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 subcategories.

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 photovoltaic* or solar* or PV) w5 (cell* or batter* or (storage w3 (element* or devi?e*))))) or cellulose or photovoltaic* or photovoltaic* 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*
```

- 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.
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 CORP
4. MITSUBISHI GROUP
5. HITACHI LTD
6. IBM CORP
7. SUMITOMO ELECTRIC CO LTD
8. SONY CORP
9. GS NANOTECH 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 is 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:

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<thead>
<tr>
<th>Country Code</th>
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<td>JP</td>
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<td>US</td>
<td>626</td>
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<tr>
<td>KR</td>
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<tr>
<td>GB</td>
<td>67</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Assignees</th>
<th>Total No. of Records</th>
<th>Avg. No. of Fwd Cites per Patents</th>
<th>Filing Trend (Absolute)</th>
<th>Filing Year Range</th>
<th>Key Inventor (Top 5)</th>
<th>Co-Assignees</th>
<th>Coverage (Includes families)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LG GROUP</td>
<td>156 (5.9%)</td>
<td>2.06</td>
<td></td>
<td>1993-2012</td>
<td>SONG HONG SEONG(6) LEE HAN SANG(5) AHN TAE JOON(4) JANG YONG HO(4) PARK KWANG SOON(4)</td>
<td>HA JEONG-MIN(1) JIN SUN-MI(1) KIM KEE-YOUNG(1) KIM NO-MA(1) KNU INDUSTRY COOPERATION FOUND(1)</td>
<td>US  9  7  31  7  5  45  5  144</td>
</tr>
<tr>
<td>PANASONIC CORP</td>
<td>126 (4.8%)</td>
<td>2.78</td>
<td></td>
<td>1968-2011</td>
<td>TARUI HASAKI(21) YAGI HIROMASA KATSUNO BUI(15) FUJITANI SHIN(15) FUJIMOTO MASAHISA(12)</td>
<td>MITSUBISHI GROUP(6)</td>
<td>US  56  20  28  105  7  1  41  1  16</td>
</tr>
<tr>
<td>SAMSUNG GROUP</td>
<td>117 (4.4%)</td>
<td>3.43</td>
<td></td>
<td>1994-2012</td>
<td>GIL JAE-HYOUNG(5) JANG JAE-HYUK(5) PARK YOUNG-SIN(4) PARK JIN WOO(3) BAE BYUNG-</td>
<td>KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY Y(1)</td>
<td>US  87  18  4  49  10  1  37  1  101</td>
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<tr>
<td>Company</td>
<td>Assignee Count</td>
<td>Impact</td>
<td>Year Range</td>
<td>Patent Holders</td>
<td>Co-Assigned Present</td>
<td>Co-Assigned Absent</td>
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<tr>
<td>MITSUBISHI GROUP</td>
<td>44 (1.7%)</td>
<td>2.98</td>
<td>1980-2011</td>
<td>TAKEHAR A MASAHIRO O(6) JINNO MARU(5) TAMURA NOBUYUKI I(5) HIDAKA HIDETOKI(4) TOKIOKA HIDETADA (3)</td>
<td>18 7 7 39 7 0 13 0 8</td>
<td>0 8</td>
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<tr>
<td>HITACHI LTD</td>
<td>36 (1.4%)</td>
<td>7</td>
<td>1976-2008</td>
<td>KUDOU TETSUICHI (12) MIYAUCHI KATSUMI(12) KANEBORI KEIICHI(9) ITO YUKIO(5) KIRINO FUMIYOSHI(3)</td>
<td>8 4 0 35 3 0 2 0 2</td>
<td>2</td>
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</tr>
<tr>
<td>IBM CORP</td>
<td>36 (1.4%)</td>
<td>0.97</td>
<td>1960-2009</td>
<td>BREITWISCH MATTHEW W(4) NOWAK EDWARD J(4) MIDDELHÖEK SIMON(2) PARKER MICHAEL A(1) UEBUSUTAA YUJJIN HAWAAD OR(1)</td>
<td>26 6 1 9 22 10 2 0 20 2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>SUMITOMO ELECTRIC CO LTD</td>
<td>32 (1.2%)</td>
<td>1.12</td>
<td>1982-2008</td>
<td>EMURA KATSUJI(21) YOSHIDA KENTARO(1) RES INST INNOVATIVE TECH EARTH(2) JAPAN FINE</td>
