Technology Insight Report

Thin Film Batteries

Patent iNSIGHT Pro
Transform Patents to Intelligence

Thin film batteries are similar to lithium-ion batteries, but they are composed of thin materials, some only nanometers or micrometers thick, which allow the finished battery to be just millimeters thick. These have been developed and advanced for the most part of the last ten years.

These can be easily fabricated. They are flexible and non-breakable. Cells or batteries made from thin films can double up as building materials.

This report takes a look into the patenting activity around thin film batteries uncovering the key companies, inventors, and different sub categories.

Note: The original version of this report dated Jan 17th, 2013 was reviewed and corrected in July, 2013 based on feedback received from our readers. Specifically, the patent search strategy has been improved upon in this new version.

Introduction

These batteries consist of a substrate, electrolyte, current collector, anode, cathode, and a charge separator. There has been much research into the determination of the most effective components for this type of battery. It has been shown recently that even ordinary printer paper can be used as a charge separator and a substrate.

The term “thin film” is derived from the fact that the deposited films are of the order of a few micrometers in thickness compared with the 10 to 50 micrometers for thick film. Often, thin film conductors are plated to improve conductivity. Thin film has the advantages of tighter absolute and ratio tolerances and more environmentally stable components with lower noise and tighter TCR than thick film.

Thin-film printing technology is being used to apply solid-state lithium polymers to a variety of substrates to create unique batteries for specialized applications. Thin-film batteries can be deposited directly onto chips or chip packages in any shape or size

The basic distinction between thick film and thin film is the method of deposition of the metallization. In thick film, specially formulated pastes are applied and fired onto a substrate. The pastes are usually applied with a silk screen method and the substrate is of 96% alumina ceramic. Thin film technology is used wherever precision resistors are needed.

Overview

With the help of Patent iNSIGHT Pro, we will analyze the patent data around thin film batteries to find answers to the following:

- What does the IP publication trend for thin film batteries look like and how have the filings evolved?
- Who are the top companies or key players in thin film batteries and what are their technology wise trends?
- How is research in thin film batteries spread across different countries?
- What are the different deposition processes used by various companies?
- How are the companies spread across different types of substrates used?
- Who are the top companies across different applications of thin film batteries?
- What is the portfolio trend for unique companies in thin film batteries?
- How is research around Thin Film Batteries spread across prominent countries?

Search Strategy

Using the commercial patent database PatSeer as our data source we used the following search query to create our patent set.

TAC- Title, Abstract, Claims
TACD – Full Text
IC– International Class

TAC: ((thin* film*) w5 (batter* or cell or cells or (storage w3 (element* or devi?e*))))

AND NOT

TACD: (((photovoltaic* or photovotaic* or solar* or PV) w5 (cell* or batter* or (storage w3 (element* or devi?e*)))) or cellulose or photovoltaic* or photovotaic* or solar* or memory cell* or bone cell* or (solar w1 radiation) or ((flash or cellular) w2 material*) or (anti* w1 microbial) or (cell* w1 tral) or (cell* w1 (position or separat* or move* or movab*)))

AND NOT

IC: A61K*

Class Description

A61K: Preparations for medical, dental, or toilet purposes

- The query was directed to search through the title, abstract and claims and a patent set of 2631 records with one publication per family was generated.
- After reviewing few results esp. from older publications, we came across some similar but irrelevant terms from Medical compositions which we then excluded by ignoring patents falling in A61K classification.
- The publications included in the report are updated as of 26th July, 2013.

Patent Categorization

To get deeper insights the thin film battery record set was classified as follows:

By Deposition Processes

- Chemical Deposition
    a) Atomic Layer Deposition
    b) Chemical Solution Deposition
    c) Chemical Vapor Deposition
        i. Atmospheric Pressure CVD (APCVD)
        ii. Low Pressure CVD (LPCVD)
        iii. Metalorganic vapor phase epitaxy (MOCVD)
        iv. Ultra High Vacuum CVD (UHVCVD)
    d) Plasma Enhanced CVD
    e) Plating
    f) Spin Coating

- Physical Deposition
    a) Cathodic Arc Deposition
    b) Pulsed Laser Deposition
    c) Sputtering
    d) Thermal Evaporator
        i. Electron Beam Evaporator
        ii. Molecular Beam Epitaxy

By Substrate Types

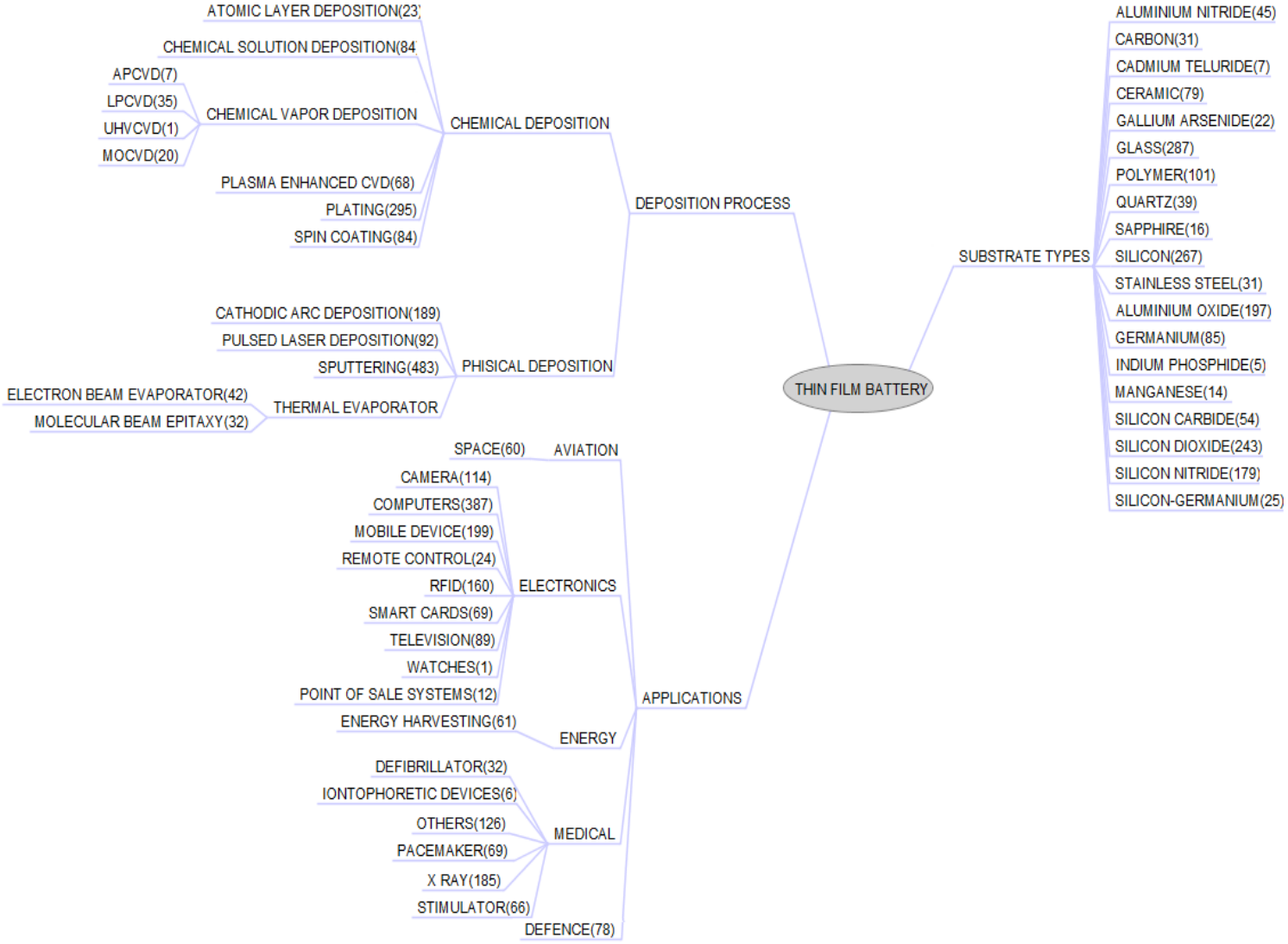
- Aluminium Nitride
- Aluminium Oxide
- Cadmium Telluride
- Carbon
- Ceramic
- Gallium Arsenide
- Germanium
- Glass
- Indium Phosphide
- Manganese
- Polymer
- Quartz
- Sapphire
- Silicon
- Silicon Carbide
- Silicon Dioxide
- Silicon Nitride
- Silicon-Germanium
- Stainless Steel

By Applications

- Aviation
    a) Space
- Defence
- Electronics
    a) Camera
    b) Computers
    c) Mobile Device
    d) Point of Sale Systems
    e) Remote Control
    f) RFID/Smart Packaging
    g) Smart Cards
    h) Television
    i) Watches
- Energy
    a) Energy Harvesting
- Medical
    a) Defibrillator
    b) Iontophoretic Devices
    c) Others
    d) Pacemaker
    e) Stimulator
    f) X Ray

The illustration below shows the different categories prepared and the number of records in each. 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.

Categorization Tree

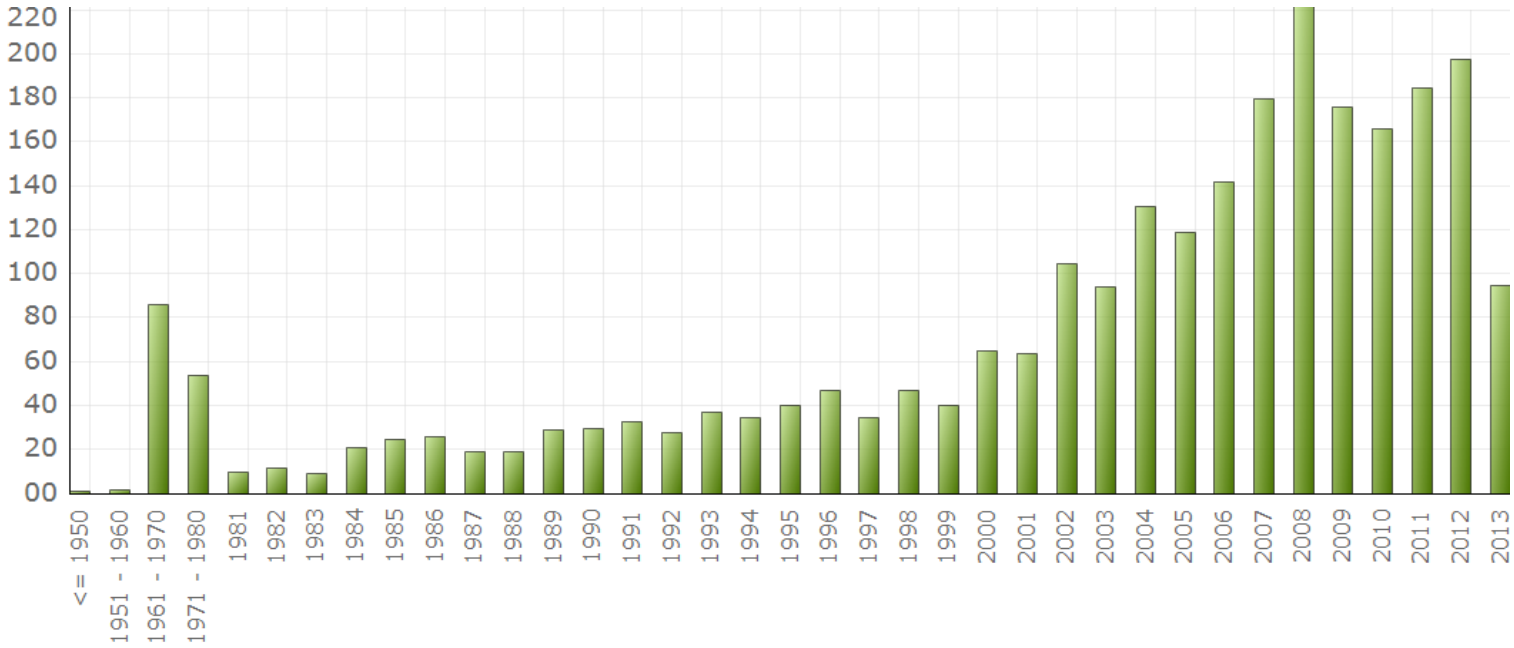


Publication Trend

What has been the IP publication trend for thin film batteries?

Patents related to thin film batteries can be traced back to before 1950 and the real surge in the activity around this technology has happened 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.

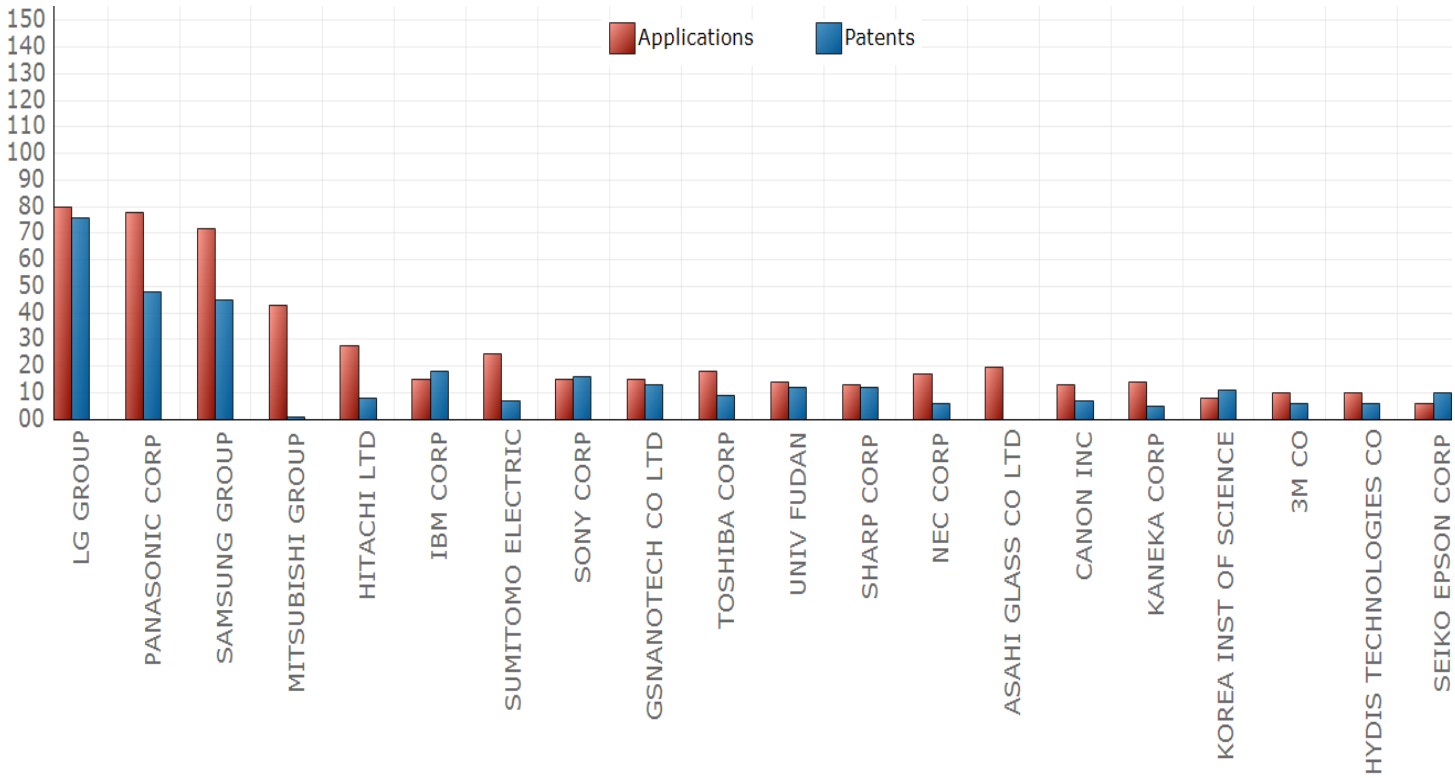


How we did it?

