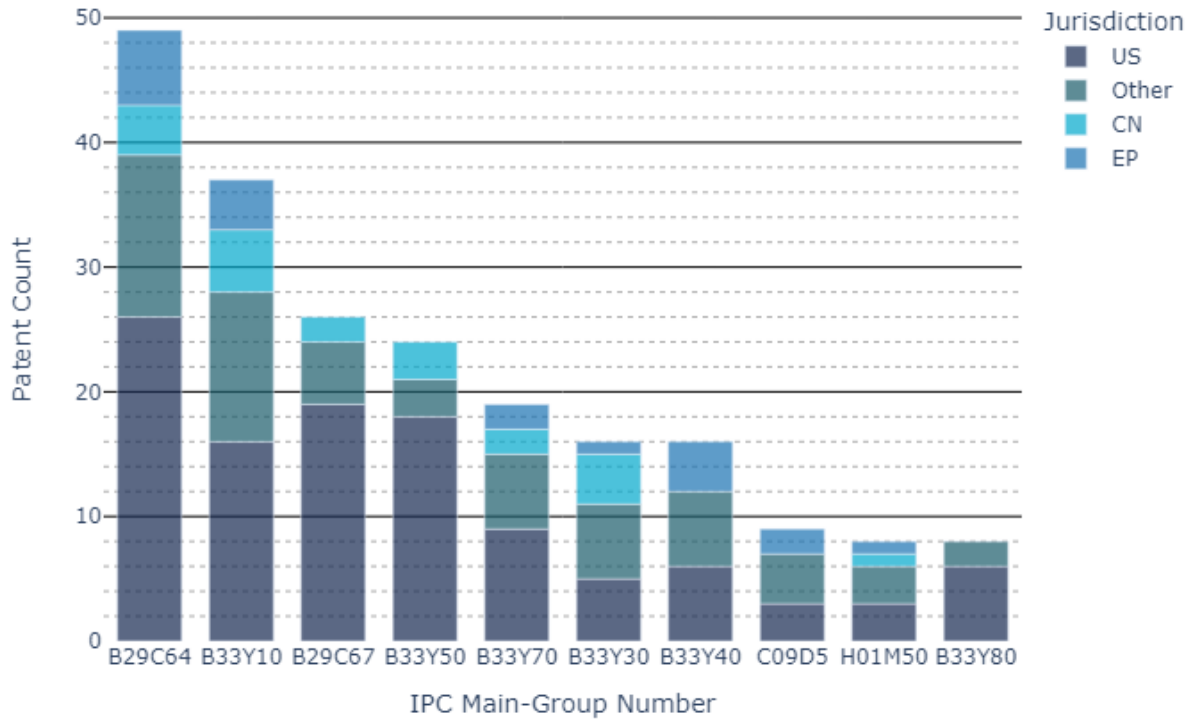
B29C64	Additive manufacturing, i.e. manufacturing of three-dimensional [3D] objects by additive deposition, additive agglomeration or additive layering, e.g. by 3D printing, stereolithography or selective laser sintering	B33Y40	Auxiliary operations or equipment, e.g. for material handling
B33Y10	Processes of additive manufacturing	C09D5	Coating compositions, e.g. paints, varnishes or lacquers, characterised by their physical nature or the effects produced; Filling pastes
B29C67	Shaping techniques not covered by groups	H01M50	Constructional details or processes of manufacture of the non-active parts of electrochemical cells other than fuel cells, e.g. hybrid cells
B33Y50	Data acquisition or data processing for additive manufacturing	B33Y80	Products made by additive manufacturing