<td>6 6 2 31 2 0 4 0 4</td>
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</tr>
<tr>
<td>Company</td>
<td>No. of Patents</td>
<td>Patent Share (%)</td>
<td>Year(s)</td>
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<td>Present Co-Assignees</td>
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</tr>
<tr>
<td>SONY CORP</td>
<td>31</td>
<td>1.2%</td>
<td>1989-2011</td>
<td>FURUYA TATSUYA(6) MORIOKA HIROYUKI(5) TAKAHARA KATSUNORI(5) SATOBI YUICHI(3) AKASHI HIROYUKI(2)</td>
<td>No Co-Assignee</td>
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<td></td>
</tr>
<tr>
<td>GSNANOT ECH CO LTD</td>
<td>28</td>
<td>1.1%</td>
<td>2007-2012</td>
<td>NAM SANG CHEOL(18) PARK HO YOUNG(14) LEE KI CHANG(13) KIM SOO HQ(8) PARK GI BACK(8)</td>
<td>AGENCY FOR DEFENSE DEVELOPMENT(1) NAM SANG-CHEOL(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOSHIBA CORP</td>
<td>27</td>
<td>1%</td>
<td>1964-2010</td>
<td>IKEDA MITSUSHI(2) AKASAKA YOSHIHIR(2) OZU HIDEYUKI(2) KAWAKUBO TAKASHI(2) KOGANEZ</td>
<td>No Co-Assignee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assignee</td>
<td>No Co-Assigned</td>
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<td>Year Range</td>
<td>Number of Inventions</td>
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<td></td>
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<tr>
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<td>----------------------</td>
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<tr>
<td>UNIV FUDAN</td>
<td>26 (1%)</td>
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<td>SHARP CORP</td>
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<td>11.96</td>
<td>1981-2012</td>
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<td>NEC CORP</td>
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<td>1.91</td>
<td>1981-2003</td>
<td>8 2 0 23 2 0 1 0 4</td>
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</tr>
</tbody>
</table>
**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.

<table>
<thead>
<tr>
<th>Inventor</th>
<th>Total No. of Records</th>
<th>Avg. No. of Fwd Cites per Patents</th>
<th>Filing Trend (Absolute)</th>
<th>Filing Year Range</th>
<th>Key Assignees (Top 5)</th>
<th>Co-Inventors</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAM SANG CHEOL</td>
<td>25 (1%)</td>
<td>0.32</td>
<td>2000-2011</td>
<td>GSNANOTECH CO LTD (18)</td>
<td>NURICELL INC (3) AGENCY FOR DEFENSE DEVELOPMENT (2) KOREA INST OF SCIENCE &amp; TECH (2) LG GROUP (1)</td>
<td>LEE Ki Chang (16) PARK Ho Young (16) LIM Young Chang (9) PARK Gi Back (9) HWANG Hosung (7)</td>
</tr>
<tr>
<td>EMURA KATSUJI</td>
<td>21 (0.8%)</td>
<td>0.67</td>
<td>2005-2007</td>
<td>SUMITOMO ELECTRIC CO LTD (21)</td>
<td>RES INST INNOVATIVE TECH EARTH (2)</td>
<td>YOSHIDA KENTARO (13) MITSUYASU OGAWA (12) KAMIMURA TAKU (9) AWATA HIDEAKI (8) IKUTA RIKIZO (5)</td>
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<tr>
<td>TARUI HASAKI</td>
<td>21 (0.8%)</td>
<td>4</td>
<td>2000-2006</td>
<td>PANASONIC CORP (21)</td>
<td></td>
<td>YAGI HIROMASA (12) FUJITANI SHIN (10) DOMOTO YOICHI (9) FUJIMOTO MASAHISA (9) OSHITA RYUJI (7)</td>
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<td>YAGI HIROMASA</td>
<td>19 (0.7%)</td>
<td>3.42</td>
<td>2000-2006</td>
<td>PANASONIC CORP (19)</td>
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<td>TARUI HASAKI (12) FUJIMOTO MASAHISA (8) FUJITANI SHIN (8) DOMOTO YOICHI (7) IKEDA HIROAKI (7)</td>