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

Who are the top companies within this industry?



The top companies are:

1. LG GROUP
2. PANASONIC CORP
3. SAMSUNG GROUP
4. MITSUBISHI GROUP
5. HITACHI LTD
6. IBM CORP
7. SUMITOMO ELECTRIC CO LTD
8. SONY CORP
9. GSNANOTECH CO LTD
10. TOSHIBA CORP
11. UNIV FUDAN
12. SHARP CORP
13. NEC CORP
14. ASAHI GLASS CO LTD
15. CANON INC
16. KANEKA CORP
17. KOREA INST OF SCIENCE & TECH
18. 3M CO
19. HYDIS TECHNOLOGIES CO LTD
20. SEIKO EPSON CORP

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:

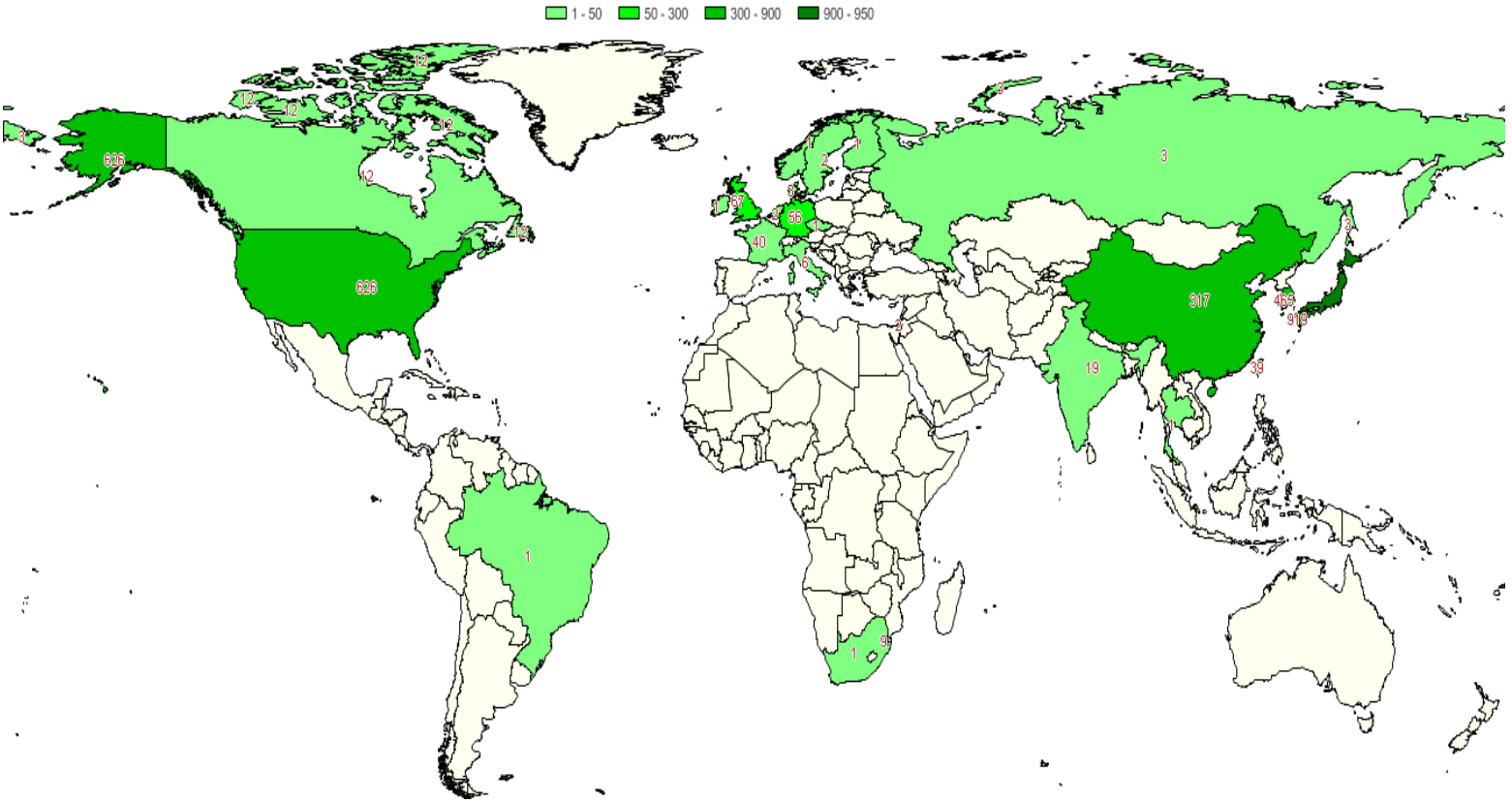
- To locate assignees for unassigned records
- To clean up records having multiple assignees
- To locate the correct assignee names for US records using the US assignments database
- To merge assignees that resulted from a merger or acquisition or name change.

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/0113/List%20of%20Assignees.xls

Top Countries

How is research around thin film batteries spread across different countries?

In terms of regional pockets where patent protection is being sought most frequently for these technologies, JP leads the count, followed by the US and KR. The table below ranks top priority countries and helps provide an indication of where innovation in this area is originating:



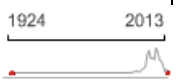
Country Code	Total
JP	919
US	626
KR	465
CN	317
GB	67

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, Top Co-Assignees and Coverage of underlying patent families

Assignees	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	FR	CN	GB	KR
LG GROUP	156 (5.9%)	2.06		1993-2012	SONG HONG SEONG(6) LEE HAN SANG(5) AHN TAE JOON(4) JANG YONG HO(4) PARK KWANG SOON(4)	HA JEONG-MIN(1) JIN SUN-MI(1) KIM KEE-YOUNG(1) KIM NO-MA(1) KNU INDUSTRY COOPERATION FOUND(1)	89	9	7	31	7	5	45	5	144
PANASONIC CORP	126 (4.8%)	2.78		1968-2011	TARUI HASAKI(21) YAGI HIROMASA(19) SAYAMA KATSUNOBU(15) FUJITANI SHIN(15) FUJIMOTO MASAHISA(12)	MITSUBISHI GROUP(6)	56	20	28	105	7	1	41	1	16
SAMSUNG GROUP	117 (4.4%)	3.43		1994-2012	GIL JAE-HYOUNG(5) JANG JAE-HYUK(5) PARK YOUNG-SIN(4) PARK JIN WOO(3) BAE BYUNG-	KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY(1)	87	18	4	49	10	1	37	1	101

					SEONG(3)										
MITSUBISHI GROUP	44 (1.7%)	2.98		1980-2011	TAKEHARA MASAHIRO(6) JINNO MARUO(5) TAMURA NOBUYUKI(5) HIDAKA HIDETO(4) TOKIOKA HIDETADA(3)	PANASONIC CORP(6) KONDO MICHIO(1) NAT INST OF ADVANCED IND SCIEN(1) RENESAS TECH CORP(1)	18	7	7	39	7	0	13	0	8
HITACHI LTD	36 (1.4%)	7		1976-2008	KUDOU TETSUICHI(12) MIYAUCHI KATSUMI(12) KANEBORI KEIICHI(9) ITO YUKIO(5) KIRINO FUMIYOSHI(3)	SHOWA DENKO KK(2) HITACHI MAXELL LTD(1)	8	4	0	35	3	0	2	0	2
IBM CORP	36 (1.4%)	0.97		1960-2009	BREITWISCH MATTHEW(4) NOWAK EDWARD J(4) MIDDELHOEK SIMON(2) PARKER MICHAEL A(1) UEBUSUTAA YUUJIN HAWAADO(1)	No Co-Assignee Present	26	6	1	9	22	10	2	20	2
SUMITOMO ELECTRIC CO LTD	32 (1.2%)	1.12		1982-2008	EMURA KATSUJI(21) YOSHIDA KENTARO(	RES INST INNOVATIVE TECH EARTH(2) JAPAN FINE	6	6	2	31	2	0	4	0	4

					14) MITSUYASU OGAWA(12) KAMIMURA TAKU(11) AWATA HIDEAKI(10)	CERAMICS CENTER(1) JAPAN INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER(1)									
SONY CORP	31 (1.2%)	0.68		1989-2011	FURUYA TATSUYA(6) MORIOKA HIROYUKI(5) TAKAHARA KATSUNORI(5) SATOBI YUICHI(3) AKASHI HIROYUKI(2)	No Co-Assignee Present	21	12	10	27	2	0	21	0	12
GSNANOTECH CO LTD	28 (1.1%)	0		2007-2012	NAM SANG CHEOL(18) PARK HO YOUNG(14) LEE KI CHANG(13) KIM SOO HO(8) PARK GI BACK(8)	AGENCY FOR DEFENSE DEVELOPMENT(1) NAM SANG-CHEOL(1)	4	0	7	2	0	0	0	0	25
TOSHIBA CORP	27 (1%)	6.7		1964-2010	IKEDA MITSUSHI(2) AKASAKA YOSHIHIRO(2) OZU HIDEYUKI(2) KAWAKUBO TAKASHI(2) KOGANEZ	No Co-Assignee Present	14	3	3	21	3	0	5	1	8

					AWA SHINJI(1)											
UNIV FUDAN	26 (1%)	0.15		2003-2012	FU ZHENGWEN(15) QIN QIZONG(4) MINGZHE XUE(4) LIU WENYUAN(2) CHILIN LI(2)	No Co-Assignee Present	0	0	0	0	0	0	26	0	0
SHARP CORP	25 (1%)	11.96		1981-2012	OOTA KENJI(4) TAKAHASHI AKIRA(4) YAMAOKA HIDEYOSHI(3) AWANE KATUNOBU(2) FUJIMORI KOHICHI(2)	ANGSTROM TECHN PARTNERSHIP(1) NAT INST OF ADVANCED IND SCIEN(1) NEC CORP(1) STANLEY ELECTRIC CO LTD(1)	13	3	6	18	2	0	4	1	3
NEC CORP	23 (0.9%)	1.91		1981-2003	YOKOYAMA HIROYUKI(3) USUI MASAYUKI(2) URAI HARUO(2) FUKUDA JUNICHI(2) OOKUBO HIROAKI(1)	ANGSTROM TECHN PARTNERSHIP(1) NAT INST OF ADVANCED IND SCIEN(1) SHARP CORP(1) UNIV WASEDA(1)	8	2	0	23	2	0	1	0	4

ASAHI GLASS CO LTD	20 (0.8%)	1.85		1978-1996	ARAKAWA TATSUMI(11) KOBAYASHI HIDEHIKO(7) KIMURA MUNEAKI(7) MASUKAWA YUKIHISA(6) OZAKI MASARU(5)	No Co-Assignee Present	0	0	0	20	0	0	0	0	0
CANON INC	20 (0.8%)	4.5		1983-2007	MORISHITA MASAKAZU(2) ENDO TADAO(2) KOBAYASHI ISAO(2) SHIMADA TETSUYA(2) INOUE HITOSHI(2)	No Co-Assignee Present	8	6	2	17	4	0	3	0	2

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
NAM SANG CHEOL	25 (1%)	0.32		2000-2011	GSNANOTECH CO LTD(18) NURICELL INC(3) AGENCY FOR DEFENSE DEVELOPMENT(2) KOREA INST OF SCIENCE & TECH(2) LG GROUP(1)	LEE KI CHANG(16) PARK HO YOUNG(16) LIM YOUNG CHANG(9) PARK GI BACK(9) HWANG HOSUNG(7)
EMURA KATSUJI	21 (0.8%)	0.67		2005-2007	SUMITOMO ELECTRIC CO LTD(21) RES INST INNOVATIVE TECH EARTH(2)	YOSHIDA KENTARO(13) MITSUYASU OGAWA(12) KAMIMURA TAKU(9) AWATA HIDEAKI(8) IKUTA RIKIZO(5)
TARUI HASAKI	21 (0.8%)	4		2000-2006	PANASONIC CORP(21)	YAGI HIROMASA(12) FUJITANI SHIN(10) DOMOTO YOICHI(9) FUJIMOTO MASAHISA(9) OSHITA RYUJI(7)
YAGI HIROMASA	19 (0.7%)	3.42		2000-2006	PANASONIC CORP(19)	TARUI HASAKI(12) FUJIMOTO MASAHISA(8) FUJITANI SHIN(8) DOMOTO YOICHI(7) IKEDA HIROAKI(7)
PARK HO YOUNG	18 (0.7%)	0		2005-2012	GSNANOTECH CO LTD(14) AGENCY FOR DEFENSE DEVELOPMENT(2) GS CALTEX CORP(2) PARK HO-YOUNG(1) NURICELL INC(1)	NAM SANG CHEOL(16) LEE KI CHANG(14) PARK GI BACK(9) HWANG HOSUNG(7) LIM YOUNG CHANG(7)

