3D Printing

Technology Insight Report

An analysis of patenting activity around 3D-Printing from 1990-Current

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Introduction

3D printing or additive manufacturing is a process of making a three-dimensional solid object of virtually any shape from a digital model. 3D printing is achieved using an additive process, where successive layers of material are laid down in different shapes. 3D printing is also considered distinct from traditional machining techniques, which mostly rely on the removal of material by methods such as cutting or drilling (subtractive processes).

The term additive manufacturing refers to technologies that create objects through sequential layering. Objects that are manufactured additively can be used anywhere throughout the product life cycle, from pre-production (i.e. rapid prototyping) to full-scale production (i.e. rapid manufacturing), in addition to tooling applications and post-production customization.

The 3D printing technology is used for both prototyping and distributed manufacturing with applications in architecture, construction (AEC), industrial design, automotive, aerospace, military, engineering, civil engineering, dental and medical industries, biotech (human tissue replacement), fashion, footwear, jewelry, eyewear, education, geographic information systems, food, and many other fields.

This report categorizes and graphically analyzes research trends around 3D printing and the processes involved and its applications from various perspectives and highlights the key companies involved.

NOTE: All analysis in this report has been done on unique families (One publication per family) and so the data in the charts should be construed accordingly.

Patent Search Strategy

Using PatSeer following search query was used to create patent set.

TAC- Title, Abstract, Claims   IC– International Class

TACD- Title, Abstract, Claims, Description   CPC- Cooperative Patent Classification

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TAC:((3D OR 3-D OR 3-dimension* OR 3 dimension* OR (three* w2 dimension*) OR desktop* OR additive*) wd2 (print* OR fabricat* OR manufactur*))

AND

(

      IC:(B29C* OR H01L* OR G06F* OR G02B* OR B32B* OR H05K* OR B41J* OR B41M* OR G06T* OR B44C* OR B22F* OR H04L* OR G03F* OR H04N* OR C04B* OR G05B* OR "G03B35" OR A61*)

      OR

      CPC:(B29C* OR H01L* OR G06F* OR G02B* OR B32B* OR H05K* OR B41J* OR B41M* OR G06T* OR H04L* OR B44C* OR B22F* OR G03F* OR H04N* OR C04B* OR G05B* OR A61* OR "G03B35")

)

AND NOT

(TACD:(stereoscopic* OR oxidation product* OR streaming interactive OR nanoweb or nano web OR nanofiber* OR nanofibre* OR nano fiber* OR nano fibre* OR nanometer fiber* OR nanometer fibre* OR non halogen OR non-halogen OR ((food* OR feed* OR liquid*) w2 additive*) OR seed culture OR nanometre fiber* OR nanometre fibre* OR antibacteria* OR media access control OR multi-wafer 3D CAM cell OR 3-sigma or three sigma or rheolog* additive* or vibration isolator*))

> ➤ The query was directed to search through the title, abstract and claims. The individual results were collapsed to one publication per family which was then exported from PatSeer and imported in Patent iNSIGHT Pro.
>
> ➤ After reviewing few results especially from older publications, we came across some similar but irrelevant terms which we then excluded from full text using NOT operator.
>
> ➤ Result set of 2863 records was imported into the software.

The publications included in the report are updated as of 05th February, 2014

Definitions of IPC Classes referred to in search query

IPC	Description
B29C	Shaping or joining of plastics; shaping of substances in a plastic state, in general; after-treatment of the shaped products, e.g. Repairing
H01L	Semiconductor Devices; Electric Solid State Devices Not Otherwise Provided For
G06F	Electric Digital Data Processing
G02B	Optical Elements, Systems, Or Apparatus
B32B	Layered products, i.e. Products built-up of strata of flat or non-flat, e.g. Cellular or honeycomb, form
H05K	Printed Circuits; Casings Or Constructional Details Of Electric Apparatus; Manufacture Of Assemblages Of Electrical Components
B41J	Typewriters; selective printing mechanisms, i.e. Mechanisms printing otherwise than from a forme; correction of typographical errors
B41M	Printing, Duplicating, Marking, Or Copying Processes; Colour Printing
G06T	Image Data Processing Or Generation, In General
B44C	Producing Decorative Effects
B22F	Working Metallic Powder; Manufacture Of Articles From Metallic Powder; Making Metallic Powder
H04L	Transmission of digital information, e.g. Telegraphic communication
G03F	Photomechanical production of textured or patterned surfaces, e.g. For printing, for processing of semiconductor devices; materials therefore
H04N	Pictorial Communication
C04B	Lime; Magnesia; Slag; Cements; Compositions Thereof
G05B	Control Or Regulating Systems In General; Functional Elements Of Such Systems; Monitoring Or Testing Arrangements For Such Systems Or Elements
G03B35/00	Stereoscopic Photography (Panoramic Or Wide-Screen Systems G03B 37/00; Photogrammetry G01C)
A61	Medical Or Veterinary Science; Hygiene

False Positives

After manual review of records, we came across unwanted and confusing terms which had to be removed for accurate analysis.

1. We eliminated some of the records for desktop printing which also meant printing on a 3D object such as cups/device etc with the help of a 2D printer instead of 3D printer. The Advanced search option within software was used to search and filter records mentioning desktop printing.

2. We also filtered, analyzed and removed all records with filing dates before 1990 .

3. Further found some irrelevant records having terms such as "3D color space", etc. and records which were talking about a 3D image being printed.

4. The original record set had 2863 records. After all the above elimination techniques we got **2635 records** (from the original 2863) which formed a base set for further analysis.

Technical Segmentation (Patent Categorization)

To analyze patents around 3D printing, we categorized them around three different criteria.

By Technologies	By Materials	By Applications
• Ballistic Layer Manufacturing	• ABS Plastic	• Aerospace
• Cladding	• Alkyd	• Aircraft
• Computer Numerical Control (CNC)	• Aluminium	• Automobiles
• Contour Crafting	• Carbon Fiber	• Clothing
• Digital Light Processing	• Ceramic	• Construction
• Direct Laser Forming	• Clay	• Defense
• Direct Manufacturing	• Elastomers	• Food Industry
• Direct Metal Deposition	• Epoxy	• Furniture
• Direct Metal Laser Sintering	• Fiberglass	• Jewellery
• Direct Shell Production Casting	• Furan	• Mechanical
• Electron Beam Melting	• High-density Polyethylene	• Medical
• Electron Beam Projection Lithography	• Melamine	• PCB
• Electrophoretic Deposition	• Methacrylic	• Phones
• Fused Deposition Modeling	• Nickel	• Prosthesis
• Inkjet Deposition	• Nylon	• Robotics
• Laminated Object Manufacturing	• PEEK	• Scaffolding
• Laser Ablation	• Palladium	• Shoes
• Laser Engineered Net Shaping	• Paper	• Television
• Laser Metal Forming	• Phenolic	• Tissue Engineering
• Laser Powder Forming	• Photopolymers	• Tooling
• LaserCusing	• Plastic	• Toys
• Microfabrication	• Poly paraphenylene terephthalamide	• Watches
• Multi-Jet Modeling	• Polyamide	
• Multiphoton Lithography	• Polyamideimide	
• Photolithography	• Polycarbonate	
• Plaster-based 3D printing	• Polyetherimide	
• Robocasting	• Polyethylene	
• Selective Fusing	• Polyethylene Terephthalate	
• Selective Laser Melting	• Polyimide	
• Selective Laser Sintering	• Polylactic Acid	
• Solid Ground Curing	• Polyolefin	
• Spin Casting	• Polyphenylsulfone	
• Stereolithography	• Polypropylene	
	• Polyvinyl Acetate	
	• Polyvinyl Chloride	
	• Polyvinylidene Chloride	
	• RTV Silicon	
	• Rubber	
	• Silver	
	• Stainless Steel	
	• Steel	
	• Thermoplastic	
	• Thermoset	
	• Titanium	
	• Wax	

The categorization involved defining a search strategy for each topic and then conducting the search using the Advanced Searching capability in Patent iNSIGHT Pro. Details of search strings used for each category are given in Appendix.

Publication Trend

What has been the publication trend for 3D printing patents?

Innovation in 3d printing and its resulting patent publications started to show up from the 1990s with the real surge in the activity around this technology happening in the last 5 years. It's clear the current activity around these technologies is likely to continue seeing more innovation in the near future.
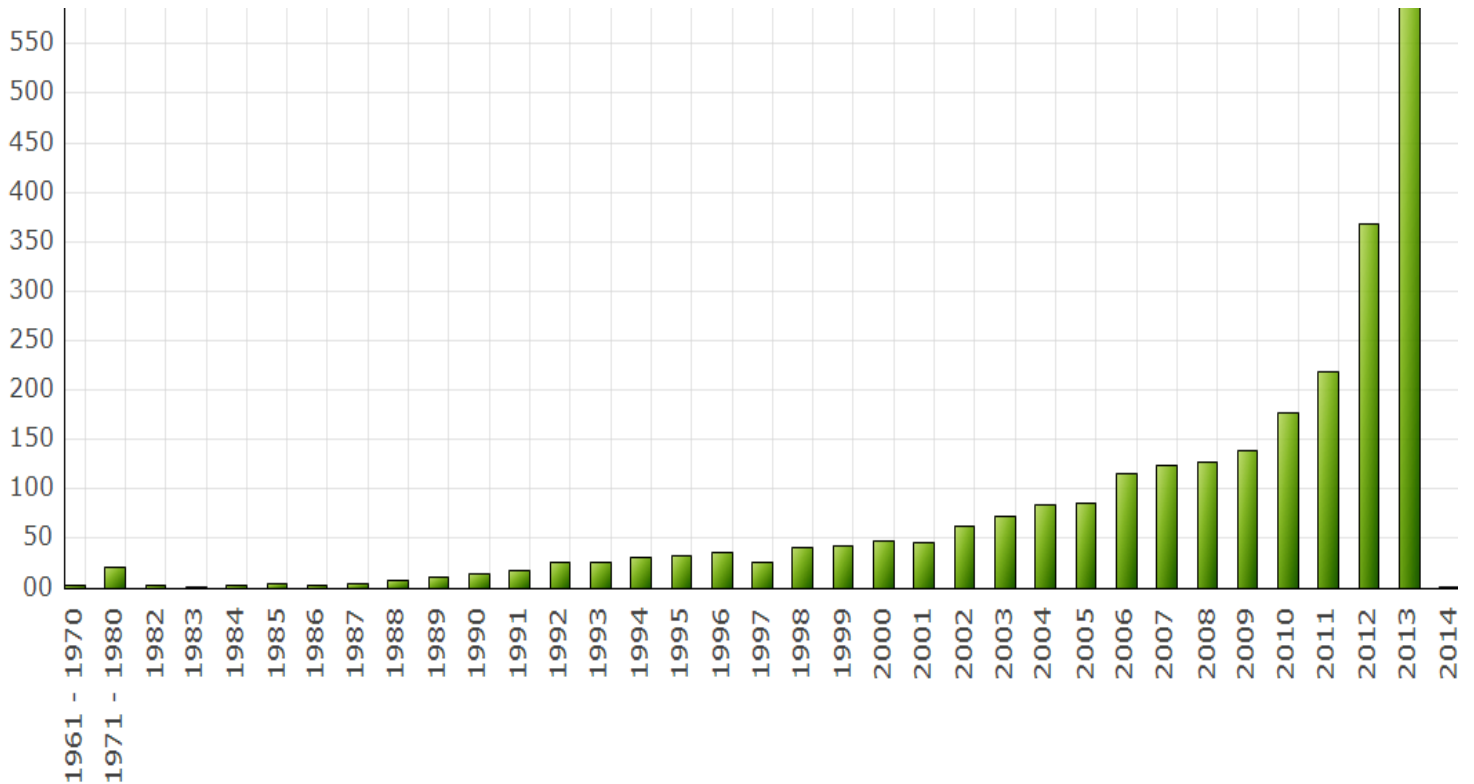
How we did it?

Once the patents were populated in Patent iNSIGHT Pro, the publication trend chart was generated on a single click using the dashboard tool.