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<tr>
<td>PARK HO YOUNG</td>
<td>18 (0.7%)</td>
<td>0</td>
<td>2005-2012</td>
<td>GSNANOTECH CO LTD (14)</td>
<td>AGENCY FOR DEFENSE DEVELOPMENT (2) GS CALTEX CORP (2) PARK Ho-YOUNG (1) NURICELL INC (1)</td>
<td>NAM SANG CHEOL (16) LEE Ki CHANG (14) PARK Gi BACK (9) HWANG Hosung (7) LIM Young Chang (7)</td>
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<tr>
<td>Patentee</td>
<td>Contribution</td>
<td>Impact Factor</td>
<td>Years</td>
<td>Institutions/Companies</td>
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<td>----------------------------------------------------------------------------------------</td>
<td></td>
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</tr>
<tr>
<td>FU ZHENGWEN</td>
<td>16 (0.6%)</td>
<td>0.25</td>
<td>2003-2010</td>
<td>UNIV FUDAN(15) QIN QIZONG(3) CHILIN LI(2) YONGNING ZHOU(2) FANMING MENG(1)</td>
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<tr>
<td>LEE KI CHANG</td>
<td>16 (0.6%)</td>
<td>0</td>
<td>2005-2011</td>
<td>GSNANOTECH CO LTD(13) AGENCY FOR DEFENSE DEVELOPMENT(2) NURICELL INC(2)</td>
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<tr>
<td>NEUDECKER BERND J</td>
<td>16 (0.6%)</td>
<td>7.56</td>
<td>1998-2010</td>
<td>INFINITE POWER SOLUTIONS INC(12) ITN ENERGY SYSTEMS INC(2) LOCKHEED MARTIN(2)</td>
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<tr>
<td>BATES JOHN B</td>
<td>15 (0.6%)</td>
<td>18.53</td>
<td>1994-2006</td>
<td>OAK RIDGE MICRO ENERGY INC. A NEVADA CORPORATION(5) MARTIN MARIETTA ENERGY SYSTEMS(3)</td>
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<td></td>
<td>LOCKHEED MARTIN(2) JOHNSON RES &amp; DEV CO INC(2) FUTURE SCIENCE RES INST LTD(1)</td>
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<tr>
<td>FUJITANI SHIN</td>
<td>15 (0.6%)</td>
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<td>2000-2006</td>
<td>PANASONIC CORP(15) MITSUBISHI GROUP(2)</td>
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<td>NIEH KAI-WEI</td>
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<td>3.4</td>
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<td>SHIH TUNG-HSIU(1)</td>
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</table>

**Feedbacks and Comments on this report can be sent to feedback_tr@patentinshiptor.com**
<table>
<thead>
<tr>
<th>Inventor</th>
<th>Count</th>
<th>Index</th>
<th>Years</th>
<th>Company/Institutions</th>
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<td>SAYAMA KATSUNOBU</td>
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<td>PANASONIC CORP(15) HIRASE MASAKI(10) KOBAYASHI KEI(8) CHITO DAIZO(7) YAGI HIROMASA(7) TARUI HASAKI(5)</td>
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<tr>
<td>YOSHIDA KENTARO</td>
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<td>0.64</td>
<td>2005-2008</td>
<td>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)</td>
</tr>
<tr>
<td>BABA MAMORU</td>
<td>13</td>
<td>3.54</td>
<td>2002-2010</td>
<td>GEOMATEC CO LTD(8) UNIV IWATE(7) BABA MAMORU(2) JAPAN SCIENCE &amp; TECH AGENCY(2) TOMOYOSE KAZU(1) SANO KIMIHIRO(8) NAKAZAWA HIROMI(7) ABE TAKASHI(2) KUMAGAI NAOAKI(2) TOMOYOSE KAZU(2)</td>
</tr>
<tr>
<td>FUJIMOTO MASAHISA</td>
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<td>3.33</td>
<td>2000-2006</td>
<td>PANASONIC CORP(12) FUJITANI SHIN(12) TARUI HASAKI(9) DOMOTO YOICHI(8) OSHITA RYUJI(8) YAGI HIROMASA(8)</td>
</tr>
</tbody>
</table>

*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.