FU ZHENGWEN	16 (0.6%)	0.25		2003-2010	UNIV FUDAN(15) INST OF ELECTRONIC ENGINEERING(1)	MINGZHE XUE(4) QIN QIZONG(3) CHILIN LI(2) YONGNING ZHOU(2) FANMING MENG(1)
LEE KI CHANG	16 (0.6%)	0		2005-2011	GSNANOTECH CO LTD(13) AGENCY FOR DEFENSE DEVELOPMENT(2) NURICELL INC(2)	NAM SANG CHEOL(16) PARK HO YOUNG(14) PARK GI BACK(9) LIM YOUNG CHANG(8) HWANG HOSUNG(7)
NEUDECKER BERND J	16 (0.6%)	7.56		1998-2010	INFINITE POWER SOLUTIONS INC(12) ITN ENERGY SYSTEMS INC(2) LOCKHEED MARTIN(2)	SNYDER SHAWN W(8) BRANTNER PAUL C(3) ARMSTRONG JOSEPH H(2) BATES JOHN B(2) BENSON MARTIN H(2)
BATES JOHN B	15 (0.6%)	18.53		1994-2006	OAK RIDGE MICRO ENERGY INC. A NEVADA CORPORATION(5) MARTIN MARIETTA ENERGY SYSTEMS(3) LOCKHEED MARTIN(2) JOHNSON RES & DEV CO INC(2) FUTURE SCIENCE RES INST LTD(1)	DUDNEY NANCY J(3) NEUDECKER BERND J(2) WEATHERSPOON KIM A(1)
FUJITANI SHIN	15 (0.6%)	3.27		2000-2006	PANASONIC CORP(15) MITSUBISHI GROUP(2)	FUJIMOTO MASAHISA(12) TARUI HASAKI(10) DOMOTO YOICHI(9) OSHITA RYUJI(9) YAGI HIROMASA(8)
NIEH KAI-WEI	15 (0.6%)	3.4		2000-2011	FRONT EDGE TECHNOLOGY INC(15) NIEH KAI-WEI(3) KRASNOV VICTOR(1) TING SU JEN(1) SHIH TUNG-HSIU(1)	KRASNOV VICTOR(9) LI JIANCHAO(4) SHIH TUNG-HSIU(3) TING SU-JEN(3) CHANG FAN-HSIU(2)

SAYAMA KATSUNOBU	15 (0.6%)	3.53		2000-2007	PANASONIC CORP(15)	HIRASE MASAKI(10) KOBAYASHI KEI(8) CHITO DAIZO(7) YAGI HIROMASA(7) TARUI HASAKI(5)
YOSHIDA KENTARO	14 (0.5%)	0.64		2005-2008	SUMITOMO ELECTRIC CO LTD(14) RES INST INNOVATIVE TECH EARTH(2)	EMURA KATSUJI(13) AWATA HIDEAKI(8) KAMIMURA TAKU(5) MITSUYASU OGAWA(5) MIZUNO OSAMU(5)
BABA MAMORU	13 (0.5%)	3.54		2002-2010	GEOMATEC CO LTD(8) UNIV IWATE(7) BABA MAMORU(2) JAPAN SCIENCE & TECH AGENCY(2) TOMOYOSE KAZU(1)	SANO KIMIHIRO(8) NAKAZAWA HIROMI(7) ABE TAKASHI(2) KUMAGAI NAOAKI(2) TOMOYOSE KAZU(2)
FUJIMOTO MASAHISA	12 (0.5%)	3.33		2000-2006	PANASONIC CORP(12)	FUJITANI SHIN(12) TARUI HASAKI(9) DOMOTO YOICHI(8) OSHITA RYUJI(8) YAGI HIROMASA(8)

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.

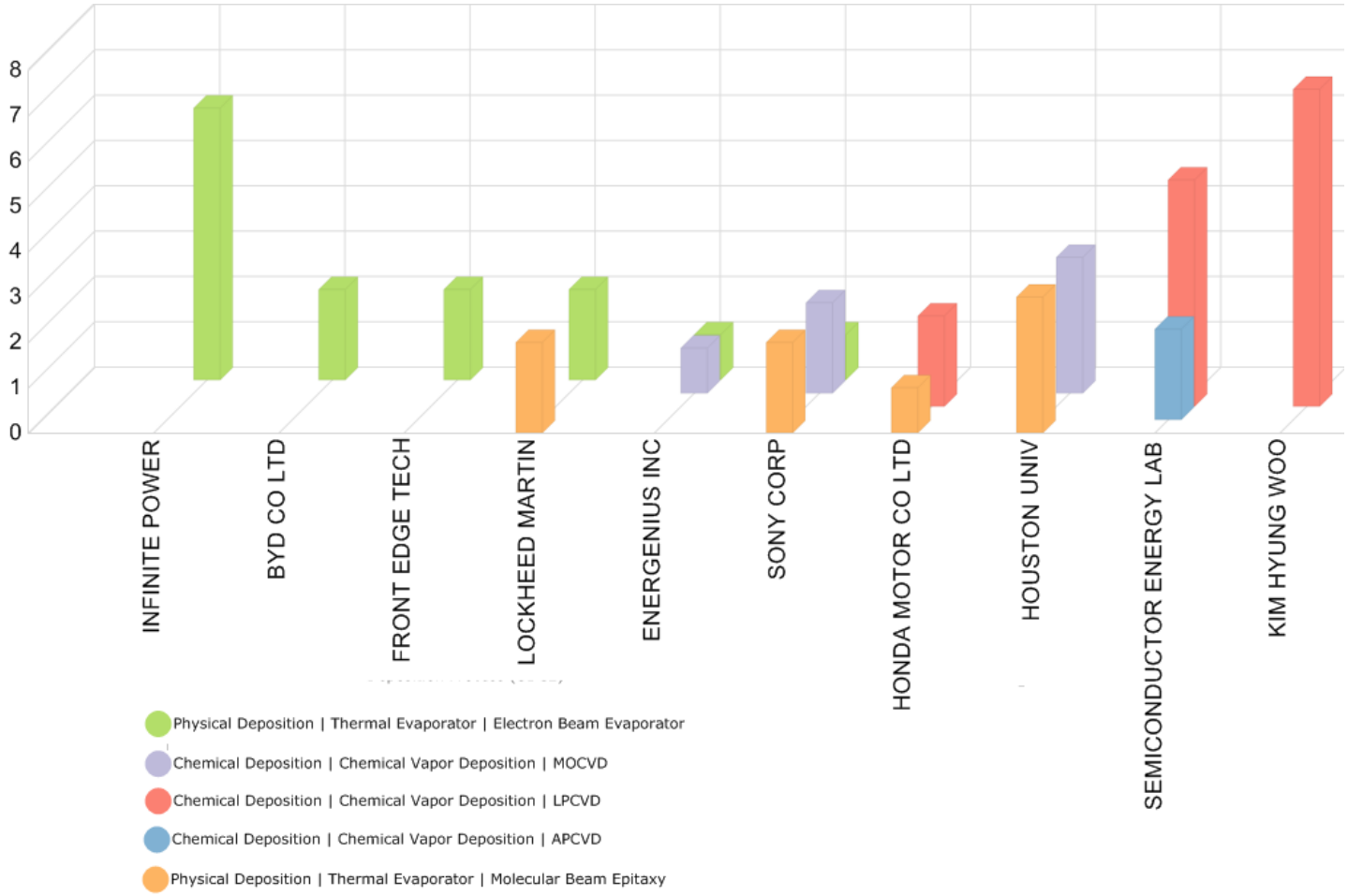
Thin Film Batteries: Deposition Processes vs Companies

What are the different deposition processes used by various companies?

In the below matrix leading patent holdings with each deposition process have been highlighted with stronger shades of green for large number of patents within that category. Samsung Group is active across Plasma Enhanced CVD and Sputtering deposition process

Deposition Process (Row) / Key Companies (Column)	Total	Chemical Deposition							Physical Deposition				
		Chemical Deposition	Spin Coating	Plating	Plasma Enhanced CVD	Chemical Vapor Deposition	Chemical Solution Deposition	Atomic Layer Deposition	Physical Deposition	Sputtering	Cathodic Arc Deposition	Pulsed Laser Deposition	Thermal Evaporator
Total	216	123	28	77	22	8	14	3	182	152	48	28	16
PANASONIC CORP	49	34	4	30					42	37	12	4	2
UNIV FUDAN	23	11		11			1		20	13	1	7	1
SAMSUNG GROUP	21	10	2	2	5			1	17	13	7	1	1
FRONT EDGE TECHNOLOGY INC	14	11		11	1				13	13	1	2	2
LG GROUP	13	7	2		5				11	10	1		
HITACHI LTD	13	3	1	2					10	8	2	1	
SONY CORP	11	10	1	8	1	2	3		9	8	4	5	3
ULVAC CORP	10								10	10			
KOREA INST OF SCIENCE & TECH	10	5	2	1	1	1	5	1	9	7	2	4	
APPLIED MATERIALS INC	10	6		2	3		2	1	7	5	2	3	
SHARP CORP	9	5	5						5	4	1		1
SEMICONDUCTOR ENERGY LAB CO LTD	9	7	3	4		5			8	8	5	1	
SEIKO EPSON CORP	8	3	2	1					7	5	5		
INFINITE POWER SOLUTIONS INC	8	7	6	1	6		3		8	8	2		6
IBM CORP	8	4		4					6	3	3		

The chart below shows top 10 companies across different sub level deposition process. It can be seen Lockheed Martin is doing research in Electron Beam Evaporator and Molecular Beam Epitaxy

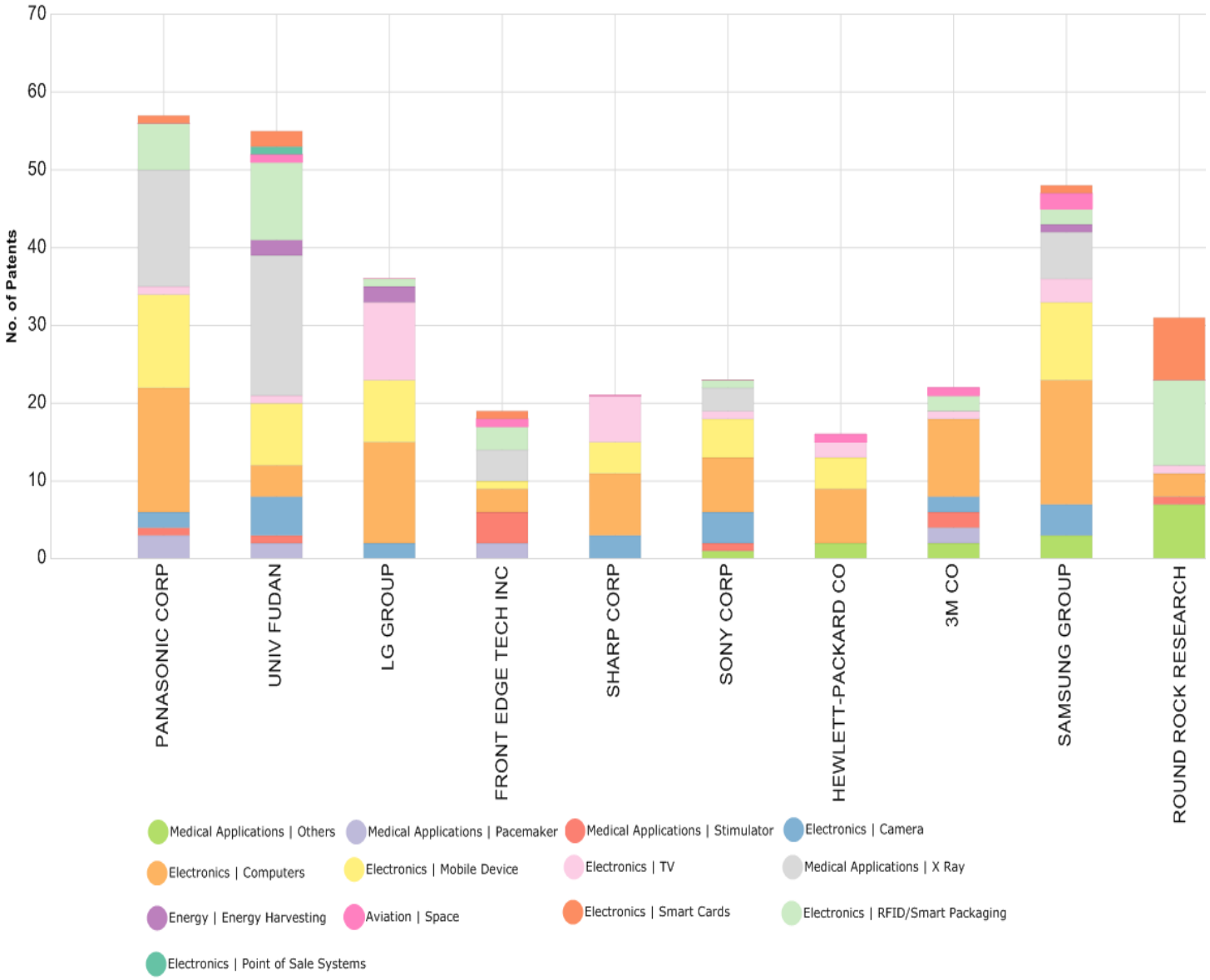


How we did it?

First various deposition processes 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, patents were categorized under different deposition processes. The clusters that were created for the analysis were correlated using the co-occurrence analyzer and the resulting matrix was converted to a 3-d column chart.

Thin Film Batteries: Applications vs Companies

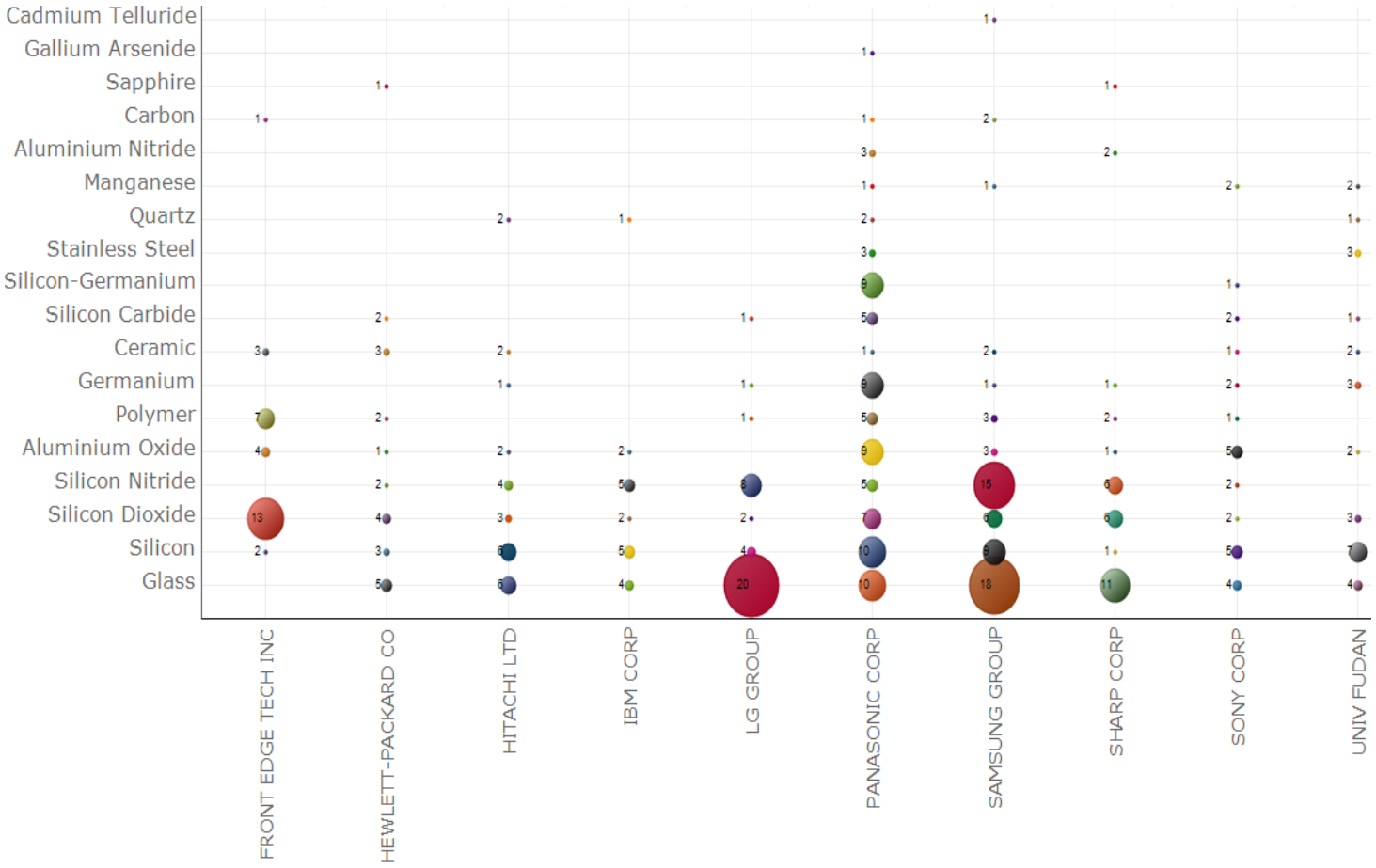
Who are the top companies across different applications of thin film batteries?



