

Status of the Battery Patents

2017 Patenting Activity

April 2018



**REPORT
SAMPLE**

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For each battery technologies

- Technology Overview
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- Main patent assignees for patents granted in 2017
- Main patent assignees of patents expired/revoked in 2017
- Noticeable new patents published in 2017
- Noticeable granted patents in 2017
- Noticeable patents expired in 2017

SCOPE OF THE REPORT

REPORT
SAMPLE

- This report provides a detailed picture of the **2017 patenting activity for Battery technologies**.
- This report covers **worldwide patents published, granted or expired in 2017**.
- We have selected and analyzed more than **65,000 patent families** relevant to the scope of this report. In 2017, more than 30,400 new patent families have been published, >30,900 patents have been granted and >6,400 patents have expired.

Included in the report

- Patents with an earliest publication date in 2017.
- Patents granted in 2017.
- Patents expired or revoked in 2017.
- Patents related to batteries:
 - All battery technologies (Li-ion, Lead-acid, Ni-MH, Redox flow, Na-ion, Mg-ion, Li-Air, Li-S etc.).
 - Battery components (materials, electrodes, electrolytes, separators etc.).
 - Battery cells.
 - Battery packs and systems.
 - Thermal management systems in batteries.
 - Battery Management Systems.

Not included in the report

- Patents without an earliest publication date in 2017 or a grant date in 2017 or an expiration/revocation date in 2017.
- Patents related to:
 - Devices comprising a battery without battery detailed description.
 - Battery recycling.
 - Raw materials mining / production (i.e. Lithium, Cobalt, Nickel etc.).
 - Manufacturing equipment.
 - Testing equipment.

General supply chain for batteries

- Included in the report
- Included but not detailed in the report
- Not included in the report



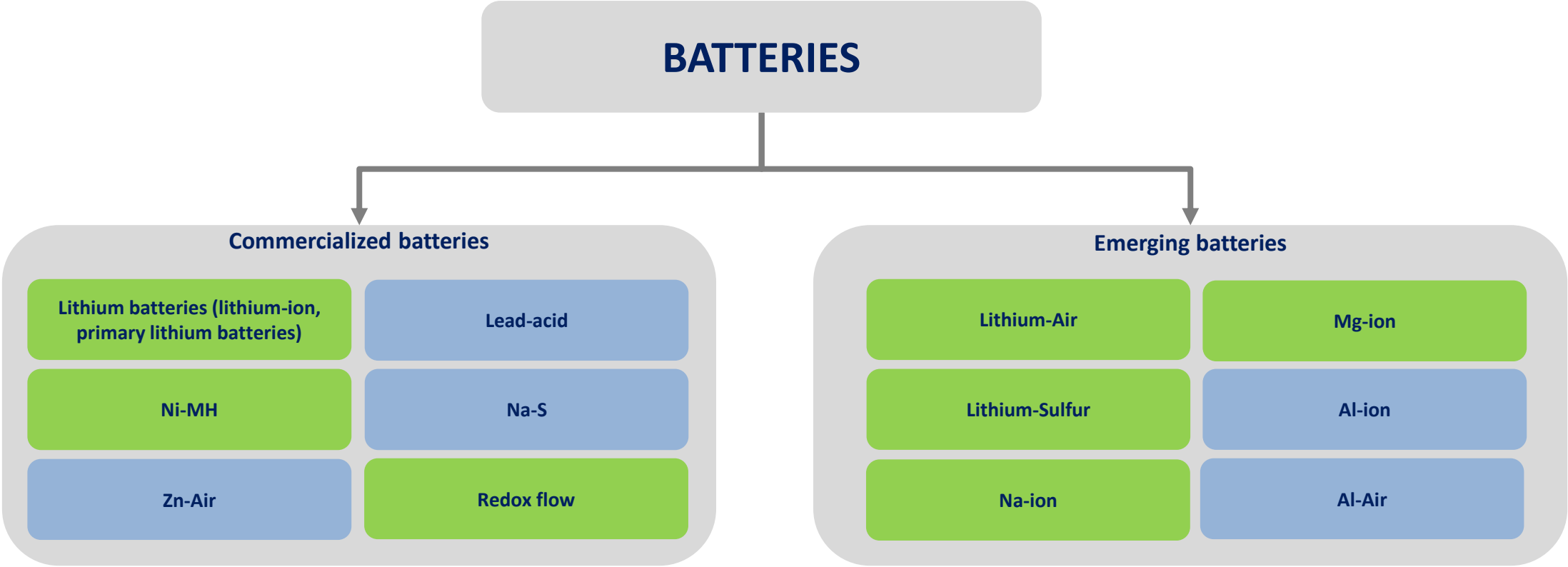
SCOPE OF THE REPORT

Battery technologies

REPORT
SAMPLE

Included in the report

Included but not detailed in the report



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KEY FEATURES OF THE REPORT (1/2)

- The report provides **essential patent data** for **Battery-related patents** newly **published, granted or expired in 2017**.
- The report includes:
 - ❖ **Categorization of patents**
 - By **supply chain segment**
(*electrolyte, separator, electrode, cell, pack/system*)
 - By **battery technology**
(*Li-ion, Ni-MH, Redox Flow, Li-Air, Li-S, Na-ion and Mg-ion*).
 - ❖ **1997-2017 worldwide IP dynamics** by supply chain segment and battery technology
 - ❖ Overview of the **2017 worldwide patenting activity** for each supply chain segment and each battery technology
 - New **patent applications**
 - New **granted** patents
 - **Expired or revoked** patents
 - ❖ Ranking of **main patent applicants** by supply chain segment and battery technology
 - For 1997-2017 period
 - For patents published in 2017
 - For patents granted in 2017
 - For patent expired in 2017
 - ❖ **Noticeable patents** newly published, granted or expired in 2017
 - For **battery cells morphology**
(*microbatteries, flexible batteries, solid-state batteries*)
 - For **battery technologies**
(*Li-ion, Ni-MH, Redox Flow, L-Air, Li-S, Na-ion, Mg-ion*)
 - For **electrode materials of Li-ion battery**
(*lithium, silicon, LTO, graphene, NMC, LCO, LFP, NCA, LMO*)
 - ❖ Main development trends **by battery technology**
 - ❖ Noteworthy 2017 news on **patent litigation**

KEY FEATURES OF THE REPORT (2/2)

- The report also provides an extensive **Excel database** containing >40,900 patent families of the **main patent assignees** and related to **the key battery technologies**.
 - Patent assignees included in the Excel file: LG Chem, Samsung, Toyota, Panasonic/Sanyo, GS Yuasa, Shenzhen Optimum Battery, Toshiba, Nissan, Hitachi, Sumitomo, Bosch, Zeon, TDK, Umicore, BASF, Sekisui Chemical, Hyundai, Tianneng Battery, Soulbrain, Asahi Kasei, Amperex, Toray industries, BAIC, Sinoev Technologies, BYD, Ford, Denso, Honda, BMW, Damler, Porsche, General Motors, Renault, Ube Industries, SK Innovation, Murata Manufacturing, Applied Materials, Shin Etsu Chemical, Showa Denko, Mitsubishi, CEA, Semiconductor Energy Laboratory, NEC.
 - Battery technologies included in the Excel file: Lithium battery, Ni-MH, Redox-flow, Li-Air, Li-S, Na-ion, Mg-ion.
- This useful patent database allows multi-criteria searches:
 - Patent publication number
 - Hyperlinks to the original documents
 - Priority date
 - Title
 - Abstract
 - Patent Assignees
 - Segmentation
 - Legal status for each member of the patent family
- Disclaimer: This report does not provide any insight analyses or counsel regarding legal aspects or the validity of any individual patent. Knowmade is a research firm that provides technical analysis and technical opinions. Knowmade is not a law firm. The research, technical analysis and/or work proposed or provided by Knowmade and contained herein is not a legal opinion and should not be construed as such.