Top Companies

The top companies in 3D printing are:

1. 3D SYSTEMS INC
2. STRATASYS INC
3. MASSACHUSETTS INST OF TECHNOLOGY
4. HEWLETT-PACKARD CO
5. HITACHI CHEM CO LTD
6. MATSUSHITA ELECTRIC
7. THERICS INC
8. MATERIALSE NV
9. OBJET LTD
10. PANASONIC CORP

11. IBM CORP
12. THE BOEING CO
13. MIMAKI ENGG CO LTD
14. 3SHAPE A/S
15. DAINIPPON PRINTING CO LTD
16. EXONE CO
17. FUJIFILM CORP
18. 3M CO
19. SIEMENS AG
20. XEROX CORP
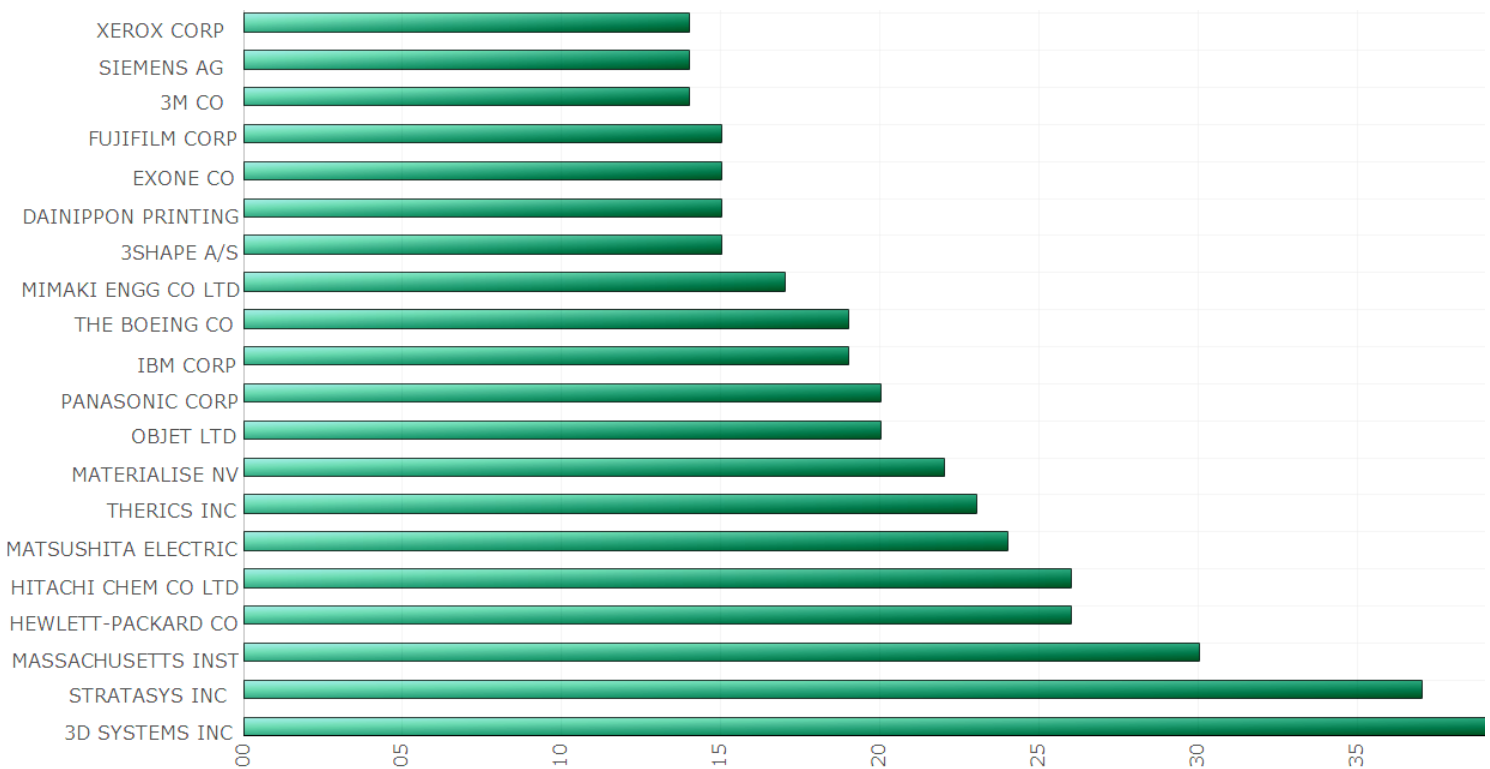
Note: Records for Objet Ltd and Makerbot Industries have not been grouped with Stratasys Inc inspite of their merger with Stratasys, as some of the patents owned by both these companies have not been transferred to a single company. Similarly, records for Z Corp have also not been merged with 3D Systems.

How we did it?

Once the patents were populated in Patent iNSIGHT Pro, the assignee clean- up tools were used to normalize the names. Different cleanup tools were leveraged:
• To locate assignees for unassigned records

• To clean up records having multiple assignees
• To locate the correct assignee names for US records using the US assignments database
• To merge assignees that resulted from a merger or acquisition or name change.

The dashboard tool within Patent iNSIGHT Pro was used to find the top 20 assignees within the given patent set. A visual graph was created based on the results of the top assignees with the number of patents alongside each one.

The complete Assignee table in available in the following Excel file:

http://www.patentinsightpro.com/techreports/0214/List%20of%20Assignees.xls

Research activity around the world

The table below ranks top priority countries and helps provide an indication of where innovation in this area is originating:

Country Code	Total
US	946
JP	498
CN	452
KR	156
DE	146
EP	85
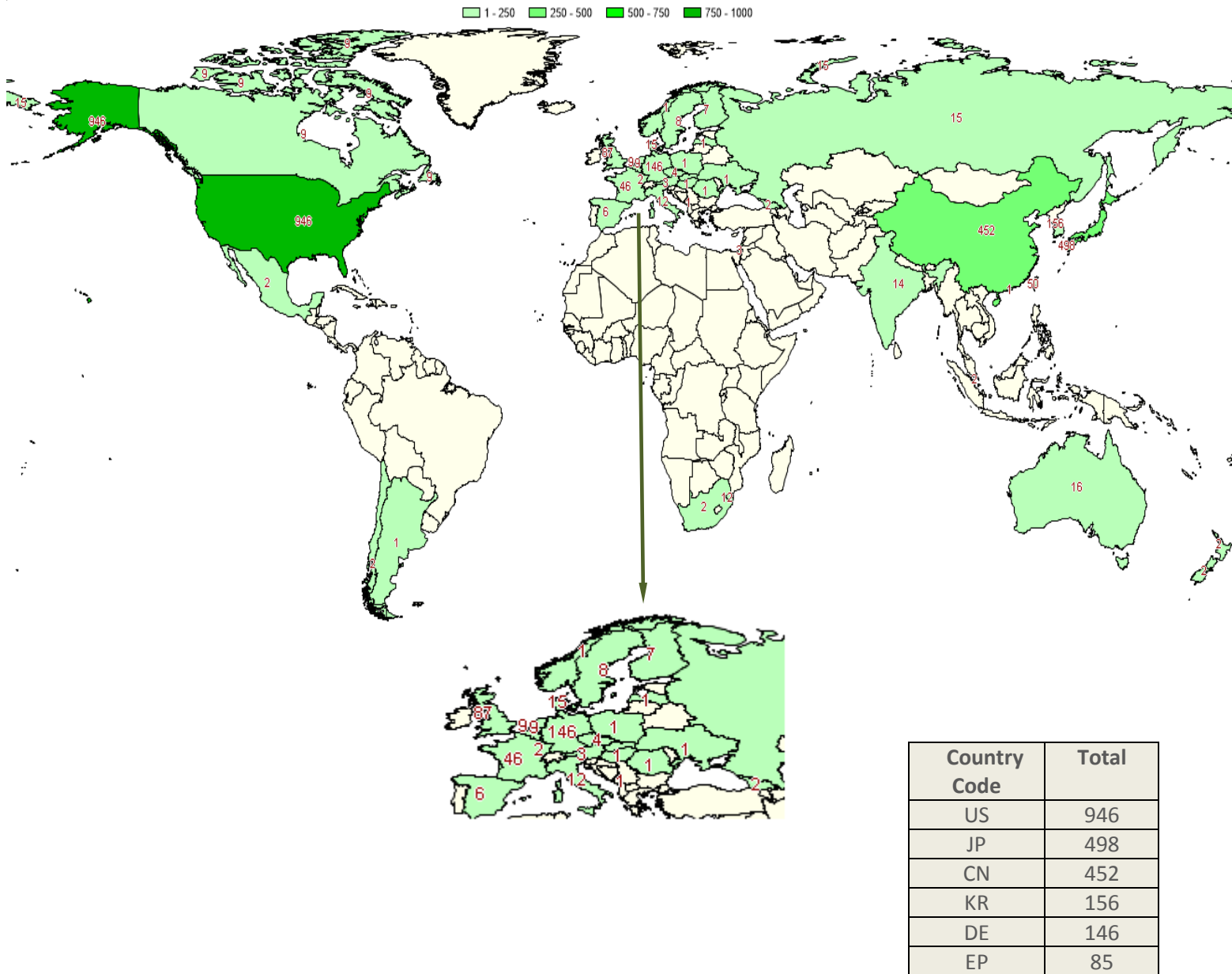
How we did it?

The map was generated using the Priority country coverage map option provided in the dashboard tool within Patent iNSIGHT Pro.

Companies - Key Statistics

Here we summarize key parameters of Top 15 companies such as filing trend, Top inventors in each company and Coverage of underlying patent families

Assignee	Total No. of Records	Avg. No. of Fwd Cites per Patents	Filing Trend (Absolute)	Filing Year Range	Key Inventor (Top 5)	Co-Assignees	Coverage (Includes families)								
							US	EP	WO	JP	DE	CN	GB	KR	IN
3D SYSTEMS INC	39 (1.5%)	3.26		1999 - 2013	BREDT JAMES F(7) RUSSELL DAVID B(6) WILLIAMS DEREK X(5) XU PINGYONG(4) MANNERS CHRIS R(3)	HUNTSMAN INTERNATIONAL LLC(2)	38	24	27	22	7	12	3	8	7
STRATASYS INC	37 (1.4%)	5.24		1993 - 2013	SWANSON WILLIAM J(10) BATCHELDER J SAMUEL(10) NAPADENSKY EDUARDO(7) COMB JAMES W(5) HJELSAND TIMOTHY A(4)	No Co-Assignee Present	33	14	19	3	4	4	0	0	1
MASSACHUSETTS INST TECH	30 (1.1%)	22.2		1992 - 2013	SACHS EMANUEL(12) CIMA MICHAEL J(10) BREDT JAMES F(8)	No Co-Assignee Present	28	18	22	15	12	0	0	0	0

Assignee	Count (%)	Avg	Trend	Years	Inventors	Co-Assignee									
					BRANCAZIO DAVID(4) CIMA MICHAEL(4)										
HEWLETT-PACKARD CO	26 (1%)	3.69		1996 - 2012	LOUGHRAN STEPHEN A(3) LAMBRIGHT TERRY M(3) BOYD MELISSA D(3) KASPERCHIK VLADEK P(3) NIELSEN JEFFREY ALLEN(2)	No Co-Assignee Present	24	13	5	14	8	6	3	3	1
HITACHI CHEM CO LTD	26 (1%)	1.96		1978 - 2001	IRINO TETSURO(8) KATO HIDEO(6) FUKAI HIROYUKI(5) AMANO SABURO(3) IWASAKI YORIO(3)	HITACHI LTD(1)	2	1	0	19	2	0	1	2	0
MATSUSHITA ELECTRIC WORKS LTD	24 (0.9%)	1		1990 - 2010	HARAZONO BUNICHI(4) FUWA ISAO(3) HIGASHI YOSHIKAZU(3) SATOSHI ABE(3) BABA DAIZO,FUKUYA NAOHITO(2)	No Co-Assignee Present	9	3	5	16	4	9	1	8	1
THERICS INC	23 (0.9%)	10.78		1998 - 2005	BRADBURY THOMAS J(10) MATERNA PETER A(9) GAYLO CHRISTOPHER M(8)	AFBS INC(12)	19	8	14	2	1	0	0	0	0

Assignee	Count	Value	Trend	Years	Inventors	Co-Assignee									
					GANZ SCOTT D(3) STIKELEATHER ROGER C(3)		6	5	17	3	1	0	5	0	0
MATERIALISE NV	22 (0.8%)	0.05		2003 - 2013	VANCRAEN WILFRIED(4) KEPPLER LOUIS JAMES(4) VANGENEUGDEN DIETER(3) PALLARI JARI HEIKKI PETTERI(3) KEPPLER LOUIS(3)	UNIV ZUERICH(1)	6	5	17	3	1	0	5	0	0
OBJET LTD	20 (0.8%)	12		1999 - 2012	GOTHAIT HANAN(6) KRITCHMAN ELIAHU M(6) NAPADENSKY EDUARDO(6) LEVY AVRAHAM(2) SHTILERMAN SLAVA(2)	No Co-Assignee Present	14	8	12	1	1	3	0	0	0
PANASONIC CORP	20 (0.8%)	1.45		1994 - 2012	FUWA ISAO(7) HIGASHI YOSHIKAZU(7) SATOSHI ABE(5) NAKAMURA SADASHI(4) UCHINONO YOSHIYUKI(3)	YOSHIDA TECHNOWORKS CO LTD(1)	12	4	9	13	5	9	0	3	2

Assignee	Count	Value	Trend	Years	Inventors	Co-Assignee									
IBM CORP	19 (0.7%)	17.26		1977 - 2012	YU ROY(3) POGGE H BERNHARD(2) PURUSHOTHAMAN SAMPATH(2) YOUNG ALBERT(1) SHAPIRO MICHAEL J(1)	No Co-Assignee Present	17	7	2	11	3	5	1	1	1
THE BOEING CO	19 (0.7%)	4.26		1975 - 2012	DIETRICH DAVID M(4) LYONS BRETT IAN(3) SLAUGHTER VICTOR BLAKEMORE (2) NOBLES ORVAL M(1) MARSH BOBBY J(1)	No Co-Assignee Present	19	8	6	5	1	4	4	1	0
MIMAKI ENGG CO LTD	17 (0.6%)	0.53		2007 - 2011	ONO NOBUYUKI(13) SEKI KAZUTOMO(11) ONOZAWA YOSHIKI(6) TEZUKA CHIKAO(5) HIGUCHI MASAYA(3)	INST NAT COLLEGES TECH JAPAN(1)	7	9	6	13	0	9	0	9	0
3SHAPE A/S	15 (0.6%)	5.67		2001 - 2012	FISKER RUNE(14) DEICHMANN NIKOLAJ(8) CLAUSEN TAIS(7) FISCHER DAVID(3) NONBOE SVEN(3)	No Co-Assignee Present	10	10	13	4	1	5	0	2	1

| DAINIPPON PRINTING CO LTD | 15 (0.6%) | 1.53 | | 1987 - 2011 | YAMAZAKI HIDEKI(3) KOBAYASHI MASAYA(1) OGATA TETSUJI(1) OZAWA HIDETOSHI(1) MATSUMOT O ISAO(1) | No Co-Assignee Present | 2 | 1 | 1 | 13 | 1 | 1 | 0 | 0 | 0 |
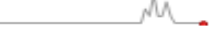
How we did it?