How we did it?

First various applications of thin film batteries 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, patents were categorized under different application areas. The clusters that were created for the previous analysis were correlated using the co-occurrence analyzer and the resulting matrix was converted into a stacked column chart.

Assignee portfolio spread across different types of substrates used

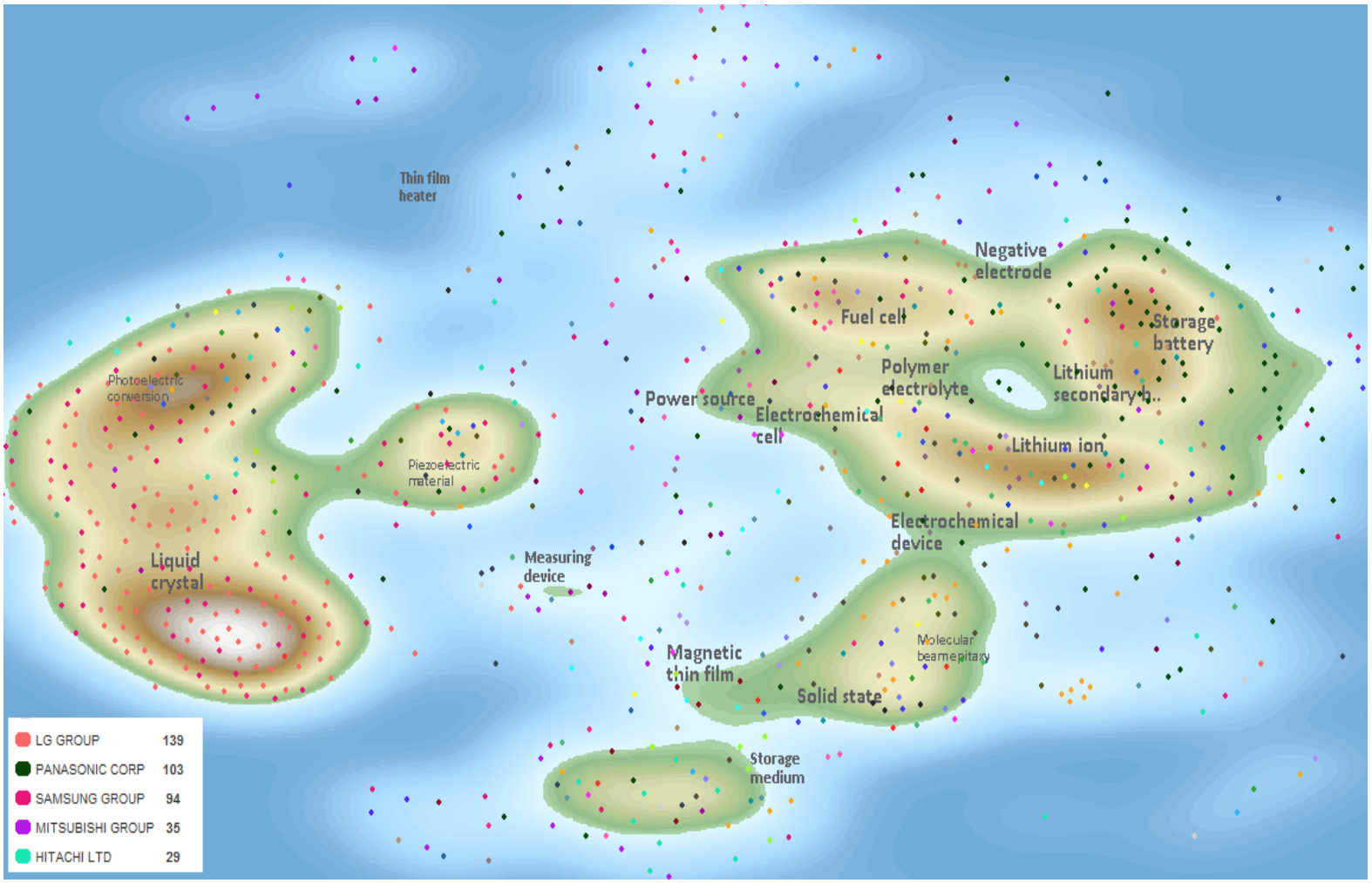


How we did it?

First various substrates used in thin film batteries 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, patents were categorized under different substrates. A co-occurrence matrix was generated and the resulting matrix was converted into a bubble chart.

Technology Landscape for Thin Film Batteries

The contour map below represents different technologies used in thin film batteries with respect to complete patent portfolio. The nodes were coloured by companies, as can be seen Panasonic Corp has presence in most of the technology areas.



How we did it?

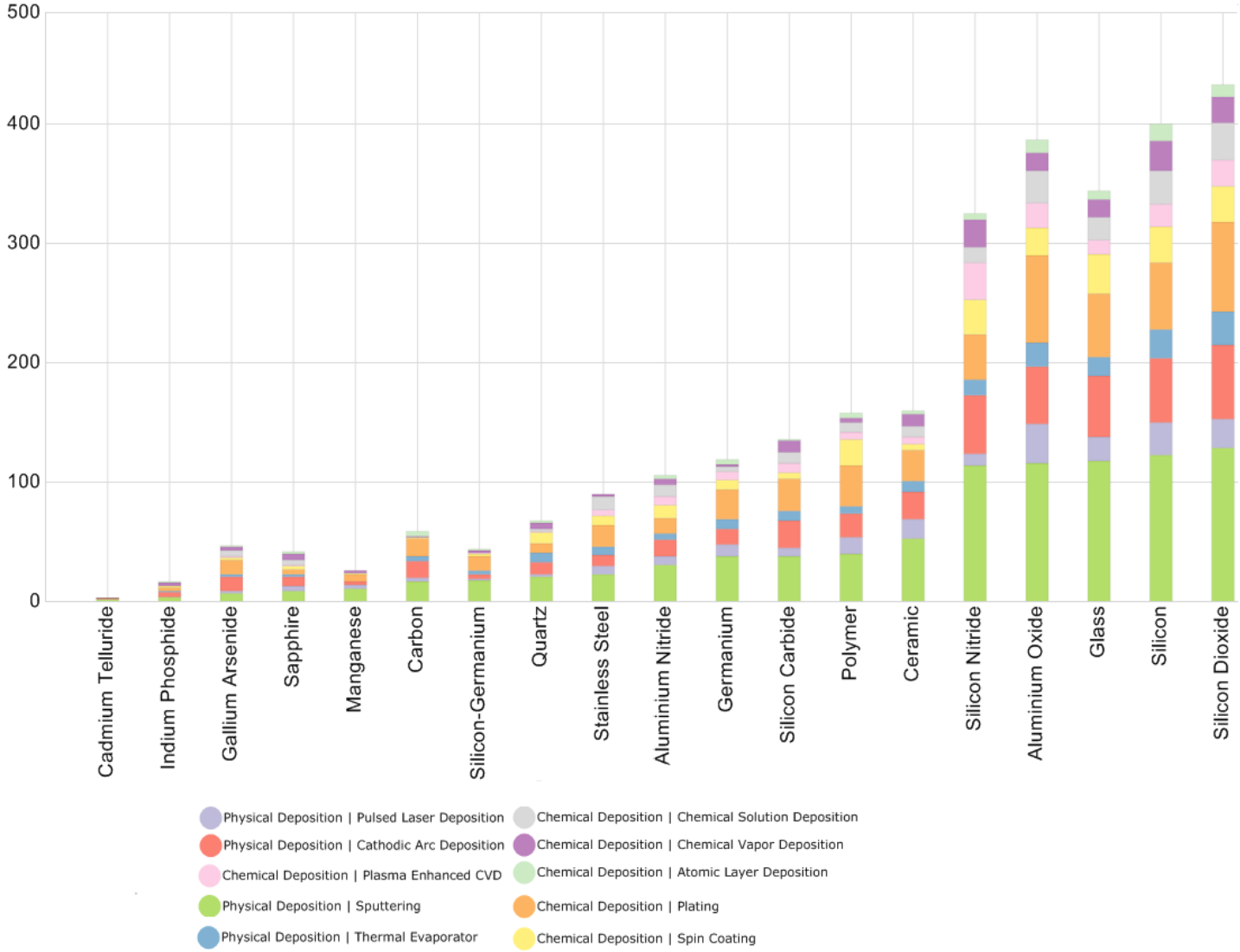
The VizMAP tool in Patent iNSIGHT Pro was used for this analysis. First the records of top companies were loaded on the map. They were analyzed on basis of their contextual similarity based on title, abstract and claims. We removed unrelated patents using the "Hide Unrelated records" option.

Thin Film Substrates Vs Deposition Process

The below matrix shows which deposition process (sub levels) are being used in different substrates

Deposition Process / Substrate Types	Total	Physical Deposition | Thermal Evaporator | Electron Beam Evaporator	Chemical Deposition | Chemical Vapor Deposition | MOCVD	Chemical Deposition | Chemical Vapor Deposition | LPCVD	Chemical Deposition | Chemical Vapor Deposition | APCVD	Physical Deposition | Thermal Evaporator | Molecular Beam Epitaxy
Total	91	37	15	33	7	21
Silicon Dioxide	46	22	7	16	4	11
Silicon	46	13	6	18	5	13
Silicon Nitride	35	11	3	19	4	5
Aluminium Oxide	31	16	8	8	1	6
Glass	27	8	7	8	4	10
Silicon Carbide	18	8		10	1	3
Ceramic	15	7	4	6	3	3
Quartz	13	5		5	1	4
Germanium	10	6		2		4
Aluminium Nitride	10	4	2	3		1
Stainless Steel	9	7		2	1	1
Polymer	9	5	1	4		3
Sapphire	6	2	2	3	1	
Silicon-Germanium	5	3		2		
Gallium Arsenide	5	1		3	1	1
Carbon	5	4		1		2
Indium Phosphide	4			3	1	1
Manganese	2			2	1	

The below chart represents different deposition process used across substrates

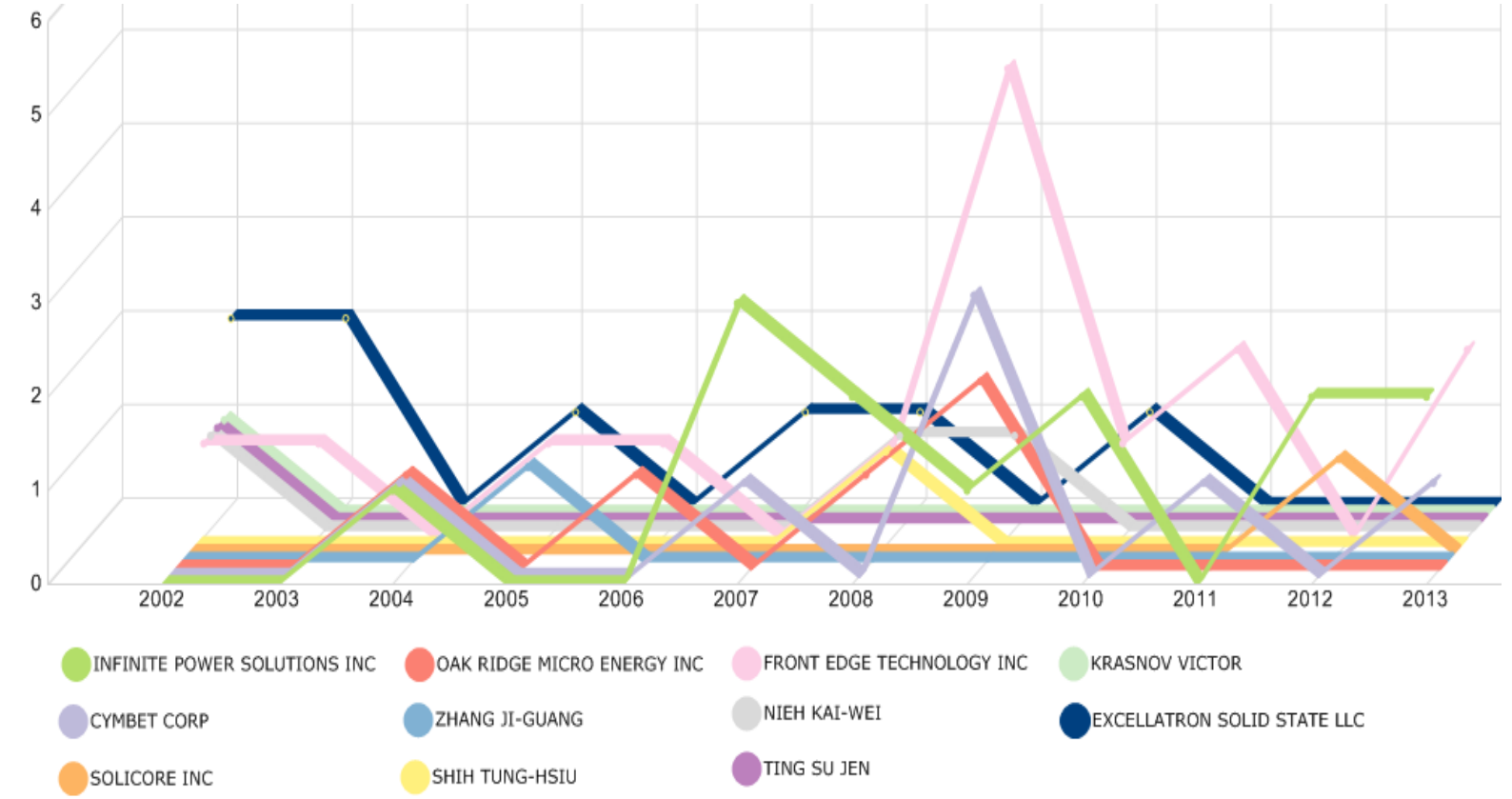


How we did it?