MAIN PATENT ASSIGNEES MENTIONED IN THIS REPORT

INDUSTRIALS

3M, A123 Systems, AGC Seimi Chemical, Amogreentech, Amperex Technology, Asahi Glass, Automotive Energy Supply, Bak International, BASF, BMW, Boston Power, Brunp Recycling Technology, BYD, Chery Automobile, China FAW Automobile, Citic Dameng Holding, Daikin Industries, Denki Kogyo/Denka, Denso, Donguan Kaixin Battery Material, Du Pont De Nemours, Easpring Material Technology, Ecopro, Enerceramic, Envia, Fujifilm, General Motors, GS Yuasa, Hitachi Chemical, Hitachi Maxell, Hitachi Metals, Hitachi Vehicle Energy, Honda Motor, Huawei Technologies, Jinhe New Materials, Johnson Controls Technology, JX Nippon Mining Metals, Kokam, L&F, Leneng Battery, Leyden Energy, LG Chem, Li-Tec Battery, Medtronic, Mitsubishi Chemical, Mitsubishi Materials, Mitsui Mining & Smelting, Murata Manufacturing, Nano One Materials, Nec, Ningxia Orient Tantalum Industry, Nippon Chemical Industrial, Nippon Shokubai, Nissan Motor, Panasonic, Posco, PPG Industries, Renault, Reshine New Material, Robert Bosch, SAFT, Samsung Electronics, Samsung SDI, Sanyo Electric, Seo, SEL, SK Innovation, Solvay, Sony, Sumitomo Chemical, Sumitomo Metal Mining, Tanaka Chemical, Techelios, Toda Kogyo, Toray Industries, Toshiba, Toyota Industries, Toyota Motor, Umicore, Wanxiang ...

R&D LABORATORIES

CEA, Central South University, CNRS, Fujian Normal University, Harbin Institute of Technology, KETI, KERI, Osaka City University, RIST, UNIST, University of Chicago, University of Jiangnan, UT Battelle ...

BENEFITS OF THE REPORT

REPORT
SAMPLE

Follow technology trends and anticipate the changes

- Identify key and new technological trends
- Detect emerging technologies
- Identify noticeable new patent publications, new granted or expired patents
- Speed your R&D and IP costs

Compare market and IP trends

- Dynamics
- Geographic coverage
- Companies
- Technologies

Follow technology trends and competitive environment from technology and patent perspective

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Keep a watch on your competitors

- Identify the major current IP players and new comers
- Track their IP activity, strategy and future intents
- Compare their IP and market position

Detect business opportunities and mitigate the risk

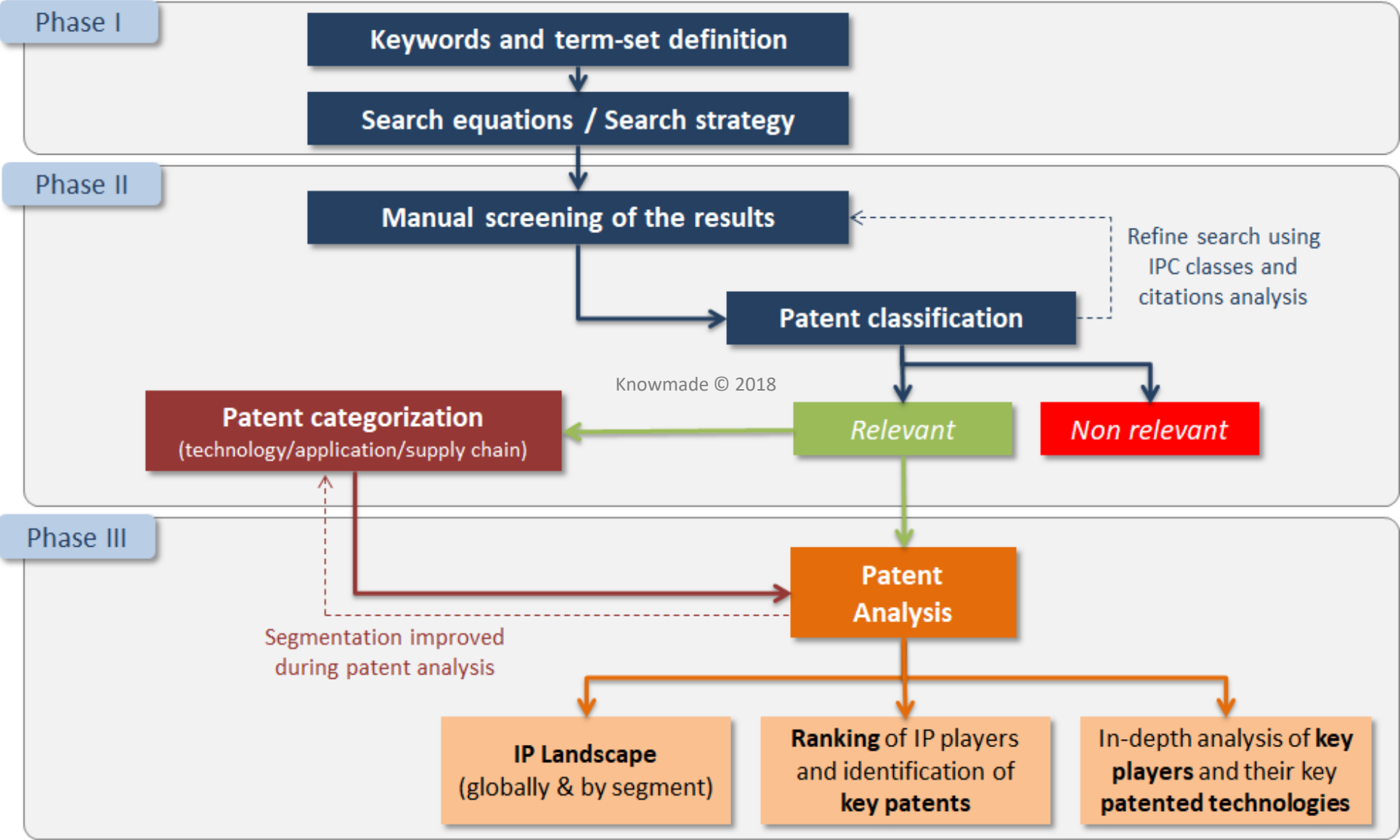
- Discover new markets & technology directions
- Identify pure play companies
- Overview of current litigation

METHODOLOGY FOR PATENT SEARCH AND SELECTION

- The data were extracted from the **FamPat worldwide database** (Questel-ORBIT) which provides 100+ million patent documents from 95 offices.
- The search for patents was performed in **January 2018**. This report is focused on patents newly published, granted or expired/revoked in 2017
- The patents were grouped by **patent family**. A patent family is a set of patents filed in multiple countries to protect a single invention by a common inventor(s). A first application is made in one country – the priority country – and is then extended to other countries.
- The **selection** of the patents has been done both automatically and **manually**. The patents were **manually categorized in technical segments** using keyword analysis of patent title, abstract and claims, in conjunction with expert review of the subject-matter of inventions.
- Data analysis will be performed using the Questel Orbit IP Business Intelligence **analytics platform** combined with **Excel-based data processing**, and will be supplemented by **expert analysis**.
- For legal status of European (EP) and PCT (WO) patent applications, EPO Register Plus has been used. For legal status of US patents, USPTO PAIR has been used. For legal status of other patents, information have been gotten from their respective national registers.

