Shape Memory Material

Technology Insight Report

SMA is an alloy that remembers its original shape and when deformed returns to its original form on heating

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Introduction

A shape-memory alloy (SMA, smart metal, memory metal, memory alloy, muscle wire, smart alloy) is an alloy that "remembers" its original shape and that when deformed returns to its pre-deformed shape when heated. Similarly shape-memory polymers (SMPs) are polymeric smart materials that have the ability to return from a deformed state (temporary shape) to their original (permanent) shape induced by an external stimulus (trigger), such as temperature change.

SMAs also display super elasticity, which is characterized by recovery of unusually large strains. Instead of transforming between the martensite and austenite phases in response to temperature, this phase transformation can be induced in response to mechanical stress. When SMAs are loaded in the austenite phase, the material will transform to the martensite phase above a critical stress, proportional to the transformation temperatures.

SMPs can retain two or sometimes three shapes, and the transition between those is induced by temperature. In addition to temperature change, the shape change of SMPs can also be triggered by an electric or magnetic field, light or solution. As well as polymers in general, SMPs also cover a wide property-range from stable to biodegradable, from soft to hard, and from elastic to rigid, depending on the structural units that constitute the SMP. SMPs include thermoplastic and thermoset (covalently cross-linked) polymeric materials. SMPs are known to be able to store up to three different shapes in memory.

This report categorizes and graphically analyzes research trends of shape memory alloys and the polymers involved and its applications from various perspectives and highlights the key companies involved.

NOTE: All analysis in this report has been done on INPADOC Families (Extended Families) 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 PBD- Publication Date

UC -US Class CPC- Cooperative Patent Classification

TAC:((((shape* w3 memory) OR memory OR smart or super-elastic) w3 (alloy)) OR ((smart* or memory) w1 (metal)) OR (muscle wd0 wire) OR shapememory OR memorymetal OR smartmetal OR smartalloy OR memoryalloy OR memory material)

AND

(
    (CPC:A61B* OR A61C* OR A61F* OR A61M* OR A61L* OR B23B* OR B25J* OR B32B* OR B63B* OR A44B18* OR A44C27* OR A47J27* OR "C21D2201/01" OR "F01P2070/02" OR "F05C2251/08" OR "F05B2280/5006" OR "F16B1/0014" OR F16D* OR H01F1* OR "H01H37/323" OR "H01H61/0107" OR "H01H71/145")

    OR

    (IC:A61B* OR "H01R4/01")

    OR

    (UC:148/563 OR 244/99.8 OR 600/143 OR 600/151 OR 600/206 OR 600/207 OR 600/208 OR 600/209 OR 606/78 OR 604/95.05 OR 604/532 OR 604/531 OR 604/530 OR 623/1.18 OR 623/1.9 OR 623/3.11)

)

AND

PBD: [1994 TO NOW]

➢ 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 the data set manually

➢ Result set of 6028 records was imported into the software

The publications included in the report are updated as of 25th February, 2015

Technical Segmentation (Patent Categorization)

Patent categorization is a process of analyzing the patent text and identifying smaller meaningful topics from the text. Various analysis can be performed using these categories. By online research (patent & non-patent literature) we found concepts relating to shape memory materials being classified into different alloys, polymers and application areas.

Alloys	Polymers	Applications
• Chromium	• ABS Plastic	• Actuators
• Chromium Molybdenum	• Acrylic	• Automotive
• Cobalt Chrome	• Cellulose	• Aviation
• Copper Aluminium Nickel	• Ceramic	• Clothing
• Copper Gold Zinc	• Electroactive SMP	• Couplers
• Copper Tin	• Fluorinated	• Crafts
• Copper Zinc	• Fluorinated Ethylene Propylene	• Damper
• Copper Zinc Aluminium Nickel	• Light-Activated SMP	• Dental Braces
• Copper Zinc Aluminum	• Nylon	• Embolic Protection Filters
• Gold Cadmium	• Polyamide	• Insulating Fabric
• Hydroxyapatite	• Polyanhydride	• Medical
• Indium Thallium	• Polybutadiene	• Optometry
• Indium Titanium	• Polycaprolactone	• Prosthetics/Orthotics
• Iron Manganese Silicon	• Polycarbonate	• Robotics
• Iron Palladium	• Polyether	• Shape Memory Screws
• Iron Platinum	• Polyether Ether Ketone	• Stent
• Manganese Copper	• Polyethylene	• Surgical Fixation
• Molybdenum	• Polyethylene Terephthalate	• Telecommunication
• Nickel	• Polyethyleneoxide	• Transducers
• Nickel Aluminium	• Polyglycolide	• Valves
• Nickel Titanium Cobalt	• Polyhydroxybutyrate	
• Nickel Titanium Copper	• Polylatic Acid	
• Nickel Titanium Platinum	• Polymethyl Methacrylate	
• Niobium	• Polynorbornene	
• Niobium Titanium	• Polyphosphazene	
• Nitinol	• Polypropylene	
• Platinum Iridium	• Polystyrene	
• Silver Cadmium	• Polytetrafluoroethylene	
• Stainless Steel	• Polyvinyl Acetate	
• Tantalum	• Polyvinyl Alcohol	
• Titanium Nickel Niobium	• Polyvinyl Chloride	
• Titanium Nitride	• Polyvinylidene Fluoride	
• Tungsten	• Thermoplastic	
• Zirconia		
• Zirconium		

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 Shape Memory Alloys?

Innovation around shape memory alloys and its resulting patent publications started to show up from the 1990s with a spike in 2004. But the real surge in the activity around this technology happens in last 5 years. It's clear the current activity around these technologies is likely to continue seeing more innovation in the near future.
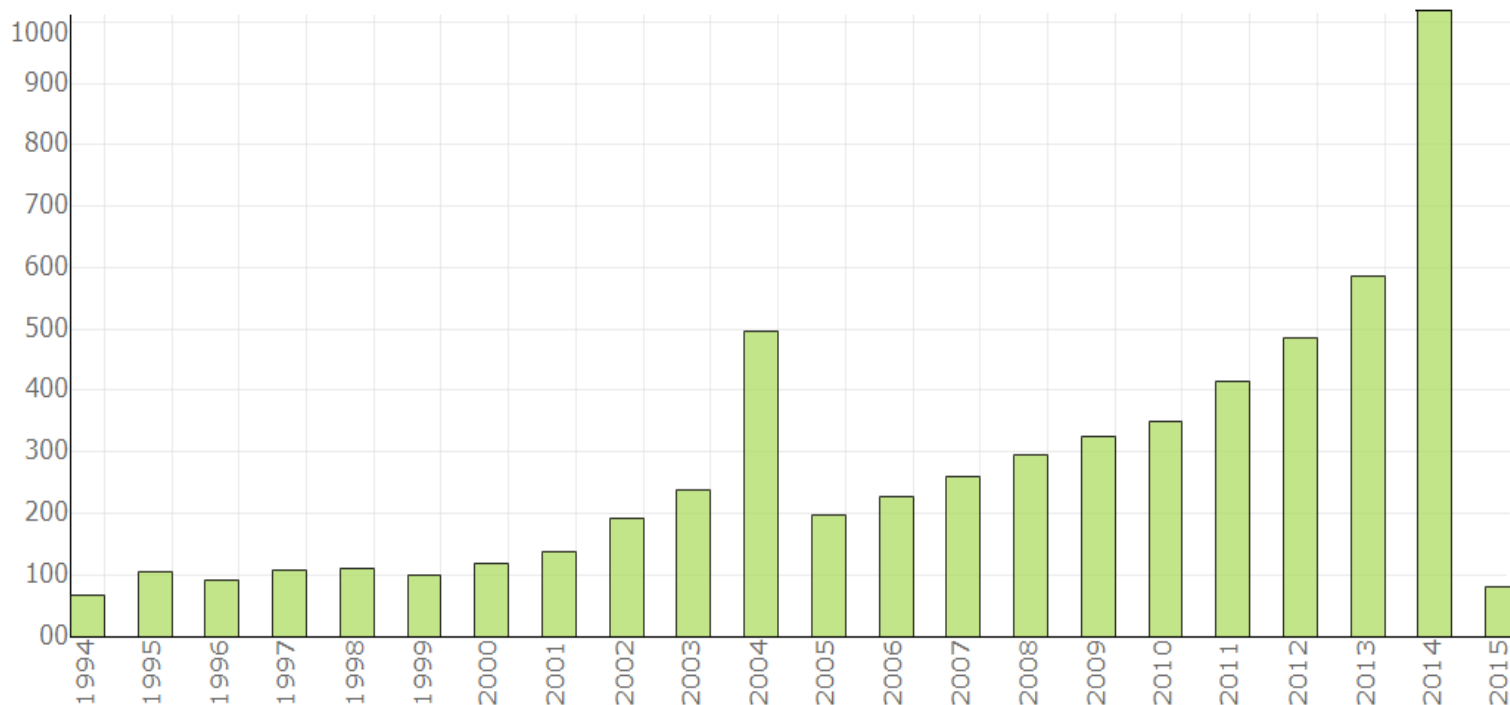
How we did it?

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
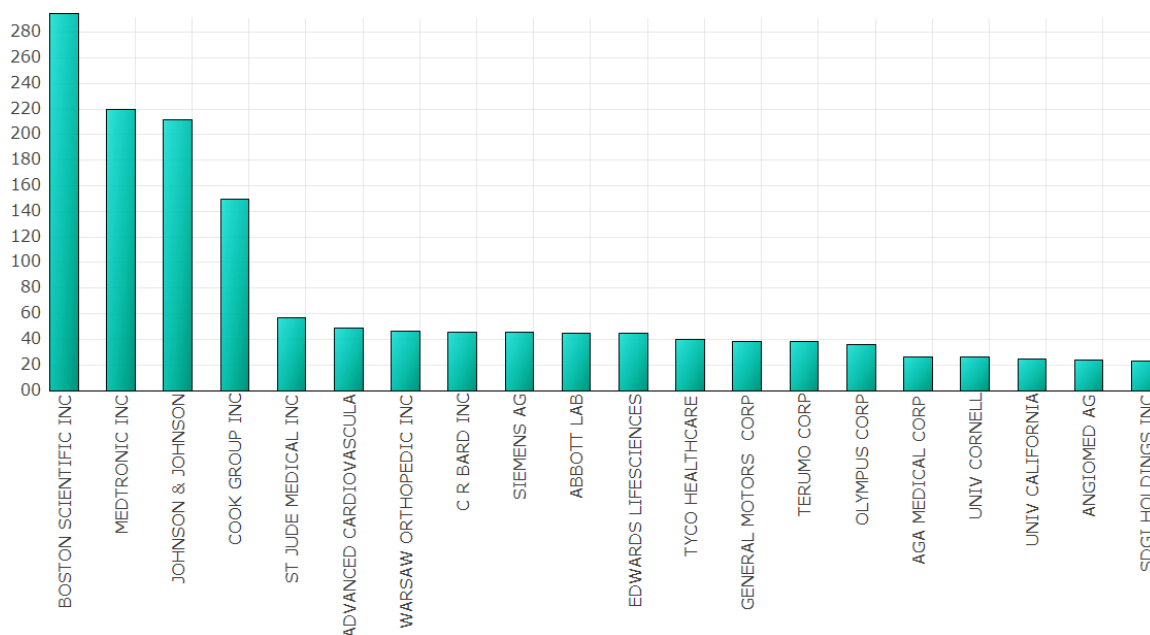
The top companies in shape memory alloy are:

1. BOSTON SCIENTIFIC INC	11. EDWARDS LIFESCIENCES CORP
2. MEDTRONIC INC	12. TYCO HEALTHCARE
3. JOHNSON & JOHNSON	13. GENERAL MOTORS CORP
4. COOK GROUP INC	14. TERUMO CORP
5. ST JUDE MEDICAL INC	15. OLYMPUS CORP
6. ADVANCEDCARDIOVASCULAR SYSTEM	16. AGA MEDICAL CORP
7. WARSAW ORTHOPEDIC INC	17. UNIV CORNELL
8. C R BARD INC	18. UNIV CALIFORNIA
9. SIEMENS AG	19. ANGIOMED AG
10. ABBOTT LAB	20. SDGI HOLDINGS INC

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
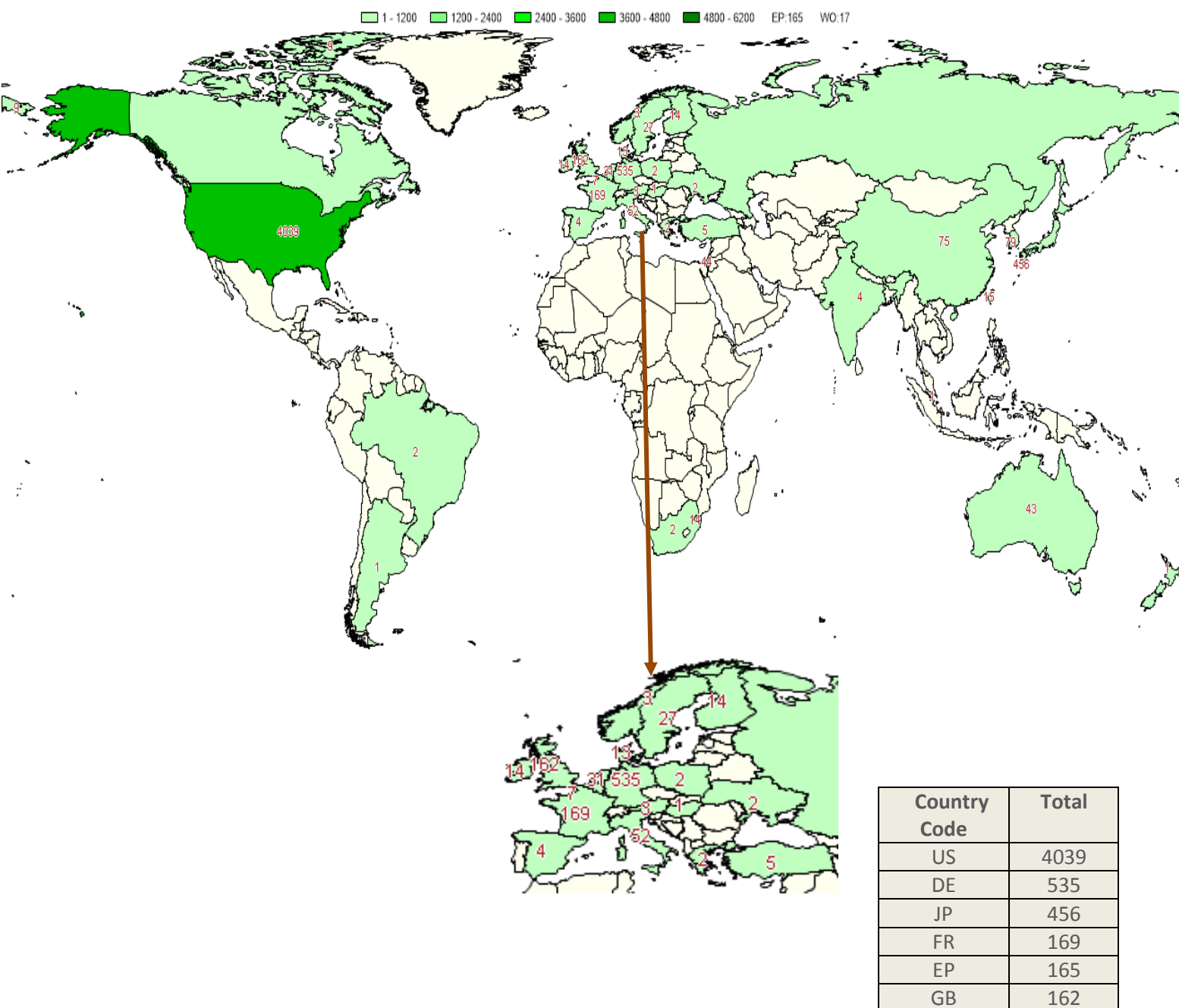
The dashboard tool within Patent iNSIGHT Pro was used to find the top 20 assignees within the given patent set. A visual graph was created based on the results of the top assignees with the number of patents alongside each one.
The complete Assignee table in available in the following Excel file:

http://www.patentinsightpro.com/techreports/0315/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. It can be seen US has 4039 filings (INPADOC Families) followed by Germany and Japan with 535 and 456 filings respectively. The strength of the colouring represents the proportion of patent publications.

Country Code	Total
US	4039
DE	535
JP	456
FR	169
EP	165
GB	162

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	JP	DE	FR	CN	IN
BOSTON SCIENTIFIC INC	295 (4.9%)	5.98	1981 2014	1992-2014	EIDENSCHINK TRACEE(12) WEBER JAN(11) VRBA ANTHONY C(7) JENSON MARK L(7) ANDERSON JAMES(7)	No Co-Assignee Present	289	190	142	88	0	3	0
MEDTRONIC INC	220 (3.6%)	7.12		1991-2014	RAFIEE NASSER(12) DOUK NAREAK(11) ROTHSTEIN PAUL T(7) BLOOM ELIOT(7) SCHALLER LAURENT(7)	CAMPBELL ROBERT P(1) CHELAK TODD(1) FRAZIER ANDREW G(1) JENAVALVE TECHNOLOGY INC(1) JOHNSON A D(1)	208	126	70	33	3	26	2
JOHNSON & JOHNSON	212 (3.5%)	6.26		1992-2014	PARK JIN S(11) MAJERCAK DAVID C(8) ORTIZ MARK S(7) ZEINER MARK S(6) FRIGG ROBERT(5)	BAAT B V ENGINEERING(1)	201	151	118	60	4	64	20

Assignee	Count	Value	Trend	Years	Inventors	Co-Assignee							
COOK GROUP INC	150 (2.5 %)	2.34		1992-2014	OSBORNE THOMAS A(9) HENDRIKSEN PER(8) HANSEN PALLE M(7) CASE BRIAN C(7) HARTLEY DAVID ERNEST(7)	WILLIAM COOK EUROPE AS(7) MED INST INC(3) LITHOTECH MEDICAL LTD(1) UNIV OREGON HEALTH & SCIENCE(1)	143	74	38	24	0	4	0
ST JUDE MEDICAL INC	57 (0.9 %)	2.32		1995-2014	EIDENSCHINK TRACEE(7) DE LA RAMA ALAN(4) TEGELS ZACHARY J(4) KOVACH MELINDA K(3) MISER JOHN(3)	No Co-Assignee Present	54	27	13	5	0	4	0
ADVANCED CARDIOVASCULAR SYSTEM	49 (0.8 %)	15.12		1994-2010	COX DANIEL L(13) LIMON TIMOTHY A(3) STALKER KENT C B(3) BOYLE WILLIAM J(3) WEBLER WILLIAM E(2)	HOSSAINY SYED F A(1)	45	18	18	6	0	0	0
WARSAW ORTHOPEDIC INC	47 (0.8 %)	2.89		2001-2012	TRIEU HAI H(12) JUSTIS JEFF R(6) METCALF JR NEWTON H(3) ANDERSON KENT M(3) ALLARD RANDALL N(3)	No Co-Assignee Present	45	24	22	6	2	13	0
C R BARD INC	46 (0.8 %)	5.98		1992-2014	CHANDUSZKO ANDRZEJ J(8) BOGERT DAVID L(5) WACK THILO(3)	No Co-Assignee Present	43	31	17	8	0	2	1