The clusters that were created for the analysis were correlated using the co-occurrence analyzer and the resulting matrix was converted to a stacked column chart.

Portfolio trend for prominent companies in thin film batteries

- Chart shows publication trend of companies which focus only on thin film batteries



How we did it?

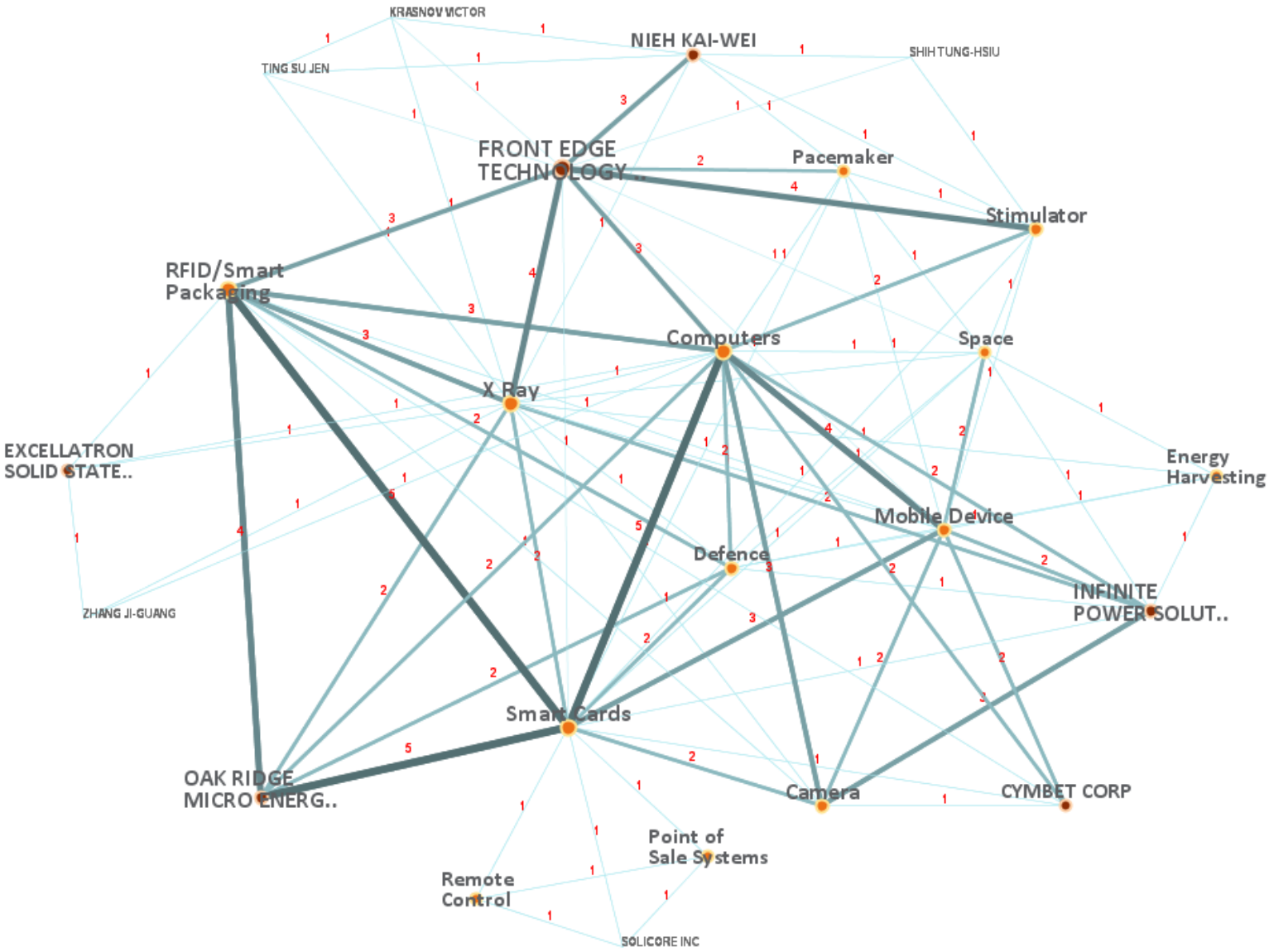
We first created a group for unique companies focusing only on thin film batteries using auto filter option. Using co-occurrence analyzer, we used that group as data filter to generate a matrix for those companies with respect to time and resulting matrix was converted to a 3-d line chart.

Unique Companies across different application areas

How do the key companies focus on various applications of thin film batteries?

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 application area.

It can be seen that computer and RFID/Smart Packaging within Electronics and XRAY and stimulator within Healthcare industry are more opted for by Front Edge Technology



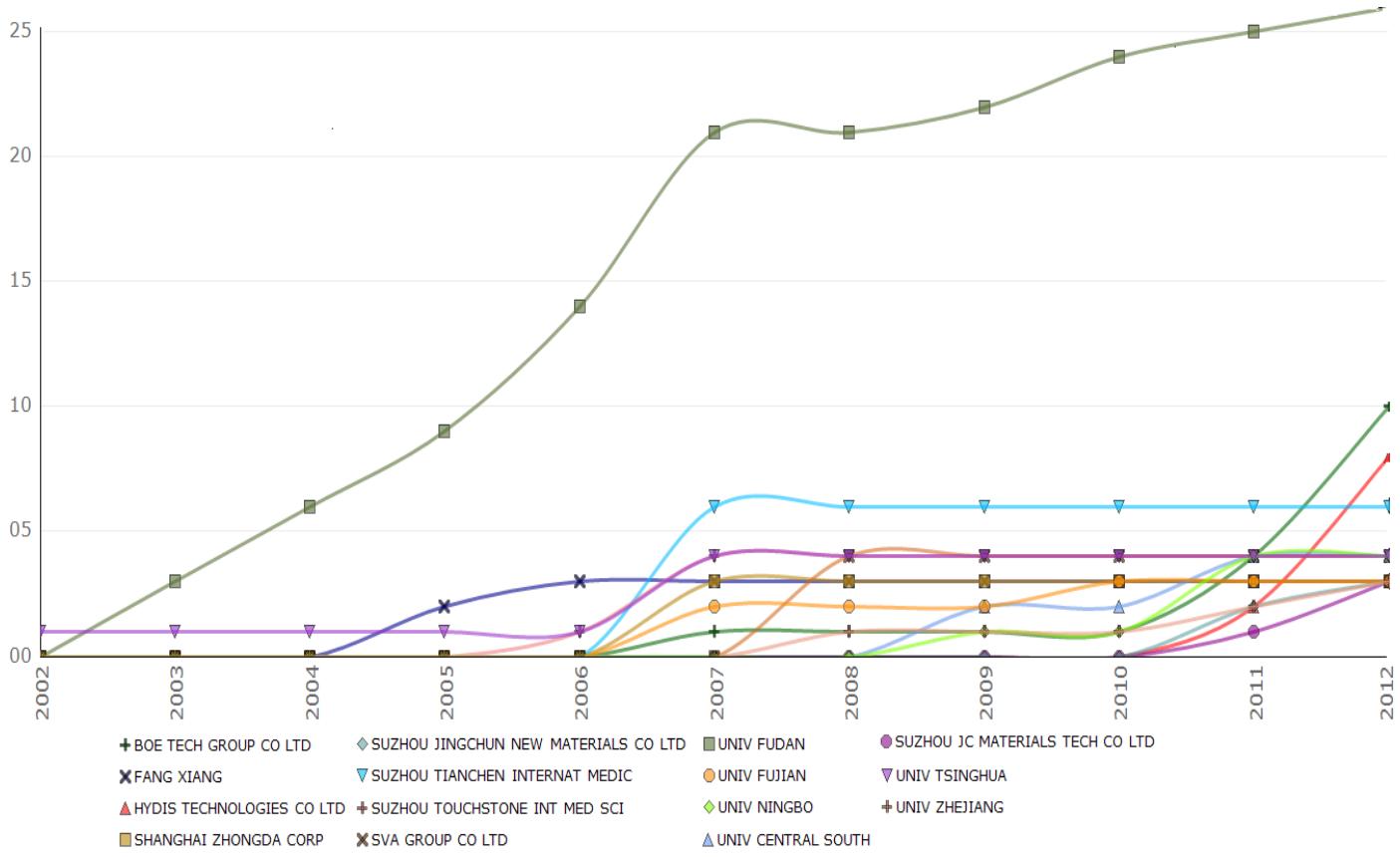
How we did it?

The group of unique companies created for previous analysis was correlated along with different application areas using the co-occurrence analyzer and resulting matrix was represented as Correlation Map.

Thin Film Batteries - Country Wise Research Trends

China: Assignee Trend

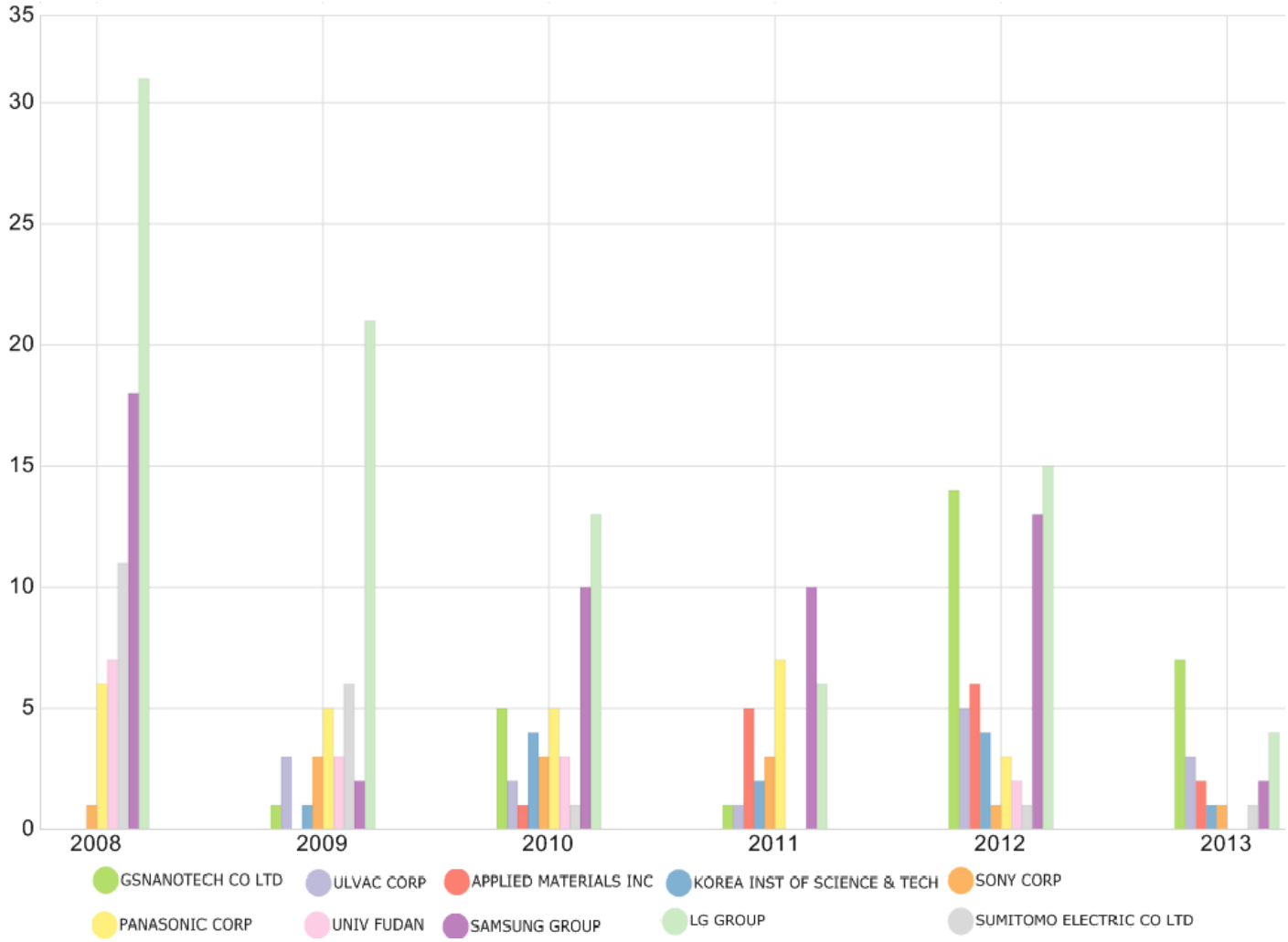
- The below trend chart represents the filing trends for Chinese firms.
- The green trend line associated with Univ Fudan shows an impressive spike from 2008 onwards. Hydis Technologies has filings from 2010 onwards.



How we did it?

We selected China as priority country from filter option within Reports Dashboard. The line graph showing the cumulative filings of top 15 assignees with respect to time was created.

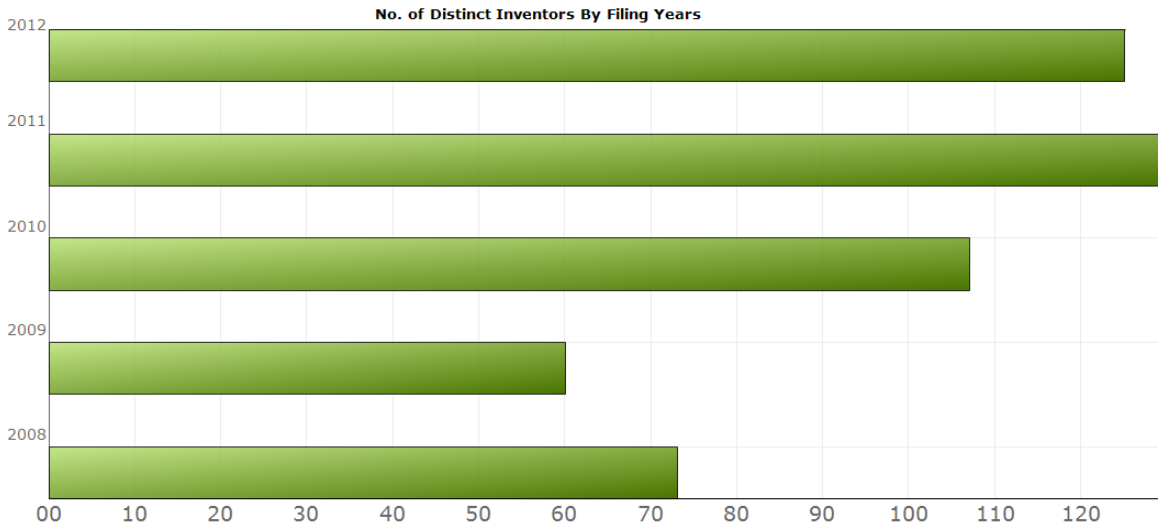
China: Publication Trend



How we did it?