From the Assignee 360° report options, we selected Top 15 Assignees and the different pieces of information we wanted to include in the singular display and then ran the report. The generated report was then exported to Excel using the option provided for the same.

Inventor - Key Statistics

Here we summarize key parameters of Top 15 Inventors such as filing trend, key associated companies and top 5 co-inventors.

Inventor	Total No. of Records	Avg. No. of Fwd Cites per Patents	Filing Trend (Absolute)	Filing Year Range	Key Assignees (Top 5)	Co-Inventors
BREDT JAMES F	21 (0.8%)	17.19		1992-2010	MASSACHUSETTS INST TECH(8) 3D SYSTEMS INC(7) Z CORP(6)	CLARK SARAH L(7) DICOLOGERO MATTHEW(6) RUSSELL DAVID B(6) SACHS EMANUEL(6) ANDERSON TIMOTHY C(4)
MATERNA PETER A	15 (0.6%)	9.07		2001-2010	THERICS INC(9) AFBS INC(6) MASSACHUSETTS INST TECH(3) THEKEN SPINE LLC(3)	BRADBURY THOMAS J(7) CIMA MICHAEL J(4) GAYLO CHRISTOPHER M(4) PRYCE LEWIS WENDY E(3) PRYOR TIMOTHY(3)
FISKER RUNE	14 (0.5%)	5.29		2002-2012	3SHAPE A/S(14)	DEICHMANN NIKOLAJ(7) CLAUSEN TAIS(6) FISCHER DAVID(3) NONBOE SVEN(3) GILLES BRIEUC(2)
CIMA MICHAEL J	13 (0.5%)	23.08		1992-2010	MASSACHUSETTS INST TECH(10) THERICS INC(2) THEKEN SPINE LLC(1)	PRYCE LEWIS WENDY E(5) MATERNA PETER A(4) CIMA LINDA G(3) ROWE CHARLES WILLIAM(3) SACHS EMANUEL(3)
GAYLO CHRISTOPHER M	13 (0.5%)	11.15		1998-2005	THERICS INC(8) AFBS INC(5) THEKEN SPINE LLC(4) MASSACHUSETTS INST TECH(1)	BRADBURY THOMAS J(4) MATERNA PETER A(4) CHESMEL KATHLEEN D(3) FAIRWEATHER JAMES A(3) CIMA MICHAEL J(2)
NAPADENSKY EDUARDO	13 (0.5%)	5.31		2001-2013	STRATASYS INC(7) OBJET LTD(6)	GOTHAIT HANAN(3) RAVICH DIANA(2) BRUSILOVSKY DAVID(1) CHECHIK DANI(1) DIKOVSKY DANIEL(1)

Name	Count	Value	Trend	Years	Assignees	Co-Inventors
ONO NOBUYUKI	13 (0.5%)	0.69		2007-2011	MIMAKI ENGG CO LTD(13) INST NAT COLLEGES TECH JAPAN(1)	SEKI KAZUTOMO(11) ONOZAWA YOSHIKI(6) TEZUKA CHIKAO(5) HIGUCHI MASAYA(3) KOMATSU KENICHIRO(3)
SHUO ZHANG	13 (0.5%)	0		2011	SUZHOU CHAOSHENG PRINTING PLATE MAKING IND CO LTD(12) SUZHOU CHAOSHENG PRINTING & SCREEN MAKING INDUSTRY CO LTD(1)	XIJIAN HUANG(13) ZHAOWEI ZHONG(13)
XIJIAN HUANG	13 (0.5%)	0		2011	SUZHOU CHAOSHENG PRINTING PLATE MAKING IND CO LTD(12) SUZHOU CHAOSHENG PRINTING & SCREEN MAKING INDUSTRY CO LTD(1)	SHUO ZHANG(13) ZHAOWEI ZHONG(13)
ZHAOWEI ZHONG	13 (0.5%)	0		2011	SUZHOU CHAOSHENG PRINTING PLATE MAKING IND CO LTD(12) SUZHOU CHAOSHENG PRINTING & SCREEN MAKING INDUSTRY CO LTD(1)	SHUO ZHANG(13) XIJIAN HUANG(13)
SACHS EMANUEL	12 (0.5%)	29.08		1992-2010	MASSACHUSETTS INST TECH(12)	BREDT JAMES F(6) BRANCAZIO DAVID(4) CIMA MICHAEL(4) CURODEAU ALAIN(4) FAN TAILIN(4)
SEKI KAZUTOMO	11 (0.4%)	0.82		2007-2010	MIMAKI ENGG CO LTD(11) INST NAT COLLEGES TECH JAPAN(1)	ONO NOBUYUKI(11) TEZUKA CHIKAO(5) ONOZAWA YOSHIKI(4) HIGUCHI MASAYA(3) KOMATSU KENICHIRO(3)
BATCHELDER J SAMUEL	10 (0.4%)	13.9		1993-2011	STRATASYS INC(10)	SWANSON WILLIAM J(5) JOHNSON KEVIN C(4) HJELSAND TIMOTHY A(3) BOSVELD MICHAEL(2) BOSVELD MICHAEL D(1)

BRADBURY THOMAS J	10 (0.4%)	11.4		2001-2005	THERICS INC(10) AFBS INC(5)	MATERNA PETER A(7) GAYLO CHRISTOPHER M(4) CHESMEL KATHLEEN D(3) GANZ SCOTT D(3) STIKELEATHER ROGER C(3)
FUWA ISAO	10 (0.4%)	2.5		2000-2011	PANASONIC CORP(7) MATSUSHITA ELECTRIC WORKS LTD(3)	HIGASHI YOSHIKAZU(8) SATOSHI ABE(6) MASATAKA TAKENAMI(3) NORIO YOSHIDA(3) UCHINONO YOSHIYUKI(3)

How we did it?

From the Inventor 360° report options, we selected the different pieces of information we wanted to include in the singular display and then ran the report. The generated report was then exported to Excel using the option provided for the same.

Company activity across technologies

- The chart below shows research activity of companies across different technologies
- Stratasys being the pioneers in Fused Deposition Modeling (FDM) have the most number of records in FDM
- Materialise also has a large research portfolio in FDM

The chart is a bubble chart plotting technologies (y-axis) against top 15 assignees (x-axis).

Technologies (y-axis, top to bottom): Plaster-based 3D printing, Robocasting, Inkjet Deposition, Multi-Jet Modeling, Direct Manufacturing, Selective Fusing, Electrophoretic Deposition, Multiphoton Lithography, Digital Light Processing, Laser Engineered Net Shaping, Electron Beam Melting, Direct Metal Laser Sintering, Selective Laser Melting, Laminated Object Manufacturing, Selective Laser Sintering, Computer Numerical Control, Ballistic Layer Manufacturing, Spin Casting, Solid Ground Curing, Cladding, Fused Deposition Modeling, Stereolithography, Microfabrication, Photolithography, Laser Ablation

Assignees (x-axis): STRATASYS INC, 3D SYSTEMS INC, MATERIALISE NV, MASSACHUSETTS INST, OBJET LTD, HEWLETT-PACKARD CO, EXONE CO, THE BOEING CO, THERICS INC, BAE SYSTEMS PLC, 3M CO, EOS GMBH, GENERAL ELECTRIC CO, IBM CORP, AFBS INC

How we did it?

First various technologies were identified by manual research. Then by using a combination of semantic analysis tools such as clustering tools and searching tools available in Patent iNSIGHT Pro, records were categorized under different technologies. A co-occurrence matrix was generated using the co-occurrence analyzer to map the different technologies with assignees. The matrix was filtered for the top 15 assignees and was converted into bubble chart using the option provided in software for the same.

Company activity across materials

- The chart below shows research activity of companies across different materials
- Objet Ltd is the most active in photopolymers
- Massachusetts Inst and Univ Northwestern are the only research institutes out of top 15 companies active across different material types
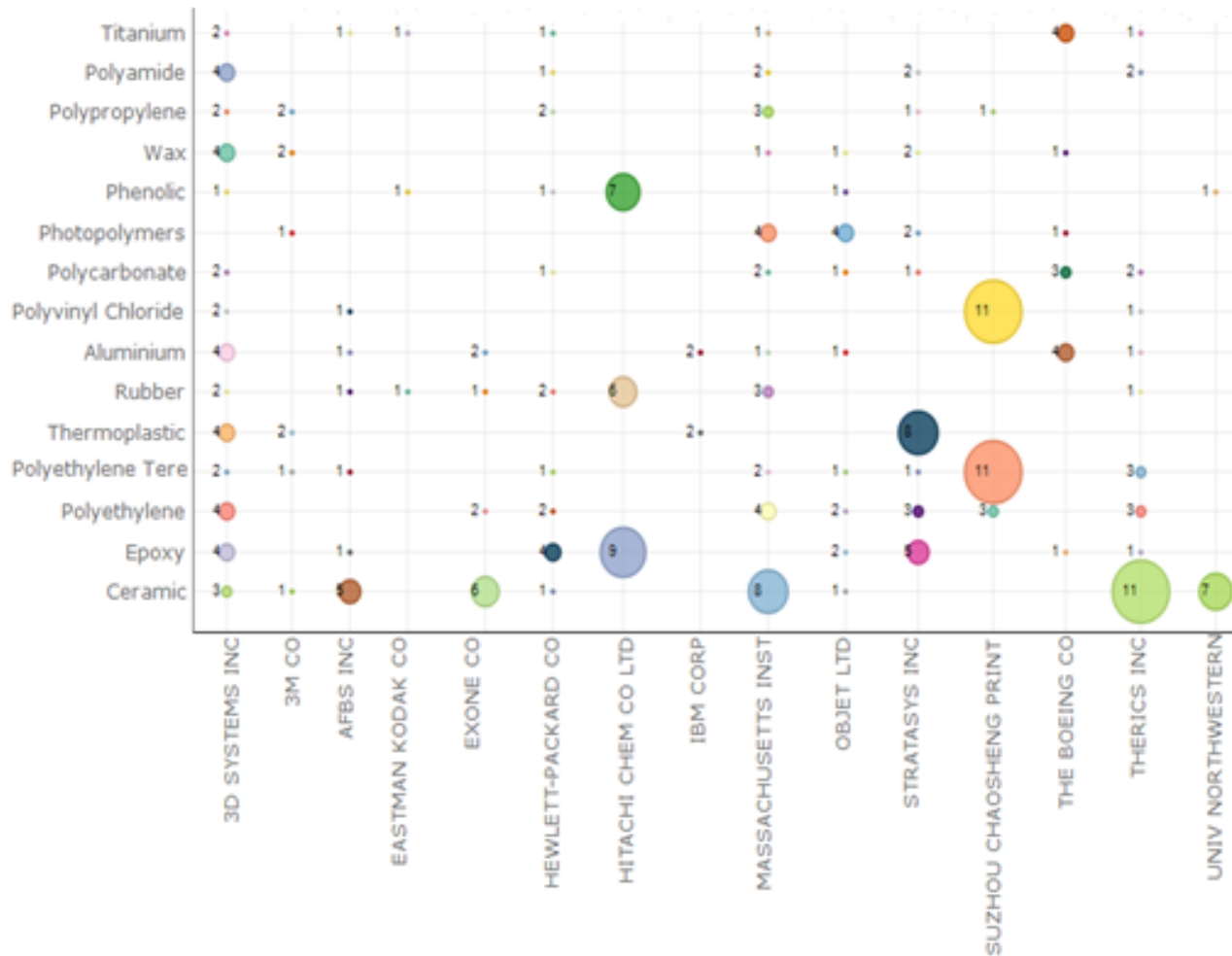
How we did it?

First various materials were identified by manual research. Then by using a combination of semantic analysis tools such as clustering tools and searching tools available in Patent iNSIGHT Pro, records were categorized under different materials. A co-occurrence matrix was generated using the co-occurrence analyzer to map the different materials with assignees. The matrix was filtered for the top 15 assignees and top 15 materials and converted into bubble chart using the option provided in software for the same.