					Inventors	Co-Assignee							
					GAMBALE RICHARD A(2) DORN JUERGEN(2)								
SIEMENS AG	46 (0.8%)	2.28		1994-2012	KAUTZ STEFAN(14) ZEININGER HEINZ(6) KUTH RAINER(5) MASCHKE MICHAEL(4) ABRAHAM-FUCHS KLAUS(3)	No Co-Assignee Present	19	14	6	37	0	3	0
ABBOTT LAB	45 (0.7%)	0.78		1998-2014	YRIBARREN TRAVIS R(6) VON OEPEN RANDOLF(5) VOSS LAVEILLE KAO(4) LUDWIG FLORIAN N(4) NEWHAUSER RICHARD(3)	PERCLOSE INC(1) SCHNEIDER USA INC(1)	45	20	9	5	0	5	1
EDWARDS LIFESCIENCES CORP	45 (0.7%)	3.93		1999-2014	SOLEM JAN OTTO(5) ROWE STANTON J(4) CONKLIN BRIAN S(3) KIMBLAD PER OLA(3) DEHDASHTIAN MARK(2)	No Co-Assignee Present	40	35	12	11	0	15	0
TYCO HEALTHCARE	40 (0.7%)	2		2000-2012	SUNG JASON(3) HEINRICH RUSSELL(3) MUELLER PETER M(2) VIOLA FRANK(2) JOSEPH HOTTER(2)	No Co-Assignee Present	40	30	23	8	0	4	1
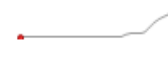
Assignee	Count	Ratio	Trend	Years	Top Inventors	Top Co-Assignees							
GENERAL MOTORS CORP	39 (0.6%)	1.05		2002-2013	BROWNE ALAN L(27) JOHNSON NANCY L(23) MANKAME NILESH D(13) ALEXANDER PAUL W(8) GAO XIUJIE(5)	DYNALLOY INC(2) UNIV MICHIGAN(1)	38	2	1	18	0	14	0
TERUMO CORP	39 (0.6%)	0.72		1987-2014	HARADA FUMIAKI(5) COX BRIAN J(3) ISHIDA TOSHINOBU(3) YAMAUCHI KIYOSHI(2) BRODIE ROBBIE(2)	JAPAN SCIENCE & TECH AGENCY(1) UNIV STRATHCLYDE(1)	31	31	20	20	0	11	1
OLYMPUS CORP	36 (0.6%)	7.44		1987-2013	UEDA YASUHIRO(5) IWASAKI SEIJI(3) MIZUNO HITOSHI(2) HIRATA YASUO(2) ADACHI HIDEYUKI(2)	No Co-Assignee Present	30	13	26	7	0	11	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 (Cumulative)	Filing Year Range	Key Assignees (Top 5)	Co-Inventors
BROWNE ALAN L	29 (0.5%)	1.1	1981 2014	2003-2013	GENERAL MOTORS CORP(27) BROWNE ALAN L(2) DYNALLOY INC(2) BARVOSA-CARTER WILLIAM(1) HERRERA GUILLERMO A(1)	JOHNSON NANCY L(23) MANKAME NILESH D(12) ALEXANDER PAUL W(6) GAO XIUJIE(4) HERRERA GUILLERMO A(4)
JOHNSON NANCY L	24 (0.4%)	0.96		2003-2013	GENERAL MOTORS CORP(23) DYNALLOY INC(2) BARVOSA-CARTER WILLIAM(1) BROWNE ALAN L(1) HERRERA GUILLERMO A(1)	BROWNE ALAN L(23) MANKAME NILESH D(9) ALEXANDER PAUL W(6) GAO XIUJIE(4) HERRERA GUILLERMO A(4)
SHAOLIAN SAMUEL M	22 (0.4%)	5.41		1997-2014	MICARDIA CORP(11) VALCARE INC(4) MOADDEB SHAHRAM(3) SHAOLIAN SAMUEL M(3) HENSON MICHAEL R(2)	MOADDEB SHAHRAM(6) DUMONTELLE JEFFREY(4) HENSON MICHAEL R(4) MOADDEB SHAWN(4) SHAOULIAN EMANUEL(4)

MCGUCKIN JAMES F JR	20 (0.3%)	3		2001-2014	REX MEDICAL LP(17) BRESSLER JAMES ERICH(1) MCGUCKIN JR JAMES F(1) SCHALLER DAVID M(1) HINCHLIFFE PETER W J(1)	HINCHLIFFE PETER W J(6) BRIGANTI RICHARD T(5) DEFONZO STEPHAN A(3) BRESSLER JAMES ERICH(2) LEEDLE JOHN D(2)
EIDENSCHINK TRACEE	19 (0.3%)	1.37		2003-2014	BOSTON SCIENTIFIC INC(12) ST JUDE MEDICAL INC(7)	DRASLER WILLIAM J(3) JENSON MARK L(3) HEIDNER MATT(2) SADASIVA ANU(2) THIELEN JOSEPH M(2)
CHANDUSZKO ANDRZEJ J	18 (0.3%)	3.06		2003-2014	C R BARD INC(8) NMT MEDICAL INC(5) GORE & ASS(3) CHANDUSZKO ANDRZEJ J(2) BRATT WILLIAM R(1)	PEAVEY TODD A(3) DEVELLIAN CAROL A(2) SMALE JOSHUA A(2) WIDOMSKI DAVID(2) ABARCA ENRIQUE(1)
FLAHERTY J CHRISTOPHER	18 (0.3%)	15.5		2002-2014	INSULET CORP(3) REX MEDICAL LP(3) LUMEN DEVICES LLC(2) NEOGRAFT TECHNOLOGIES INC(2) OC2 LLC(1)	GARIBOTTO JOHN T(5) BRENNEMAN RODNEY(3) GORMAN WILLIAM(3) GREGORY CHRISTOPHER CARTER(3) MAHONEY DEREK DWAYNE(3)
TRIEU HAI H	17 (0.3%)	5.24		2003-2011	WARSAW ORTHOPEDIC INC(12) TRIEU HAI H(3) KYPHON INC(1) SDGI HOLDINGS INC(1)	JUSTIS JEFF R(3) METCALF JR NEWTON H(2) ALLARD RANDALL L(1) AMERY DREW(1) ANDERSON KENT M(1)

COX DANIEL L	15 (0.2%)	17.47		1997-2008	ADVANCED CARDIOVASCULAR SYSTEM(13) COX DANIEL L(1) ABBOTT LAB(1)	AINSWORTH ROBERT D(1) ALLEN RICHARD T(1) BOYLAN JOHN F(1) CHAN GREGORY W(1) CHENG E T(1)
KAUTZ STEFAN	15 (0.2%)	2.07		2000-2003	SIEMENS AG(14) BOSCH SIEMENS HAUSGERAETE GMBH(1)	ZEININGER HEINZ(6) KUEHL HANNES(3) MARONDEL MATTHIAS(3) GREINER ROBERT(2) ZEININGER HEINRICH(2)
SHADDUCK JOHN H	15 (0.2%)	22.6		2001-2014	SHADDUCK JOHN H.(10) TRUCKAI CSABA(8) LUZZI ROBERT(4) POWERVISION INC(2) ADORJAN TASS(1)	TRUCKAI CSABA(9) LUZZI ROBERT(4) ADORJAN TASS(1) ESCH VICTOR(1) HOEY MICHAEL(1)
SHALEV ALON	15 (0.2%)	0.33		2009-2012	ENDOSPAN LTD(13) LEV TIFFANY(1) SHALEV ALON(1) ESTIMME LTD(1)	BENARY RAPHAEL(4) RAZ SAGI(2) BENARY RAFI(1) LEV TIFFANY(1) NAE NIR SHALOM(1)
KLESHINSKI STEPHEN J	14 (0.2%)	30.14		1994-2012	NITINOL DEV CORP(4) NMT MEDICAL INC(3) C R BARD INC(2) STOUT MEDICAL GROUP LP(1) SEPTRX INC(1)	RAVENSCROFT ADRIAN C(3) GREENHALGH E SKOTT(2) COLLINS JAMES J(1) HARRY JASON D(1) KINST THOMAS(1)
LENKER JAY A	14 (0.2%)	23.21		1998-2013	LENKER JAY A(3) THERACARDIA INC(2) ELLIPSE TECHNOLOGIES INC(2) MICARDIA CORP(2) BUCKMAN JR ROBERT F(2)	EVANS MICHAEL A(3) KOLEHMAINEN DONALD J(3) MOADDEB SHAWN(3) SHAOLIAN SAMUEL M(3) BRENNEMAN RODNEY(2)

SOLEM JAN OTTO	14 (0.2%)	0.71		2000-2014	SYNTACH AG(5) EDWARDS LIFESCIENCES CORP(5) SYNERGIO AG(2) SOLEM JAN OTTO(1) JOMED GMBH(1)	SEIBOLD GERD(3) JOERGENSEN IB(2) KIMBLAD PER OLA(2) NIELSEN STEVAN(2) QUINT BODO(2)

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 Polymers

- The chart below shows research activity of companies across different types of polymers
- Boston Scientific has the most number of records in Polyurethane Films and PET
- Medtronic leads the research around thermoplastics and has research interest in almost all the polymers
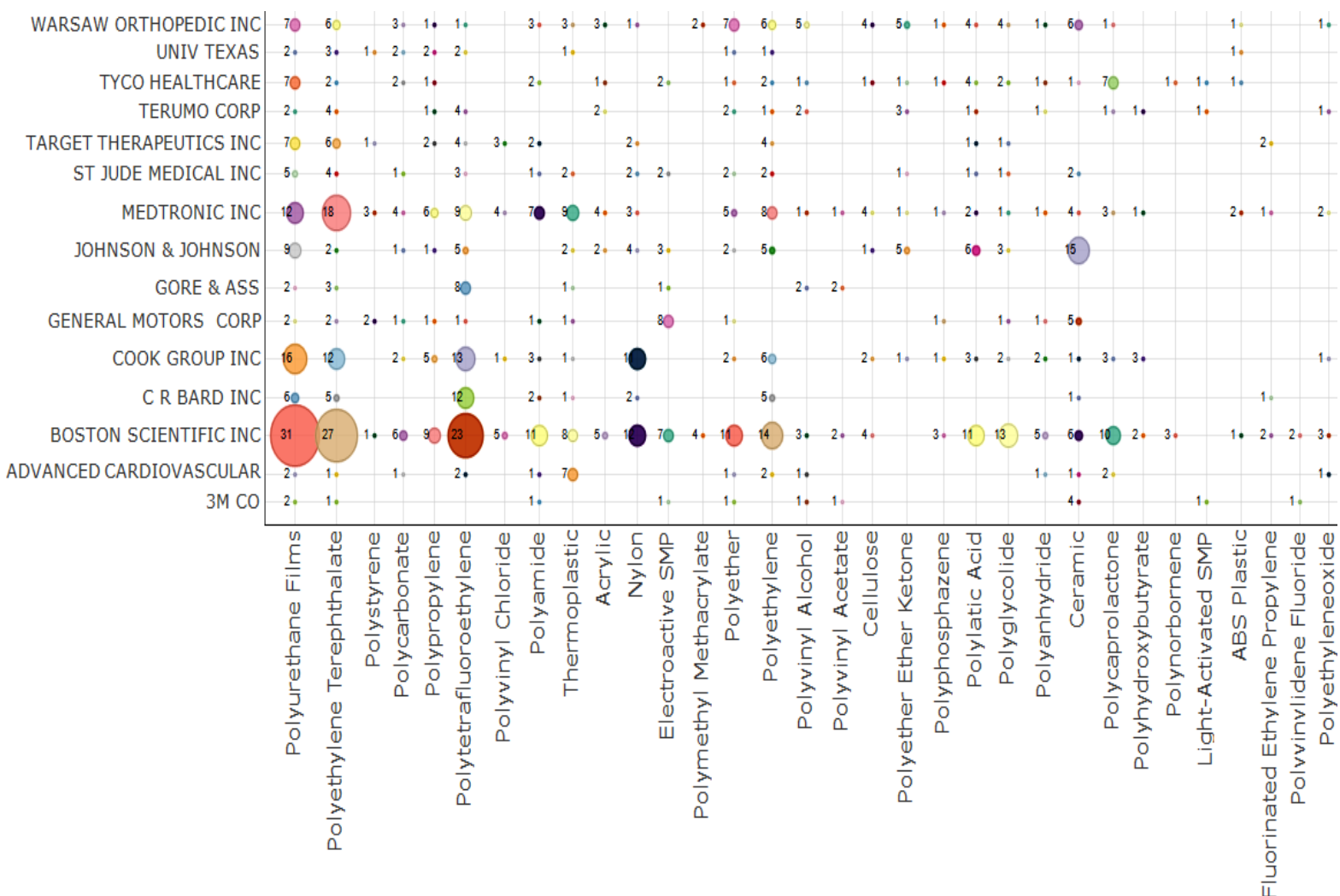
How we did it?

First various polymers 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 polymers. A co-occurrence matrix was generated using the co-occurrence analyzer to map the different polymers 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 Alloys

- The chart below shows research activity of companies across different alloys
- Advanced Cardiovascular is most active in Tantalum
- Boston Scientific leads in research interest in Nitinol, Stainless Steel and Tungsten
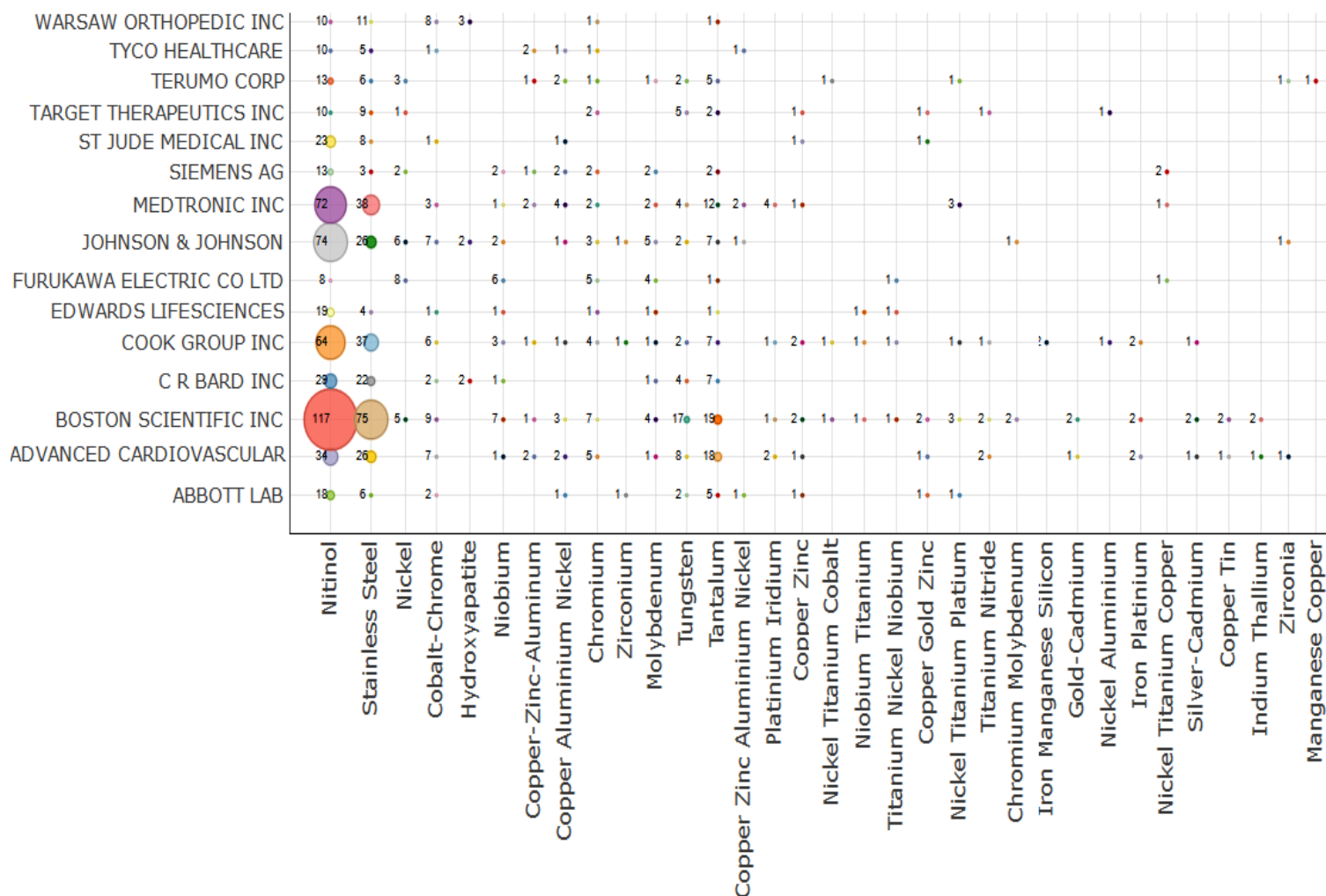
How we did it?

First various alloys 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 alloys. A co-occurrence matrix was generated using the co-occurrence analyzer to map the different alloys with assignees. The matrix was filtered for the top 15 assignees 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
- Stent is the most researched application area and is focused by most of the companies
- Johnson & Johnson leads the record count for surgical fixation and prosthesis
- Siemens is the only company focusing on aviation applications of shape memory alloys
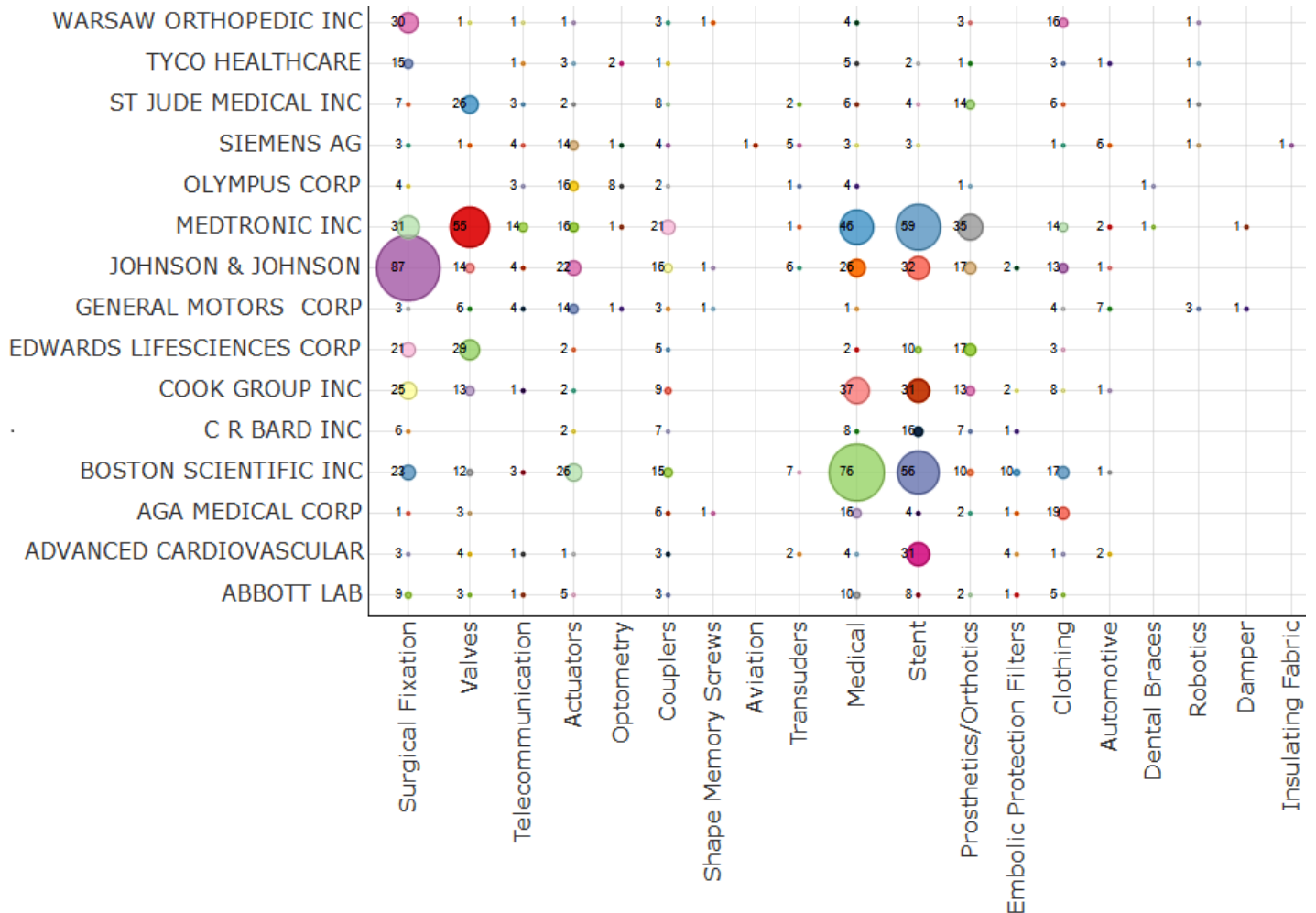
How we did it?