We selected China as priority country from filter option within Co-occurrence analyzer. A matrix was generated for companies with respect to time and generated matrix was converted into a clustered column chart.

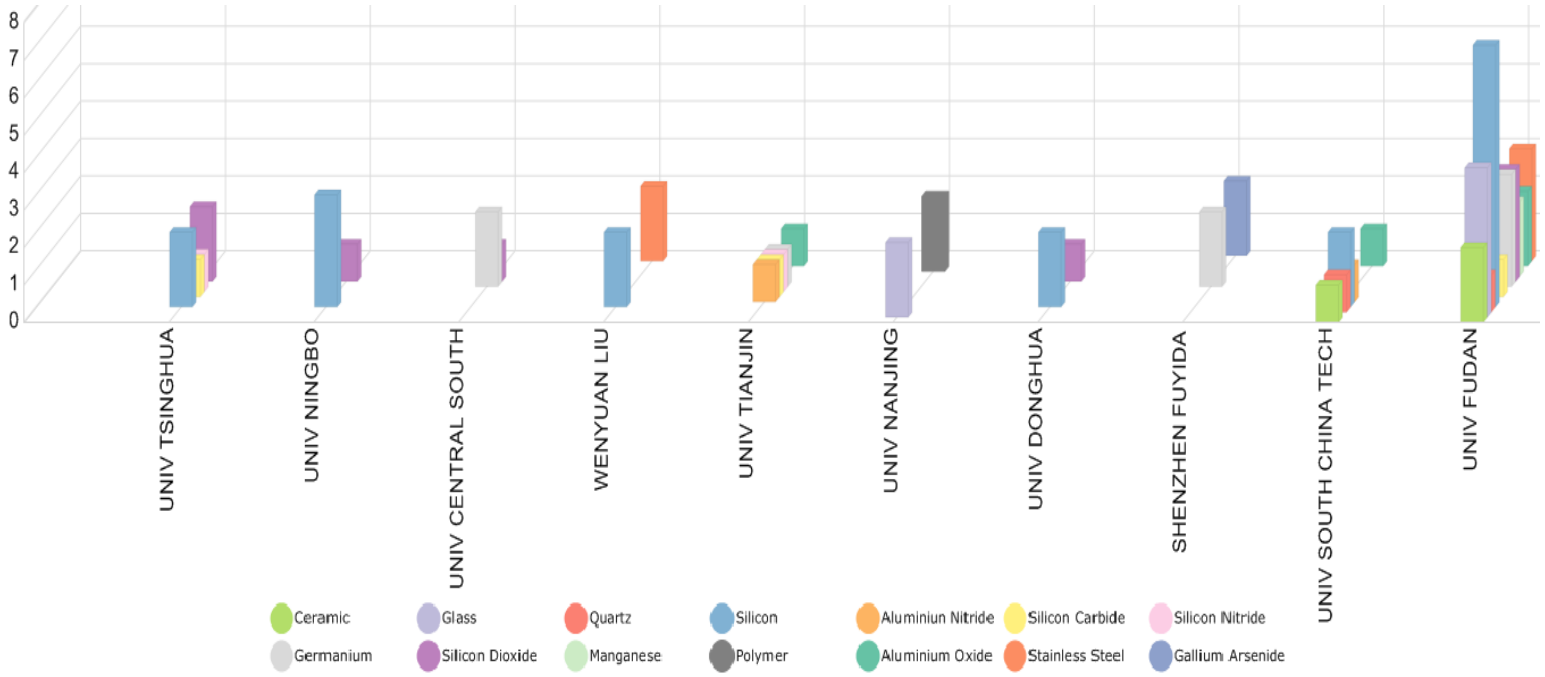
China: Distinct Inventors in the last 5 years



How we did it?

We selected China as priority country from filter option within Reports Dashboard. A filter for last 5 years was applied and a horizontal bar chart was generated.

China: Company wise research across different substrates

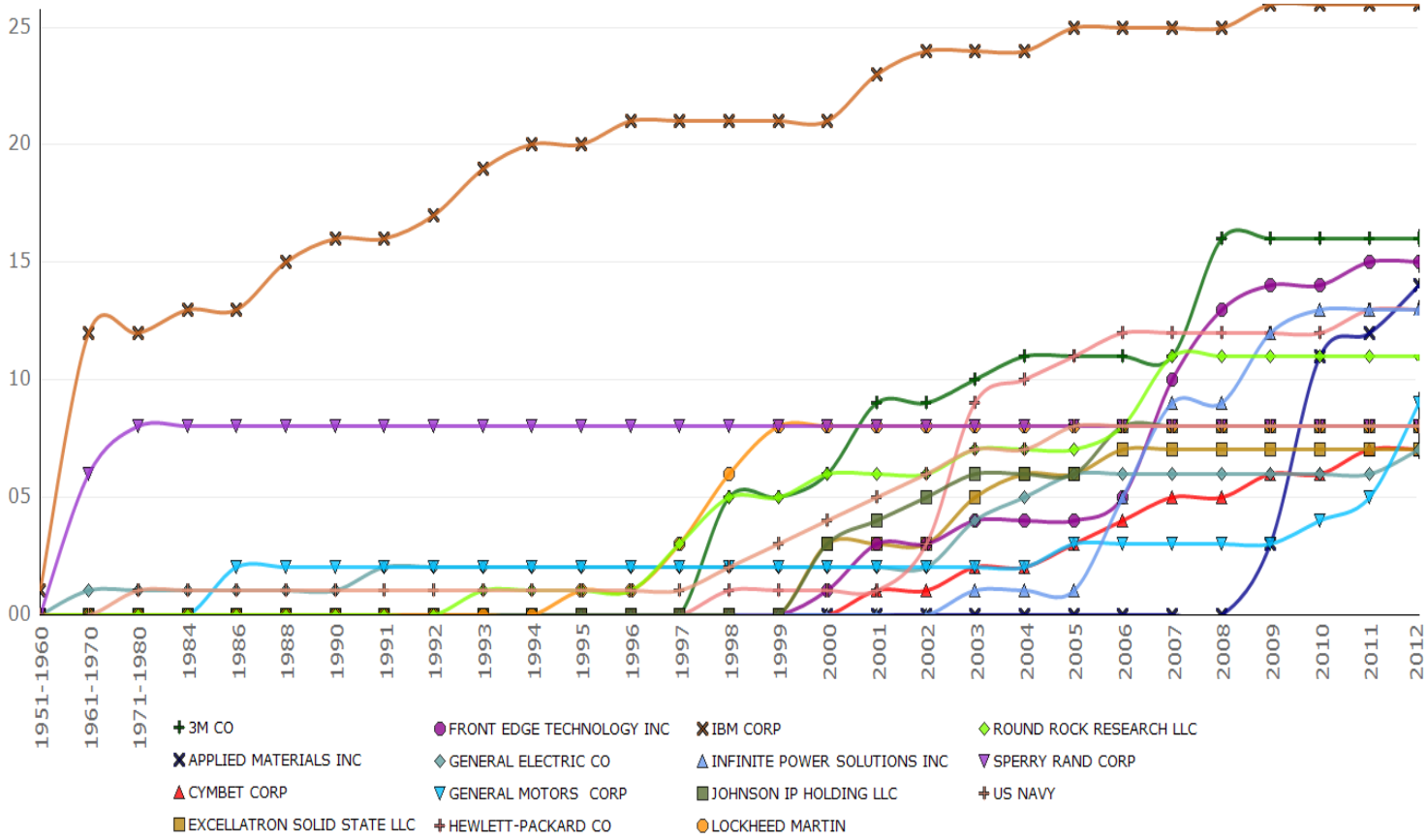


How we did it?

We selected China as priority country from filter option within Co-occurrence analyzer. A matrix was generated for companies with respect to substrate types and generated matrix was converted into a 3-d column chart.

US: Assignee Trend

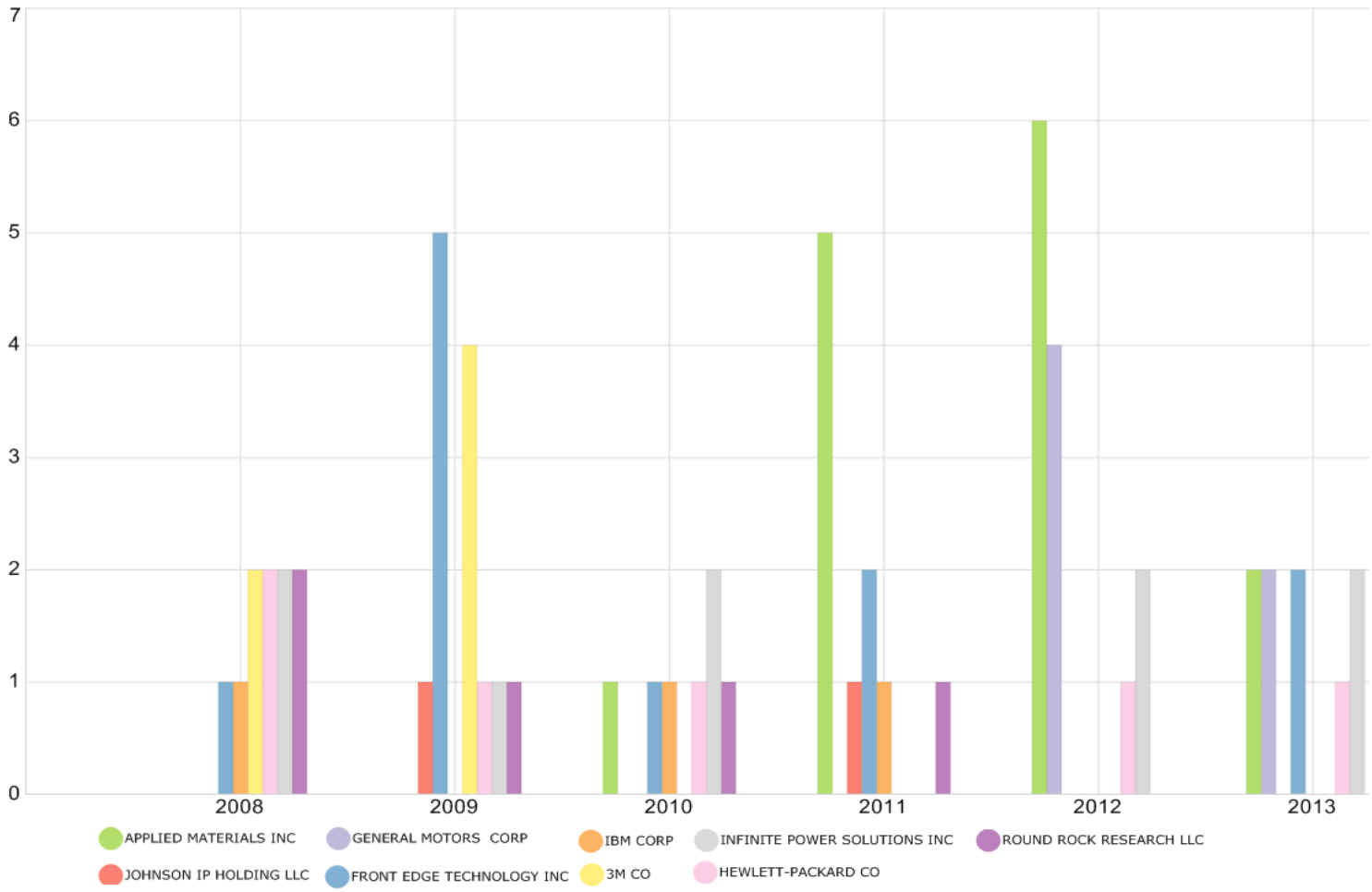
- The below trend chart represents the filing trends for US firms.
- The blue trend line associated with Infinite Power Solutions shows an impressive spike from 2002 onwards.



How we did it?

We selected US as priority country from filter option within Reports Dashboard. The line graph showing the cumulative filings of top 15 assignees with respect to time was created.

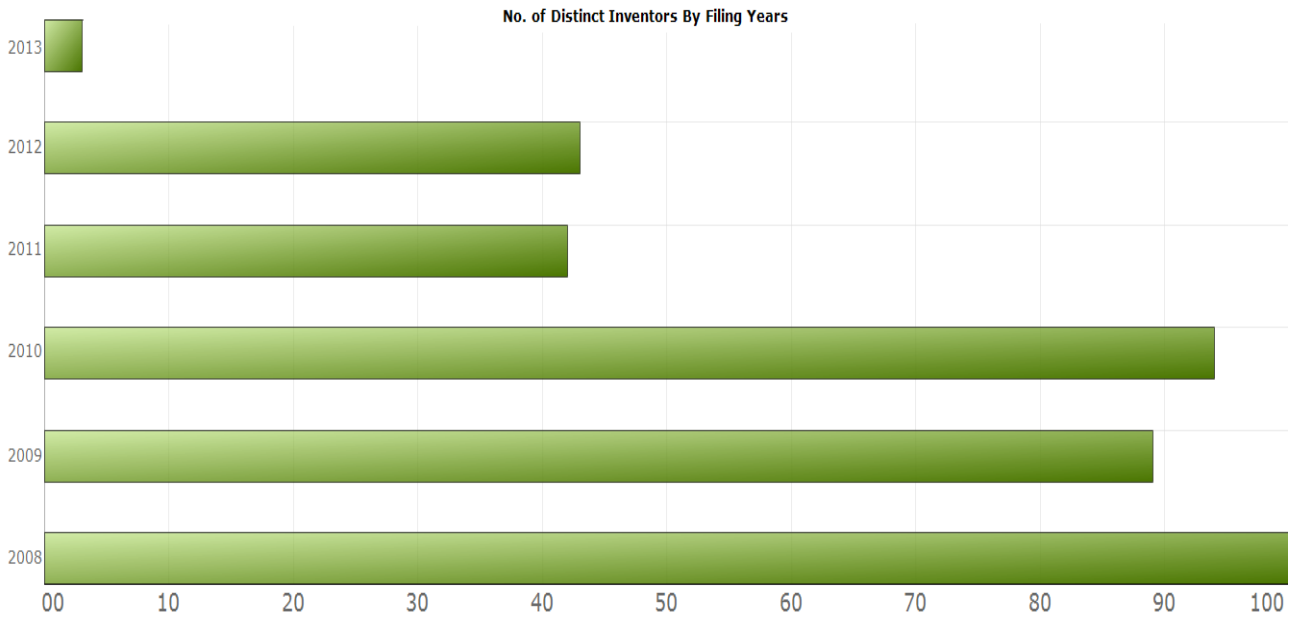
US: Publication Trend



How we did it?