<table>
<thead>
<tr>
<th>Deposition Process (Row)</th>
<th>Total</th>
<th>Chemical Deposition</th>
<th>Spin Coating</th>
<th>Plating</th>
<th>Plasma Enhanced CVD</th>
<th>Chemical Vapor Deposition</th>
<th>Chemical Solution Deposition</th>
<th>Atomic Layer Deposition</th>
<th>Physical Deposition</th>
<th>Sputtering</th>
<th>Cathodic Arc Deposition</th>
<th>Pulsed Laser Deposition</th>
<th>Thermal Evaporator</th>
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<tbody>
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<td>77</td>
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<td>8</td>
<td>14</td>
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<td>182</td>
<td>152</td>
<td>48</td>
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<td>PANASONIC CORP</td>
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<td>30</td>
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<td></td>
<td></td>
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<td>42</td>
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<td>12</td>
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<tr>
<td>UNIV FUDAN</td>
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<td>11</td>
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<td>FRONT EDGE TECHNOLOGY INC</td>
<td>14</td>
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<td>11</td>
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<tr>
<td>LG GROUP</td>
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<td>2</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td>HITACHI LTD</td>
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</tr>
<tr>
<td>SONY CORP</td>
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<td>10</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td>9</td>
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<td>4</td>
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<td>3</td>
</tr>
<tr>
<td>ULVAC CORP</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KOREA INST OF SCIENCE &amp; TECH</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>9</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>APPLIED MATERIALS INC</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHARP CORP</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SEMICONDUCTOR ENERGY LAB CO LTD</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEIKO EPSON CORP</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>INFINITE POWER SOLUTIONS INC</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IBM CORP</td>
<td>8</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
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.

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

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.
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.
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.
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.
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 "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 vapor 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**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium Nitride</td>
<td>45</td>
</tr>
<tr>
<td>(FT) contains (&quot;aluminium* nitride*&quot; or al or ain) w/5 (substrate* or wafer* or chip*) or &quot;AIN&quot;)</td>
<td></td>
</tr>
</tbody>
</table>

2. **Aluminium Oxide**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium Oxide</td>
<td>197</td>
</tr>
<tr>
<td>(FT) contains (&quot;aluminium* oxide*&quot; or Al2O3 or &quot;aluminium(III) oxide*&quot; or alumina or aloxide or aloxite or alundum)</td>
<td></td>
</tr>
</tbody>
</table>

3. **Cadmium Telluride**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium Telluride</td>
<td>7</td>
</tr>