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.

Shape Memory: Polymers vs Applications

- The below matrix shows different polymers used in different application areas
- Polyurethane and Polyethylene are actively used in Surgical Fixations
- Electroactive SMP has wide range of applications across telecommunication sector

Polymers \ Applications	Total	Actuators	Surgical Fixation	Couplers	Aviation	Telecommunication	Transuders	Medical	Optometry	Valves	Stent	Clothing	Prosthetics	Automotive	Dental Braces	Shape Memory Screws	Embolic Protection Filters	Robotics	Crafts	Damper
Total	870	101	335	125	4	54	17	161	37	163	180	174	126	33	16	12	8	21	4	2
Polyurethane Films	260	18	105	28	1	13	3	61	7	49	57	58	36	10	5	1	5	3	1	
Polytetrafluoroethylene	243	18	85	30		9	3	39	6	57	84	62	50	4	2	1	3	2	1	
Polyethylene Terephthalate	241	20	101	29		9	1	39	5	56	66	71	53	11	2		3	2	1	
Ceramic	151	18	84	22	1	9	3	29	8	28	12	32	27	14	7	5	2	4	2	
Polyethylene	135	10	65	18	1	5	4	24	5	24	24	24	26	4	1	7	1		2	1
Thermoplastic	113	13	33	20	2	7	3	22	3	17	25	21	9	6	5	1		2		
Polypropylene	106	6	63	12		7	1	16	7	25	15	26	20	4	2	3		1	1	
Polyether	94	7	51	15	2	1	1	13	2	15	14	15	12	3	3	3	2			
Polycarbonate	89	5	49	13		6	1	14	5	18	13	11	11	6	2	2	1		1	
Nylon	88	8	42	10		6	2	16	2	16	14	19	11	2	3		3	1		
Polyamide	85	8	36	8	1	1	3	17	1	13	17	21	14	7	2				1	
Electroactive SMP	82	36	20	17		12	4	18	5	14	5	8	10	4				11		1
Polylatic Acid	79	3	53	12		5	1	11	1	13	11	12	12	6	1	1	1			
Polyglycolide	67	3	37	11		4	1	11	1	10	9	16	8	6	1		1			
Polyether Ether Ketone	67	7	48	10	2	2		5	2	6	5	10	9	1	1	3	1			
Acrylic	67	5	30	11	1	8	2	11	16	8	10	11	6	4	2	1		2		
Cellulose	54	7	32	13	1	3	2	12	4	12	5	13	12	3	3	2				
Polycaprolactone	53	2	30	6		4	1	15	1	6	11	6	8	7	1					
Polyvinyl Chloride	50	9	20	8	1	4	2	10	6	8	5	7	4	2	1		1	1		

| Polymer	Total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Polyanhydride	33	2	18	7		2	1	9	1	6	3	4	9	7	1	1			
Polystyrene	32	4	15	7		4	1	9	4	5	5	6	2	4	1			1	
Polyvinyl Alcohol	31	1	15	5	1	3	1	7	2	4	9	8	5	1					1
Polymethyl Methacrylate	28	2	11	4		2		6	9		4	5	2	2	1				1
Polyethyleneoxide	19	2	8	1		1		6		4	5	1	6	2			1		
ABS Plastic	19	3	9	2		4	1	6		2	3	3	1					1	
Polyvinyl Acetate	18	4	5	3	1	1	1	3	2	4	5	5	3						
Polyphosphazene	18	1	12	3				5	1	3	1	1	3	1					
Fluorinated Ethylene Propylene	17	1	6	1				6		1	5	4	1						
Polyhydroxybutyrate	12		8	1		1		3	1	4	2	1	3	3			1		
Polyvinylidene Fluoride	11	2	3	1				3	1	1	2	3							
Light-Activated SMP	10	2	3	1		1		2	2	1		2		2	1				
Polybutadiene	5	1	2	1				1	1	1	1		1	1					
Polynorbornene	4	1				1		1				1							

How we did it?

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

Inventor group of key companies in Shape Memory Material

The generated map below highlights the key inventor groups of top companies. In map below the groups are created using network relationships and the records are positioned on the map based on their relationship to the Assignee and inventors listed on the graph.

Kleshinki Stephen J has filings for C R Bard, NMT Medical and Nitinol Dev Corp. Also groups of inventors who file together appear clustered together.

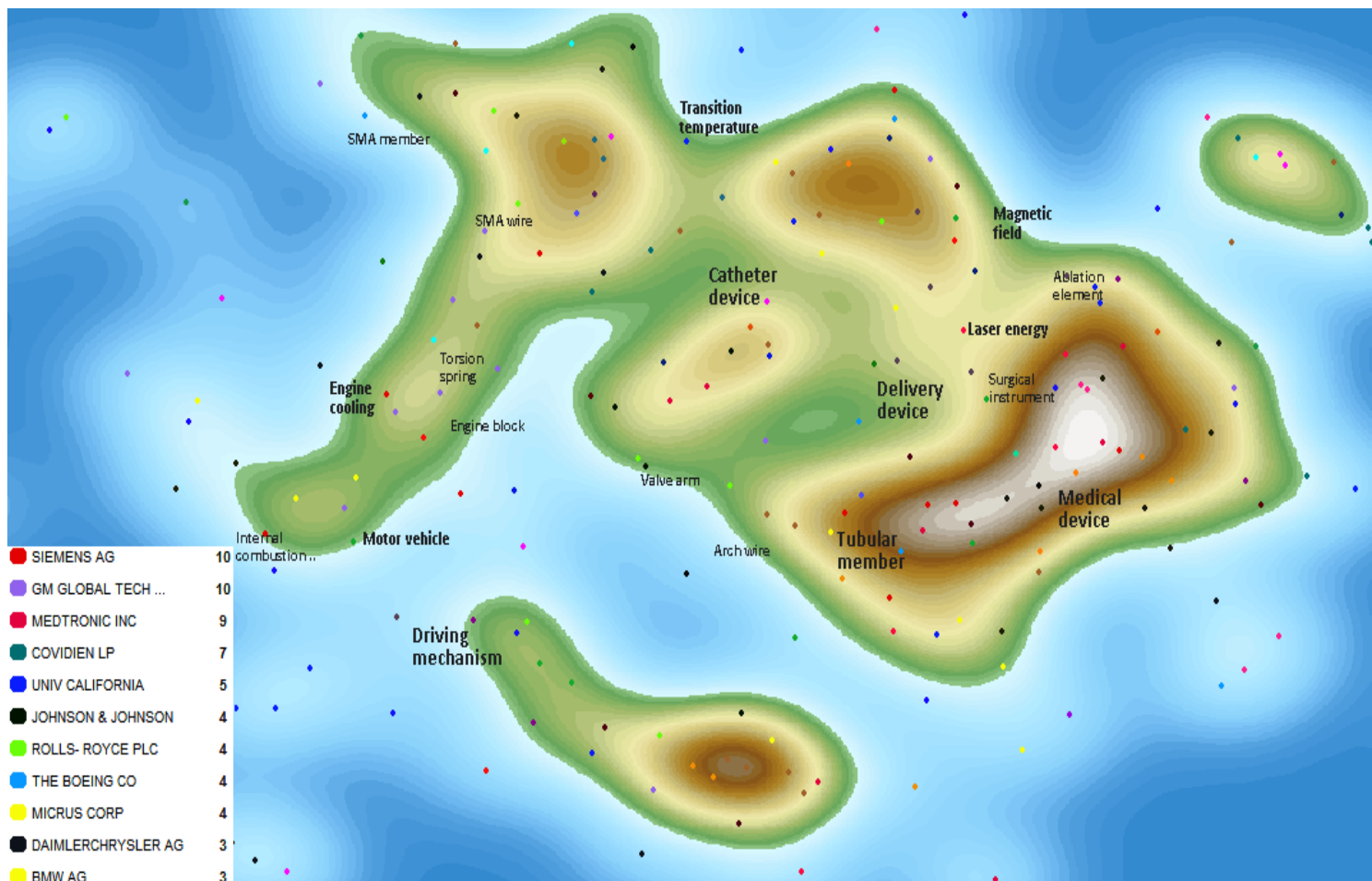Numbers besides the nodes represent citation count for the respective record.
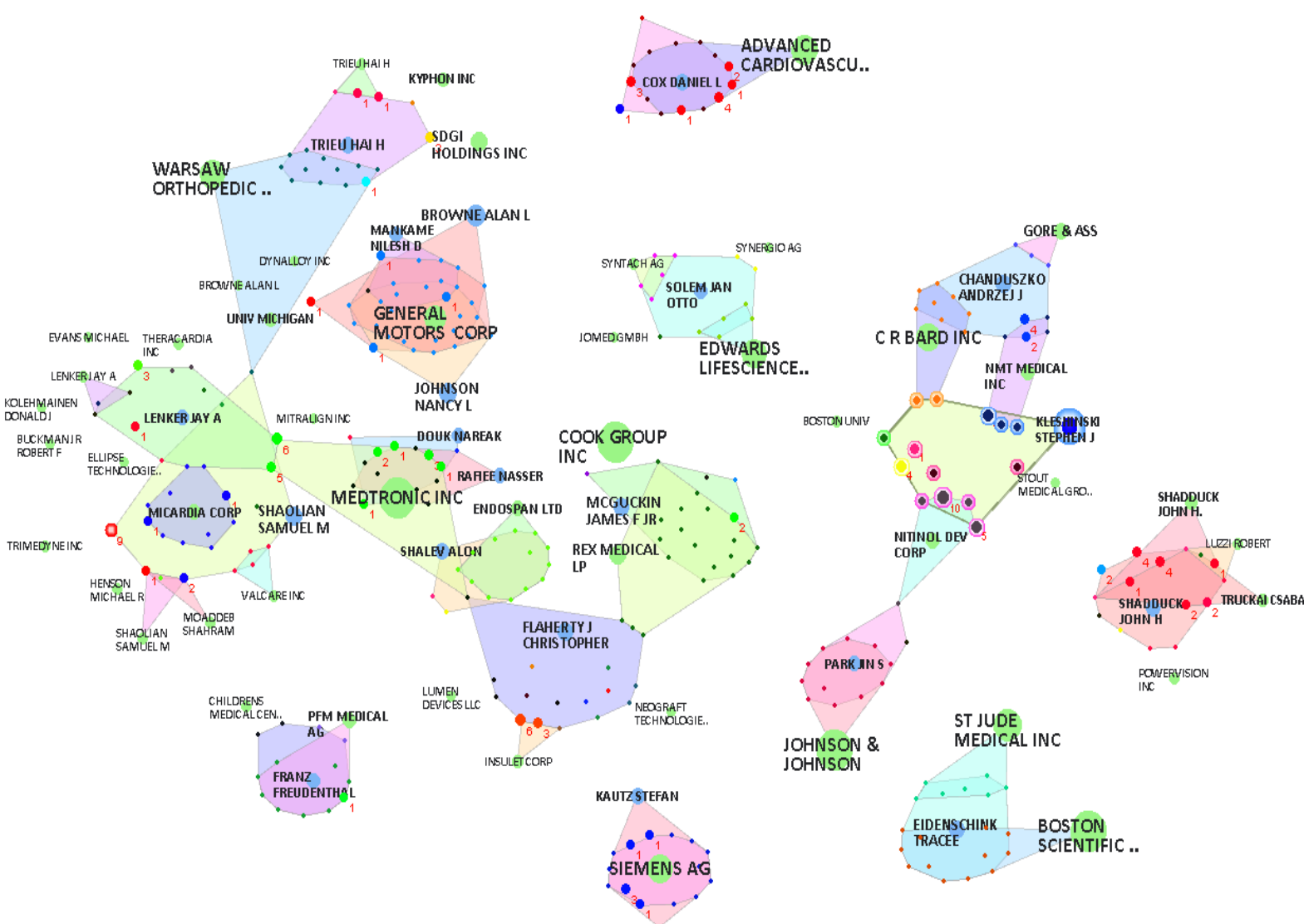
How we did it?

Using the VizMAP tool, patents of top 20 inventors were loaded on the map. These were then expanded by assignee names. The VizShade option was used to shade the inventors and assignees with potential overlapping patents between them.

Technology Landscape

- The contour map below represents key concepts across automation (engine cooling, driving mechanism, Internal combustion engines) and medical industries (lasers, surgical instruments and catheter devices)
- The patents represented by dots were coloured by company
- Clusters for Daimler which relate to Internal Combustion Engine, engine block and engine cooling are close to each other as there is high degree of relevance between the records present in those technology areas
- Medtronic focuses mainly on medical devices and surgical instruments

SIEMENS AG	10
GM GLOBAL TECH ...	10
MEDTRONIC INC	9
COVIDIEN LP	7
UNIV CALIFORNIA	5
JOHNSON & JOHNSON	4
ROLLS- ROYCE PLC	4
THE BOEING CO	4
MICRUS CORP	4
DAIMLERCHRYSLER AG	3
BMW AG	3

How we did it?

The VizMAP tool in Patent iNSIGHT Pro was used for this analysis. First the clusters for different applications 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.

Portfolio analysis for key companies focusing on shape memory

Publication Trend

- The chart below shows publication trend for key companies
- Nitinol Corp shows consistent growth since 2004
- Micardia which has publications since 2006 but has shown a steep rise in publications over last 5 years
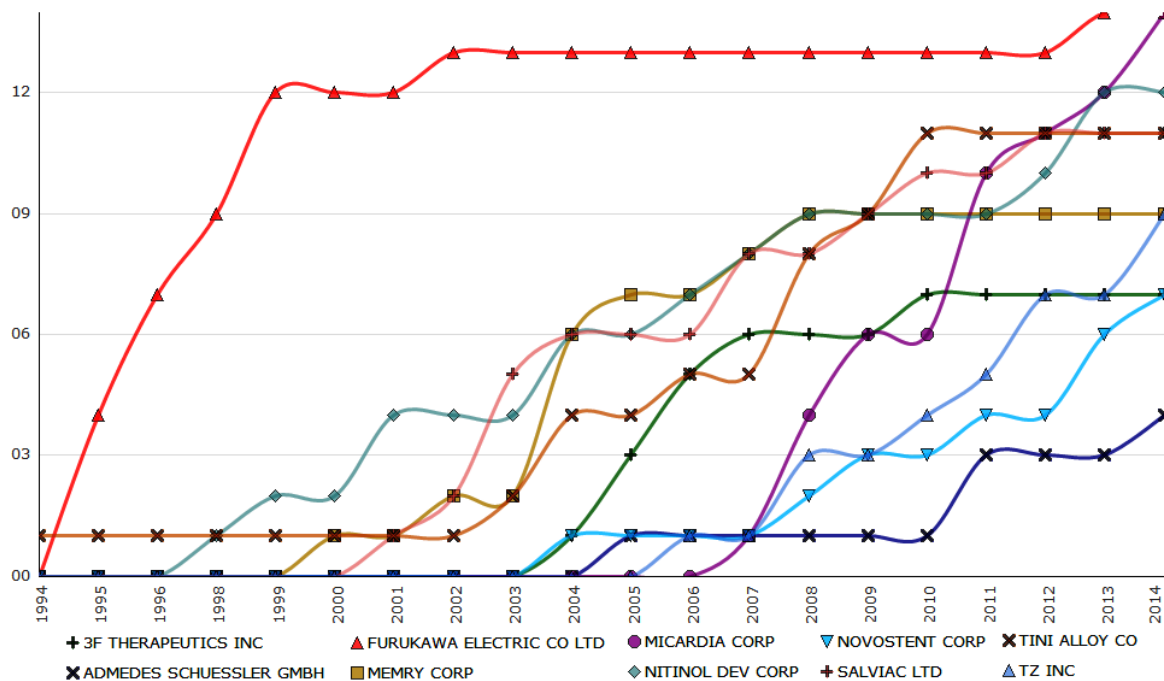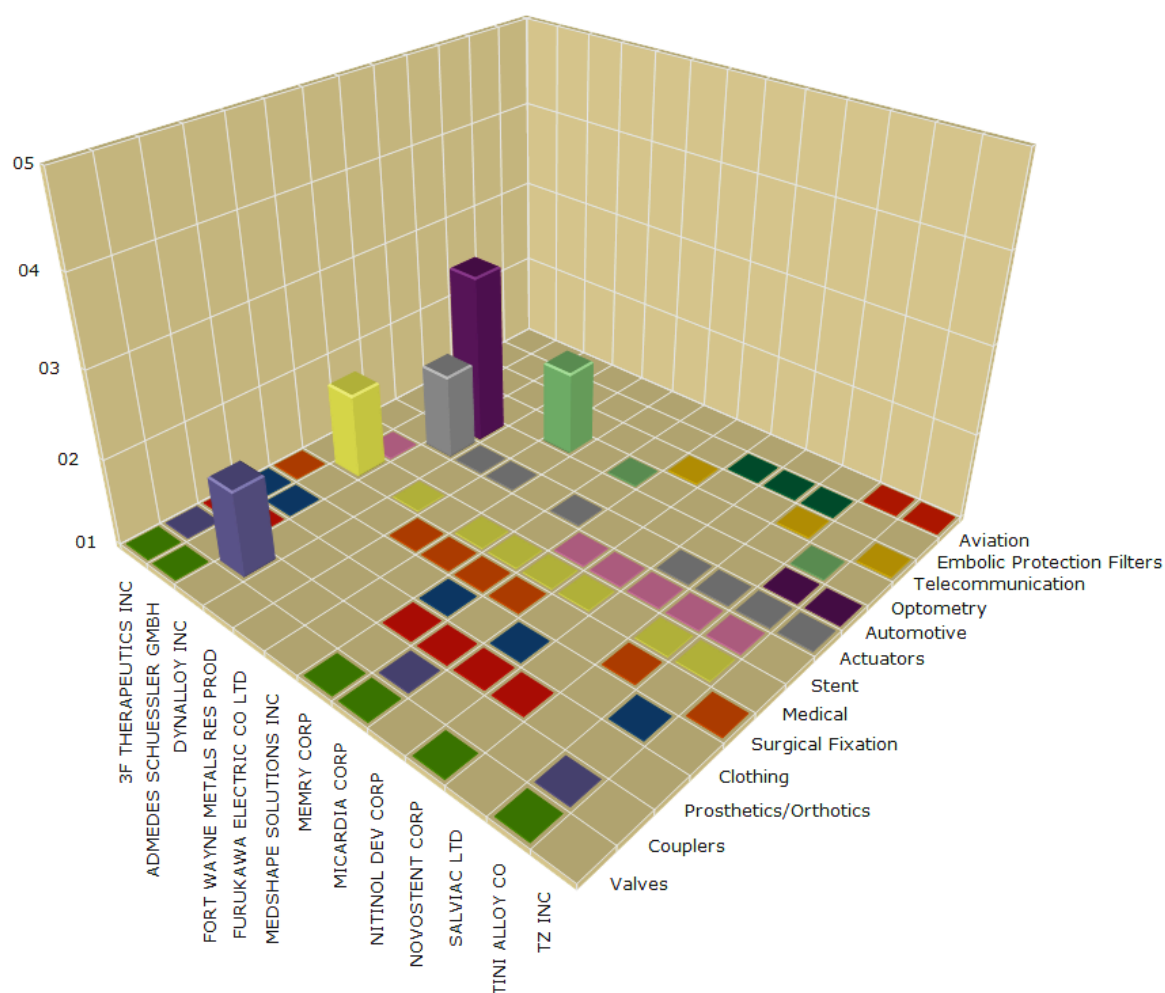

How we did it?