METHODOLOGY FOR PATENT SEARCH AND SELECTION

REPORT
SAMPLE



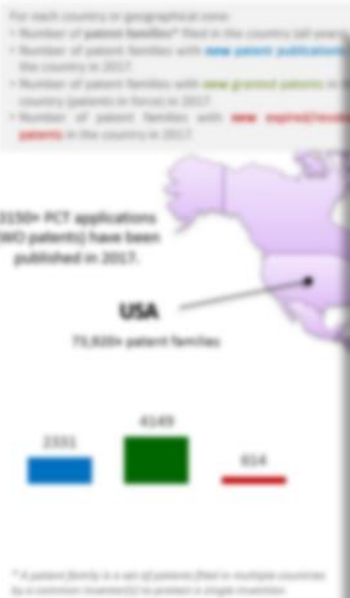
WORLDWIDE PATENTING ACTIVITY

1997-2017 patenting activity



WORLDWIDE PATENTING ACTIVITY

2017 patenting activity



WORLDWIDE PATENTING ACTIVITY

Comparison with market trends

- Battery cell production factory projects in Europe**
- Most of granted patents in battery field are located in Asia (China, Japan, Korea). In fact, major companies working on batteries are Asian companies (LG, Samsung, Sony, Murata, Amperex, BYD, Toyota ...) and most of battery cells worldwide are produced in Asia and mainly in China. China shows the highest patenting activity in battery field. The patenting activity of Chinese universities and emerging Chinese battery manufacturers is increasing.
 - Patenting activity in the US is relatively high and companies show a constant interest in the country. It is worth to note that Li-ion cell production capacity increases in 2017 thanks to the construction of a Gigafactory built by Tesla in collaboration with Panasonic.
 - There are much more pending patent applications than granted patents in Europe, indicating a growing interest of companies from these geographic areas.
 - The goal of India government is to remove gas-powered vehicles from its road by 2030. Thus, it attracts battery material manufacturers and manufacturers. Main electric vehicle manufacturers in India are Mahindra & Mahindra, Tata.
 - Up to now, in Europe, there are mainly chemical industries (BASF, BASF, Johnson Matthey, WGL, Solvay, Wacker, Rockwood Lithium etc.), machinery (Siemens, UES, PCC, MAN, MAN, etc.) and battery pack producers (Varta, AEG, Bosch etc.).
 - The growing market and interest for electric vehicles attract major car manufacturers to have operation units in Europe (Volkswagen, Daimler, BMW, Jaguar, etc.) and lead to an increase of their patenting activity.
 - Recently, several companies announce the construction of Li-ion battery cell factory in Europe driven by the growing automotive market: BMW in Austria, UTHOPS in Italy, Northvolt in Sweden, LG Chem in Poland, Samsung SDI in Hungary, Tesla (country not decided yet).



A WORLDWIDE
PATENTING
ACTIVITY

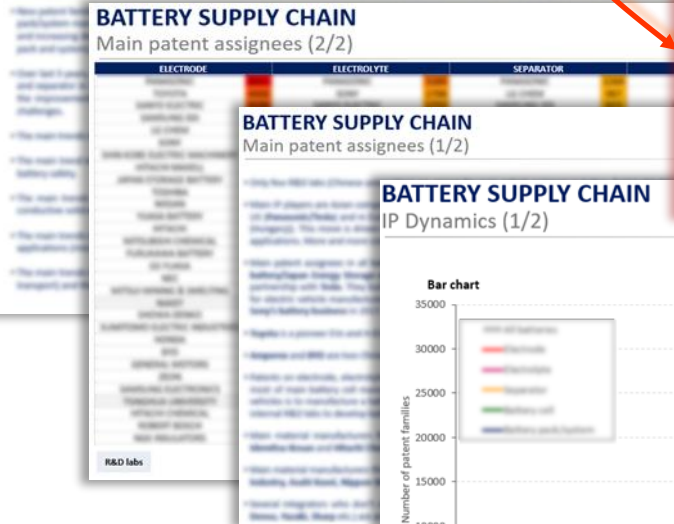
BATTERY SUPPLY CHAIN

Overview of Patenting Activity by Supply Chain segments

REPORT
SAMPLE

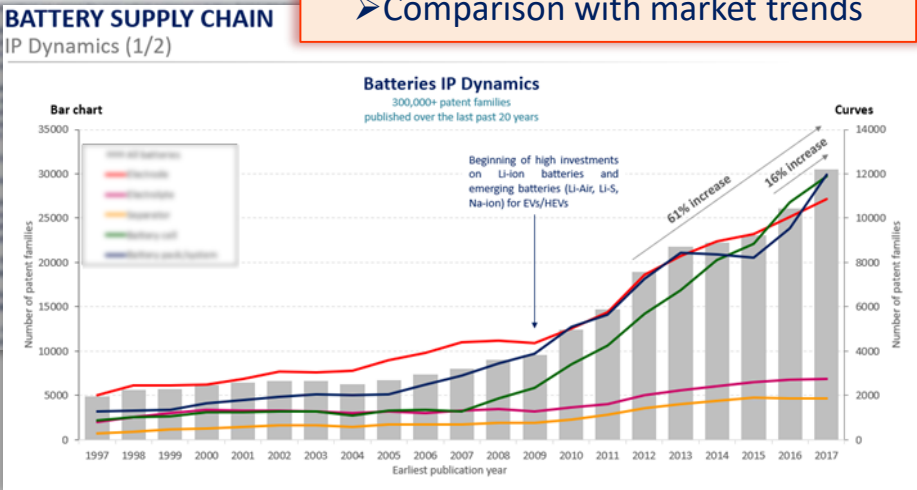


BATTERY SUPPLY CHAIN
IP Dynamics (2/2)



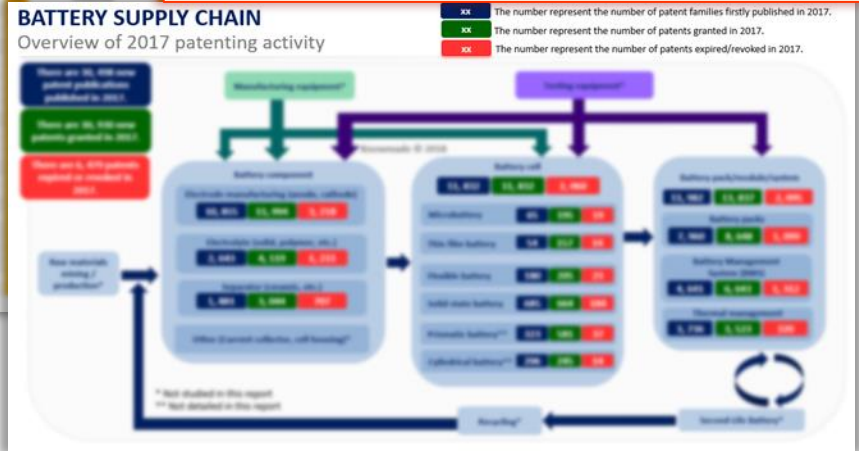
Overview of last 20 years patenting activity

- IP Dynamics
- Main patent assignees
- Comparison with market trends



Overview of 2017 patenting activity

- Patenting activity by supply chain segments
- Main patent assignees
- Main technology trends
- Comparison with market trends