We selected US as priority country from filter option within Co-occurrence analyzer. A matrix was generated for companies with respect to time and generated matrix was converted into a clustered column chart.

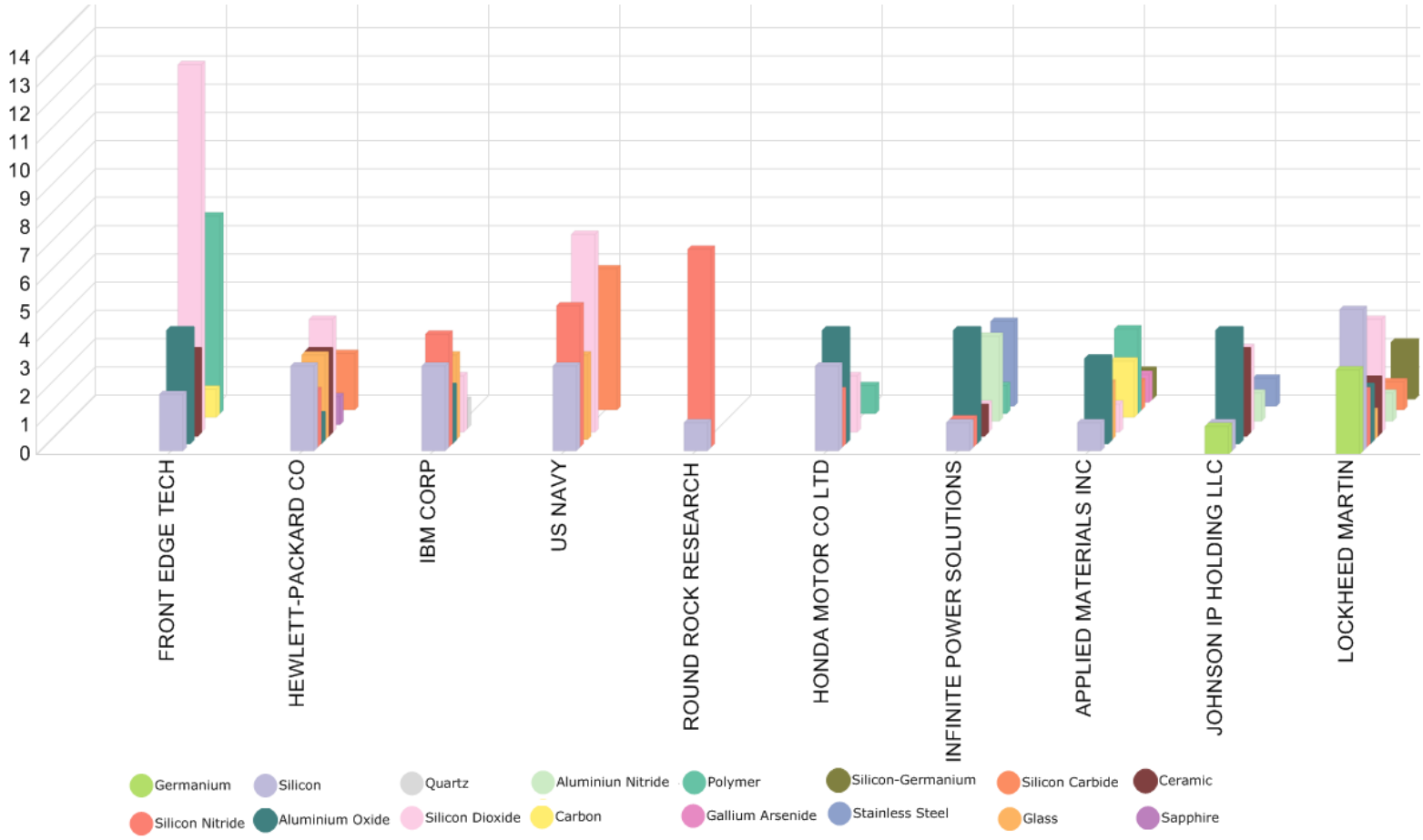
US: Distinct Inventors in the last 5 years



How we did it?

We selected US as priority country from filter option within Reports Dashboard. A filter for last 5 years was applied and a column was generated.

US: Company wise research across different substrates

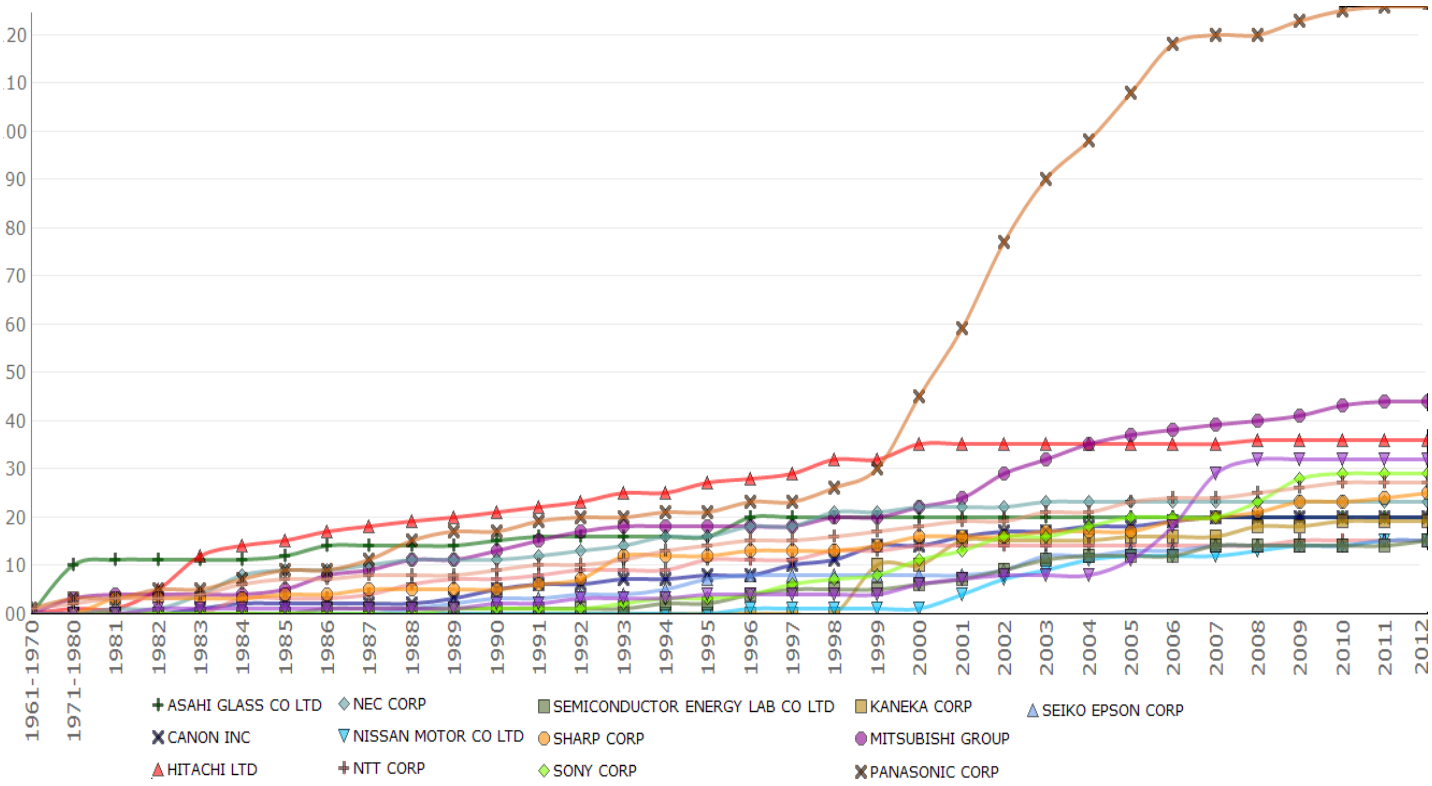


How we did it?

We selected US as priority country from filter option within Co-occurrence analyzer. A matrix was generated for companies with respect to substrate types and generated matrix was converted into a 3-d column chart.

Japan: Assignee Trend

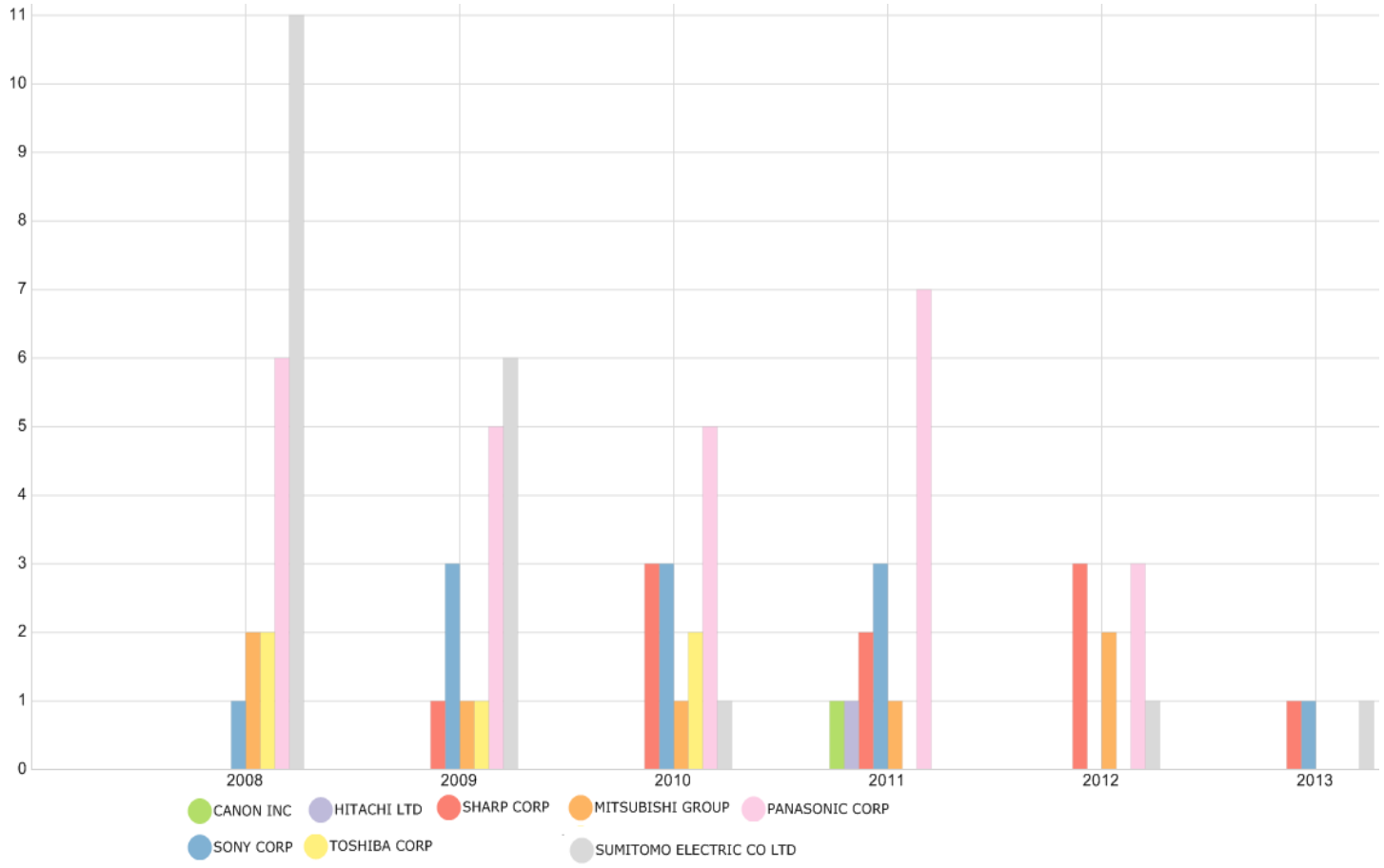
- The below trend chart represents the filing trends for Japanese firms.
- Panasonic Corp has increased filings after 2010.



How we did it?

We filtered records having JP as priority country from auto filter option in main dashboard. Then we created a group of those records and used it within Reports Dashboard option. The line graph showing the cumulative filings of top 15 assignees with respect to time was created.

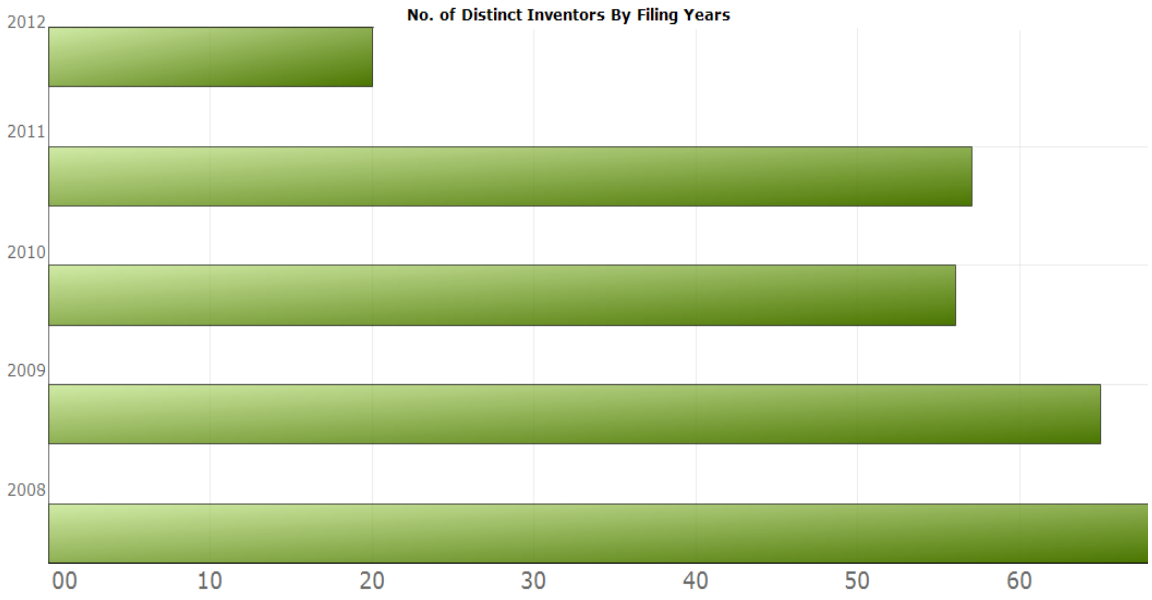
JP: Publication Trend



How we did it?