We first created a group for companies focusing primarily around shape memory using auto filter option. Using co-occurrence analyzer, we used that group as data filter to generate a matrix for those companies with respect to publication year and resulting matrix was converted to a line chart.

Company activity across Applications

- The chart below shows company activity for key companies across different application areas
- Dynalloy focuses only in automobile applications with maximum records across actuators, couplers
- Admedes Schuessler is active in self expandable implants for medical device industry using alloys such as Nitinol

How we did it?

The group of companies created for previous analysis was correlated along with different applications using the co-occurrence analyzer and resulting matrix was represented as a 3D column chart.

Company activity across Alloys

- The chart below shows company activity for key companies across different alloys
- Admedes Schuessler uses alloys such as Nitinol, Stainless Steel, Titanium, Tantalum for various medical applications
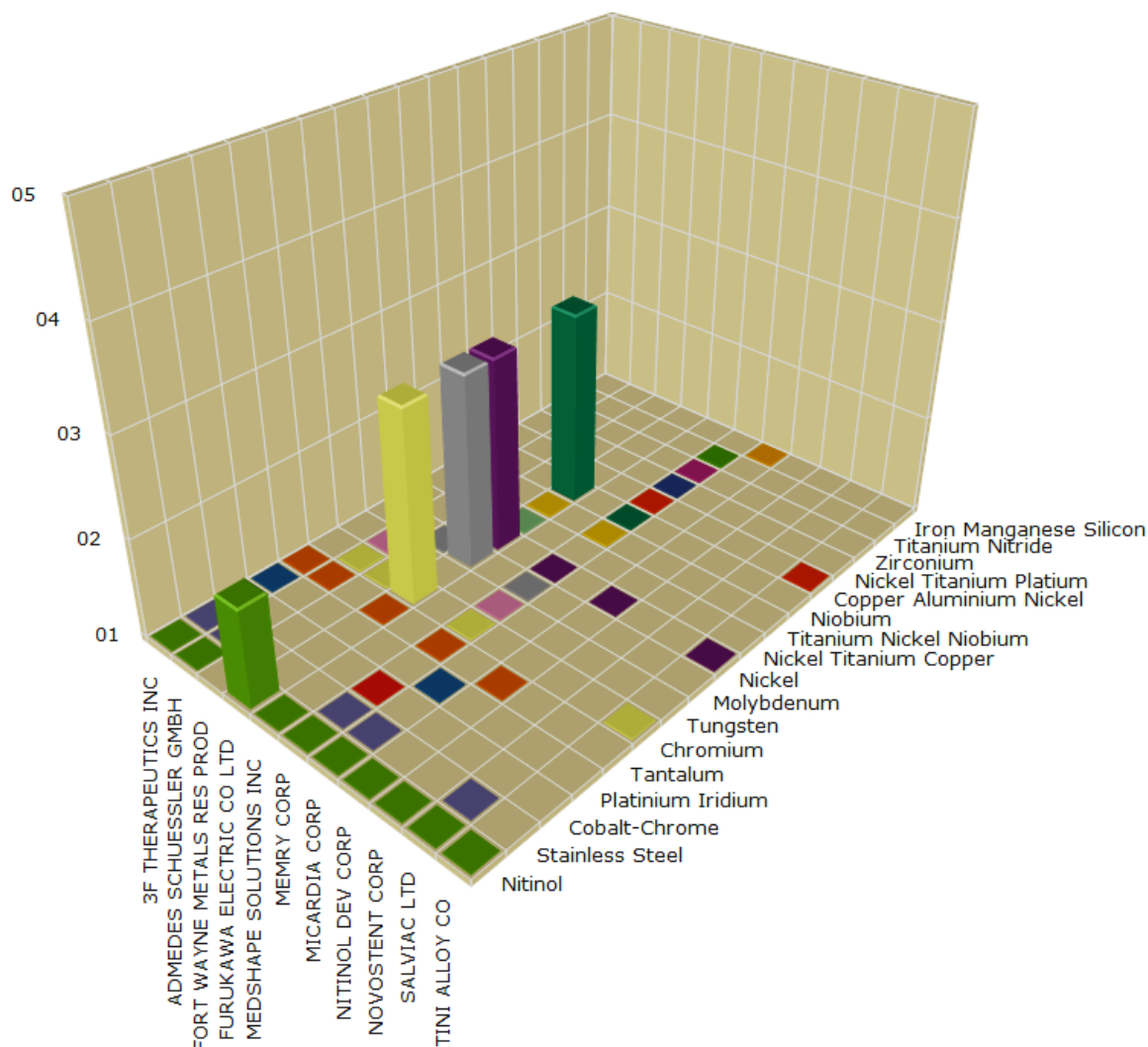- Memry Corp has records across most of the alloys used in medical, dental, industrial, automotive sectors

How we did it?

The group of companies created for previous analysis was correlated along with different alloys using the co-occurrence analyzer and resulting matrix was represented as a 3D column chart.

Shape Memory Alloy - US Trends

Top Companies

- The chart shows top 20 companies in shape memory alloy
- Several of the top medical companies have records for shape memory alloys, with a few manufacturing companies (3M, General Motors)
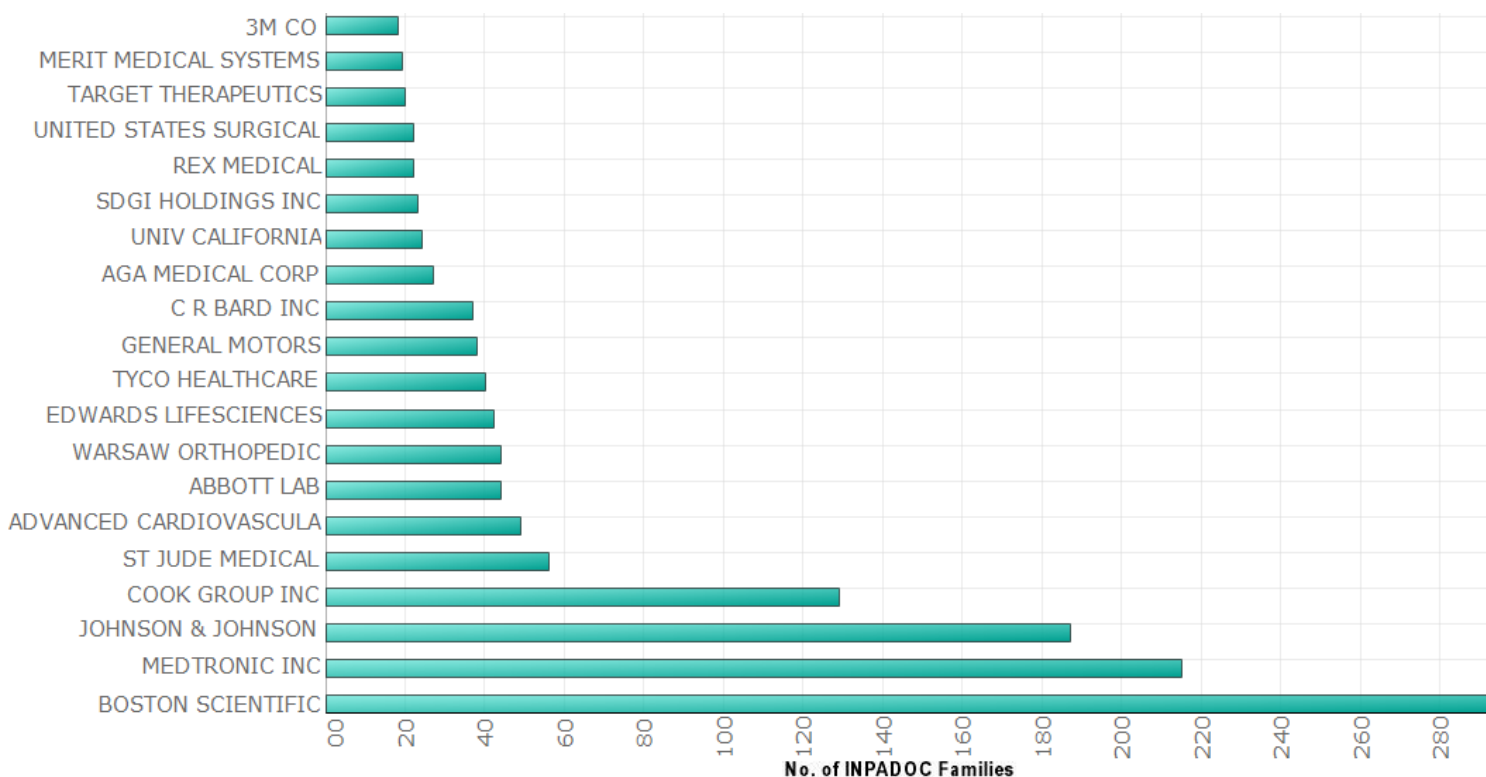
How we did it?

We applied filter for US as the priority country from the options present within dashboard and then the chart for top assignees was generated on a single click using the assignees tab present.

Patent iNSIGHT Pro
Transform Patents to Intelligence

Alloys

The pie chart shows research activity for different alloys in US
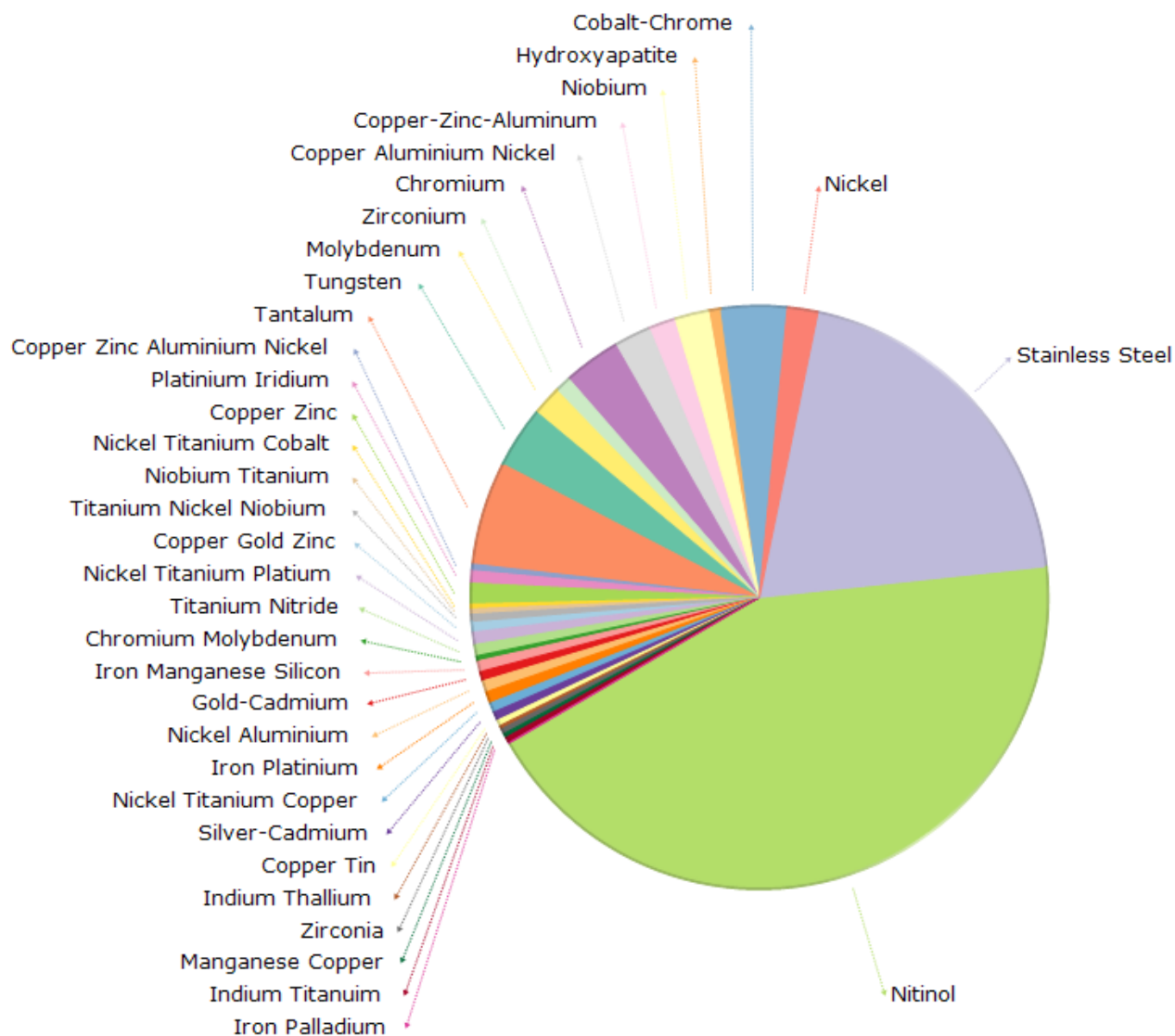
Shape Memory Alloy - US Trends

Polymers

The pie chart shows research activity for various polymers in US

How we did it?

We selected US as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for alloys first followed by polymers and the respective matrix was converted to a pie.

Company across different applications

- The chart below shows which companies are conducting research activity across different applications of shape memory alloys
- Boston Scientific has more records in Stents as compared to other companies
- Medtronic leads the count for records across Valves and Prosthetics

How we did it?

We selected US as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for top 10 companies with respect to applications and generated matrix was converted into a bubble chart.

Shape Memory Alloy - DE Trends

Top Companies

- The chart shows top 20 companies for shape memory alloy
- Several of the top manufacturing companies have records for shape memory alloys in Germany

How we did it?

We applied filter for DE as the priority country from the options present within dashboard and then the chart for top assignees was generated on a single click using the assignees tab present.
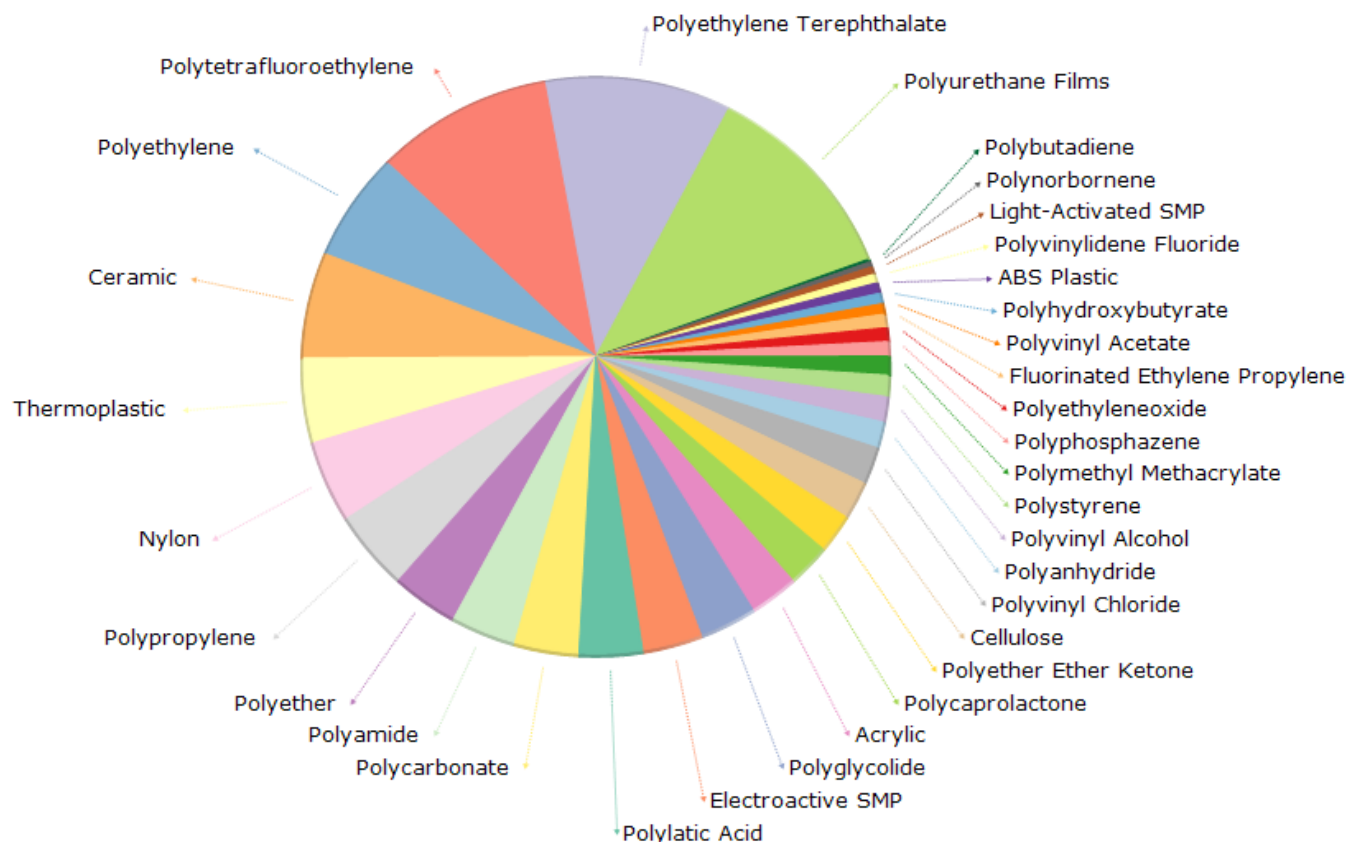
Shape Memory Alloy - DE Trends

Alloys

The pie chart shows research activity for Different alloys in Germany

Shape Memory Alloy - DE Trends

Polymers

The pie chart shows research activity for various polymers in Germany
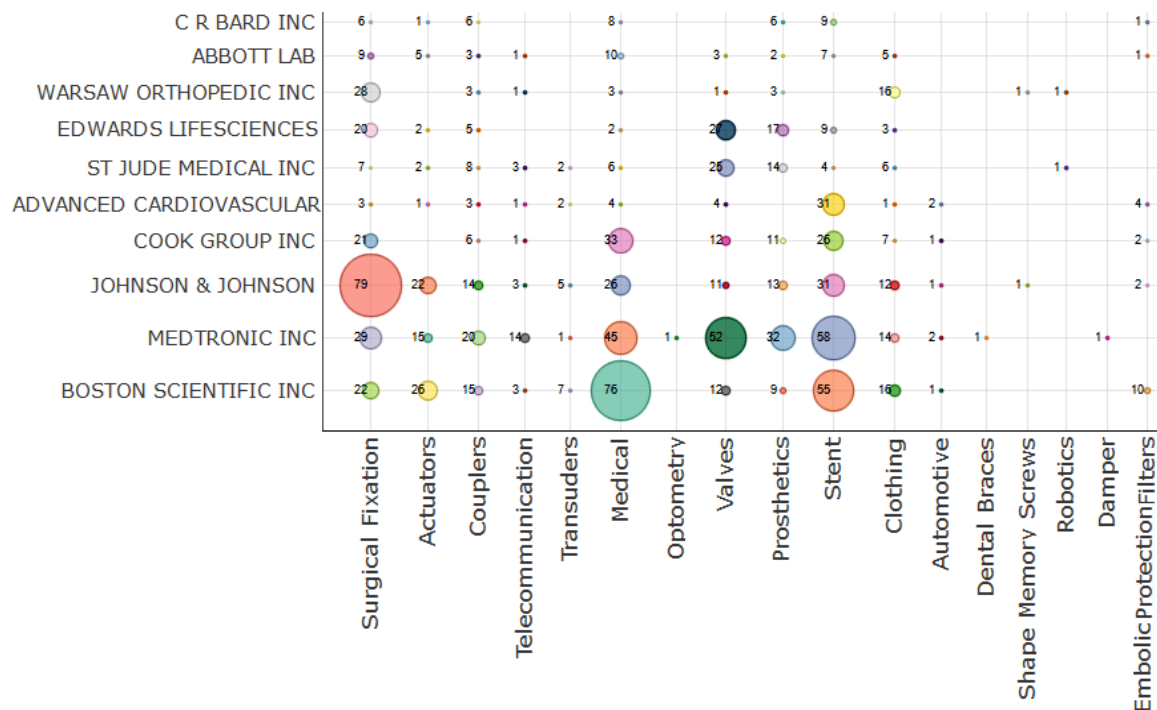

How we did it?