BATTERY CELLS

Overview of Patenting Activity by Supply Chain segments

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SAMPLE

BATTERY CELLS

Technology overview

A battery cell is composed of two electrodes, an electrolyte and a separator encapsulated within a package. In solid-state batteries, solid electrolyte also play the role of separator. Battery cells can be assembled in module/pack/system. Main battery cell morphologies are represented below:



SOLID-STATE BATTERIES

Noticeable patent families having patents granted in 2017



SOLID-STATE BATTERIES

Noticeable patent families comprising patents that have expired in 2017



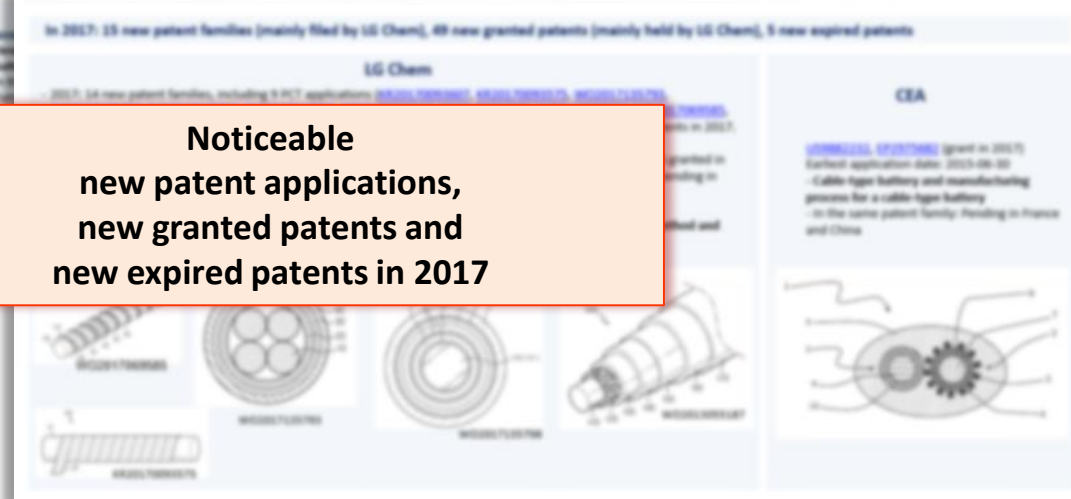
CURVED BATTERIES

Noticeable patent families having patents granted or published in 2017



CABLE-TYPE BATTERIES

Noticeable patent families having patents granted or published in 2017



Noticeable
new patent applications,
new granted patents and
new expired patents in 2017

Overview of 2017 patenting activity

Focus on microbatteries, thin film batteries,
flexible batteries and solid-state batteries
Main patent assignees
Main technology trends
Comparison with market trends

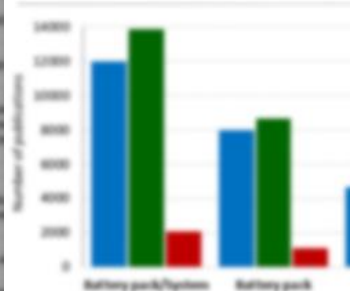
**REPORT
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The number represent the number of patents that expired or have been revoked in 2017.

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Overview of 2017 patenting activity



- * Most of major companies with new patient families are Toshiba, Siemens (Optima) Baffert, Samsung SDI, Matsuda, Hitachi, Honda, Daikin). Some companies, (Jangson, H&M, Porsche, BMW, Volkswagen, etc., New Mexico and Minnesota. Renault has a strategic partner.
- * It is worth to note that Nissan and NEC are no more competitors.
- * There are much more electronics integrations among the firms developed for automotive electronic devices in U.S.

Technology overview

- **Battery module:** A group of cells connected together either in series and/or parallel configuration, encased in metal/plastic enclosure and with attached terminals.
- **Battery pack:** A battery which is ready for use, contained in a rigid enclosure with protective devices and thermal control system.
- **Battery system:** Battery system is different to battery pack. A battery system may include more than one battery pack, each including its own temperature management system, housing, protection devices ... It includes power system conversion (i.e. inverter, charger) and EMS to manage the energy flow between the application and the battery packs that supply energy for the application.
- **BMS:** Electronic system, associated with a battery pack, which monitors and/or manages in a safe manner its electric and thermal state by controlling its environment, and which provides communication between the battery system and other macro-system controllers.

- Several safety measures are set-up at the pack level to decrease risks related to Li-ion batteries (thermal, overcurrent, short-circuit, overvoltage, under voltage and overpressure protection, cell-state monitoring and control)

Components in a battery pack



Source: Yole développement, Beyond Li-ion batteries, 2016

BATTERY TECHNOLOGIES

Technology description

REPORT
SAMPLE

BATTERY TECHNOLOGIES

Main emerging technologies

| Battery technology | Technological maturity | R&D efforts | Market adoption | Applications | First date of commercialization | Advantages | Drawbacks |
|--------------------|------------------------|-------------|-----------------|--------------|---------------------------------|------------|-----------|
|--------------------|------------------------|-------------|-----------------|--------------|---------------------------------|------------|-----------|

• Safer technology compared to Li-ion (not flammable, not toxic)