Company activity across applications

- The chart below shows research activity of companies across different applications
- Tissue Engineering is the most researched application area focused by most of the companies
- Boeing leads the record count for defense and aerospace industry
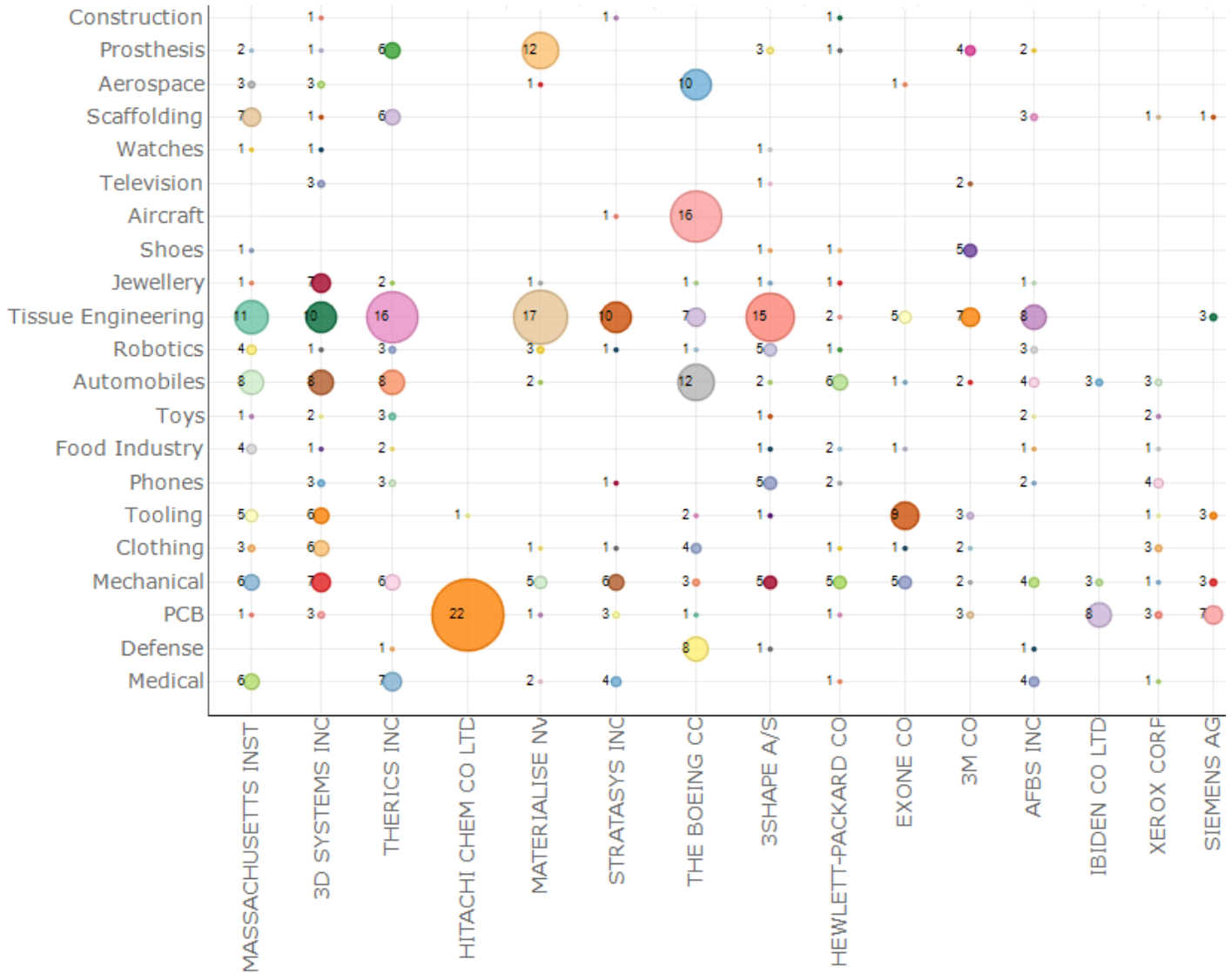
How we did it?

First various applications were identified by manual research. Then by using a combination of semantic analysis tools such as clustering tools and searching tools available in Patent iNSIGHT Pro, records were categorized under different applications. A co-occurrence matrix was generated using the co-occurrence analyzer to map the different applications with assignees. The matrix was filtered for the top 15 assignees and was converted into bubble chart using the option provided in software for the same.

3D printing – Materials vs Technologies

- The chart below shows research activity of key material types with respect to different technologies
- Stereolithography is the most widely used technology across all material types
- Selective laser sintering has wide applications across ceramics, metals
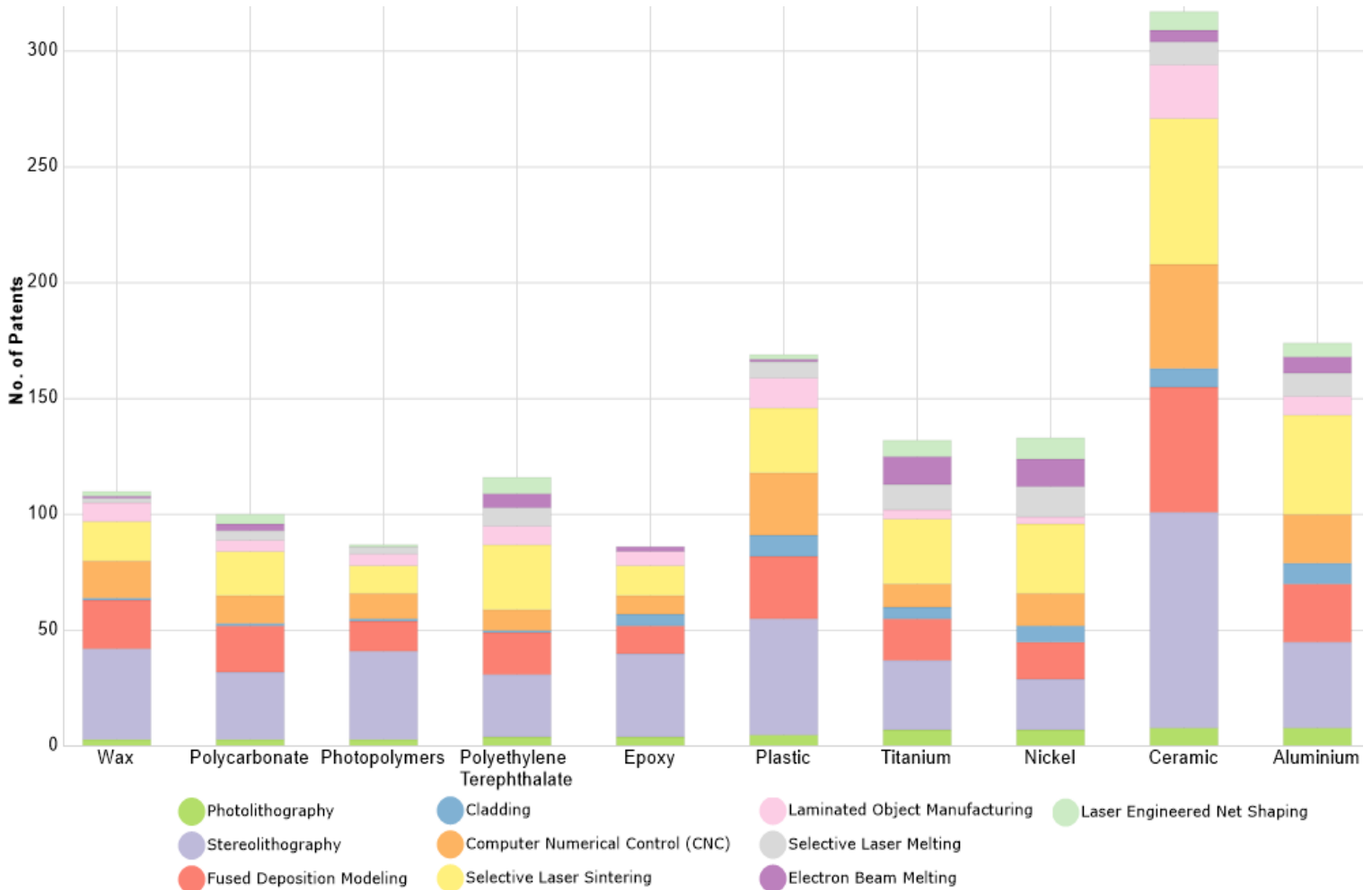
How we did it?

A co-occurrence matrix was generated using the co-occurrence analyzer to map the different materials with technologies. The matrix was filtered for the top 10 materials and top 10 technologies and converted into stacked column chart using the option provided in software for the same.

3D printing – Materials vs Applications

- The below matrix shows different materials used in different application areas
- Aluminium and Titanium are actively used in Aircraft and Automobile manufacturing
- Epoxy has wide range of applications across printed circuit board (PCB)

	Total	Medical	Defense	PCB	Mechanical	Clothing	Tooling	Phones	Food Industry	Toys	Automobiles	Robotics	Tissue Engineering	Aircraft	Scaffolding	Aerospace	Furniture	Shoes	Jewellery	Television	Watches	Prosthesis	Construction
Total	687	79	30	130	126	134	140	64	59	31	143	48	253	53	38	53	15	22	35	19	11	77	6
Paper	76	9	5	13	15	27	16	21	8	16	25	8	23	18		11	5	2	6	7	2	4	2
Elastomers	38	7	4	9	11	12	4	4	6	1	7	4	19		3	1		2	1			5	
Plastic	120	9	8	11	30	27	36	16	11	5	23	13	44	11	3	6	5	4	7	6	3	20	1
Polycarbonate	70	8	5	16	13	18	23	19	9	10	27	8	32	14	5	14	2	3	1	3		6	2
Polyimide	27	3	3	16	4	8	7	1	3		4	2	10	3	4	4	1	1			1	2	
Silver	35	10	3	15	8	13	11	5	3	1	11		6	6		8	2	1	2	1	1	1	
Titanium	70	15	4	10	15	14	21	8	6	3	15	7	27	11	6	11	2	3	1		1	13	1
Wax	59	10	4	3	11	6	16	3	11	1	14	6	37	3	8	2	3	2	3	1		25	1
Rubber	81	11	4	22	21	29	19	12	11	4	14	3	21	4	4	4	2	5	2		3	2	
Aluminium	85	14	7	20	21	19	33	16	4	8	26	13	29	19	1	19	2	2	2	2	3	4	3
Nickel	64	9	10	13	15	9	18	7	3	1	17	1	15	13		15		1	5	1	2	6	
Ceramic	152	10	5	15	33	22	59	18	14	10	35	18	91	18	14	16	4	2	9	1		38	3
ABS Plastic	35	4	2	10	6	5	16	13	5	9	18	8	17	10	1	10				1		3	2
Alkyd	7	2	1	2	1	3	4	3	4	1	2		3	2		2	1					2	
Epoxy	88	8	5	43	12	18	11	5	9	3	22	5	17	4	3	7	2	2	6	1	1	3	1
Polyethylene Terephthalate	101	10	3	14	15	40	20	8	11	4	21	10	45	6	9	4	6	6	1	1	2	9	1
Polypropylene	41	5	2	5	8	17	9	2	8	1	14	1	21	3	4	2	3	3	1			4	
Polyvinyl Chloride	41	5	3	7	7	18	10	4	6	2	11	5	13	3	2	3	3	2				2	1
Stainless Steel	27	7	2	3	5	3	8	3	1	1	2	2	10	1	1					1	1	6	
Methacrylic	20	5	1	6	4	5	5		3		5		7	1	1	2	1		2				
Carbon Fiber	29	9	2	3	5	14	6	4	3		9	2	8	9		7			2			2	
Polyethylene	63	15	1	6	8	16	10	1	10	2	14	3	29	3	6	2	2	2	6	1	1	7	1
RTV Silicon	2			2			2					2											
Thermoplastic	51	7	4	11	11	16	10	5	3	2	11	5	20	3	2	10	2	6	2	1	2	1	
Polyamide	55	10	2	8	11	17	19	3	9	3	17	4	23	6	4	5	6	4	3		1	5	1
Phenolic	45	8	2	22	6	18	8	3	5		4		6	4		2	1	2	2			3	1
Palladium	18	3		10	3	7	5	2	1		4		3	1		3		1	1		1		
Polylactic Acid	15	2			1	4	2		2		2		11	1	7			1				2	
Melamine	8	1	1	3	1	3	4	2	3		2		3	2		2	1					2	
Polyvinyl Acetate	19	3	2	3	4	6	3	2	7		6	2	14	3	3	1	1					3	
Steel	23	7	2	3	9	5	10	1		1	7	1	5	4		3	1	4			1	2	1

		Medical	Defense	PCB	Mechanical	Clothing	Tooling	Phones	Food Industry	Toys	Automobiles	Robotics	Tissue Engineering	Aircraft	Scaffolding	Aerospace	Furniture	Shoes	Jewellery	Television	Watches	Prosthesis	Construction
Furan	4	1	1	1	1	3	1				2		2	1		1	1		1				
Thermoset	33	2	1	19	2	9	8	2	2	1	7	1	4	2		3		1				1	
Nylon	24	3	2	3	4	5	8	4	6	2	9	2	11	1	3	1	3			1	1	4	
PEEK	10	3	1	2	2	1	5	1	2		2	2	5		1	1						2	
Poly paraphenylene terephthalamide	7		3			4		2			4	2	4	2		3				1	1		
Polyolefin	22	3	1	2		11	3	1	3		8	3	13		1		2	1			1		
Photopolymers	27		3	6	6	1	3	2	3	2	5	4	17	3	4	3		1	3	1	1	6	1
High-density Polyethylene	5	1	1	2	2	2	1				2	1	2			1							
Clay	17	1	1	3	7	8	3		7	1	6	3	12	2		2	1	1	1			2	
Polyamideimide	5	1	1	2	1	2	4	1	2		1		3	2		2	1					2	
Polyetherimide	9	2	1	4	1	4	3	1			2	2	2	2		3		1					1
Polyvinylidene Chloride	2		1	1	1	1	1				1		2	1		1	1						
Fiberglass	7		2	1	3	3	1			1	4	1	6	3		4	1		1			1	1
Polyphenylsulfone	11	1	1	6		1	8	7		7	9	7	10	7	1	7							2

How we did it?

A co-occurrence matrix was generated using the co-occurrence analyzer to map the different materials with application areas. The generated matrix was then exported to Excel using the option provided for the same.

Landscape for technologies used for 3D printing

The contour map below represents different materials used for the production of 3D objects with respect to complete patent portfolio. Clusters for Stereolithography and photolithography are close to each other as there is high degree of relevance between the records present in those technology areas. The patents represented by dots were coloured by company.

How we did it?

The VizMAP tool in Patent iNSIGHT Pro was used for this analysis. First the clusters for different materials were loaded on the map. They were analyzed on basis of their contextual similarity using title, abstract and claims as Text and technology as UDC from the 'Context mode' option. We removed unrelated patents using the "Hide Unrelated records" option and one patent assignee using the options available in VizMAP.