<tr>
<td>(FT) contains (CdTe or ((cadmium* w/2 telluride*) w/3 (substrate* or wafer* or chip*)))</td>
<td></td>
</tr>
</tbody>
</table>

4. **Carbon**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>31</td>
</tr>
<tr>
<td>(FT) contains (carbon* w/5 (substrate* or wafer* or chip*))</td>
<td></td>
</tr>
</tbody>
</table>

5. **Ceramic**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic</td>
<td>79</td>
</tr>
<tr>
<td>(FT) contains (ceramic* w/5 (substrate* or wafer* or chip*))</td>
<td></td>
</tr>
</tbody>
</table>

6. **Gallium Arsenide**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallium Arsenide</td>
<td>22</td>
</tr>
<tr>
<td>(FT) contains (GaAs or ((gallium* w/3 arsenide*) w/3 (substrate* or wafer* or chip*)))</td>
<td></td>
</tr>
</tbody>
</table>

7. **Germanium**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germanium</td>
<td>85</td>
</tr>
<tr>
<td>(FT) contains (Germanium or Ge) and not (&quot;silicon germanium&quot;)</td>
<td></td>
</tr>
</tbody>
</table>

8. **Glass**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>287</td>
</tr>
<tr>
<td>(FT) contains (glass* w/5 (substrate* or wafer* or chip*))</td>
<td></td>
</tr>
</tbody>
</table>

9. **Indium Phosphide**

<table>
<thead>
<tr>
<th>Substrate Types</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indium Phosphide</td>
<td>5</td>
</tr>
<tr>
<td>(FT) contains (&quot;Indium phosphide*&quot; or InP)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>10. Manganese</td>
<td>Manganese</td>
</tr>
<tr>
<td>(FT) contains (manganese* w/5 (substrate* or wafer* or chip*) or Mn)</td>
<td>14 results</td>
</tr>
<tr>
<td>11. Polymer</td>
<td>Polymer</td>
</tr>
<tr>
<td>(FT) contains (polymer* w/5 (substrate* or wafer* or chip*))</td>
<td>101 results</td>
</tr>
<tr>
<td>12. Quartz</td>
<td>Quartz</td>
</tr>
<tr>
<td>(FT) contains (quartz* w/5 (substrate* or wafer* or chip*))</td>
<td>39 results</td>
</tr>
<tr>
<td>13. Sapphire</td>
<td>Sapphire</td>
</tr>
<tr>
<td>(FT) contains (sapphire* w/5 (substrate* or wafer* or chip*)) or &quot;silicon on sapphire&quot; or SOS)</td>
<td>16 results</td>
</tr>
<tr>
<td>14. Silicon</td>
<td>Silicon</td>
</tr>
<tr>
<td>(FT) contains ((silicon* or Si) w/5 (substrate* or wafer* or chip*)) and not (carbide* or (&quot;silicon solar&quot;) w/2 (batter* or cell or cells or (storage w/3 (element* or device* or devise*))))</td>
<td>267 results</td>
</tr>
<tr>
<td>15. Silicon Carbide</td>
<td>Silicon Carbide</td>
</tr>
<tr>
<td>(FT) contains (&quot;silicon* carbide*&quot; or SiC or carborundum)</td>
<td>54 results</td>
</tr>
<tr>
<td>16. Silicon Dioxide</td>
<td>Silicon Dioxide</td>
</tr>
<tr>
<td>(FT) contains (silica or &quot;silicon* dioxide*&quot; or SiO2)</td>
<td>243 results</td>
</tr>
<tr>
<td>17. Silicon Nitride</td>
<td>Silicon Nitride</td>
</tr>
<tr>
<td>(FT) contains (&quot;silicon* nitride*&quot; or Si3N4 or SiN)</td>
<td>179 results</td>
</tr>
<tr>
<td>18. Silicon-Germanium</td>
<td>Silicon-Germanium</td>
</tr>
<tr>
<td>(FT) contains (&quot;Si1–xGex&quot; or SiGe or silicon-germanium or &quot;silicon germanium&quot;)</td>
<td>25 results</td>
</tr>
</tbody>
</table>
19. Stainless Steel

<table>
<thead>
<tr>
<th>Stainless Steel</th>
<th>31 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (&quot;stainless* steel*&quot; or &quot;inox* steel*&quot; or inox or inoxydable*) w/2 (substrate* or wafer* or chip*)</td>
<td></td>
</tr>
</tbody>
</table>

**Categorization: Applications**

1. **Aviation**
   a. **Space**

<table>
<thead>
<tr>
<th>Space</th>
<th>60 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (rocket* or satellite* or spacecraft* or &quot;space craft&quot; or &quot;space station&quot; or aircraft* or helicopter* or aerospace* or aeronautic* or aviation* or airplane*)</td>