We selected DE as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for alloys first followed by polymers and the respective matrix was converted to a pie.

Shape Memory Alloy - DE Trends

Company across different applications

- The chart below shows which companies are conducting research activity across different applications of shape memory alloys
- Aesculap and Foerster Bernhard have maximum records in Surgical Fixation
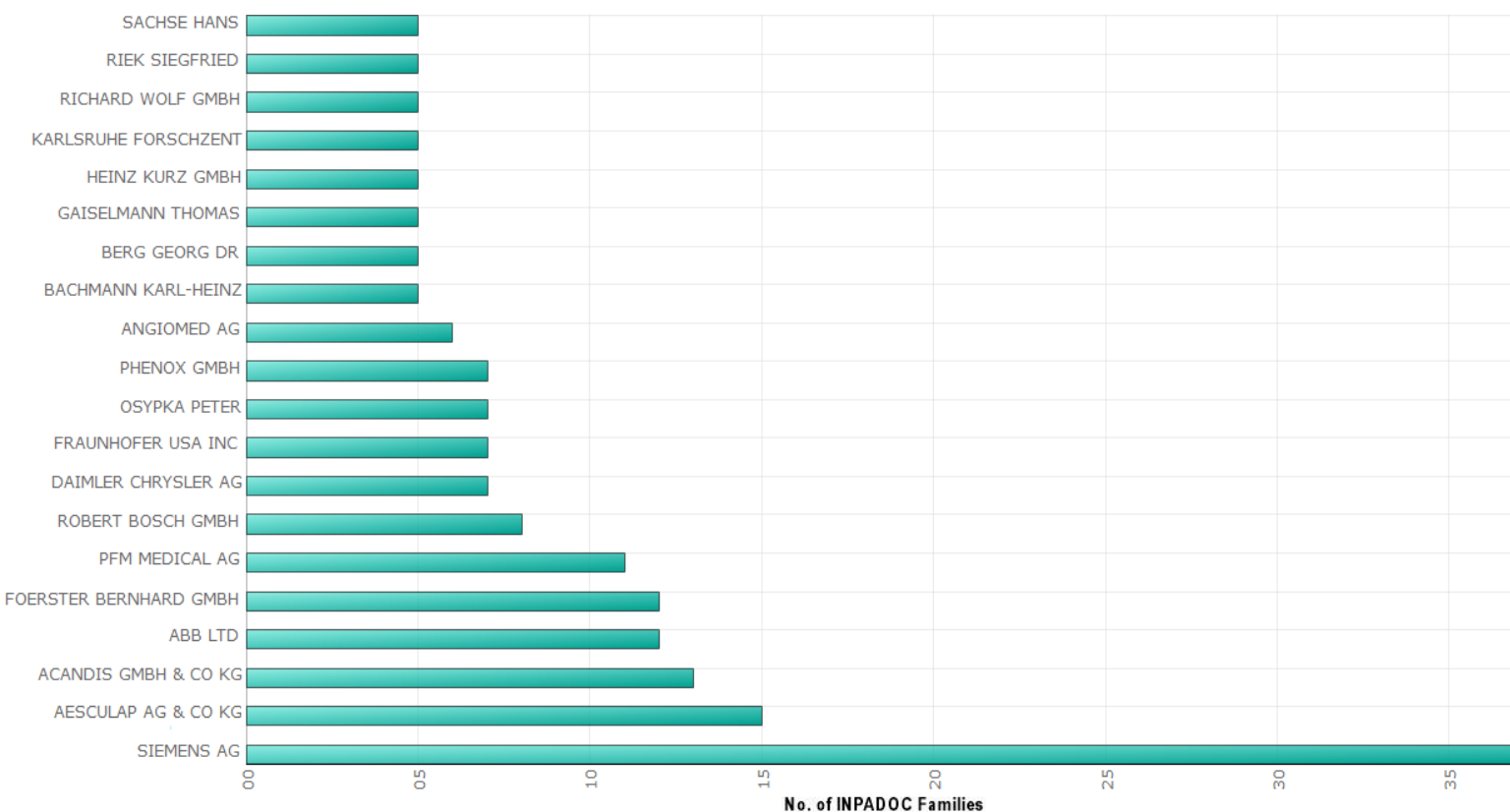- Siemens is the only company focusing on automotive applications

How we did it?

We selected DE as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for top 10 companies with respect to applications and generated matrix was converted into a bubble chart.

Shape Memory Alloy - GB Trends

Top Companies

- The chart shows top 20 companies for shape memory alloy in Britain
- Cook Group leads with maximum number of records closely followed by Angiomed
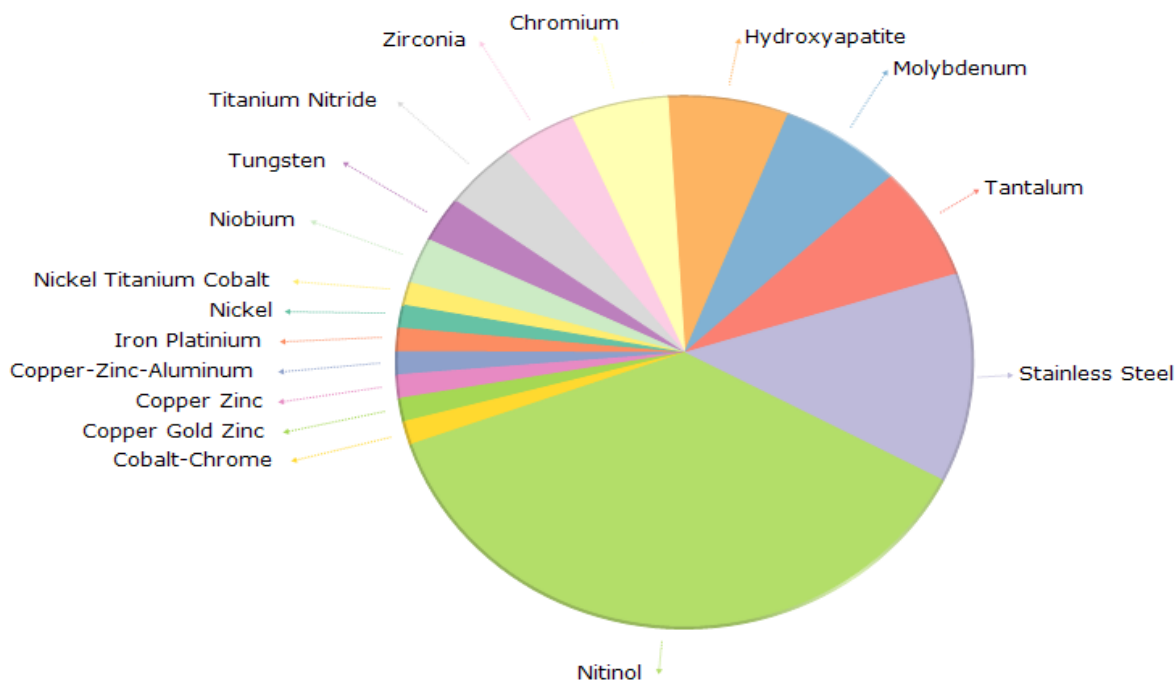

How we did it?

We applied filter for GB as the priority country from the options present within dashboard and then the chart for top assignees was generated on a single click using the assignees tab present.
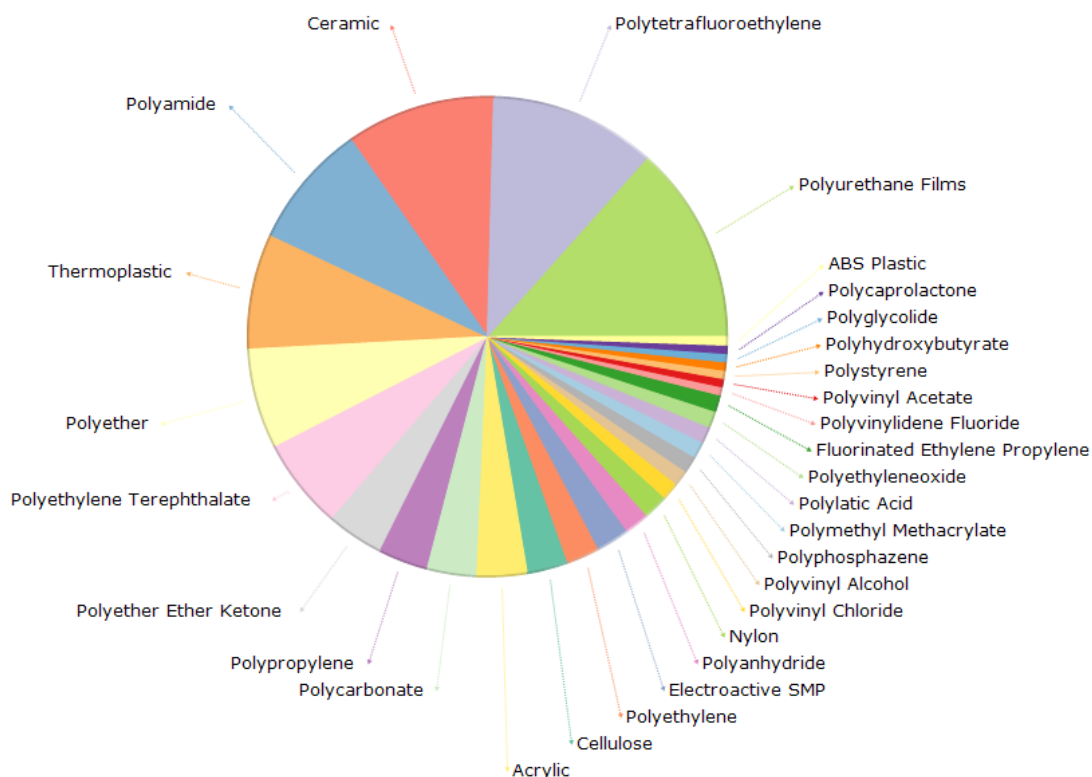
Shape Memory Alloy - GB Trends

Alloys

The pie chart shows research activity for different alloys in Britain
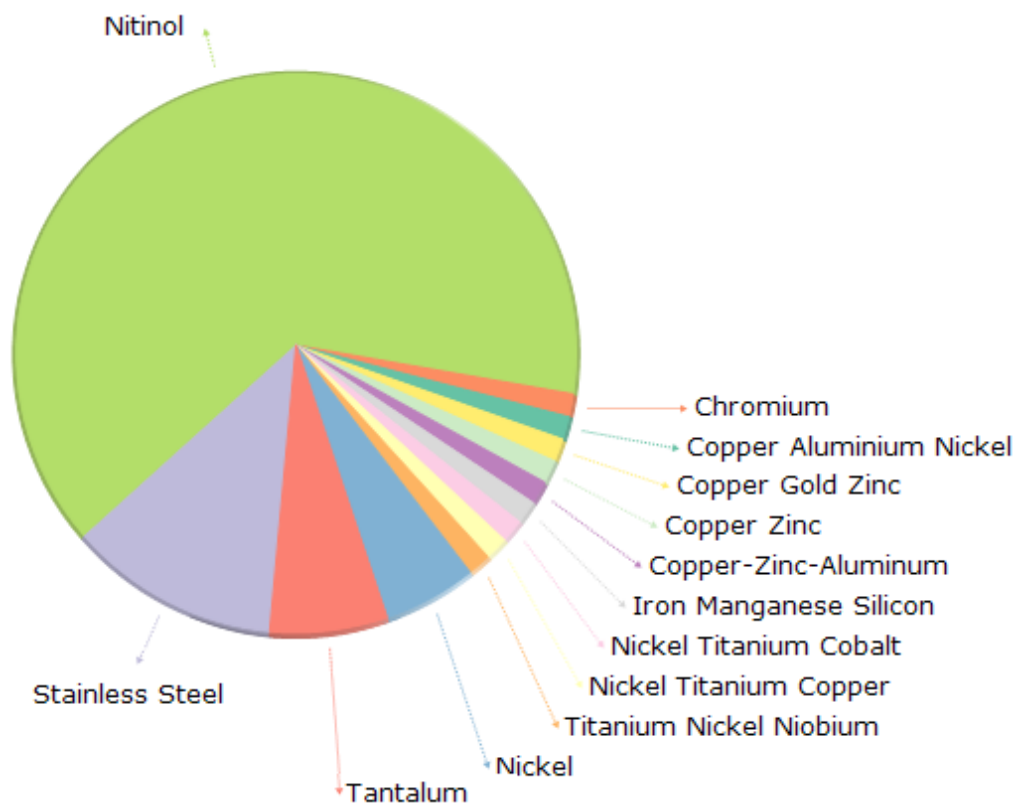
Shape Memory Alloy - GB Trends

Polymers

The pie chart shows research activity for various polymers in Britain
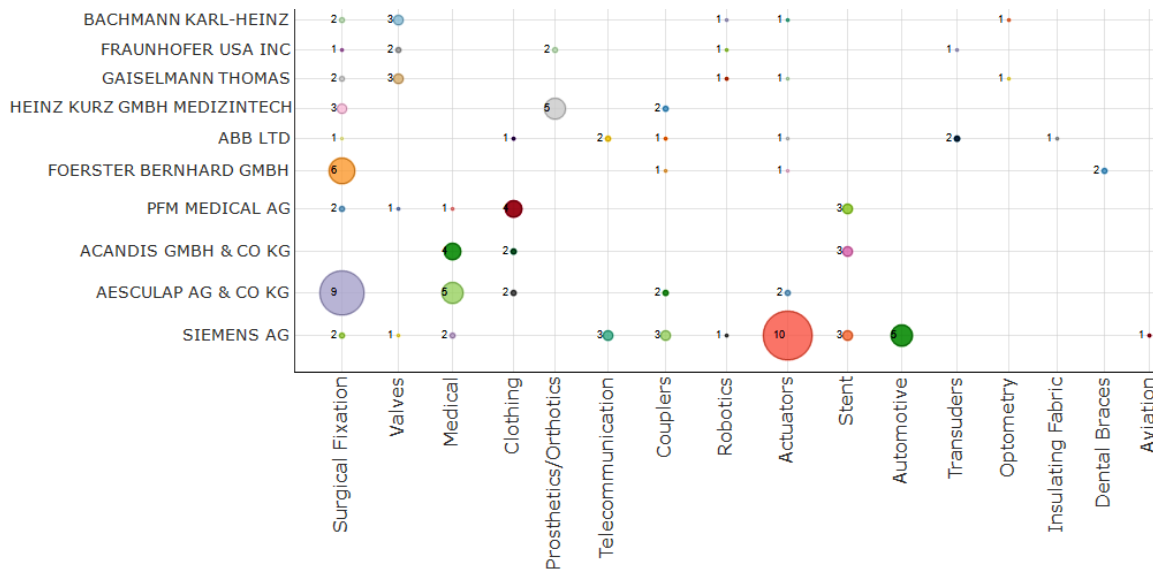

How we did it?

We selected GB as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for alloys first followed by polymers and the respective matrix was converted to a pie.