Inventor groups of key companies in 3D printing

The generated maps below highlight the key inventor groups of top five companies. In map below the groups are created using network relationships and the records (blue dots) are positioned on the map based on their relationship to the Assignee and to the inventors listed on the graph.

Key inventors present in the map, for instance, Bredt James F in case of 3D Systems and Z Corp appear in the middle of the graph. Also groups of inventors who file together will appear clustered together. Finally, only those inventors with 2 or more records are shown in the map
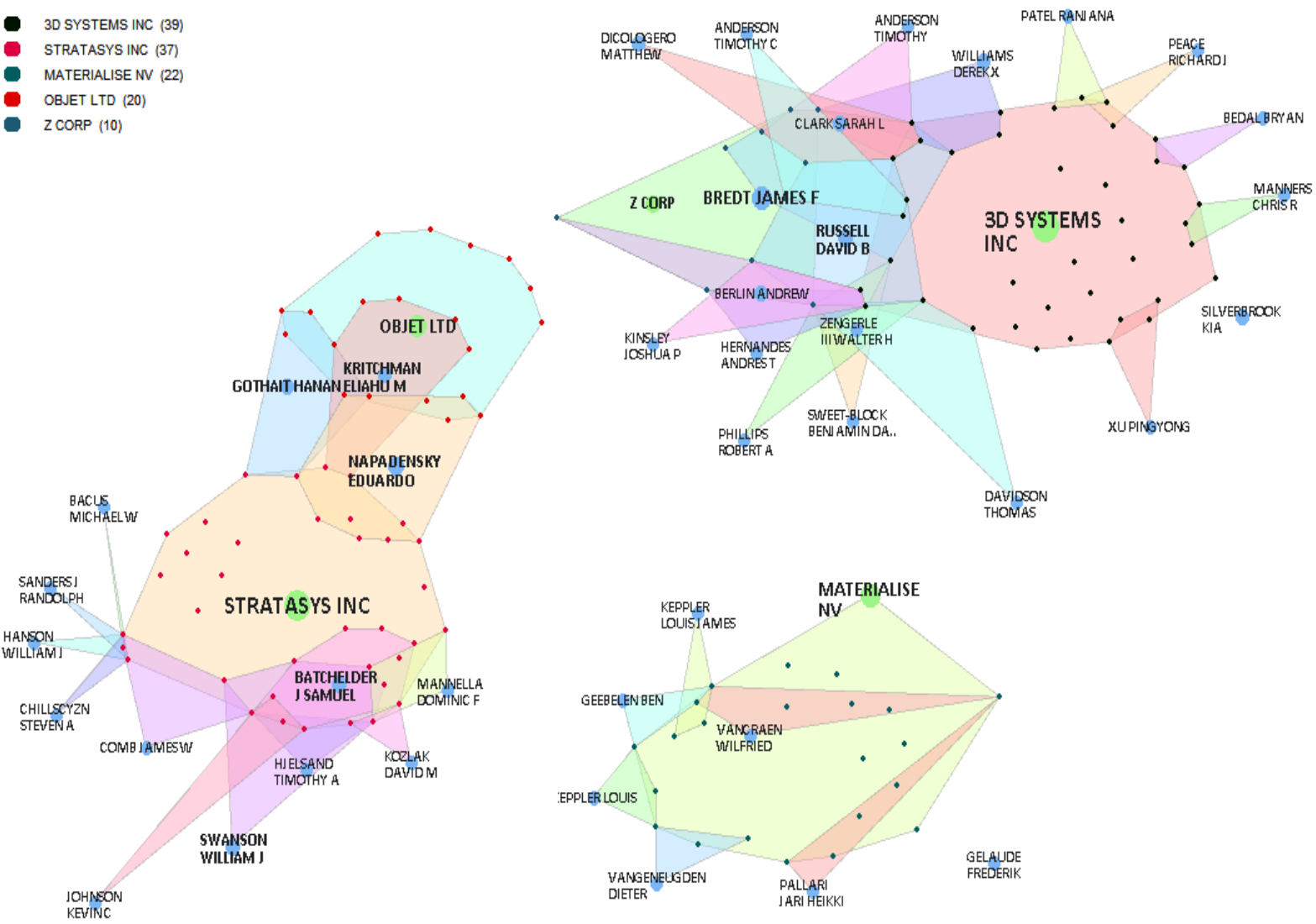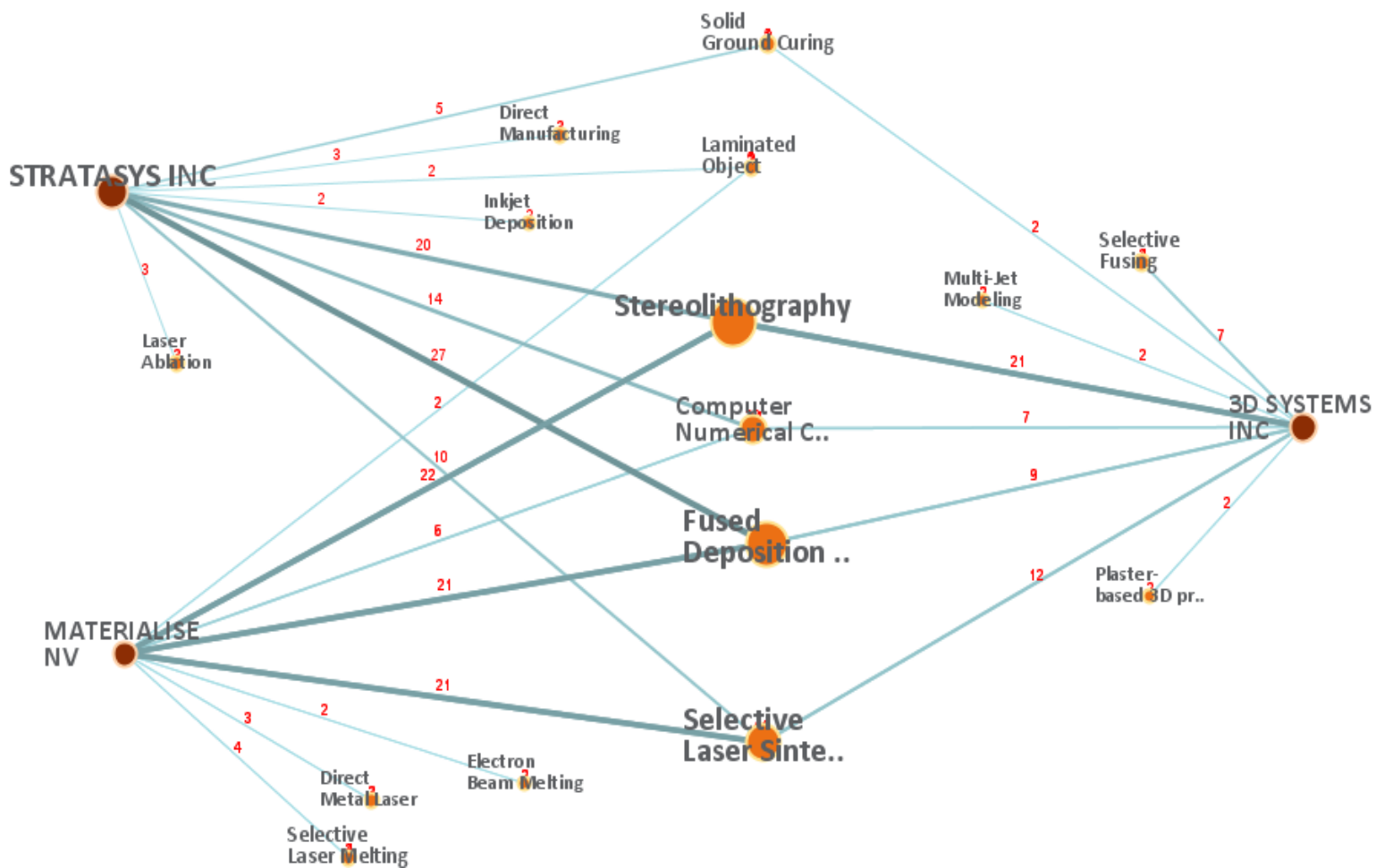

How we did it?

Using the VizMAP tool, patents of top five companies were loaded on the map. These were then expanded by their respective inventor names. The VizShade option was used to shade the inventors and assignees with potential overlapping patents between them.

Correlation Map of key 3 companies across different technologies

In the map, each company is connected to particular application area through links whose thickness and color intensity is directly proportional to the number of records relating them. The number (in red) next to each line represents the number of records held by company present in a particular technology area.

It can be seen that Stratasys and Materialise focus more on Stereolithography and Fused Deposition Modeling. It can also be seen that Stratasys has more number of records for Computer Numerical Control as compared to 3D Systems and Materialise

*How we did it?*

We applied multifilters to filter records for key 3D printing companies; 3D Systems, Stratasys and Materialise using multifilter option within co-occurrence analyzer. A matrix for those companies with respect to technologies was generated and resulting matrix was represented as Correlation Map. Also, links between same field types were removed using the option provided.

Portfolio analysis for key 3D printing companies

3D Systems: Publication Trend

- Chart shows the US patent filings and grants for 3D systems for the last 15 years
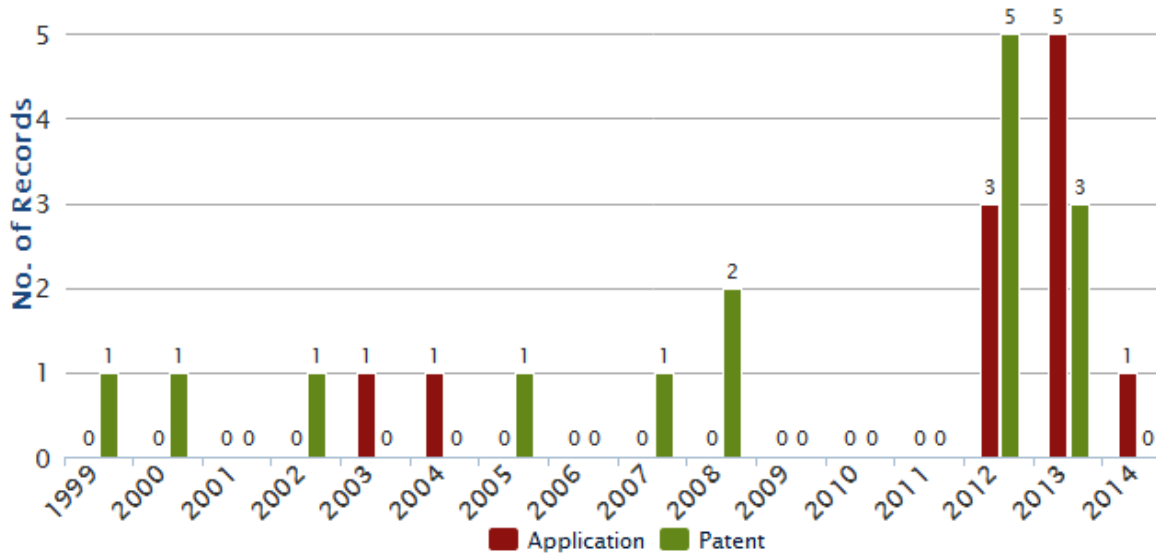
Applications:

- The pie chart shows records spread across different application areas
- Tissue Engineering is the most focused area

Total		24
Tissue Engineering		10
Automobiles		8
Mechanical		7
Jewellery		7
Tooling		6
Clothing		6
Television		3
Phones		3
PCB		3
Aerospace		3
Toys		2
Watches		1
Scaffolding		1
Robotics		1
Prosthesis		1
Food Industry		1
Construction		1

Materials:

- The pie chart shows records spread across different materials
- It can be seen aluminium and epoxy are the most widely used materials