<td></td>
</tr>
</tbody>
</table>

2. **Defence**

<table>
<thead>
<tr>
<th>Defence</th>
<th>78 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(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)</td>
<td></td>
</tr>
</tbody>
</table>

3. **Electronics**
   a. **Camera**

<table>
<thead>
<tr>
<th>Camera</th>
<th>114 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(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</td>
<td></td>
</tr>
</tbody>
</table>
   b. **Computers**

<table>
<thead>
<tr>
<th>Computers</th>
<th>387 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (computer* or PDA or &quot;personal data assistance&quot; or laptop* or desktop* or netbook* or notebook* or ultrabook* or scanner* or calculator* or &quot;palm top&quot;)</td>
<td></td>
</tr>
</tbody>
</table>
   c. **Mobile Device**

<table>
<thead>
<tr>
<th>Mobile Device</th>
<th>199 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (mobile w/5 (phone* or device*)) or cellphone* or (cell* w/2 phone*) or &quot;hand* held** or tablet*)</td>
<td></td>
</tr>
</tbody>
</table>
   d. **Point of Sale Systems**

<table>
<thead>
<tr>
<th>Point of Sale Systems</th>
<th>12 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (&quot;Point-of-sale*&quot; or &quot;Point of sale&quot; or POS or ((automated* or automatic*) w/2 machine*) or ATM or &quot;automated banking&quot;</td>
<td></td>
</tr>
<tr>
<td>Topic</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>e. Remote Control</td>
<td>Remote Control (FT) contains (remote w/3 control*) 24 results</td>
</tr>
<tr>
<td>f. RFID/Smart Packaging</td>
<td>RFID (FT) contains (&quot;radio frequency identification&quot; or RFID or (radio w/2 frequency) or &quot;smart packag**&quot; or (smart* w/3 packag*) or (wireless* w/5 (sensor* or detect*))) 160 results</td>
</tr>
<tr>
<td>g. Smart Cards</td>
<td>Smart Cards (FT) contains (((smart* or chip* or integrated* or powered) w/5 card*) or ICC) 69 results</td>
</tr>
<tr>
<td>h. Television</td>
<td>Television (FT) contains (TV or television) 89 results</td>
</tr>
<tr>
<td>i. Watches</td>
<td>Watches (FT) contains ((watch* or clock*) w/5 (wrist* or wall*)) 1 result</td>
</tr>
<tr>
<td>4. Energy</td>
<td>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</td>
</tr>
<tr>
<td>5. Medical</td>
<td>Defibrillator (FT) contains (defibrillat* or dysrhythmias or cardiac* or ventric* or cardioverter* or cardiovertor*) 32 results</td>
</tr>
</tbody>
</table>
b. Iontophoretic Devices

<table>
<thead>
<tr>
<th>Iontophoretic Devices</th>
<th>6 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (Iontophoretic or &quot;electromotive drug administration&quot; or EMDA or &quot;ICD-9-CM&quot;)</td>
<td></td>
</tr>
</tbody>
</table>

c. Others

<table>
<thead>
<tr>
<th>Others</th>
<th>126 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains ((implant* or neural* or drug* or medicinal* or medical* or bandage* or cosmetic* or surg* or pharma*) and not ion*)</td>
<td></td>
</tr>
</tbody>
</table>

d. Pacemaker

<table>
<thead>
<tr>
<th>Pacemaker</th>
<th>69 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (cardiac* or pacemaker* or heart*)</td>
<td></td>
</tr>
</tbody>
</table>

e. Stimulator

<table>
<thead>
<tr>
<th>Stimulator</th>
<th>66 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (stimulat*)</td>
<td></td>
</tr>
</tbody>
</table>

f. X Ray

<table>
<thead>
<tr>
<th>X Ray</th>
<th>185 results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FT) contains (xray* or x-ray* or &quot;x ray&quot;* or XRD or X-radiation or &quot;X radiation&quot;)</td>
<td></td>
</tr>
</tbody>
</table>
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

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