Shape Memory Alloy - GB Trends

Company across different applications

- The chart below shows which companies are conducting research activity across different applications of shape memory alloys
- Angiomed primarily focuses on medical applications such as stent and prosthetics
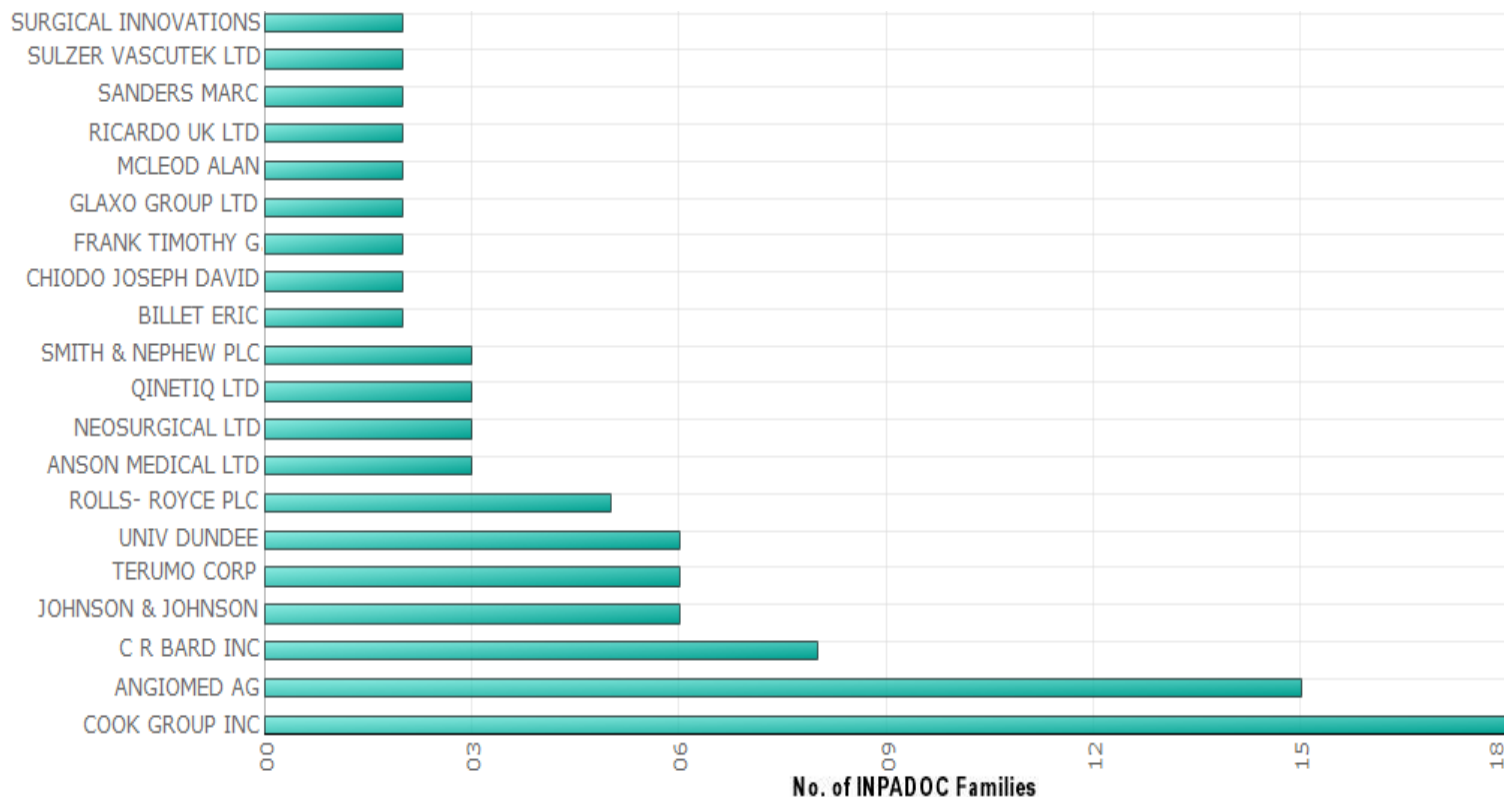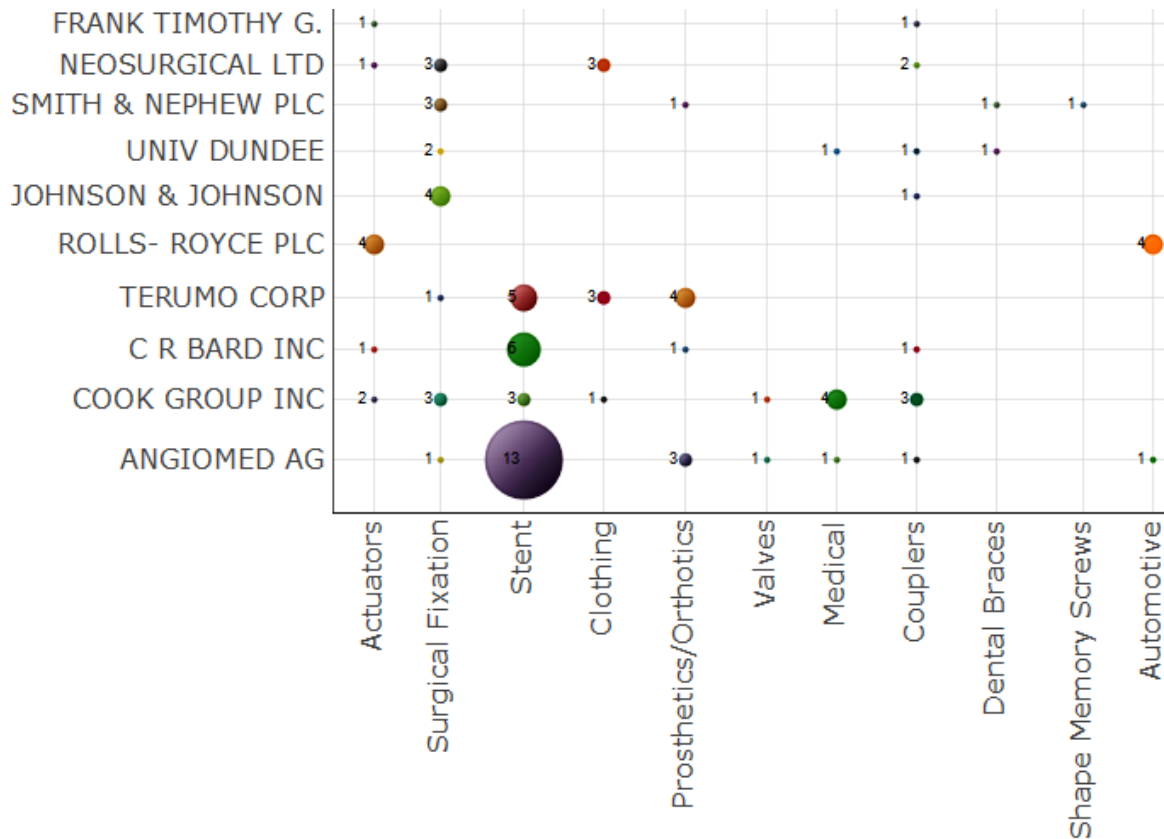

How we did it?

We selected GB as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for top 10 companies with respect to applications and generated matrix was converted into a bubble chart.

Shape Memory Alloy - JP Trends

Top Companies

- The chart shows top 20 companies for shape memory alloy in Japan
- Olympus has the maximum number of records

How we did it?

We applied filter for JP as the priority country from the options present within dashboard and then the chart for top assignees was generated on a single click using the assignees tab present.

Shape Memory Alloy - JP Trends

Alloys

The pie chart shows research activity for different alloys in Japan
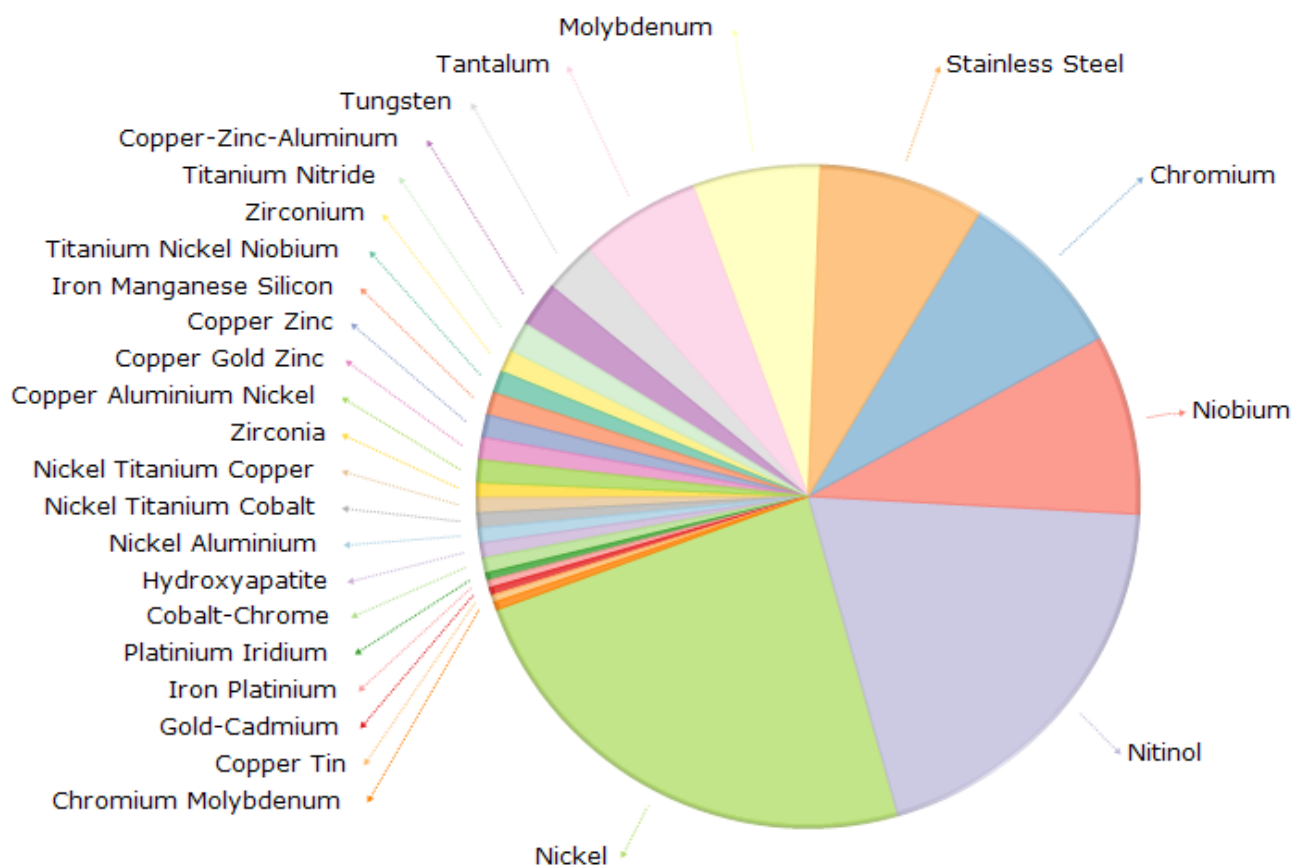
Shape Memory Alloy - JP Trends

Polymers

The pie chart shows research activity for various polymers in Japan
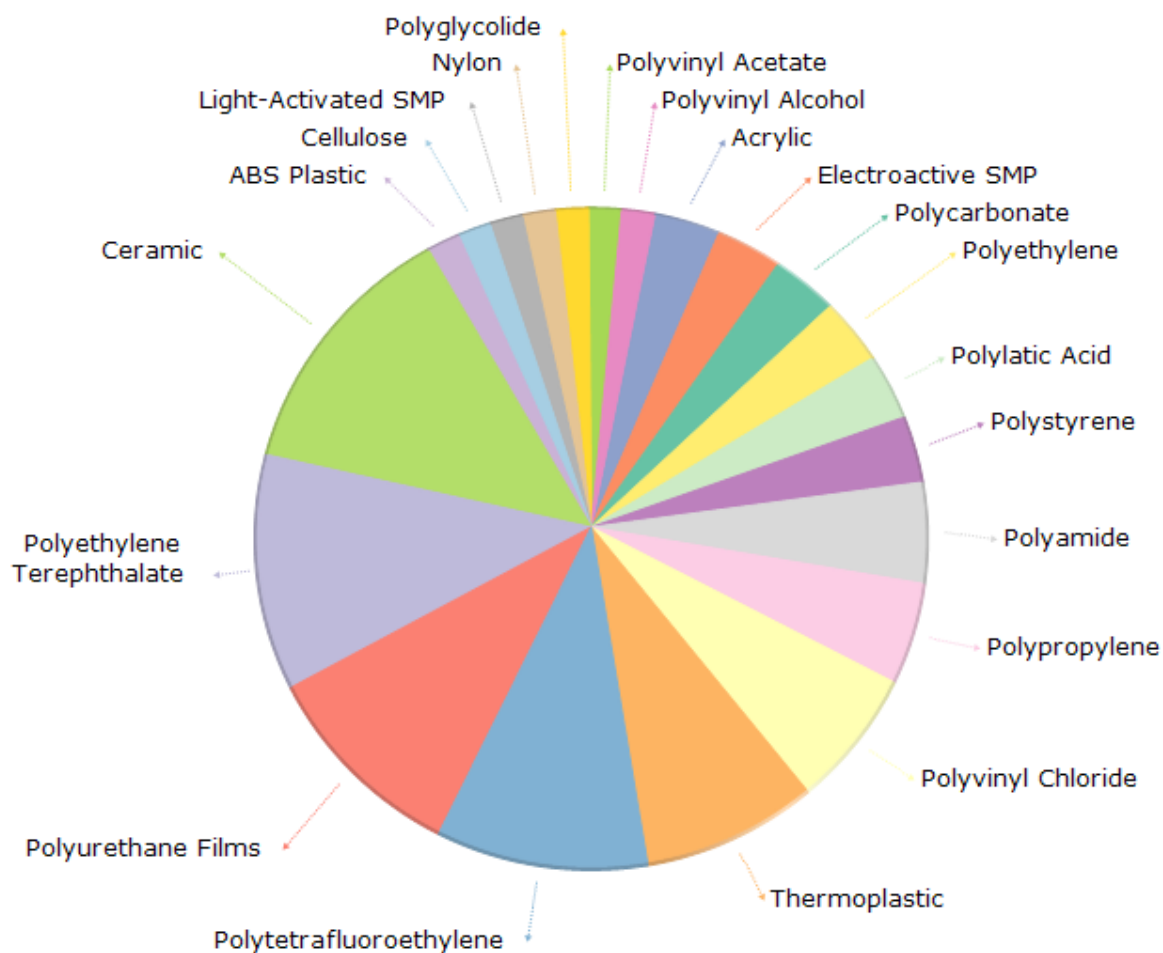
How we did it?

We selected JP as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for alloys first followed by polymers and the respective matrix was converted to a pie.

Shape Memory Alloy - JP Trends

Company across different applications

- The chart below shows which companies are conducting research activity across different applications of shape memory alloys
- Olympus leads the record count for actuators having applications in digital voice recorders
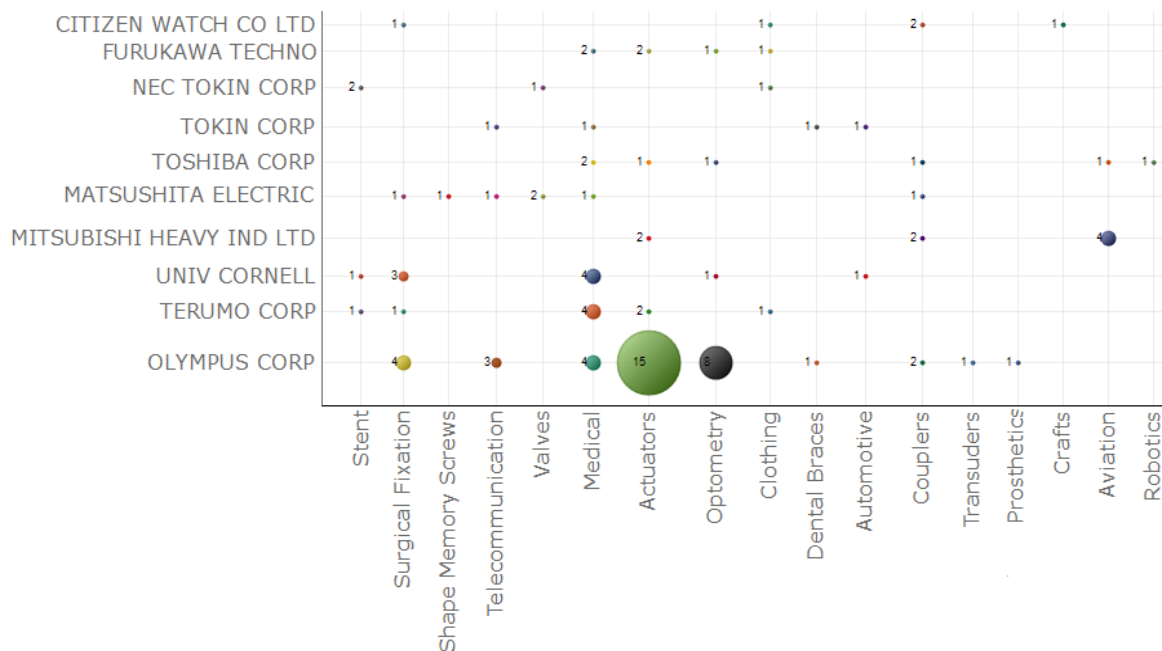
How we did it?

We selected JP as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for top 10 companies with respect to applications and generated matrix was converted into a bubble chart.

Shape Memory Alloy - FR Trends

Top Companies

- The chart shows top 20 companies in shape memory alloy
- Aerospatiale leads the record count and several of the top records holders in france are inventors
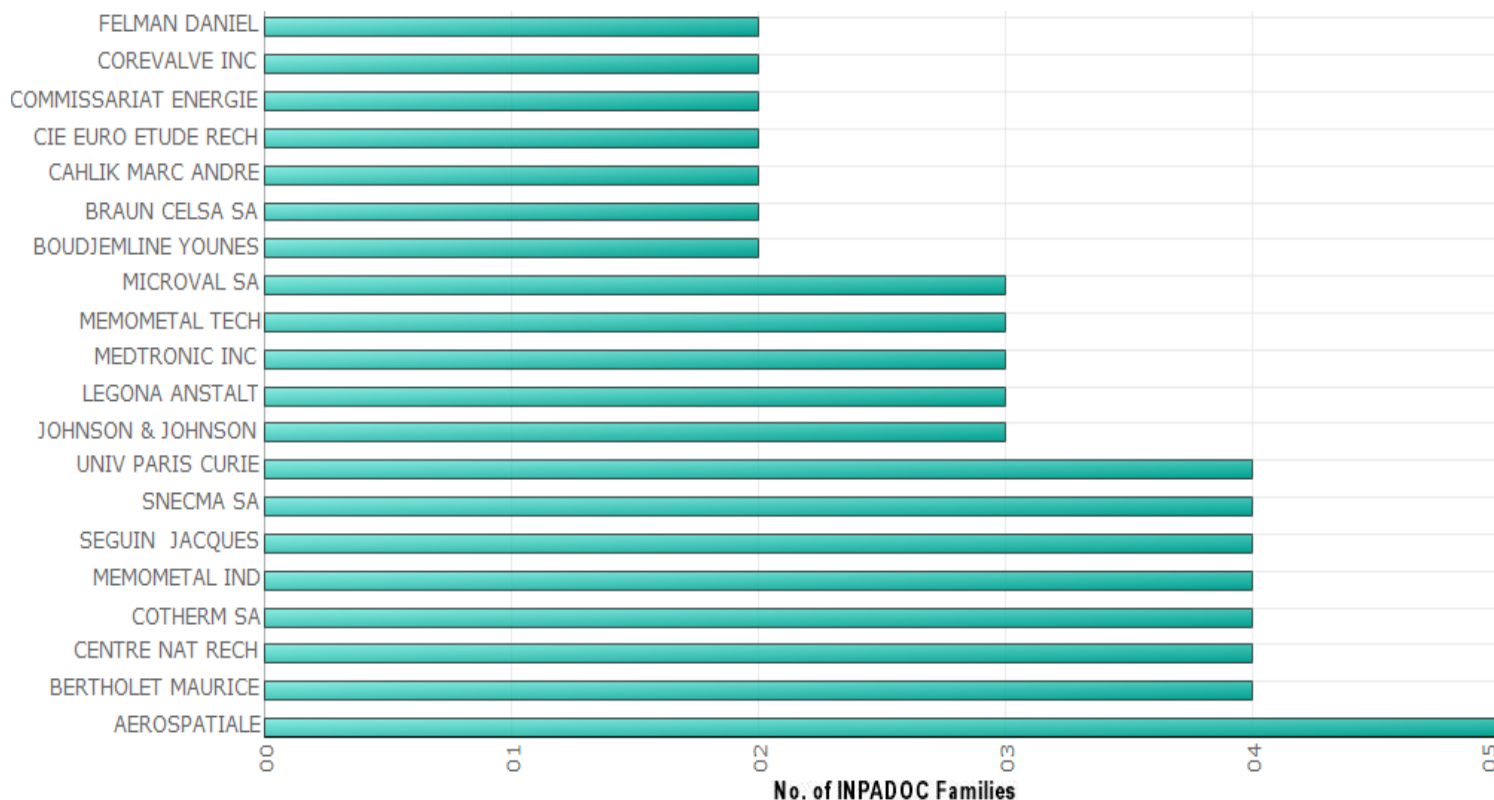
How we did it?