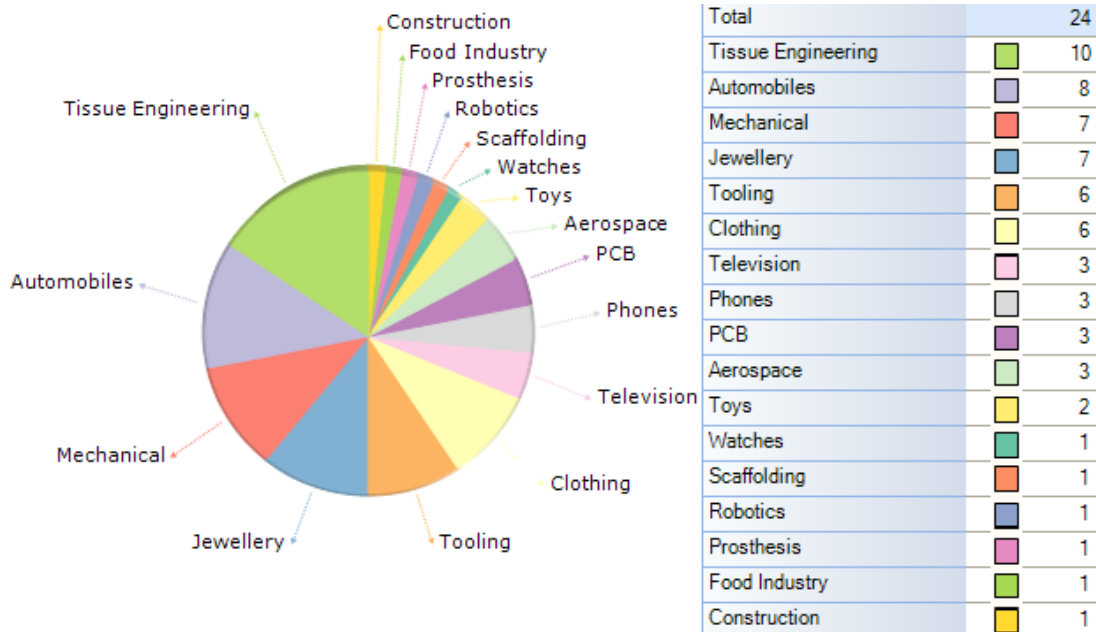| Total		19
Wax		4
Thermoplastic		4
Polyethylene		4
Polyamide		4
Epoxy		4
Aluminium		4
Polyolefin		3
Ceramic		3
Titanium		2
Rubber		2
Polyvinyl Chloride		2
Polypropylene		2
Polyethylene Terephthalate		2
Nylon		2
Carbon Fiber		2
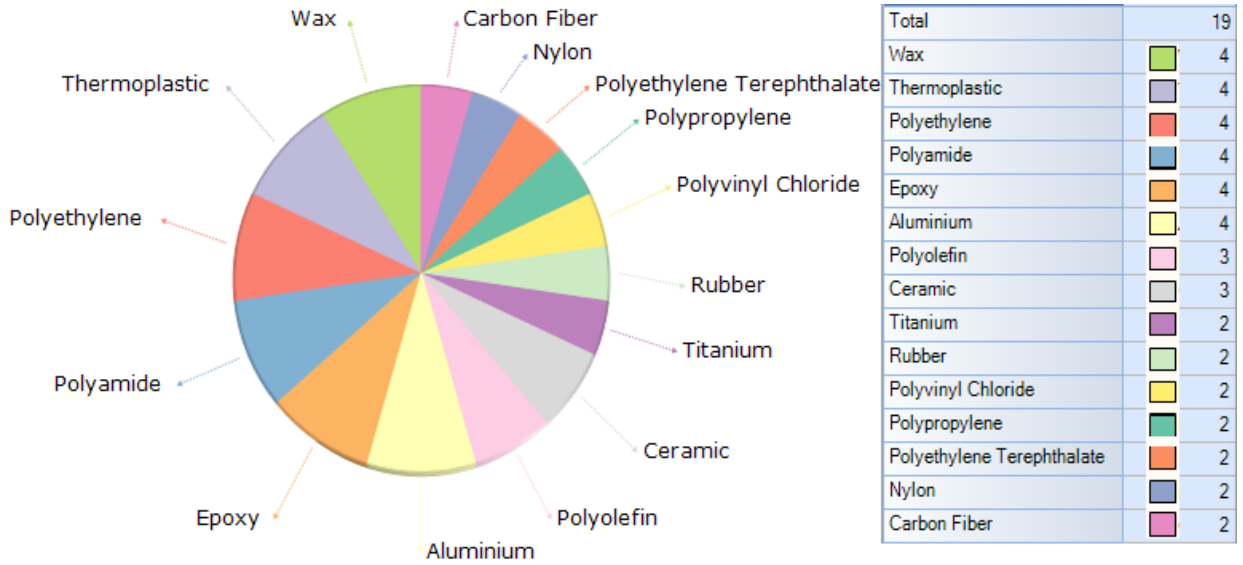
Stratasys Inc: Publication Trend

- Chart shows the US patent filings and grants for Stratasys Inc for the last 15 years

Applications:

- The pie chart shows records spread across application areas
- Stratasys focuses more on mechanical applications

Total		19
Tissue Engineering		10
Mechanical		6
Medical		4
PCB		3
Robotics		1
Phones		1
Construction		1
Clothing		1
Aircraft		1
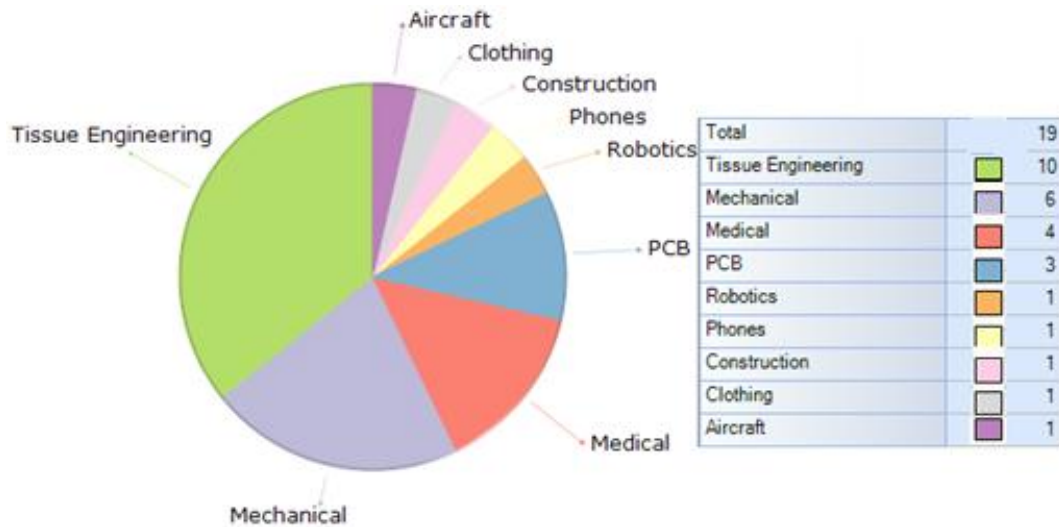
Materials:

- The pie chart shows records spread across different materials
- Thermoplastic is widely used material type

Total		15
Thermoplastic		8
Epoxy		5
Polyethylene		3
Wax		2
Polyamide		2
Photopolymers		2
Nylon		2
Polypropylene		1
Polyethylene Terephthalate		1
PEEK		1
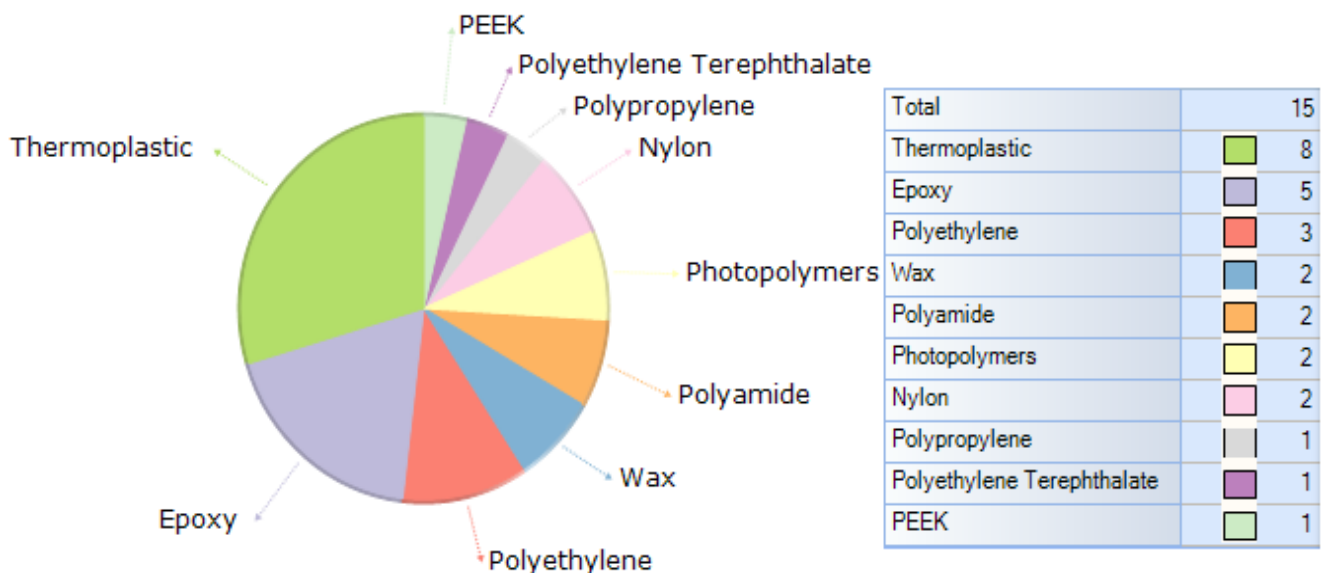
Materialise NV: Publication Trend

- Being a company based outside of US Materialise NV had only 3 applications published in US and hence the chart shows the overall publication trend (global) for 3D Printing in the last 10 years
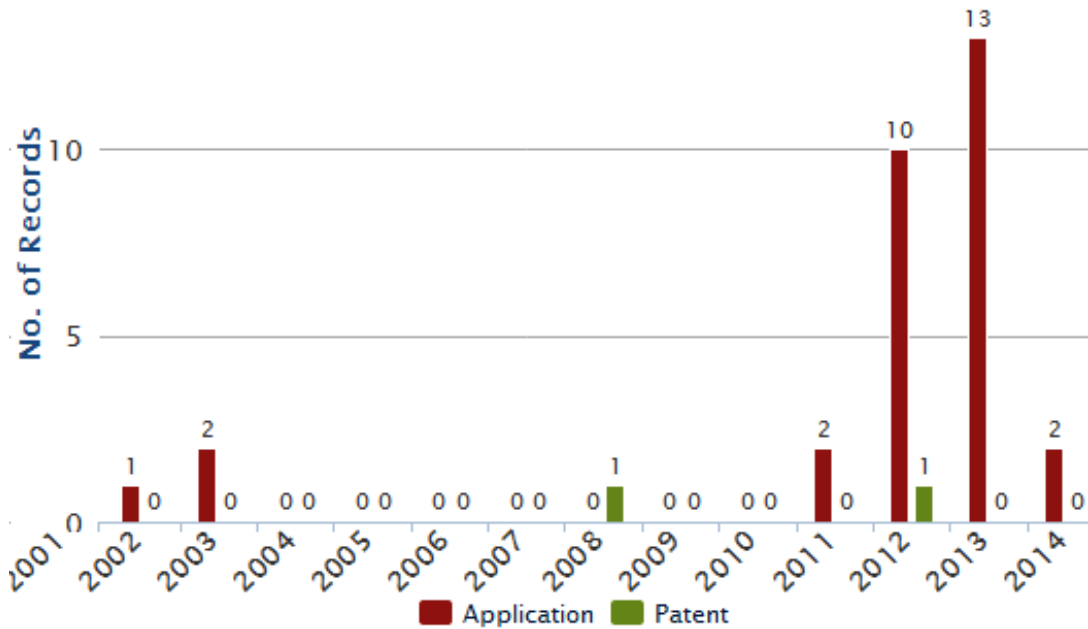
Applications:

- The pie chart shows records spread across different application areas
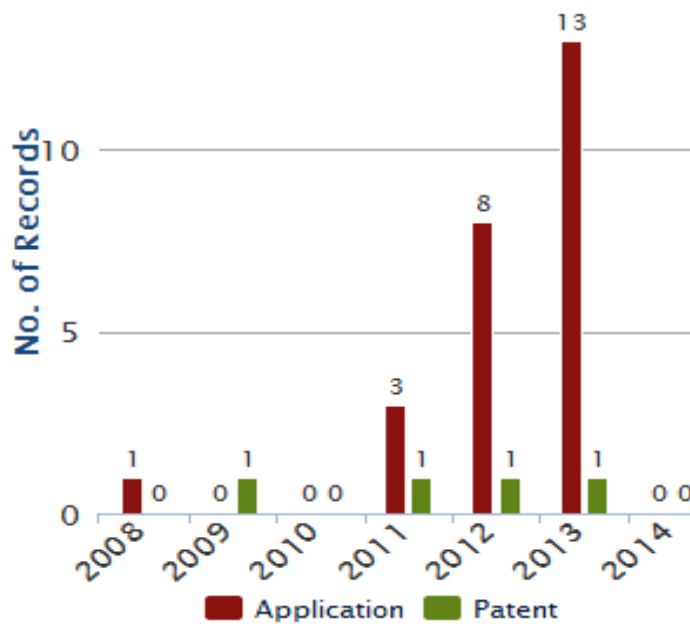- Materialise NV focuses more on medical applications as compared to other application areas

Total		21
Tissue Engineering		17
Prosthesis		12
Mechanical		5
Robotics		3
Medical		2
Automobiles		2
PCB		1
Jewellery		1
Clothing		1
Aerospace		1
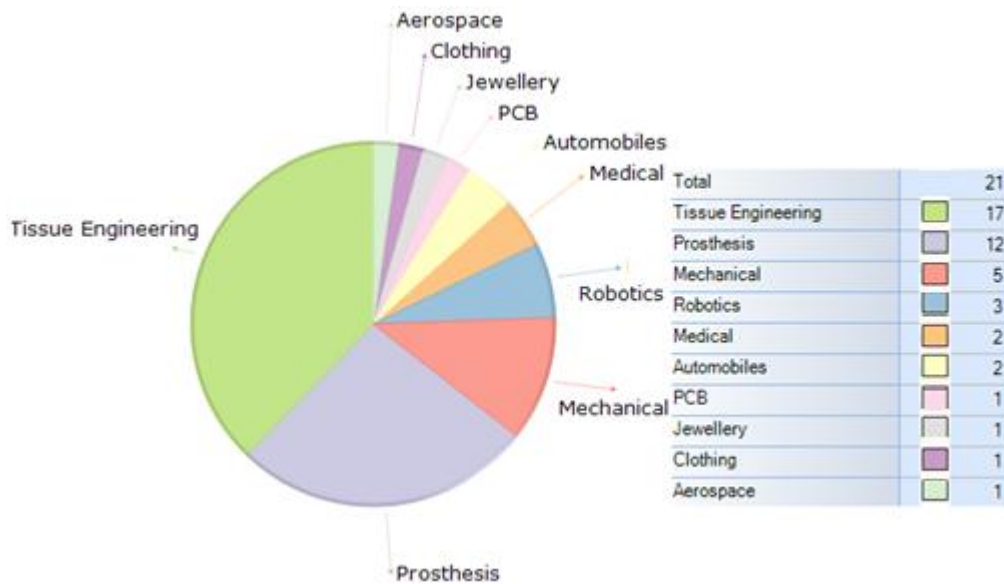
Materials:

- The pie chart represents shows the portfolio breakup across different materials

Total		4
Stainless Steel	🟩	1
Rubber	⬜	1
Polyethylene Terephthalate	🟥	1
Polyamide	🟦	1
Ceramic	🟧	1

How we did it?