The main patenting activities of Xerox Company in a deeper layer of the technology tree are related Data acquisition or data processing for additive manufacturing for for controlling or regulating additive manufacturing processes, and for controlling or regulating additive manufacturing processes. These priorities indicate that this company focuses on data acquisition and processing.
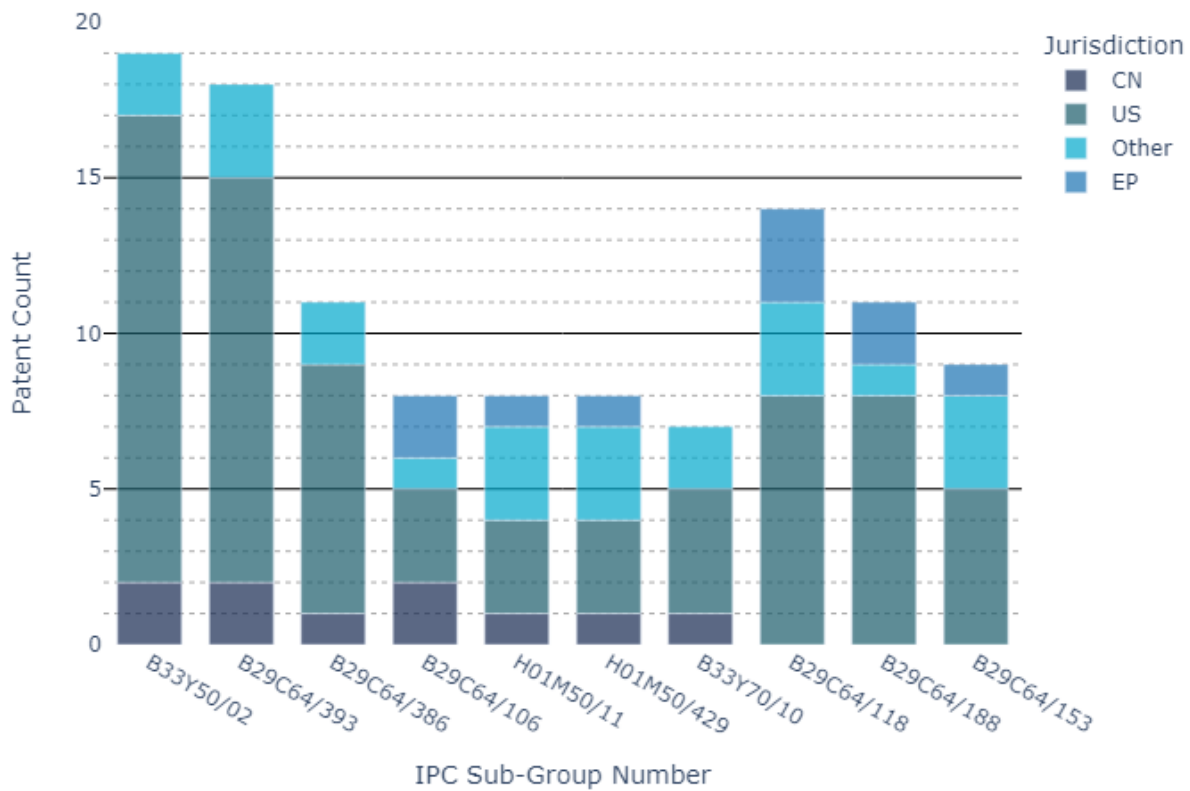
| B33Y50/02 | for controlling or regulating additive manufacturing processes | H01M50/429 | Constructional details or processes of manufacture of the non-active parts of electrochemical cells (Natural polymers) |
| B29C64/393 | for controlling or regulating additive manufacturing processes | B33Y70/10 | Composites of different types of material, e.g. mixtures of ceramics and polymers or mixtures of metals and biomaterials |

| B29C64/386	Data acquisition or data processing for additive manufacturing	B29C64/118	Additive manufacturing using filamentary material being melted, e.g. fused deposition modelling
B29C64/106	Additive manufacturing using only liquids or viscous materials, e.g. depositing a continuous bead of viscous material	B29C64/188	Additive manufacturing involving additional operations performed on the added layers
H01M50/11	Constructional details or processes of manufacture of the non-active parts of electrochemical cells (having a structure in the form of a chip)	B29C64/153	Additive manufacturing using layers of powder being selectively joined, e.g. by selective laser sintering or melting