We applied filter for FR as the priority country from the options present within dashboard and then the chart for top assignees was generated on a single click using the assignees tab present.
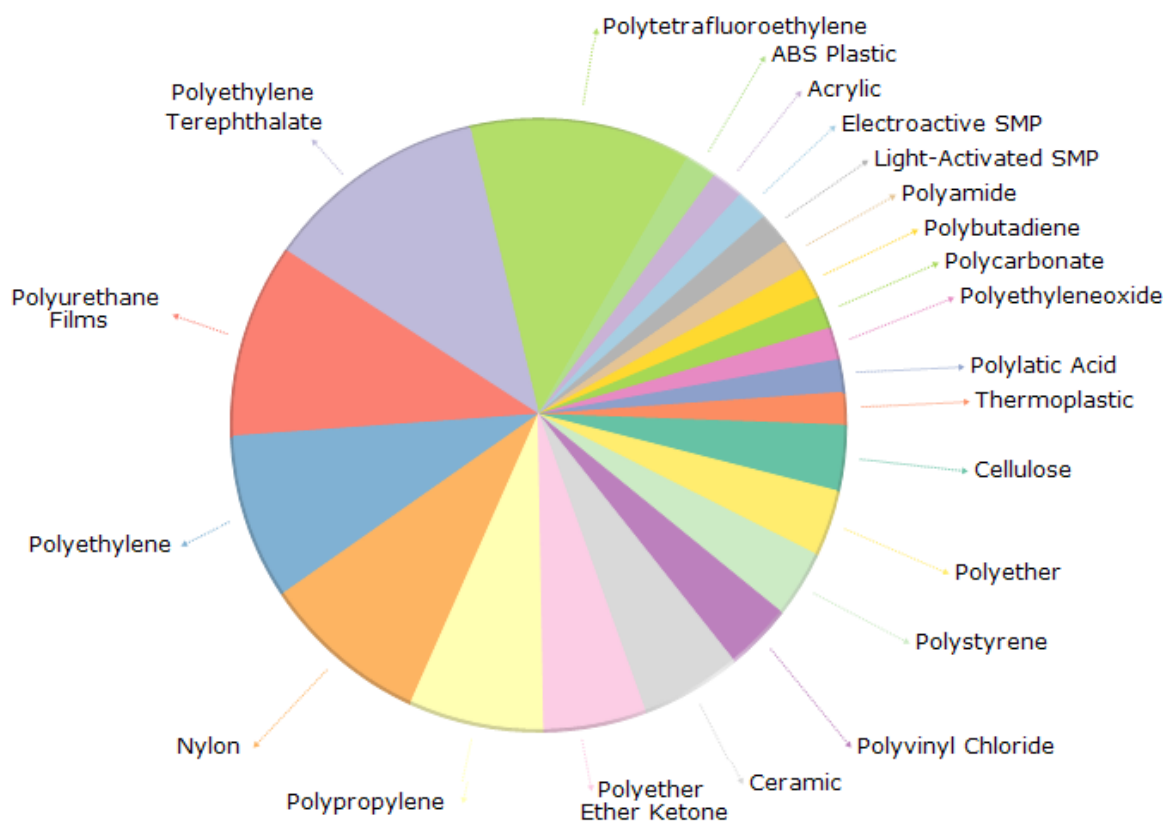
Shape Memory Alloy - FR Trends

Alloys

The pie chart shows research activity for different alloys in France
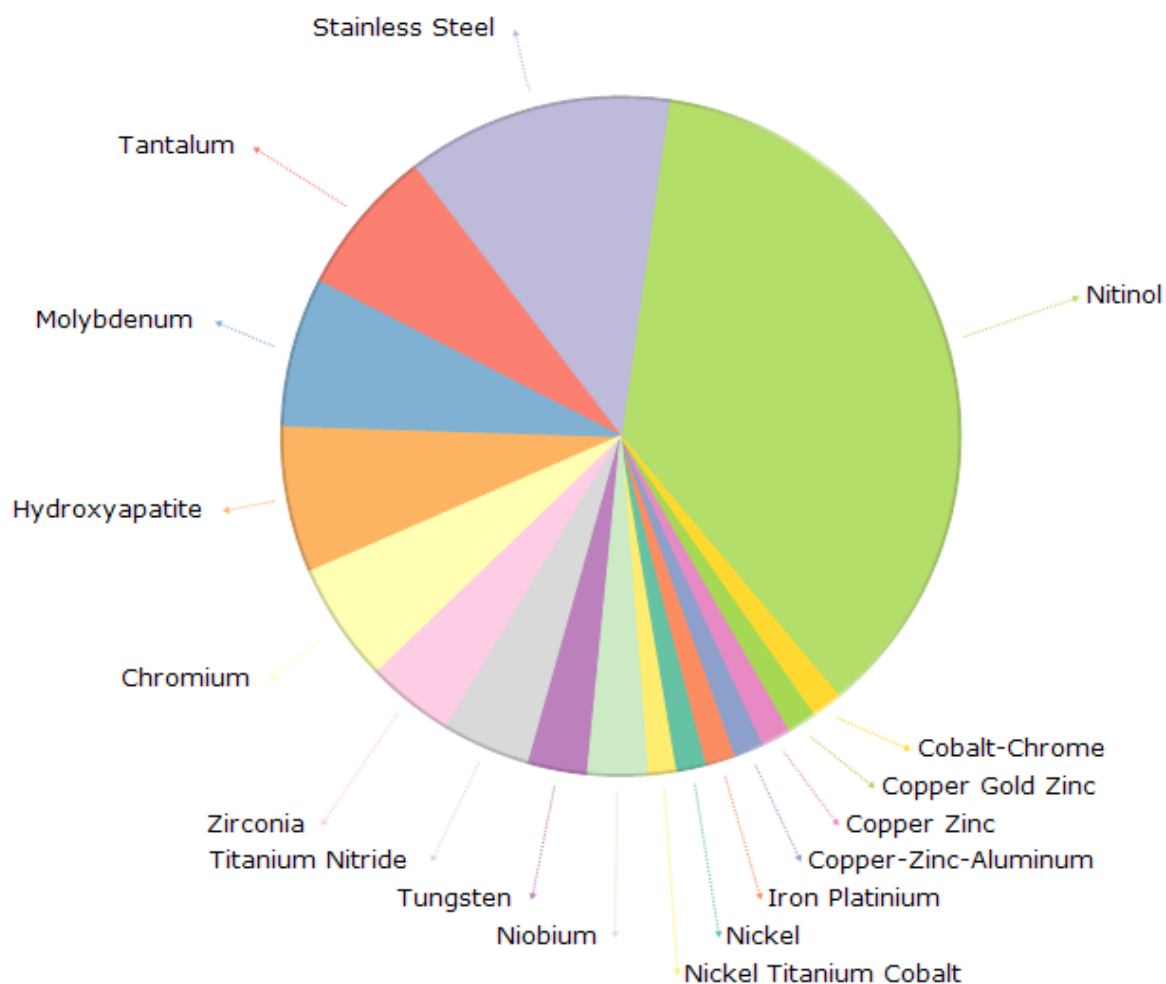
Polymers

The pie chart shows research activity for various polymers in France
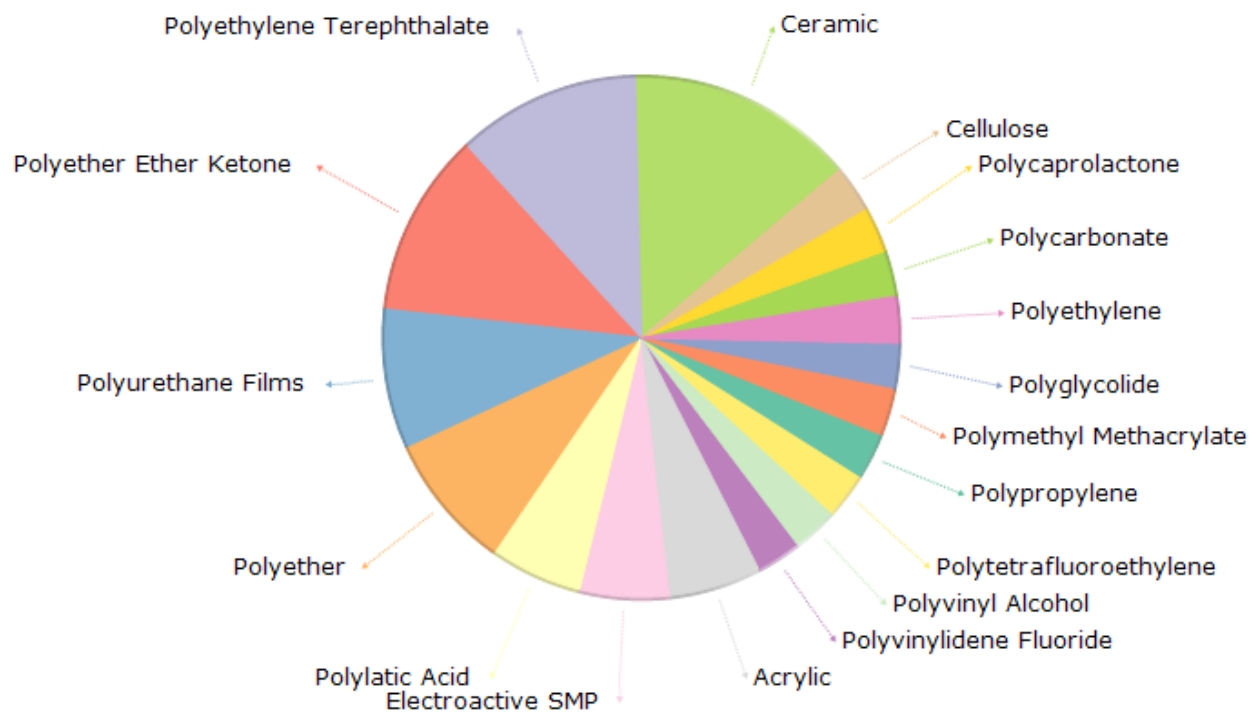
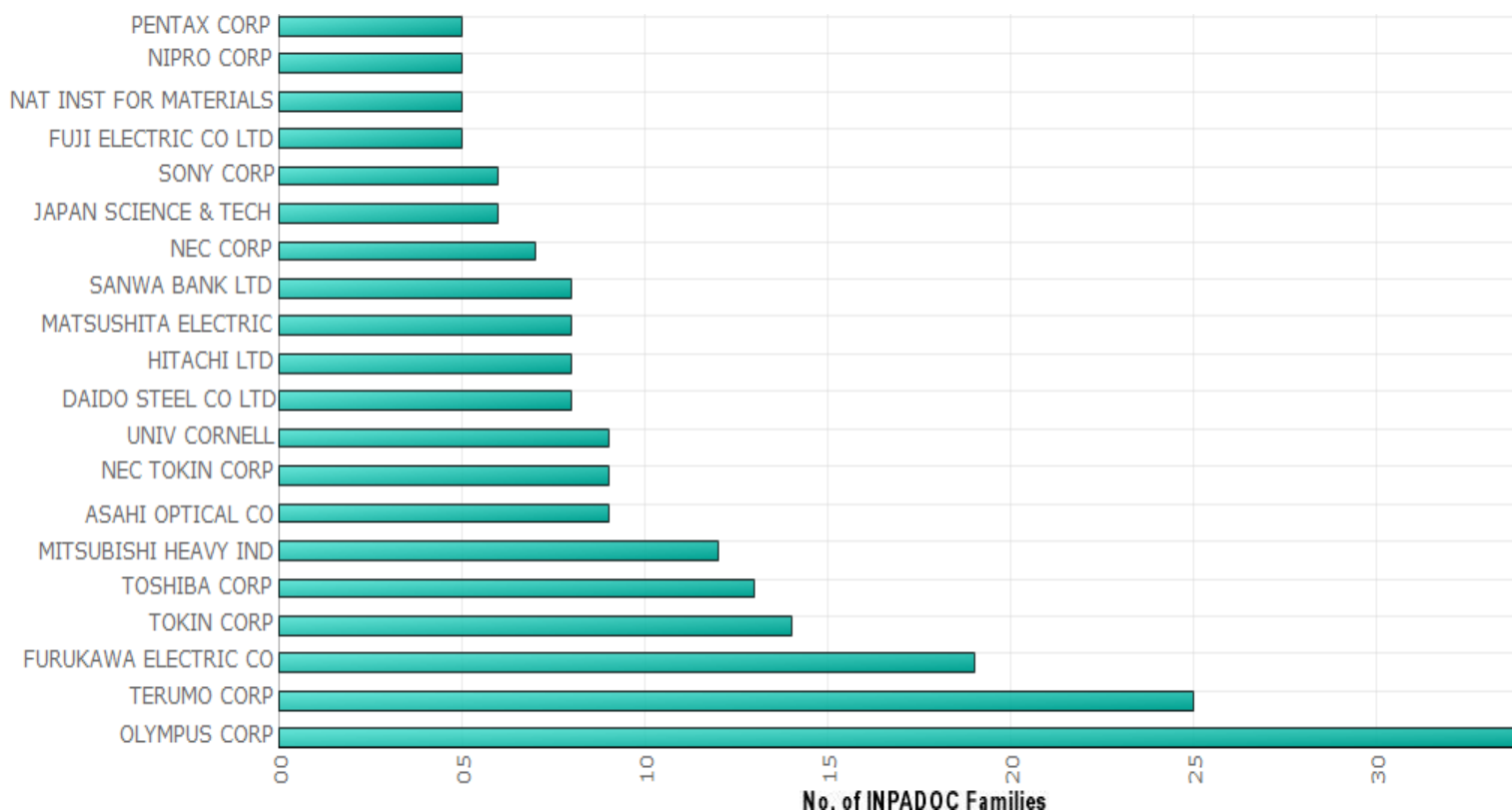*How we did it?*

We selected FR as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for alloys first followed by polymers and the respective matrix was converted to a pie.

Company across different applications

- The chart below shows which companies are conducting research activity across different applications of shape memory alloys
- Out of many inventors amongst the top 15 assignees, it can be seen Bertholet Maurice focuses mainly on medical applications (surgical fixation, prosthetics)

How we did it?

We selected FR as priority country from data filter option within Co-occurrence analyzer. A matrix was generated for top 15 companies with respect to applications and generated matrix was converted into a bubble chart.

# Appendix: Search Strings Used for Categorization And Class Definitions

Definitions of Classes referred to in search query

CPC:

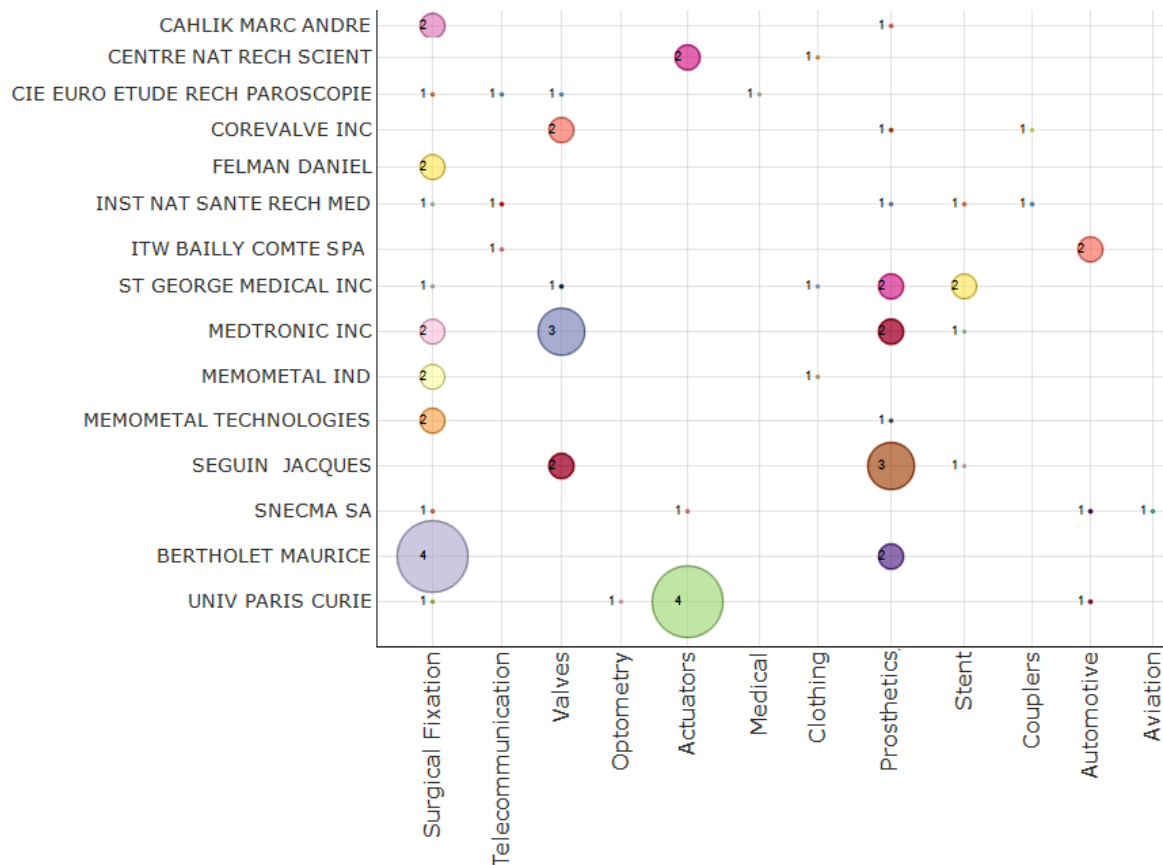| CPC	Description
A61B	DIAGNOSIS; SURGERY; IDENTIFICATION (analysing biological material)
A61C	DENTISTRY; APPARATUS OR METHODS FOR ORAL OR DENTAL HYGIENE
A61F	FILTERS IMPLANTABLE INTO BLOOD VESSELS; PROSTHESES, STENTS; ORTHOPAEDIC, NURSING OR CONTRACEPTIVE DEVICES; FOMENTATION; TREATMENT
A61M	DEVICES FOR INTRODUCING MEDIA INTO, OR ONTO, THE BODY.DEVICES FOR TRANSDUCING BODY MEDIA OR FOR TAKING MEDIA FROM THE BODY
A61L	METHODS OR APPARATUS FOR STERILISING(preservation of bodies or disinfecting characterised by the agent employed; preserving, e.g. sterilising, food or foodstuffs; preparations for medical, dental or toilet purposes)
B23B	TURNING; BORING (using an electrode which takes the place of a tool, e.g. making holes; working by laser beam; copying or controlling)
B25J	MANIPULATORS; CHAMBERS PROVIDED WITH MANIPULATION DEVICES(robotic devices for individually picking fruits, vegetables, hops or the like; needle manipulators for surgery; manipulators associated with rolling mills; manipulators associated with forging machines; means for holding wheels or parts thereof; cranes; arrangements for handling fuel or other materials which are used within nuclear reactors; structural combination of manipulators with cells or rooms shielded against radiation)
B32B	LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM
B63B	SHIPS OR OTHER WATERBORNE VESSELS; EQUIPMENT FOR SHIPPING (arrangements of vessel ventilation, heating, cooling, air-conditioning; floating substructures as supports of dredgers or soil-shifting machines)
B44C	PRODUCING DECORATIVE EFFECTS (processes for applying liquids or other fluent materials to surface)
A44B18	BUTTONS, PINS, BUCKLES, SLIDE FASTENERS, OR THE LIKE (fastenings specially adapted for footwear)
A44C27	Making jewellery or other personal adornments
A47J27	KITCHEN EQUIPMENT(domestic washing or cleaning A47L; refuse receptacles); COFFEE MILLS; SPICE MILLS; APPARATUS FOR MAKING BEVERAGES
C21D2201/01	Treatment for obtaining particular effects
F01P2070/02	COOLING OF MACHINES OR ENGINES IN GENERAL; COOLING OF INTERNAL-COMBUSTION ENGINES (arrangements in connection with cooling of propulsion units in vehicles ; heat-transfer, heat-exchange or heat-storage materials; (cooling of gas-turbine engines); heat exchange in general, radiators
F05C2251/08	INDEXING SCHEME RELATING TO MATERIALS, MATERIAL PROPERTIES OR MATERIAL CHARACTERISTICS FOR MACHINES, ENGINES OR PUMPS OTHER THAN NON-POSITIVE-DISPLACEMENT MACHINES OR ENGINES
F05B2280/5006	SCHEME RELATING TO MACHINES OR ENGINES OTHER THAN NON-POSITIVE-DISPLACEMENT MACHINES OR ENGINES, Materials; Properties thereof
F16B1/0014	Devices for securing together, or preventing relative movement between, constructional elements or machine parts
F16D	COUPLINGS FOR TRANSMITTING ROTATION; CLUTCHES; BRAKES
H01F1	Magnets or magnetic bodies characterised by the magnetic materials therefor; Selection of materials for their magnetic properties
H01H37/323	Making use of shape memory materials (in thermal relays; release mechanism; treatment of SMF alloys; in general; for control of temperature)
H01H61/0107	Electrothermal relay(making use of shape memory materials)
H01H71/145	Details of the protective switches or relays covered by groups(making use of shape memory materials)

US Classification:

US Class	Description
148/563	Mechanical memory (e.g., shape memory, heat-recoverable, etc.)
244/99.8	Actively deformable material (e.g., piezoelectric, shape memory, magnetostrictive, electrostrictive)
600/143	SURGERY(Having shape memory retaining material component)
600/151	Having temperature sensitive shape memory retaining material
600/206	Having flexible, malleable or shape memory material
600/207	Inflatable
600/208	Circular or eliptically shaped retracting surface
600/209	Unitary wire construction
606/78	SURGERY(Shape memory material)
604/95.05	SURGERY (Having remote control for applying light, electricity, or heat to alter conduit shape (e.g., shape memory alloy, etc.)
604/532	Shaped for cardiovascular system
604/531	SURGERY (Temperature activated)
604/530	SURGERY (With shape retaining memory)
623/1.18	PROSTHESIS (I.E.,ARTIFICIAL BODY MEMBERS), PARTS THEREOF, OR AIDS AND ACCESSORIES THEREFOR,Having shape memory
623/3.11	Including electrical or magnetic means adjacent to flexible diaphragm or chamber to effect contraction thereto (e.g., electromagnet, shape memory material, etc.)