BATTERY TECHNOLOGIES

Main commercialized technologies

| Battery technology | Technological maturity | R&D efforts | Market adoption | Applications | First date of commercialization | Advantages | Drawbacks |
|--------------------|------------------------|-------------|-----------------|---|---------------------------------|--|--|
| Lead-acid | Commercialized | Low | High | Transport, stationary | 1858 | • High energy density, wide operating temperature range • High recyclability • High energy and power density, high voltage • Relatively long cycle life, high efficiency, no memory effect • Large operating temperature range (-30°C - 50°C) • Low self-discharge • No heavy metals | • Low energy density, low cycle • Expansion risk due to gas formation, size of heavy metals • Safety risk of fire or explosion if improperly handled, issues of thermal runaway - BMS needed • Low performance at extreme temperatures • Not fast charging rates • High costs |
| Li-ion | Commercialized | Very high | High | Electronics, consumer, transport, stationary, medical devices | 1981 | • High energy density • More safe than other battery (deposits eliminated) • Low toxicity (highly recyclable and recharged) • Large operating temperature range (-30°C - 50°C) | • Low energy density, high cycle • Requires complex charge algorithm (does not absorb overcharge well) • High self-discharge rate, limited service life • Deposits build during fast charge and high load discharge • Costs, memory effect • High self-discharge rates, low capacity and energy density • Use of cadmium (environmentally toxic) • High volumes, expensive electrolytes • Restricted to large scale stationary applications • Relatively complex related to the aging use • Very difficult to make rechargable (low efficiency, short cycle life, high self-discharge) • Low self-voltage, low power delivery capacity • Dendrites formation, non-uniform ion distribution, limited stability in electrolytes, electrolyte degradation • Restricted to high temperature (-30°C - 50°C) • Use of highly corrosive and volatile organic solvents (high safety requirements, higher costs, electrolyte becomes gradually conductive, increasing self-discharge) • No flexibility in power/energy ratio • Restricted to large scale stationary applications • Very low energy density compared to Li-ion (not flammable, not toxic) |
| Na-S | Commercialized | Medium | Medium | Stationary applications, hybrid electric vehicles, consumer and industrial applications | 1970 | • High energy density • More safe than other battery (deposits eliminated) • Low toxicity (highly recyclable and recharged) • Large operating temperature range (-30°C - 50°C) | • Low energy density, high cycle • Requires complex charge algorithm (does not absorb overcharge well) • High self-discharge rate, limited service life • Deposits build during fast charge and high load discharge • Costs, memory effect • High self-discharge rates, low capacity and energy density • Use of cadmium (environmentally toxic) • High volumes, expensive electrolytes • Restricted to large scale stationary applications • Relatively complex related to the aging use • Very difficult to make rechargable (low efficiency, short cycle life, high self-discharge) • Low self-voltage, low power delivery capacity • Dendrites formation, non-uniform ion distribution, limited stability in electrolytes, electrolyte degradation • Restricted to high temperature (-30°C - 50°C) • Use of highly corrosive and volatile organic solvents (high safety requirements, higher costs, electrolyte becomes gradually conductive, increasing self-discharge) • No flexibility in power/energy ratio • Restricted to large scale stationary applications • Very low energy density compared to Li-ion (not flammable, not toxic) |
| Na-Cd | Commercialized | No | Low | Electronics, consumer, emergency lighting, medical devices | 1988 | • Good cycle life and performance at low temperatures • Safe at high discharge rate | • Low energy density, high cycle • Requires complex charge algorithm (does not absorb overcharge well) • High self-discharge rate, limited service life • Deposits build during fast charge and high load discharge • Costs, memory effect • High self-discharge rates, low capacity and energy density • Use of cadmium (environmentally toxic) • High volumes, expensive electrolytes • Restricted to large scale stationary applications • Relatively complex related to the aging use • Very difficult to make rechargable (low efficiency, short cycle life, high self-discharge) • Low self-voltage, low power delivery capacity • Dendrites formation, non-uniform ion distribution, limited stability in electrolytes, electrolyte degradation • Restricted to high temperature (-30°C - 50°C) • Use of highly corrosive and volatile organic solvents (high safety requirements, higher costs, electrolyte becomes gradually conductive, increasing self-discharge) • No flexibility in power/energy ratio • Restricted to large scale stationary applications • Very low energy density compared to Li-ion (not flammable, not toxic) |
| Redox Flow | Commercialized | High | Low | Stationary | 1970 | • Scalable in power and energy • Unlimited number of cycles, virtually no aging of electrode • No dendrites, no electrolyte | • Low energy density, high cycle • Requires complex charge algorithm (does not absorb overcharge well) • High self-discharge rate, limited service life • Deposits build during fast charge and high load discharge • Costs, memory effect • High self-discharge rates, low capacity and energy density • Use of cadmium (environmentally toxic) • High volumes, expensive electrolytes • Restricted to large scale stationary applications • Relatively complex related to the aging use • Very difficult to make rechargable (low efficiency, short cycle life, high self-discharge) • Low self-voltage, low power delivery capacity • Dendrites formation, non-uniform ion distribution, limited stability in electrolytes, electrolyte degradation • Restricted to high temperature (-30°C - 50°C) • Use of highly corrosive and volatile organic solvents (high safety requirements, higher costs, electrolyte becomes gradually conductive, increasing self-discharge) • No flexibility in power/energy ratio • Restricted to large scale stationary applications • Very low energy density compared to Li-ion (not flammable, not toxic) |
| Flow-Bat | Commercialized | Low | Low | Heating, cold, transport, stationary | 1988 | • Good cycle life and performance at low temperatures • Safe at high discharge rate | • Low energy density, high cycle • Requires complex charge algorithm (does not absorb overcharge well) • High self-discharge rate, limited service life • Deposits build during fast charge and high load discharge • Costs, memory effect • High self-discharge rates, low capacity and energy density • Use of cadmium (environmentally toxic) • High volumes, expensive electrolytes • Restricted to large scale stationary applications • Relatively complex related to the aging use • Very difficult to make rechargable (low efficiency, short cycle life, high self-discharge) • Low self-voltage, low power delivery capacity • Dendrites formation, non-uniform ion distribution, limited stability in electrolytes, electrolyte degradation • Restricted to high temperature (-30°C - 50°C) • Use of highly corrosive and volatile organic solvents (high safety requirements, higher costs, electrolyte becomes gradually conductive, increasing self-discharge) • No flexibility in power/energy ratio • Restricted to large scale stationary applications • Very low energy density compared to Li-ion (not flammable, not toxic) |
| Na-S | Commercialized | High | Low | Stationary | 1970 | • High energy density • High efficiency • No self-discharge and memory effect • Long calendar life and high cycle life • Responsive and non-toxic materials | • Low energy density, high cycle • Requires complex charge algorithm (does not absorb overcharge well) • High self-discharge rate, limited service life • Deposits build during fast charge and high load discharge • Costs, memory effect • High self-discharge rates, low capacity and energy density • Use of cadmium (environmentally toxic) • High volumes, expensive electrolytes • Restricted to large scale stationary applications • Relatively complex related to the aging use • Very difficult to make rechargable (low efficiency, short cycle life, high self-discharge) • Low self-voltage, low power delivery capacity • Dendrites formation, non-uniform ion distribution, limited stability in electrolytes, electrolyte degradation • Restricted to high temperature (-30°C - 50°C) • Use of highly corrosive and volatile organic solvents (high safety requirements, higher costs, electrolyte becomes gradually conductive, increasing self-discharge) • No flexibility in power/energy ratio • Restricted to large scale stationary applications • Very low energy density compared to Li-ion (not flammable, not toxic) |
| Na-ion (emerging) | Commercialized | Low | Low | Stationary | 2012 | • Safer technology compared to Li-ion (not flammable, not toxic) | • Low energy density, high cycle • Requires complex charge algorithm (does not absorb overcharge well) • High self-discharge rate, limited service life • Deposits build during fast charge and high load discharge • Costs, memory effect • High self-discharge rates, low capacity and energy density • Use of cadmium (environmentally toxic) • High volumes, expensive electrolytes • Restricted to large scale stationary applications • Relatively complex related to the aging use • Very difficult to make rechargable (low efficiency, short cycle life, high self-discharge) • Low self-voltage, low power delivery capacity • Dendrites formation, non-uniform ion distribution, limited stability in electrolytes, electrolyte degradation • Restricted to high temperature (-30°C - 50°C) • Use of highly corrosive and volatile organic solvents (high safety requirements, higher costs, electrolyte becomes gradually conductive, increasing self-discharge) • No flexibility in power/energy ratio • Restricted to large scale stationary applications • Very low energy density compared to Li-ion (not flammable, not toxic) |

Technology description

- Technology principle
- Advantages/Drawbacks
- Challenges and envisioned solutions
- Main market players
- Technology maturity
- R&D effort level
- Market adoption
- Market applications
- First date of commercialization

MAGNESIUM-ION BATTERY

Technology overview

SODIUM-ION BATTERY

Technology overview

LITHIUM-SULFUR BATTERY

Technology overview

LITHIUM-AIR BATTERY

Technology overview

REDOX FLOW BATTERY

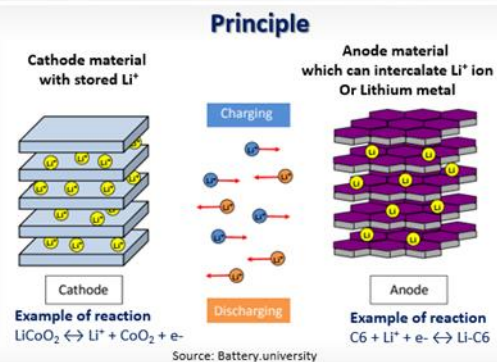
Technology overview

NI-MH BATTERY

Technology overview

LITHIUM-ION BATTERY

Technology overview



Advantages

- High energy and power density
- High voltage
- Relatively long cycle life
- High efficiency
- No memory effect
- Large operating temperature range
- Low self-discharge
- No heavy metals