5.3.3. Collaboration

The figure below shows that Xerox's most cooperation is with Palo Alto Research Center with more than 10 collaboration for patent application.
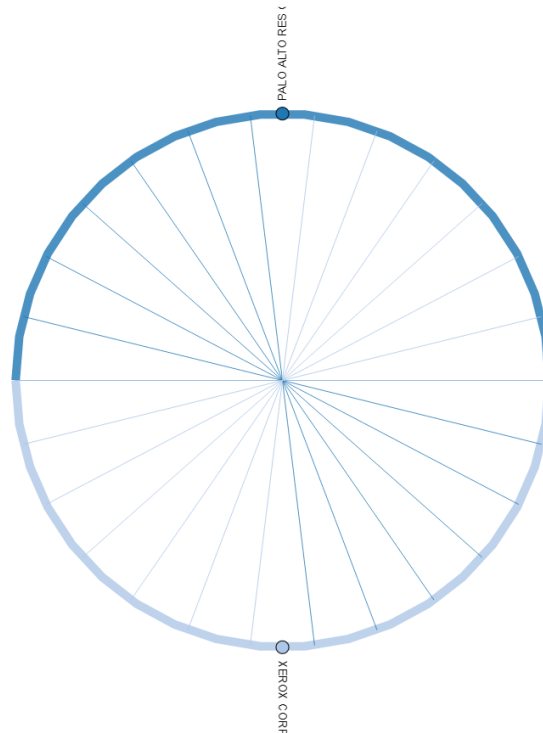
5.3.4. Key patents

The key patents of Xerox Company, which have the highest number of citations, can be seen in the figure below.
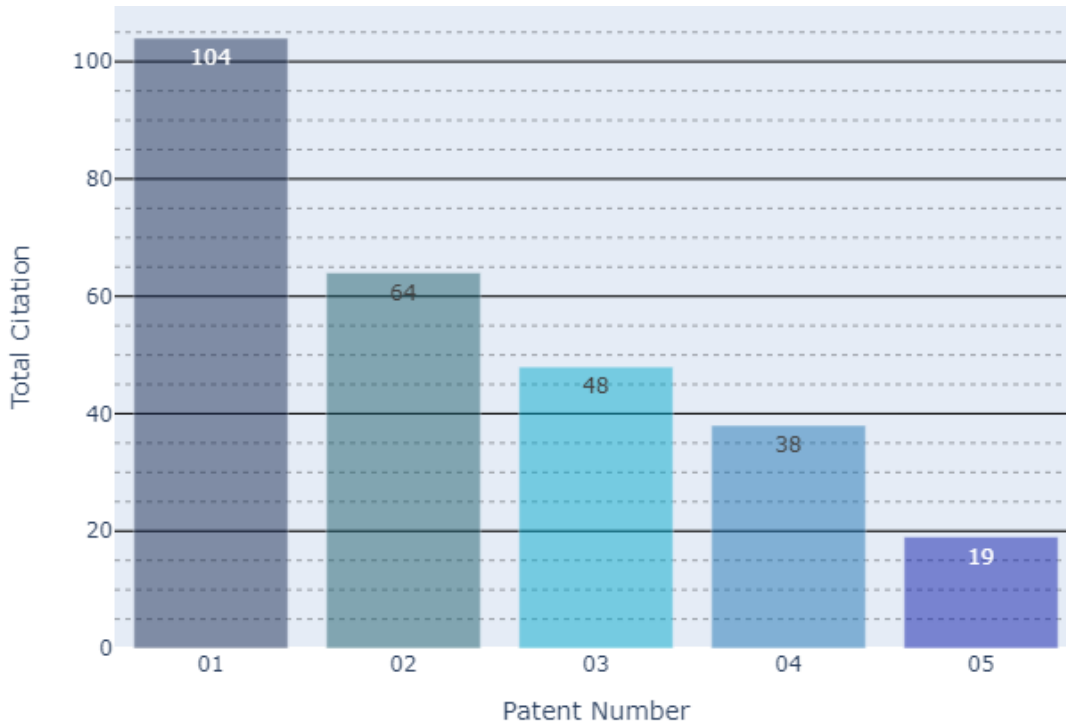
1 US 2017/0284876 A1
3D PRINTED CONDUCTIVE COMPOSITIONS ANTICIPATING OR INDICATING STRUCTURAL COMPROMISE
Publish year: 2017