IPC:

| IPC	Description
A61B	DIAGNOSIS; SURGERY; IDENTIFICATION(analyzing material)
H01R4/01	Electrically-conductive connections between two or more conductive members in direct contact(Connections using shape memory materials, e.g. shape memory metal)

Search Strings:

Applications

Application Area	Search Query	Results
Actuators	(TAC) contains (actuator* or actuater* or microactuator*)	657
Automotive	(TAC) contains (car or cars or vehicle* or automobile* or automotive* or bus or buses or engine* or (auto* w/2 part*) or motorcar* or autocar* or "steering wheel*" or pedals)	177
Aviation	(TAC) contains (aerospace* or aeronautic* or rocket* or spacecraft* or aircraft* or aviation* or helicopter* or "fighter jet" or helicoptor* or aeroplane* or airplane*)	36
Clothing	(TAC) contains (cloth* or dress or apparel* or fabric or fabrics or shirt* or t-shirt* or garment*)	514
Couplers	(TAC) contains (coupler* or coupling)	587
Crafts	(TAC) contains (bracelet* or necklace* or crafts or jwellery or jewel* or anklet*)	22
Damper	(TAC) contains (damper*)	15
Dental Braces	(TAC) contains (dental*)	94
Embolic Protection Filers	(TAC) contains (embolic* w/3 Filter*)	43
Insulating Fabric	(TAC) contains ((insulat* or thermal*) w/5 fabric* or (thermal* w/2 jacket*) or Insul-Fab or Temptrol)	5
Medical	(TAC) contains ((medic* or osteotomies or orthopaedic) and not (stent* or braces or brace or dental))	797
Optometry	(TAC) contains ((eyeglass* w/3 Frame*) or optometr* or ophthalmic* or optometrist* or "eye care" or vision or cornea* or short-sightedness or long-sightedness* or astigmatism* or presbyopia* or hyperopia* or myopia or intraocular* or lens*)	132
Prosthetic	(TAC) contains (prosthet* or orthotic* or prosthesis*)	475
Robotics	(TAC) contains (robot* or android or humanoid or "muscle wire" or (electroactive w/1polymer*) or ((vacuum or mechanical) w/3 gripper*))	65
Shape Memory Screws	(TAC) contains ((Shape* w/5 Screw*) or (Pedicle* w/1 Screw*))	54
Stent	(TAC) contains ((stent*) and not medic*)	756
Surgical Fixation	(TAC) contains ((surgical w/2 Fix*) or fracture* or bone* or ligament* or "skin tape" or sutur* or staples or clips or screw* or surger*)	1453
Telecommunication	(TAC) contains (telecommunicat* or "optical w/3 stabili*" or autofocus or mobile* or "fiber optic*" or "fibre optic*" or microwave* or antenna* or telephone*)	223
Transducers	(TAC) contains (transducer*)	117
Valves	(TAC) contains (microvalve* or valve*)	773

Alloys

Technologies	Search Query	Results
Chromium	(TAC) contains (chromium* or "Cr")	150
Chromium Molybdenum	(TAC) contains ("Chromium*-Molybdenum*" or "molybdenum* chrome*" or MoCr or "Chrome-Moly*" or "chrome-moly*" or "cro-moly" or CrMo or CRMO or CR-MOLY or chromoly or ((Chromium* or Chrome*) w/2 Moly*))	13
Cobalt-Chrome	(TAC) contains ("Cobalt-chrome*" or "cobalt-chromium*" or CoCr or "Cobalt* chrome*" or "cobalt* chromium*" or "Co-Cr" or (cobalt* w/2 chromium*))	128
Copper Aluminium Nickel	(TAC) contains ("copper-aluminum-nickel*" or "copper aluminum nickle*" or Cu-Al-Ni or CuAlNi or (copper* w/1 (nickle* or nickel*)) or "copper-aluminum-nickle" or "copper aluminum nickel")	82
Copper Gold Zinc	(TAC) contains ("copper-gold-zinc" or "copper gold zinc" or CuAuZn or "Cu-Au-Zn" or (copper w/1 zinc))	29
Copper Tin	(TAC) contains ("copper-tin" or "copper tin" or "tin bronzes" or CuSn or "Cu—Sn")	12
Copper Zinc	(TAC) contains ("copper-zinc" or brass or "copper* zinc*" or "zinc* copper*" or Cu—Zn or CuZn)	47
Copper Zinc Aluminium Nickel	(TAC) contains ("copper-zinc-aluminum-nickel" or "copper-zinc-aluminum-nickle" or "copper zinc aluminum nickel" or "copper zinc aluminum nickel" or CuZnAlNi)	12
Copper-Zinc-Aluminum	(TAC) contains ("copper-zinc-aluminum" or (copper w/1 aluminum*) or Cu-Zn-Al or CuZnAl or CuAlZn or AlCuZn or Cu-Au-Zn or CuAuZn or Al-Cu-Zn or "copper zinc* aluminum" or "copper aluminum zinc")	68
Gold-Cadmium	(TAC) contains ("gold-cadmium" or "gold cadmium" or "cadmium gold" or "cadmium-gold" or AuCd or Au-Cd or Au—Cd)	20
Hydroxyapatite	(TAC) contains (hydroxyapatite* or Hydroxylapatite*)	33
Indium Thallium	(TAC) contains ("indium–thallium" or "indium* thallium*" or InTi or InTl or In-Tl or In—Ti or (indium* w/1 thallium*))	7
Indium Titanuim	(TAC) contains ("indium-titanium" or "indium titanium" or InTi or In-Ti)	11
Iron Manganese Silicon	(TAC) contains (iron manganese silicon" or "iron – manganese – silicon" or "Fe-Mn-Si" or FeMnSi or "iron-manganese-silicon" or (iron* w/1 silicon*))	29
Iron Palladium	(TAC) contains ("iron-palladium" or "iron* palladium" or "iron - palladium" or (iron* w/1 palladium*))	6
Iron Platinium	(TAC) contains ("iron-platinum" or "Iron - platinum" or "iron platinum" or "iron* platinum" or FePt or Fe—Pt or (iron* w/1 platinum*))	24
Manganese Copper	(TAC) contains ("manganese-copper" or "manganese copper" or (manganese w/1 copper) or MnCu)	7
Molybdenum	(TAC) contains (molybdenum* or "Mo")	86
Nickel	(TAC) contains (nickel* or nickle* or Ni) and not (titanium or copper or manganese or gallium or aluminium or "nickel-titanium " or cobalt* or "nickel-cobalt-chromium-molybdenum" or "nickel-copper ")	146
Nickel Aluminium	(TAC) contains ("nickel-aluminum" or "nickle-aluminum" or "nickel* aluminum*" or "nickle* aluminum*" or NiAl or Ni-Al or ((nickel* or nickle*) w/1 aluminum*))	23
Nickel Titanium Cobalt	(TAC) contains ("nickel-titanium-cobalt" or "nickle-titanium-cobalt" or "nickel titanium cobalt" or "nickle titanium cobalt" or TiNiCo or Ti-Ni-Co or Ti-Co-Ni or (titanium w/1 cobalt))	16

Nickel Titanium Copper	(TAC) contains ("nickle titanium copper" or "nickel titanium copper" or "nickel-titanium-copper" or "nickle-titanium-copper" or Ti-Cu-Ni or TiNiCu or NiTiCu or Ni-Ti-Cu or (titanium w/1 copper))	24
Nickel Titanium Platium	(TAC) contains ("nickel titanium platinum" or "nickle titanium platinum" or "nickle-titanium-platinum" or "nickel-titanium-platinum" or NiTiPt or (titanium w/1 platinum))	23
Niobium	(TAC) contains (niobium* or columbium* or Nb or Cb)	100
Niobium Titanium	(TAC) contains ("Niobium-titanium" or "titanium-niobium" or "titanium - niobium" or "Niobium - titanium" or (niobium* w/1 titanium) or NbTi or Ti—Nb)	9
Nitinol	(TAC) contains ("Nickel-titanium" or "nickle-titanium" or nitinol* or "nickel* titanium*" or "nickle* titanium*" or ((nickel* or nickle*) w/1 titanium*) or Ti-Ni or TiNi or Ni—Ti or NiTi)	1769
Platinium Iridium	(TAC) contains ("platinum-iridium" or "platinum iridium" or PtIr)	30
Silver-Cadmium	(TAC) contains ("Silver-cadmium*" or "silver - cadmium*" or Ag-Cd or AgCd or "silver* cadmium*" or (silver* w/1 cadmium*)or silvercadmuim)	16
Stainless Steel	(TAC) contains ((stainless* or inox*) w/3 steel*)	760
Tantalum	(TAC) contains (Tantalum* or Ta or tantalium*)	239
Titanium Nickel Niobium	(TAC) contains ("titanium-nickel-niobium" or "titanium-nickle-niobium" or TiNiNb or Ni-Ti-Nb or NiTiNb or (titanium w/1 niobium))	15
Titanium Nitride	(TAC) contains ("titanium* nitride*" or TiN or Tinite or TiNite or TiN)	33
Tungsten	(TAC) contains (tungsten* or wolfram*)	126
Zirconia	(TAC) contains ("Cubic* zirconia" or "Zirconium dioxide*" or "ZrO 2" or zirconia or "Zirconium(IV) oxide*" or Baddeleyite)	15
Zirconium	(TAC) contains zirconium* or Zr)	35
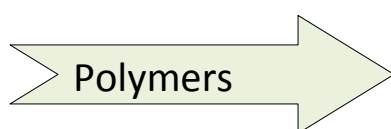
Polymers

| Materials	Search Query	Results
ABS Plastic	(TAC) contains ("Acrylonitrilebutadienestyrene" or ABS or (acrylonitrile* w/5 styrene*) or acrylonitrile*)	23
Acrylic	(TAC) contains (Acrylic* or (poly(methyl methacrylate)) or PMMA or methylmethacrylate* or Lucite* or Perspex* or Plexiglas)	78
Cellulose	(TAC) contains (cellulose*)	65
Ceramic	(TAC) contains (ceramic*)	197
Electroactive SMP	(TAC) contains ((Electro* w/4 (polymer* or nanocomposit*)) or electroactive*)	93
Fluorinated Ethylene Propylene	(TAC) contains ("fluorinated ethylene propylene*" or FEP or Neoflon or Daikin or Dyneon)	24
Light-Activated SMP	(TAC) contains ((Light* w/4 polymer*) or LASMP or "cinnamic acid" or "cinnamylidene acetic" or (Photo w/2 crosslink*))	13
Nylon	(TAC) contains (Nylon*)	126
Polyamide	(TAC) contains (polyamide* or "poly amide*" or "PA 6*" or "PA 66*")	114
Polyanhydride	(TAC) contains (polyanhydride* or "poly anhydride*")	42
Polybutadiene	(TAC) contains (Polybutadiene*)	5

Polycaprolactone	(TAC) contains (caprolactone* or "epsilon caprolactone*" or Polycaprolactone* or ((1,7)-polyoxepan-2-one) or "2-Oxepanone homopolymer" or "6-Caprolactone polymer" or "epsilon-caprolactone*" or PCL)	64
Polycarbonate	(TAC) contains (polycarbonate* or PC or Lexan or Makrolon or Makroclear or arcoPlus)	107
Polyether	(TAC) contains (Polyether* or "Polyphenyl ether*" or PPE or (Poly(p-phenylene oxide)) or "polyether* amide*" or "polyether ester*")	111
Polyether Ether Ketone	(TAC) contains ("Polyether ether ketone*" or PEEK or polyaryletherketone* or PAEK or "poly aryl ether ketone*" OR polyetheretherketone*)	75
Polyethylene	(TAC) contains (Polyethylene* or polythene* or polyethene* or poly(methylene)) and not (plastic or plastics or "Polyethylene Terephthalate*")	173
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)	306
Polyethyleneoxide	(TAC) contains (polyethyleneoxide or "polyethylene oxide" or PEO or polyoxyethylene or POE or poly(oxyethylene) or Carbowax or GoLYTELY or GlycoLax or Fortrans or TriLyte or Colyte or Halflytely or Macrogol or MiraLAX or MoviPrep)	24
Polyglycolide	(TAC) contains ("polyglycolic acid" or PGA or Polyglycolide* or (Poly[oxy(1-oxo-1,2-ethanediyl)]) or (poly(lactic-co-glycolic acid)))	85
Polyhydroxybutyrate	(TAC) contains (Polyhydroxybutyrate* or PHB or polyhydroxyalkanoate* or PHA or "poly-4-hydroxybutyrate*" or P4HB or polyhydroxyvalerate* or PHV or polyhydroxyhexanoate* or PHH or polyhydroxyoctanoate* or PHO or "poly-3-hydroxybutyrate*" or P3HB)	19
Polylatic Acid	(TAC) contains (Polylactic* or polylactide or "poly lactic acid*" or PLA)	97
Polymethyl Methacrylate	(TAC) contains (poly(methyl methacrylate) or PMMA or methylmethacrylate* or (Poly(methyl 2-methylpropenoate)) or "methyl methacrylate*" or Plexiglas or Acrylite or Lucite or Perspex)	31
Polynorbornene	(TAC) contains (polynorbornene*)	7
Polyphosphazene	(TAC) contains (polyphosphazene* or hexachlorocyclotriphosphazene* or poly(dichlorophosphazene))	22
Polypropylene	(TAC) contains (Polypropylene* or polypropene* or poly(propene) or Polipropene or "Propene polymer*" or "Propylene polymer*" or 1-Propene)	134
Polystyrene	(TAC) contains (polystyrene* or Poly(1-phenylethylene) or Thermocole*)	38
Polytetrafluoroethylene	(TAC) contains (Polytetrafluoroethylene or PTFE or poly(1,1,2,2-tetrafluoroethylene) or Syncolon or Fluon or Poly(tetrafluoroethene) or Poly(difluoromethylene) or Poly(tetrafluoroethylene) or ePTFE or teflon)	302
Polyurethane Films	(TAC) contains (Polyurethane* or "urethanes")	348
Polyvinyl Acetate	(TAC) contains ("Polyvinyl acetate*" or PVA or PVAc or poly(ethenylethanoate) or (poly (1-acetyloxiethene)))	19
Polyvinyl Alcohol	(TAC) contains ("Polyvinyl alcohol" or (PVOH or PVA or PVAl) or PVOH or Poly(Ethenol) or Ethenol or homopolymer or PVA or Polyviol or Vinol or Alvyl or Alkotex or Covol or Gelvatol or Lemol or Mowiol or "Kuraray Poval" or Mowiflex or Alcotex or Elvanol or Gelvatol or Gohsenol or Lemol or Mowiol or "Nelfilcon A" or Polyviol und Rhodoviol)	38
Polyvinyl Chloride	(TAC) contains (("Poly(vinyl chloride)" or PVC or Polychloroethylene* or "poly(1-chloroethylene)" or "polyvinyl* chloride*" or Polyvinylchlorid*) and not "porcine circovirus")	65

Polyvinylidene Fluoride	(TAC) contains ("Polyvinylidene* fluoride*" or "polyvinylidene difluoride*" or PVDF or (poly(1,1-difluoroethylene)) or "Polyvinylidene difluoride*" or (poly(vinylene fluoride)) or Kynar or Hylar or Solef or Sygef)	16
Thermoplastic	(TAC) contains (Thermoplastic* or "thermo plastic")	142

Summary

This report categorizes and graphically analyzes research trends around Shape Memory Alloys and the processes involved and applications from various perspectives and highlights the key companies involved.

Nitinol i.e. Nickel Titanium Alloy which is one of the major shape memory alloys has superelastic capability, and not always has to be enforced by heating .It absorbs stress and returns to its original form. Shape memory alloys (SMAs) belong to a class of shape memory materials (SMMs), which have the ability to 'memorise' or retain their previous form when subjected to certain stimulus such as thermomechanical or magnetic variations. SMAs have drawn significant attention and interest in recent years in a broad range of commercial applications (particularly medical, biomedical, robotics, automotive); due to their unique and superior properties; this commercial development has been supported by fundamental and applied research studies.
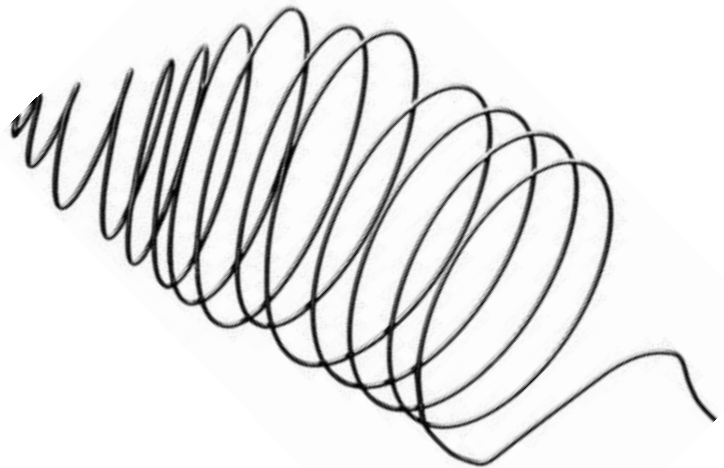
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Note: In combination with above links, we also referred some non patent literature