Drawbacks

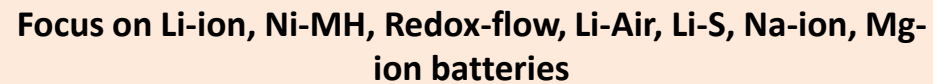
- Safety (risk of fire or explosion if improperly handled, issues of thermal runaway) - BMS needed
- Low performances at extreme temperatures
- Not fast charging rates
- High costs

Challenges and envisioned solutions

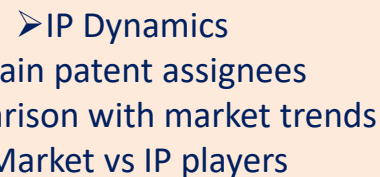
- **Improve performances** (energy density, power density (fast charging batteries), life duration especially for frequent and rapid charge/discharge and high temperature operation)
 - Develop new electrode materials (Anodes with high capacity and low voltage, cathode with high capacity and high voltage)
 - Develop new electrolytes (High voltage electrolytes-new solvents, salts or additives, solid electrolytes with high ionic conductivity)
 - Develop new separators (High ionic conductivity, high resistance to solvents, high mechanical strength (do not cracks if dendrites are created), No electric conductivity
 - Improve the battery control by BMS
- **Improve safety**
 - Use solid/non-flammable electrolytes or with fire retardant
 - Improve cells arrangements in battery packs to avoid fire propagation upon failure and resistance to exterior constraints
 - Develop new separators (High ionic conductivity, high resistance to solvents, high mechanical strength (do not cracks if dendrites are created), No electric conductivity
 - Improve thermal management in battery packs (BMS + cooling systems + fire retardant products)
 - Improve BMS (circuit protection to maintain safe operation)
- **Decrease costs**
 - Costs should decrease with an increasing market size.
 - Cost could be decrease at cell level (decrease costs of materials (anode, cathode, electrolyte, separator, cell design, manufacturing process and equipment improvements) and at pack level (improvements BMS, thermal management, safety devices).

Overview of patenting activity by battery technologies

**REPORT
SAMPLE**



- Patenting activity by battery technology and supply chain
 - Main patent assignees
 - Main technology trends
 - Comparison with market trends



BATTERY TECHNOLOGIES

Focus on Lithium-ion battery

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SAMPLE

LITHIUM BATTERY SUPPLY CHAIN

Main patent applicants for new patent published in 2017

| ALL SUPPLY CHAIN | ELECTRODE MANUFACTURING | ELECTROLYTE | SEPARATOR | BATTERY CELL | BATTERY PACK/SYSTEM |
|------------------|-------------------------|-------------|-----------|--------------|---------------------|
| 1 | 2 | 3 | 4 | 5 | 6 |

The number represent the number of patent families firstly published in 2017.

LITHIUM BATTERY Electrolyte

Main Lithium battery electrolytes

Liquid Gel-polymer Solid

Salt + Solvent + Additives
Salts: LiPF₆, LiTFSI etc.
Organic solvents: EC, DMC, PC etc.
Additives: FEC, LiBOB, BP, CBH etc.

• **Market:** Main electrolyte use in commercialized cells
• **R&D:** New salts, solvents and additives

• An electrolyte must have a high ionic conductivity in presence of electrode

• The trends in Li-ion battery electrolyte
• The development of high voltage electrolyte
• The development of safer electrolyte
• The development of solid electrolyte

LITHIUM BATTERY

2017 patenting activity by supply chain segment



Patenting activity by supply chain segments

- Main patent assignees
- Main technology trends for electrolytes
- Main technology trends
- Comparison with market trends

LITHIUM BATTERY ELECTRODE

Main patent applicants for new patent published in 2017

| ANODE MATERIAL | CATHODE MATERIAL |
|----------------|------------------|
| 1 | 1 |

The number represent the number of patent families firstly published in 2017.

LITHIUM BATTERY ELECTRODE

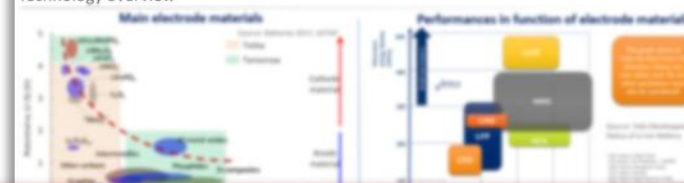
Anode: 2017 patenting activity

LITHIUM BATTERY ELECTRODE

Cathode: 2017 patenting activity

LITHIUM BATTERY ELECTRODE

Technology overview



Focus on electrode materials

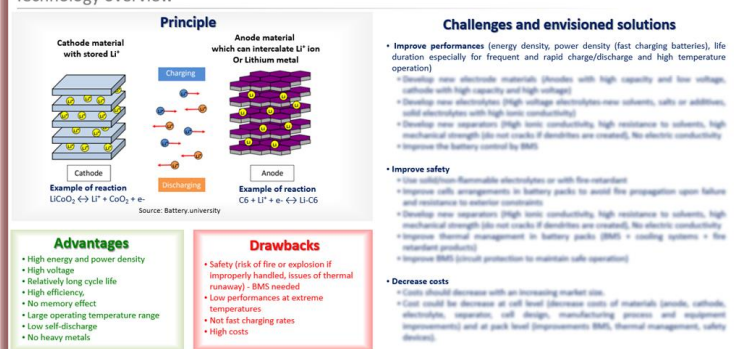
Anode: Graphite, Silicon, Lithium metal, LTO, Graphene

Cathode: NMC, NCA, LFP, LMO, LCO

- Electrode materials performances
- Main patent assignees
- Main technology trends
- Comparison with market trends