2 US 10234342 B2
3D PRINTED CONDUCTIVE COMPOSITIONS ANTICIPATING OR INDICATING STRUCTURAL COMPROMISE
Publish year: 2019

3 US 2016/0260001 A1
METHOD AND SYSTEM FOR GENERATING AND PRINTING THREE DIMENSIONAL BARCODES
Publish year: 2016

4 US 2015/0145158 A1
3D PRINT MANUFACTURING OF PACKAGES WITH PERSONALIZED LABELING TECHNOLOGY
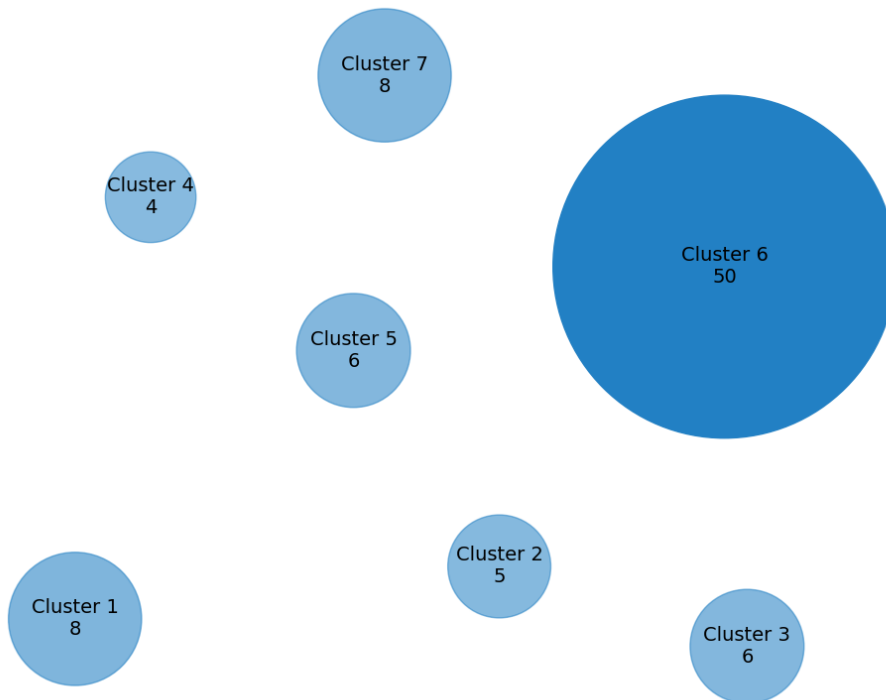Publish year: 2015

5 US 2016/0259306 A1
SYSTEM TO AUTHENTICATE 3D PRINTED OBJECTS
Publish year: 2016

5.3.5. Topic modeling

Patents registered by Xerox Co can be classified in terms of content in the following 6 groups. As can be seen, the main focus of this company's patents is in the fields of additive manufacturing processes and materials.
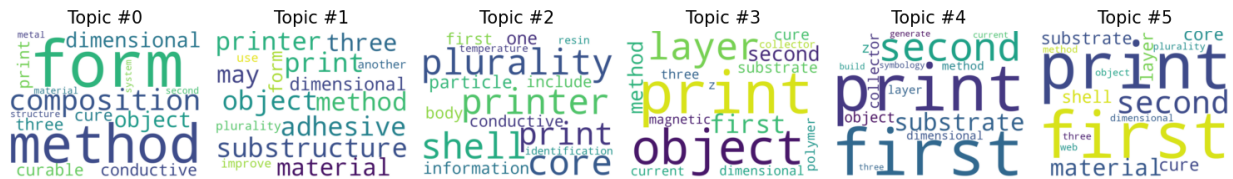
5.3.6. Patents clustering

The number of 103 patents registered by Xerox Co can be classified in the following 7 clusters. The top terms of each cluster are also presented below. As can be seen, the largest number of patents of this company is in cluster number 6 with 50 patents and top terms of "cure, object, material, print, build". After this cluster, there are cluster number 1

and 7 with 8 patents and top terms of "magnetic, polymer, object, axis, strength" and "substrate, current, collector".

01   Top terms: magnetic, polymer, object, axis, strength
The number of Patents: 8

02   Top terms: composition, conductive, curable, trace, structure
The number of Patents: 5

03   Top terms: substructure, adhesive
The number of Patents: 6

04   Top terms: device, build, datum, object
The number of Patents: 4

05   Top terms: shell, core, plurality, particle, polyester
The number of Patents: 6

06   Top terms: cure, object, material, print, build
The number of Patents: 50

07   Top terms: substrate, current, collector
The number of Patents: 8

STIMAnalytics

STIMAnalytics, InnoTech Co

Unit JLT-PH2-RET-5, Jumeirah Lakes Towers,

Dubai, UAE

For contact details of STIMAnalytics

Visit www.STIMAnalytics.net