We selected Japan as priority country from filter option within Co-occurrence analyzer. A matrix was generated for companies with respect to time and generated matrix was converted into a clustered column chart.

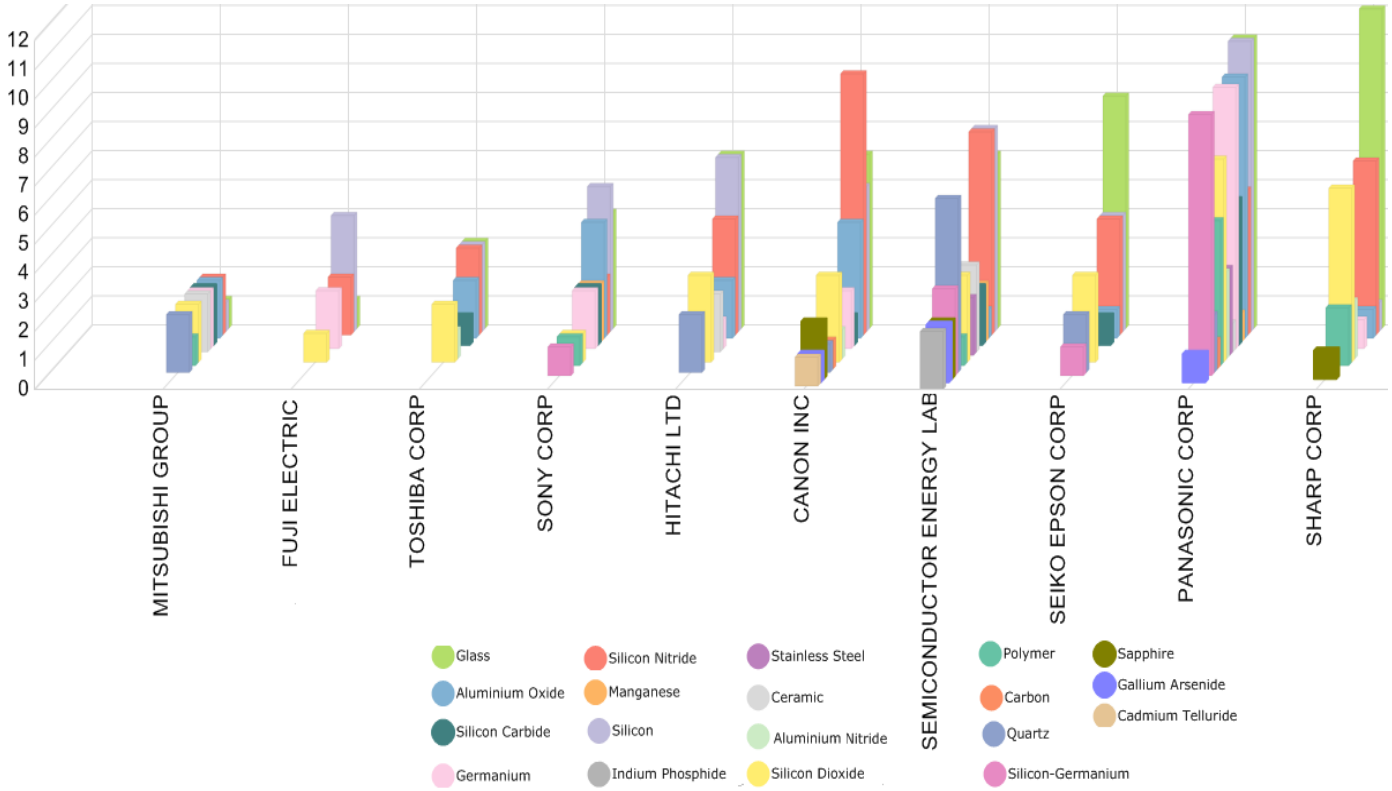
Japan: Distinct Inventors in the last 5 years



How we did it?

We selected JP as priority country from filter option within Reports Dashboard. A filter for last 5 years was applied and a column was generated.

JP: Company wise research across different substrates



How we did it?

We selected JP as priority country from filter option within Co-occurrence analyzer. A matrix was generated for companies with respect to substrate types and generated matrix was converted into a 3-d column chart.

Appendix: Search Strings Used for Categorization

Categorization: Deposition Process

1. Chemical Deposition

    a. Atomic Layer Deposition

Atomic Layer Deposition	
(FT) contains ("atomic layer deposit*" or ALD)	23 results

    b. Chemical Solution Deposition

Chemical Solution Deposition	
(FT) contains ("chemical solution deposit*" or CSD or "Chemical bath deposit*" or CBD or "sol-gel" or "sol* gel*")	84 results

    c. Chemical Vapor Deposition

        i. Atmospheric Pressure CVD (APCVD)

Atmospheric Pressure CVD (APCVD)	
(FT) contains ("Atmospheric pressure chemical vapor deposition" or "Atmospheric pressure chemical vapour deposition" or APCVD or "atmospheric pressure CVD")	7 results

        ii. Low Pressure CVD (LPCVD)

Low Pressure CVD (LPCVD)	
(FT) contains ("low pressure chemical vapor deposition" or "low pressure chemical vapour deposition" or LPCVD or "low* pressure CVD")	35 results

        iii. Metalorganic vapour phase epitaxy (MOCVD)

Metalorganic vapour phase epitaxy (MOCVD)	
(FT) contains ("metalorganic vapour phase epitaxy" or "metalorganic vapor phase epitaxy"or MOVPE or "organometallic vapour phase epitaxy" or "metallo-organic CVD" or "organometallic vapor phase epitaxy" or OMVPE or "metalorganic chemical vapour deposition" or "metalorganic chemical vapor deposition" or MOCVD)	20 results

        iv. Ultra High Vacuum CVD (UHVCVD)

Ultra High Vacuum CVD (UHVCVD)	
(FT) contains ("UHV chemical vapor deposition" or "UHV chemical vapour deposition" or UHVCVD or "Ultra High Vacuum CVD" or " Ultra-high vacuum"	1 result

d. Plasma Enhanced CVD

Plasma Enhanced CVD	
(FT) contains ((("plasma* enhanced chemical") w/3 deposit*) or PECVD)	68 results

e. Plating

Plating	
(FT) contains ((electroplat* or electrodeposit* or "Electroless plating" or plating or plated) and (thin* w/5 (film* or cell* or batter*)))	295 results

f. Spin Coating

Spin Coating	
(FT) contains (Spin w/5 (coat* or cast*))	84 results

2. Physical Deposition

a. Cathodic Arc Deposition

Cathodic Arc Deposition	
(FT) contains ("Cathodic arc deposit*" or "arc-PVD" or (ion w/3 (beam* or implant* or optic*)) or (ion w/3 deposit*) or IBAD or IAD or Ioniz* or ionis*)	189 results

b. Pulsed Laser Deposition

Pulsed Laser Deposition	
(FT) contains ("pulsed laser deposit*" or ablation or "plasma formation" or exfoliation or PLD)	92 results

c. Sputtering

Sputtering	
(FT) contains ("sputter* deposit*" or resputter* or "sputter etch*" or sputter*)	483 results

d. Thermal Evaporator

i. Electron Beam Evaporator

Electron Beam Evaporator	
(FT) contains ("electron beam physical vapor deposition" or "electron beam physical vapour deposition" or EBPVD or "electron beam evaporat*")	42 results

ii. Molecular Beam Epitaxy

Molecular Beam Epitaxy	
(FT) contains (((molecular* or chemical*) w/3 epitaxy*) or MBE or CBE or MOMBE or (("metal-organic*") w/3 epitaxy*))	32 results

Categorization: Substrate Types

1. Aluminium Nitride

Aluminium Nitride	
(FT) contains (("aluminium* nitride*" or al or ain) w/5 (substrate* or wafer* or chip*) or "AIN")	45 results

2. Aluminium Oxide

Aluminium Oxide	
(FT) contains ("aluminium* oxide*" or Al2O3 or "aluminium(III) oxide*" or alumina or aloxide or aloxite or alundum)	197 results

3. Cadmium Telluride

Cadmium Telluride	
(FT) contains (CdTe or ((cadium* w/2 telluride*) w/3 (substrate* or wafer* or chip*)))	7 results

4. Carbon

Carbon	
(FT) contains (carbon* w/5 (substrate* or wafer* or chip*))	31 results

5. Ceramic

Ceramic	
(FT) contains (ceramic* w/5 (substrate* or wafer* or chip*))	79 results

6. Gallium Arsenide

Gallium Arsenide	
(FT) contains (GaAs or ((gallium* w/3 arsenide*) w/3 (substrate* or wafer* or chip*)))	22 results

7. Germanium

Germanium	
(FT) contains (Germanium or Ge) and not ("silicon germanium")	85 results

8. Glass

Glass	
(FT) contains (glass* w/5 (substrate* or wafer* or chip*))	287 results

9. Indium Phosphide

Indium Phosphide	
(FT) contains ("Indium phosphide*" or InP)	5 results

10. Manganese

Manganese	
(FT) contains (manganese* w/5 (substrate* or wafer* or chip*) or Mn)	14 results

11. Polymer

Polymer	
(FT) contains (polymer* w/5 (substrate* or wafer* or chip*))	101 results

12. Quartz

Quartz	
(FT) contains (quartz* w/5 (substrate* or wafer* or chip*))	39 results

13. Sapphire

Sapphire	
(FT) contains (sapphire* w/5 (substrate* or wafer* or chip*) or "silicon on sapphire" or SOS)	16 results

14. Silicon

Silicon	
(FT) contains ((silicon* or Si) w/5 (substrate* or wafer* or chip*)) and not (carbide* or (("silicon solar") w/2 (batter* or cell or cells or (storage w/3 (element* or device* or devise*)))))	267 results

15. Silicon Carbide

Silicon Carbide	
(FT) contains ("silicon* carbide*" or SiC or carborundum)	54 results

16. Silicon Dioxide

Silicon Dioxide	
(FT) contains (silica or "silicon* dioxide*" or SiO2)	243 results

17. Silicon Nitride

Silicon Nitride	
(FT) contains ("silicon* nitride*" or Si3N4 or SiN)	179 results

18. Silicon-Germanium

Silicon-Germanium	
(FT) contains ("Si1−xGex" or SiGe or silicon-germanium or "silicon germanium")	25 results

19. Stainless Steel

Stainless Steel	
(FT) contains (("stainless* steel*" or "inox* steel*" or inox or inoxydable*) w/2 (substrate* or wafer* or chip*))	31 results

Categorization: Applications

1. Aviation

a. Space

Space	
(FT) contains (rocket* or satellite* or spacecraft* or "space craft" or "space station" or aircraft* or helicopter* or aerospace* or aeronautic* or aviation* or airplane*)	60 results

2. Defence

Defence	
(FT) contains (defense or defence or navy or naval* or army or airforce or military or weapon* or submarine* or missile* or ballistic* or boat or boats or ship or ships)	78 results

3. Electronics

a. Camera

Camera	
(FT) contains (((digital or video) w/3 (record* or camera* or camcorder*)) or camcorder* or camera* or ((video or image or photo or visual) w/3 record*) or DVR)	114 results

b. Computers

Computers	
(FT) contains (computer* or PDA or "personal data assistance" or laptop* or desktop* or netbook* or notebook*or ultrabook* or scanner* or calculator* or "palm top*")	387 results

c. Mobile Device

Mobile Device	
(FT) contains ((mobile w/5 (phone* or device*)) or cellphone* or (cell* w/2 phone*) or “hand* held*” or tablet*)	199 results

d. Point of Sale Systems

Point of Sale Systems	
(FT) contains ("Point-of-sale*" or "Point of sale" or POS or ((automated* or automatic*) w/2 machine*) or ATM or "automated banking"	12 results

machine*" or ABM or "cash machine" or "cashpoint" or cashline*)	

e. Remote Control

Remote Control	
(FT) contains (remote w/3 control*)	24 results

f. RFID/Smart Packaging

RFID	
(FT) contains ("radio frequency identification" or RFID or (radio w/2 frequency) or "smart packag*" or (smart* w/3 packag*) or (wireless* w/5 (sensor* or detect*)))	160 results

g. Smart Cards

Smart Cards	
(FT) contains (((smart* or chip* or integrated* or powered) w/5 card*) or ICC)	69 results

h. Television

Television	
(FT) contains (TV or television)	89 results

i. Watches

Watches	
(FT) contains ((watch* or clock*) w/5 (wrist* or wall*))	1 result

4. Energy

a. Energy Harvesting

Energy Harvesting	
(FT) contains ((energy* w/3 (scaveng* or harvest*)) or (power* w/2 harvest*) or thermodynamic* or (wind* w/3 (power or turbine* or energy*)) or (vibrat* w/3 scaveng*))	61 results

5. Medical

a. Defibrillator

Defibrillator	
(FT) contains (defibrillat* or dysrhythmias or cardiac* or ventric* or cardioverter* or cardiovertor*)	32 results

b. Iontophoretic Devices

Iontophoretic Devices	
(FT) contains (Iontophoretic or "electromotive drug administration" or EMDA or "ICD-9-CM")	6 results

c. Others

Others	
(FT) contains ((implant* or neural* or drug* or medicinal* or medical* or bandage* or cosmetic* or surg* or pharma*) and not ion*)	126 results

d. Pacemaker

Pacemaker	
(FT) contains (cardiac* or pacemaker* or heart*)	69 results

e. Stimulator

Stimulator	
(FT) contains (stimulat*)	66 results

f. X Ray

X Ray	
(FT) contains (xray* or x-ray* or "x ray*"' or XRD or X-radiation or "X radiation")	185 results

Summary

A thin film battery is a form of lithium ion battery that can be as small as a few millimeters thick. In addition to being smaller, they also last longer, can operate under more extreme temperatures, and can be formed into any shape.

These batteries can be used in devices like cell phones, laptops and implantable medical devices and can reduce the weight of common devices that run on battery power because of their high energy density.

This report talks about the existing & emerging trends in the different technological advancements in thin film battery domain.

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Sources & References

http://en.wikipedia.org/wiki/Thin_film_rechargeable_lithium_battery

http://en.wikipedia.org/wiki/Thin_film#Deposition

http://www.wiseqeek.com/what-is-a-thin-film-battery.htm

http://en.wikipedia.org/wiki/Chemical_Vapor_Deposition

http://en.wikipedia.org/wiki/Pulsed_Laser_Deposition

http://sadoway.mit.edu/research/thin-film-polymer-batteries