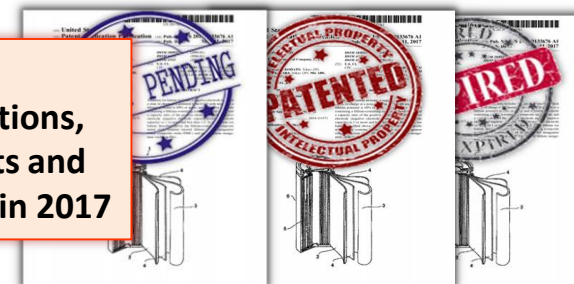
LITHIUM-ION BATTERY

Technology overview



Noticeable

new patent applications,
new granted patents and
new expired patents in 2017



Focus on Ni-MH, Redox-flow, Li-Air, Li-S, Na-ion and Mg-ion Batteries

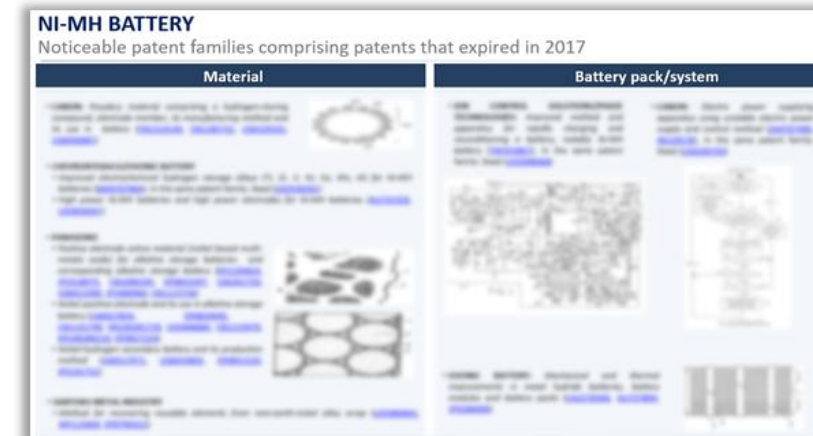
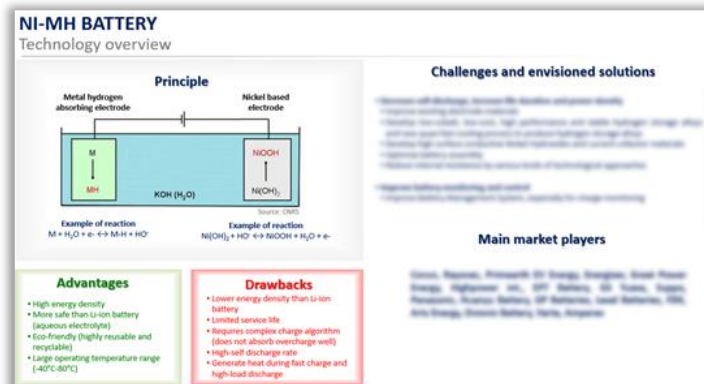
**REPORT
SAMPLE**

Technology description

- Principle, Advantages, drawbacks
 - Main challenges,
 - Main market players

- Number of patents by supply chain segments
 - Main patent assignees
 - Main technology trends
 - Comparison with market trends

**Noticeable
new patent applications,
new granted patents and
new expired patents in 2017**



US PATENT LITIGATION

REPORT
SAMPLE



US PATENT LITIGATION

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US PATENT LITIGATION

University of Chicago / BASF litigation campaign (1/5)

On February 2015, BASF and University of Chicago (Chicago) filed a patent infringement suit and an International Trade Commission (ITC) investigation against Umicore and Moli Energy. The accused products are Moli materials and cell batteries using these. Umicore was accused to manufacture, import and sell Moli cathode material infringing BASF patents of University of Chicago. Moli was accused to manufacture, import and sell products in the cell that incorporate Moli cathode active material infringing BASF patents of University of Chicago.

Two patents, covering the same patent family are involved in the lawsuit (US9,778,664; US9,999,525). These are related to the chemical compositions of cathode double phase layered materials used in lithium-ion batteries having a general formula $\text{LiMO}_2 \cdot \text{Li}_x\text{O}$.

University of Chicago (Chicago) is the assignor of the patents and has partnered with BASF to commercialize Moli technology, granting BASF an exclusive license under these patents. During the procedure, Umicore and Moli Energy tried to invalidate the two patents via IPR Review, without success (USPTO 2015-02330 and USPTO 2015-02331 for BASF; USPTO 2015-02332 and USPTO 2015-02333 for Moli).

| Case Number | Date of filing (litigation) | Court | Judge | Plaintiff | Defendant | Case Status | Related to the lawsuit |
|---------------|-----------------------------|-------|-----------------|-----------|-------------|-------------|---------------------------|
| US 2015-02330 | 02-02-2015 | ITC | Thomas B. Stark | BASF | Umicore | Open | USPTO Patent Infringement |
| US 2015-02331 | 02-02-2015 | ITC | Thomas B. Stark | BASF | Moli Energy | Open | USPTO Patent Infringement |

Conclusions of the patent lawsuits by defendants

| Patent | Defendant | Status | Termination date (if any) | Conclusion |
|--------------|-------------|--------|---------------------------|---|
| US 9,778,664 | Umicore | Closed | 05-05-2017 | Umicore's motion to terminate the ITC investigation was granted. The ITC investigation is terminated. |
| US 9,999,525 | Moli Energy | Closed | 05-05-2017 | Moli Energy's motion to terminate the ITC investigation was granted. The ITC investigation is terminated. |

US PATENT LITIGATION

University of Chicago / BASF litigation campaign (2/5)

Key issues involved in the patent litigation campaign

- The challenged claims require an electrode having a general formula $\text{LiMO}_2 \cdot \text{Li}_x\text{O}$ in which "both the LiMO_2 and Li_xO components are layered" and the "transition of the LiMO_2 and Li_xO components with Li_xO ". The specification describes in detail the layered structure of the new electrode materials comprising ability and capacity. The specification also refers to the "layered electrode structure" represented by (general formula $\text{LiMO}_2 \cdot \text{Li}_x\text{O}$).
- Regarding the IPR Review, the issue of the dispute is whether, under the broader reasonable interpretation of the claims, the term "layered structure" and in particular the "Li" transition, defines a structural relationship between the two electrode components LiMO_2 and Li_xO . The conclusion was that BASF patents of University of Chicago are valid.
- Regarding the litigation with Moli Energy, the key point was to determine if Moli Energy's Moli materials were made of double phase materials. Several chemical and structural analyses have been performed on Moli Energy materials and compared to the description of the material in the patents. The conclusion was that Moli Energy's Moli patents of University of Chicago are valid.

Layered LiMO_2

Layered $\text{LiMO}_2 \cdot \text{Li}_x\text{O}$

Focus on main US patent litigation
University of Chicago/BASF vs Umicore
LG Chem/Toray Industries vs Amperex

US PATENT LITIGATION

Details of US patent litigation filed or closed in 2017 (1/2)

| Case | Plaintiff | Defendant | Case Status | Filing date (YYYY-MM-DD) | Closing date (YYYY-MM-DD) | Patents in lawsuit | Non-Patenting Entity | Accused Products | Battery supply chain position of accused products |
|----------------|-----------|-----------|-------------|--------------------------|---------------------------|----------------------------|----------------------|--------------------------------------|---|
| US 2017-010001 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010002 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010003 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010004 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010005 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010006 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010007 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010008 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010009 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |
| US 2017-010010 | Umicore | Umicore | Closed | 2017-01-01 | 2017-01-01 | US 9,778,664; US 9,999,525 | No | Umicore materials and cell batteries | Umicore |

US Patent litigation filed or closed in 2017
Plaintiffs/defendants, Dates, Case status
Accused products, Patents in lawsuits

US PATENT LITIGATION

University of Chicago / BASF litigation campaign (3/5)

Chronology of main events during the patent lawsuits

2015

2016

2017

2018

US PATENT LITIGATION

University of Chicago / BASF litigation campaign (4/5)

Geographic coverage and legal status of patents in the patent family

World map showing geographic coverage of patents in the patent family.