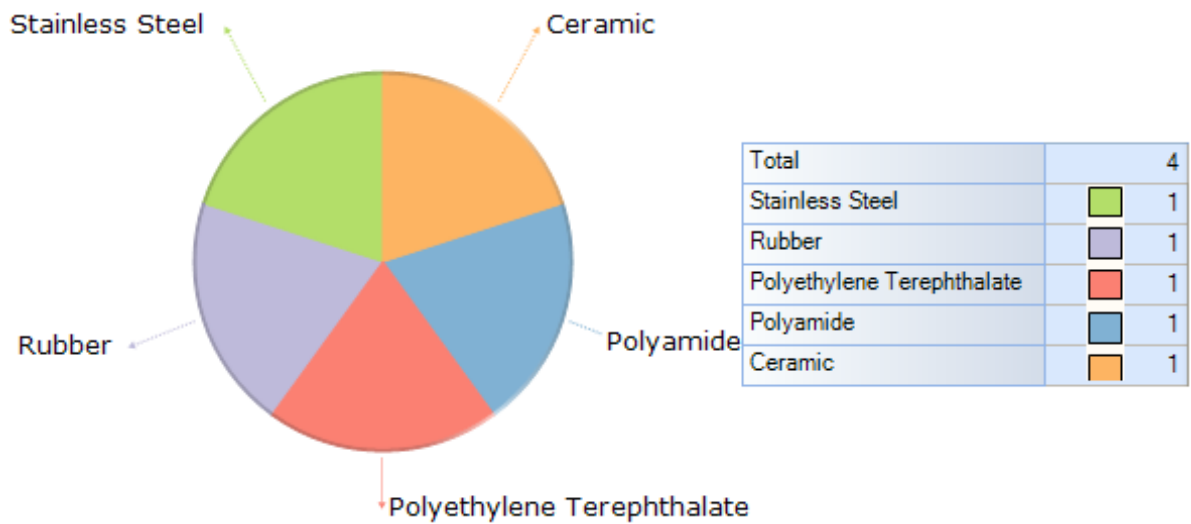Records for 3D Systems, Stratasys Inc and Materialise along with publication country as US were filtered using the filter option in PatSeer. Publication year chart was generated for last 15 years. Using the Chart Layer option, we selected Record Type as application and selected column chart as appearance and then generated the chart. Similarly, we selected Record Type as patent and appearance as line and then generated the chart and total was hidden. Record count was displayed using data labels present within settings option. Using co-occurrence analyzer within Patent Insight Pro, we filtered respective company from data filter option. A matrix for that company with respect to applications first; followed by materials was generated and resulting matrix was converted to a pie chart using the option provided for the same.

Portfolio Citation Analysis

The top companies in the space have been aggressively acquiring other firms that have promising and unique technologies. Much of this M&A activity is based on the ranking of the patent portfolios.

A portfolio that is frequently cited by many companies is given a higher ranking usually in IP analysis. We selected top two companies; 3D Systems and Stratasys and another key company Exone with relatively smaller patent portfolios but with a higher degree of forward citations. 3D Systems' and its acquired company patent portfolio contains 49 records in 3D Printing. This portfolio has 174 forward citing records as compared to 387 forward citations of Stratasys Group which has overall 64 records. Also Exone patent portfolio has 15 records in 3D printing with 22 forward citing records.

Assignee Breakup of 3D SYSTEMS forward citations (single generation)

Please click on image for full size image of forward citation tree for patent portfolio of 3D Systems

The chart below shows the count of assignees citing records of **3D Systems and its acquired company Z Corp**. It can be seen Stratasys Inc cites most number of records of the group.
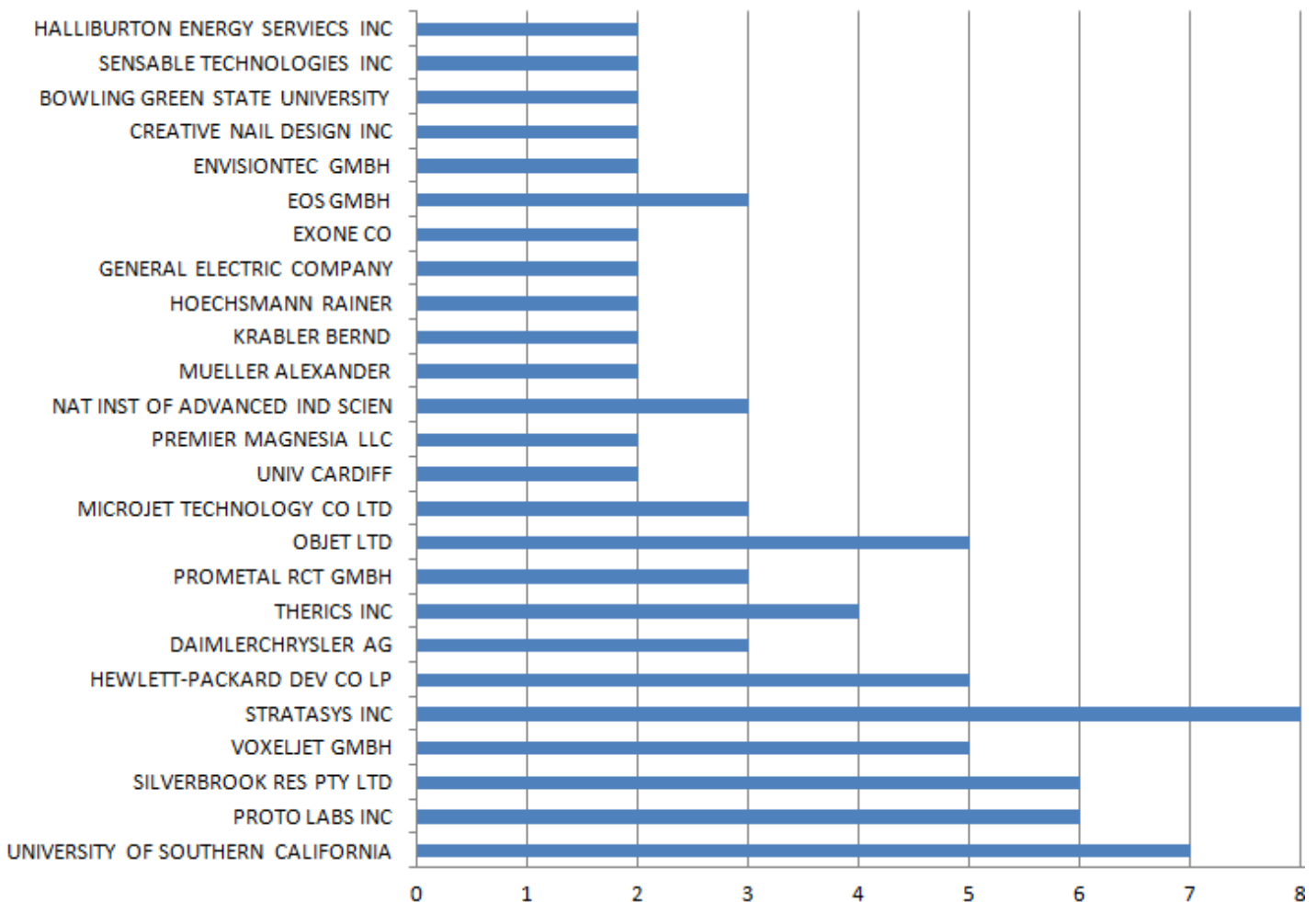
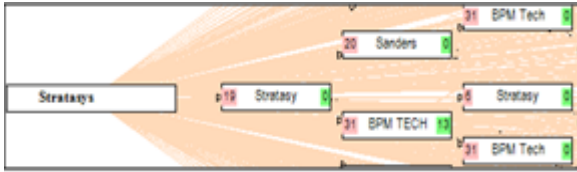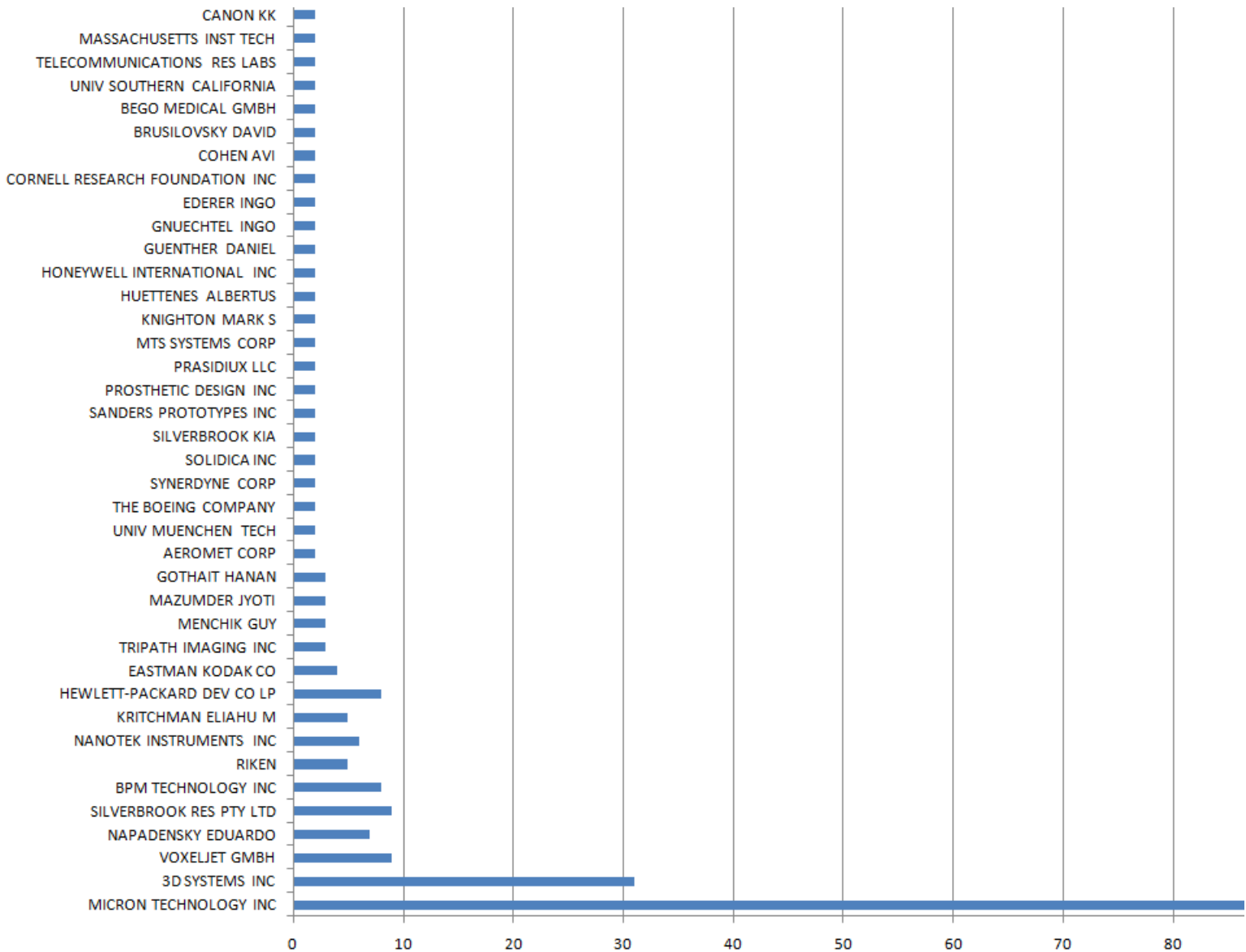# Assignee Breakup of STRATASYS INC'S forward citations (single generation)

Please click on image for full size image of forward citation tree for patent portfolio of Stratasys Inc.

The chart below shows the count of assignees citing records of **Stratasys and its acquired companies Makerbot Industries and Objet Ltd**. It can be seen Micron and 3D Systems cite most number of records of the group.

Assignee Breakup of EXONE forward citations (single generation)

The chart below shows the count of assignees citing records of Exone. It can be seen Halliburton cites most number of records.

The citation tree below shows each citation according to the publication year. Each cell also shows the forward and backward citations for the record with Green and Light Red highlighting respectively. The display option was used to view the assignee names in the tree.

How we did it?

We created 3 separate patent groups for records of Stratasys Inc and their acquired companies Makerbot Industries and Objet Ltd; 3D Systems and its acquired company Z Corp. Another prominent company in 3D printing space, EXONE was also selected for the analysis using auto filter option. Using the citation analysis option, we applied the created group individually and downloaded the forward citations of each

group. After selecting the individual group, we generated column chart representing assignee breakup within Analyze Citation Sets option. The chart was then converted to a table format and exported to excel. In excel, record count for each assignee was totaled and assigned to a unique assignee name. Parent company was removed from the assignee column and bar chart for same was generated in Excel.

Appendix: Search Strings Used for Categorization

Applications

| Application Area	Search Query	Results
Aerospace	(FT) contains (aerospace* or aeronautic* or rocket* or spacecraft*)	93
Aircraft	(FT) contains (aircraft* or aviation* or helicopter* or "fighter jet" or helicoptor* or aeroplane* or airplane*)	92
Automobiles	(FT) contains (automotive* or car or cars or (auto* w/2 part*) or vehicle* or automobile* or motorcar* or autocar* or "steering wheel*" or pedals)	264
Clothing	(FT) contains (cloth* or dress or apparel* or fabric or fabrics or shirt* or t-shirt* or garment*)	234
Construction	(FT) contains ("contour craft*" or "d shape" or D-Shape or "building* print*" or roof* or Diorama or walling or flooring)	16
Defense	(FT) contains (military* or missile* or firearm* or rifle* or pistol* or weapon* or navy* or naval* or army)	48
Food Industry	(FT) contains (food* or pizza* or candy or candies or chocolate* or sweet* or "canned ham" or "meat slices" or "cooked meat" or pastr* or soup* or ice-cream* or fruit* or vegetable* or confection* or foodstuff*) and not "Food and Drug Administration"	111
Furniture	(FT) contains furniture*	25
Jewellery	(FT) contains (jewel* or ornament* or brooche or necklace* or earring* or bracelet* or pendant* or cufflink*)	81
Mechanical	(FT) contains (plug or plugs or gasket* or seal or hinges or bumper* or isolator-fastner* or spacer* or "shock absorber*")	281
Medical	(FT) contains (medic* or pharma* or healthcare* or "health-care*" or cosmetic* or "health care" or orthopedic* or orthopaedic* or capsule* or pills or bandage* or MRI or "magnetic resonance imaging" or radiolog* or ultrasound*)	175
PCB	(FT) contains (((printed* or etched*) w/2 board*) or PCB* or PWB* or "printed circuit assembly*" or PCA or PCBA or "printed board*")	275
Phones	(FT) contains (((mobile* or cell* or hand*) w/3 phone*) or ((wireless* or handheld*) w/2 device*) or phone* or telephone* or handset* or "personal digital assistant*" or smartphone* or pager* or cellphone* or PDA)	163
Prosthesis	(FT) contains (prosthetic* or prosthesis*)	143
Robotics	(FT) contains (robot* or (artificial w/2 intelligen*) or android* or cyborg* or humanoid*)	117
Scaffolding	(FT) contains (scaffold* or nano-scaffold* or nanoscaffold*)	82
Shoes	(FT) contains (shoe* or footware* or boot)	52
Television	(FT) contains (television* or TV or (set* w/2 box*))	61
Tissue Engineering	(FT) contains ("3D Organ" or "Tissue Print*" or "tissue engineer*" or "tissue-engineer*" or "regenerative medic*" or bone* or cartilage or "blood vessels" or bladder* or skin* or muscle* or jaw* or "organ print*" or (bio w/2 print*) or ear or kidney* or liver* or (medic* w/2 implant*) or teeth* or dental* or orthopaedic* or orthopedic*)	528
Tooling	(FT) contains ((inject* w/2 (mould* or mold*)) or (die w/1 cast*) or handtool* or ((hand or repair*) w/2 tool*))	214

Toys	(FT) contains (toy* or game* or joystick* or (gaming w/2 consol*))	100
Watches	(FT) contains (watch or watches or wristwatch* or "wrist watch*")	19
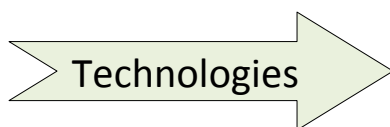
Technologies

Technologies	Search Query	Results
Ballistic Particle Manufacturing	(FT) contains ((ballistic* w/2 manufactur*) or BPM)	25
Cladding	(FT) contains (cladding or ((roll or explosive) w/2 weld*))	53
Computer Numerical Control (CNC)	(FT) contains ((computer* w/1 control*) or CNC)	270
Contour Crafting	(FT) contains (contour* w/3 craft*)	2
Digital Light Processing	(FT) contains ((((digital* or direct*) w/2 light*) w/3 process*) or DLP)	25
Direct Laser Forming	(FT) contains ((direct laser form*") or DLF)	2
Direct Manufacturing	(FT) contains ("direct manufactur*")	27
Direct Metal Deposition	(FT) contains ((direct* w/3 deposit*) or DMD) and not ("digital micro mirror device*" or "digital micromirror device*" or "digital micro-mirror device*")	27
Direct Metal Laser Sintering	(FT) contains ((direct w/3 (sinter* or fusion*)) or DMLS or DMLF)	45
Direct Shell Production Casting	(FT) contains ("direct shell production cast*" or DSPC)	5
Electron Beam Melting	(FT) contains ((electron w/3 (melt* or fabricat* or manufact*)) or EBM or EBF3 or SEBM)	59
Electron Beam Projection Lithography	(FT) contains (("electron-beam" or "electron beam") w/3 lithograph*)	9
Electrophoretic Deposition	(FT) contains ("electrophoretic* deposit*" or electrocoat* or "e-coating" or electrodeposit* or "e coating")	32
Fused Deposition Modeling	(FT) contains (((fuse* or fusion* or extrusion*) w/3 (deposit* or model* or fabricat* or manufactur*)) or "free form" or FFF or FDM or "fusion deposit*") and not ("Finite Difference Method") and not ("solid free form" or SFF)	321
InkJet Deposition	(FT) contains (inkjet* w/3 deposit*)	15
Laminated Object Manufacturing	(FT) contains ((laminat* w/3 (manufactur* or fabricat*)) or LOM) and not ("Layered Object Manufacturing")	118
Laser Ablation	(FT) contains (laser* w/2 ablat*)	42
Laser Engineered Net Shaping	(FT) contains (laser* w/3 shap*)	43
Laser Metal Forming	(FT) contains (("laser metal Form*") or LMF)	3
Laser Powder Forming	(FT) contains ("laser powder forming" or LPF)	5
LaserCusing	(FT) contains ("laser cusing" or lasercusing)	4
Microfabrication	(FT) contains ("micro w/3 fabricat*" or microfabricat*)	40
Multi-Jet Modelling	(FT) contains ((("multi jet*" or multi-jet* or multijet* or polyjet*) w/3 model*) or MJM)	16

Multiphoton Lithography	(FT) contains ((multiphoton* or direct* or multi-photon* or "multi* photon*") w/3 (lithograph* or writ*))	27
Photolithography	(FT) contains (photolithograph* or "photo-lithograph*" or "photo* lithograph*")	88
Plaster-based 3D printing	(FT) contains (plaster* w/3 print*)	4
Robocasting	(FT) contains (robocasting or "robo-cast*")	11
Selective Fusing	(FT) contains (select* w/2 fusing*)	48
Selective Laser Melting	(FT) contains ((selective w/3 melt*) or SLM or (laser w/2 melt*))	95
Selective Laser Sintering	(FT) contains ((selective w/3 sinter*) or SLS or (laser* w/2 sinter*))	365
Solid Ground Curing	(FT) contains ((solid w/3 curing) or SGC or "solider system*")	35
Spin Casting	(FT) contains ((spin* w/2 cast*) or (centrifugal* w/3 cast*) or CRMC)	16
Stereolithography	(FT) contains (stereolithograph* or "stereo lithograph*"or SLA or (photo* w/2 solidificat*) or ((solid* or optical) w/3 (fabricat* or manufactur*)) or "solid imag*" or STL or SFF or SL or Photopolymer* or stereolsthograph*)	557
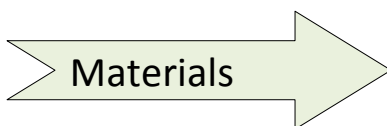
Materials

Materials	Search Query	Results
ABS Plastic	(TAC) contains (ABS or (acrylonitrile* w/3 styrene*))	44
Alkyd	(TAC) contains (alkyd*)	7
Aluminium	(TAC) contains (aluminium* or aluminum*)	142
Carbon Fiber	(TAC) contains (((Carbon or graphite) w/1 (fiber* or fibre*)) or "carbon graphite*" or CFRP or CRP or CFRTP or CF)	37
Ceramic	(TAC) contains (ceramic* or porcelain* or "Fine China" or "Bone china" or Stoneware*)	211
Clay	(TAC) contains (clay* or Plasticine* or putty) and not (Pleistocene*)	25
Elastomers	(TAC) contains (Elastomer* OR "elastic polymer*")	44
Epoxy	(TAC) contains (Epoxy* or polyepoxides)	112
Fiberglass	(TAC) contains (Fiberglass* or fibreglass* or "glass-reinforced plastic*" or GRP or GFRP or "glass-fiber reinforced plastic*" or ((fiber or fibre) w/0 glass*))	7
Furan	(TAC) contains furan*	4
High-density Polyethylene	(TAC) contains ("high* density polyethylene*" or HDPE or PEHD or "polyethylene high-density")	6
Melamine	(TAC) contains (melamine* or Cyanurotriamide* or Cyanurotriamine* or Cyanuramide* or "2,4,6-Triamino-s-triazine")	14
Methacrylic	(TAC) contains (Methacrylic* or "2-methylpropenoic acid*" or "2-methyl-2-propenoic" or MAA)	22
Nickel	(TAC) contains (nickel* or nickle* or Ni)	92
Nylon	(TAC) contains (nylon* or "nylon-6,6" or "nylon-6" or "nylon-6,9" or "nylon-6,10" or "nylon-6,12" or "nylon-11" or "nylon-12" or "nylon-4,6" or "glass filled polyamide")	33
Palladium	(TAC) contains (palladium* or Pd)	21
Paper	(TAC) contains paper*	144
PEEK	(TAC) contains ("Polyether ether ketone*" or PEEK or polyaryletherketone* or	16

	PAEK or "poly aryl ether ketone*" OR polyetheretherketone*)	
Phenolic	(TAC) contains (phenol* or "carbolic acid")	55
Photopolymers	(TAC) contains (photopolymer* or "photo polymer" or "photo-polymer")	38
Plastic	(plastic or plastics) and not (Polyethylene* or PE or polythene* or polyethene* or poly(methylene) or ABS or (acrylonitrile* w/3 styrene*))	183
Poly paraphenylene terephthalamide	(TAC) contains ("Poly paraphenylene terephthalamide*" or kevlar* or aramid*)	8
Polyamide	(TAC) contains (polyamide* or "poly amide*" or "PA 6*" or "PA 66*")	63
Polyamideimide	(TAC) contains (Polyamide-imide* or Polyamideimide*)	5
Polycarbonate	(TAC) contains (polycarbonate* or PC)	82
Polyetherimide	(TAC) contains (Polyetherimide* or PEI)	12
Polyethylene	(TAC) contains (Polyethylene* or PE or polythene* or polyethene* or poly(methylene)) and not (plastic or plastics or "Polyethylene Terephthalate*")	85
Polyethylene Terephthalate	(TAC) contains (polyester* or "Polyethylene* terephthalate*" or "poly(ethylene terephthalate)" or polyethylenephthlate or Polyethylenterephthalat* or PET or PETE or PETP or PET-P)	131
Polyimide	(TAC) contains (Polyimide* or PI)	40
Polylatic Acid	(TAC) contains ("poly lactic acid*" or PLA or polylactide*)	19
Polyolefin	(TAC) contains (polyolefin* or polyalkene*)	28
Polyphenylsulfone	(TAC) contains (Polyphenylsulfone* or PPSF or PPSU)	11
Polypropylene	(TAC) contains (Polypropylene* OR polypropene* OR PP)	56
Polyvinyl Acetate	(TAC) contains ("Polyvinyl acetate*" or PVA or PVAc or poly(ethenyl ethanoate))	24
Polyvinyl Chloride	(TAC) contains (("Poly(vinyl chloride)" or PVC or Polychloroethylene* or "poly(1-chloroethylene)" or "polyvinyl* chloride*" or Polyvinylchlorid*) and not "porcine circovirus")	59
Polyvinylidene chloride	(TAC) contains (Polyvinylidene chloride* or "Poly(vinylidene dichloride)" or PVDC or polydene* or "Poly(1,1-dichloroethene)")	3
RTV Silicon	(TAC) contains ((RTV or Room*) w/3 silicon*)	2
Rubber	(TAC) contains (rubber* or Sugru* or caoutchouc* or latex*)	114
Silver	(TAC) contains (silver* or Ag)	56
Stainless Steel	(TAC) contains ((stainless* or inox*) w/3 steel*)	40
Steel	(TAC) contains (steel* and not ("stainless steel" or "inox steel" or inox))	39
Thermoplastic	(TAC) contains (thermoplastic* or "thermosoftening plastic*") and not (plastic or plastics) and not (Polyethylene* or PE or polythene* or polyethene* or poly(methylene))	70
Thermoset	(TAC) contains ((thermoset* w/2 resin*) or thermoset)	44
Titanium	(TAC) contains (titanium* or Ti)	95
Wax	(TAC) contains (Cetyl palmitate* or wax*)	80

Summary

This report categorizes and graphically analyzes research trends around 3D printing and the processes involved and its applications from various perspectives and highlights the key companies involved.

For all the potential in the industry, however, not all 3D printing companies will see the same levels of success. Jefferies rates 3D Systems and Stratasys at the top of the sector, with the former edging out the latter for supremacy.

The wildcard in all of this is, of course, a face of traditional, 2D printing: Hewlett Packard. For all its connotations of old-school paper and ink, HP actually signed an agreement with Stratasys in 2010 that allowed HP to sell HP-branded 3D printers that were made by Stratasys. While the HP-branded printers accounted for roughly 10% of Stratasys sales at the time, the agreement dissolved in 2012. "HP could eventually become a major player in 3D printing as it has ink jet technology/patents and huge distribution." (Source)

One study has found that open source 3D printing could become a mass market item because domestic 3D printers can offset their capital costs by enabling consumers to avoid costs associated with purchasing common household objects.

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