Patent legal status: Green = Granted, Blue = Pending, Red = Closed

**REPORT
SAMPLE**

The report also includes an **Excel database** containing >40,900 patent families of the **main patent assignees** and related to **the key battery technologies**. This useful patent database allows **multi-criteria searches**, including patent numbers, priority/publication dates, patent assignees, titles, abstracts, claims, legal status of patents, hyperlinks to original documents, and **technical segmentation** (electrode, electrolyte, separator, battery cell, battery pack/system, Li-ion, Ni-MH, Redox flow, Lead, Li-Air, Li-S, Na-ion, Mg-ion, solid-state).

| Patent information | | | | | | | | | | Categorization of the patents | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | X | Y | Z | AA | AB | AC | AD | AE | AF | AG | AH | AI | AJ | AK | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 | 211 | 212 | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 | 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 | 257 | 258 | 259 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 269 | 270 | 271 | 272 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 | 301 | 302 | 303 | 304 | 305 | 306 | 307 | 308 | 309 | 310 | 311 | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 | 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 | 331 | 332 | 333 | 334 | 335 | 336 | 337 | 338 | 339 | 340 | 341 | 342 | 343 | 344 | 345 | 346 | 347 | 348 | 349 | 350 | 351 | 352 | 353 | 354 | 355 | 356 | 357 | 358 | 359 | 360 | 361 | 362 | 363 | 364 | 365 | 366 | 367 | 368 | 369 | 370 | 371 | 372 | 373 | 374 | 375 | 376 | 377 | 378 | 379 | 380 | 381 | 382 | 383 | 384 | 385 | 386 | 387 | 388 | 389 | 390 | 391 | 392 | 393 | 394 | 395 | 396 | 397 | 398 | 399 | 400 | 401 | 402 | 403 | 404 | 405 | 406 | 407 | 408 | 409 | 410 | 411 | 412 | 413 | 414 | 415 | 416 | 417 | 418 | 419 | 420 | 421 | 422 | 423 | 424 | 425 | 426 | 427 | 428 | 429 | 430 | 431 | 432 | 433 | 434 | 435 | 436 | 437 | 438 | 439 | 440 | 441 | 442 | 443 | 444 | 445 | 446 | 447 | 448 | 449 | 450 | 451 | 452 | 453 | 454 | 455 | 456 | 457 | 458 | 459 | 460 | 461 | 462 | 463 | 464 | 465 | 466 | 467 | 468 | 469 | 470 | 471 | 472 | 473 | 474 | 475 | 476 | 477 | 478 | 479 | 480 | 481 | 482 | 483 | 484 | 485 | 486 | 487 | 488 | 489 | 490 | 491 | 492 | 493 | 494 | 495 | 496 | 497 | 498 | 499 | 500 | 501 | 502 | 503 | 504 | 505 | 506 | 507 | 508 | 509 | 510 | 511 | 512 | 513 | 514 | 515 | 516 | 517 | 518 | 519 | 520 | 521 | 522 | 523 | 524 | 525 | 526 | 527 | 528 | 529 | 530 | 531 | 532 | 533 | 534 | 535 | 536 | 537 | 538 | 539 | 540 | 541 | 542 | 543 | 544 | 545 | 546 | 547 | 548 | 549 | 550 | 551 | 552 | 553 | 554 | 555 | 556 | 557 | 558 | 559 | 560 | 561 | 562 | 563 | 564 | 565 | 566 | 567 | 568 | 569 | 570 | 571 | 572 | 573 | 574 | 575 | 576 | 577 | 578 | 579 | 580 | 581 | 582 | 583 | 584 | 585 | 586 | 587 | 588 | 589 | 590 | 591 | 592 | 593 | 594 | 595 | 596 | 597 | 598 | 599 | 600 | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 | 611 | 612 | 613 | 614 | 615 | 616 | 617 | 618 | 619 | 620 | 621 | 622 | 623 | 624 | 625 | 626 | 627 | 628 | 629 | 630 | 631 | 632 | 633 | 634 | 635 | 636 | 637 | 638 | 639 | 640 | 641 | 642 | 643 | 644 | 645 | 646 | 647 | 648 | 649 | 650 | 651 | 652 | 653 | 654 | 655 | 656 | 657 | 658 | 659 | 660 | 661 | 662 | 663 | 664 | 665 | 666 | 667 | 668 | 669 | 670 | 671 | 672 | 673 | 674 | 675 | 676 | 677 | 678 | 679 | 680 | 681 | 682 | 683 | 684 | 685 | 686 | 687 | 688 | 689 | 690 | 691 | 692 | 693 | 694 | 695 | 696 | 697 | 698 | 699 | 700 | 701 | 702 | 703 | 704 | 705 | 706 | 707 | 708 | 709 | 710 | 711 | 712 | 713 | 714 | 715 | 716 | 717 | 718 | 719 | 720 | 721 | 722 | 723 | 724 | 725 | 726 | 727 | 728 | 729 | 730 | 731 | 732 | 733 | 734 | 735 | 736 | 737 | 738 | 739 | 740 | 741 | 742 | 743 | 744 | 745 | 746 | 747 | 748 | 749 | 750 | 751 | 752 | 753 | 754 | 755 | 756 | 757 | 758 | 759 | 760 | 761 | 762 | 763 | 764 | 765 | 766 | 767 | 768 | 769 | 770 | 771 | 772 | 773 | 774 | 775 | 776 | 777 | 778 | 779 | 780 | 781 | 782 | 783 | 784 | 785 | 786 | 787 | 788 | 789 | 790 | 791 | 792 | 793 | 794 | 795 | 796 | 797 | 798 | 799 | 800 | 801 | 802 | 803 | 804 | 805 | 806 | 807 | 808 | 809 | 810 | 811 | 812 | 813 | 814 | 815 | 816 | 817 | 818 | 819 | 820 | 821 | 822 | 823 | 824 | 825 | 826 | 827 | 828 | 829 | 830 | 831 | 832 | 833 | 834 | 835 | 836 | 837 | 838 | 839 | 840 | 841 | 842 | 843 | 844 | 845 | 846 | 847 | 848 | 849 | 850 | 851 | 852 | 853 | 854 | 855 | 856 | 857 | 858 | 859 | 860 | 861 | 862 | 863 | 864 | 865 | 866 | 867 | 868 | 869 | 870 | 871 | 872 | 873 | 874 | 875 | 876 | 877 | 878 | 879 | 880 | 881 | 882 | 883 | 884 | 885 | 886 | 887 | 888 | 889 | 890 | 891 | 892 | 893 | 894 | 895 | 896 | 897 | 898 | 899 | 900 | 901 | 902 | 903 | 904 | 905 | 906 | 907 | 908 | 909 | 910 | 911 | 912 | 913 | 914 | 915 | 916 | 917 | 918 | 919 | 920 | 921 | 922 | 923 | 924 | 925 | 926 | 927 | 928 | 929 | 930 | 931 | 932 | 933 | 934 | 935 | 936 | 937 | 938 | 939 | 940 | 941 | 942 | 943 | 944 | 945 | 946 | 947 | 948 | 949 | 950 | 951 | 952 | 953 | 954 | 955 | 956 | 957 | 958 | 959 | 960 | 961 | 962 | 963 | 964 | 965 | 966 | 967 | 968 | 969 | 970 | 971 | 972 | 973 | 974 | 975 | 976 | 977 | 978 | 979 | 980 | 981 | 982 | 983 | 984 | 985 | 986 | 987 | 988 | 989 | 990 | 991 | 992 | 993 | 994 | 995 | 996 | 997 | 998 | 999 | 1000 |
| numbers | Publication stage | Publication date | Earliest publication date | Original document no. | Application date | Priority date | Filing date | Expected date of expiry | Legal action | Family legal status | Legal status (Pending, Granted, Revoked) | Family legal status | Grant date | Current assignee | Inventor's name | English title | English abstract | Electrode | Electrolyte | Separator | Battery cell | Battery pack/system | BMS | Thermal management | Microbattery | Flexible battery | Solid-state battery | Li-ion battery | Ni-MH battery | Fedox-flow battery | Li-Air battery | Li-S battery | Na-ion battery | Mg-ion battery | Lithium-metal electrode | Silicon anode | NMC cathode | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | US2002023731 (A2) | 2002-02-23 | 2002-02-23 | 2000-08-08 | US002385 | 20020022 | 20020022 | 20020022 | GRANTED | 20020022 | GRANTED | 20020022 | 20020022 | US002385 | LG CHEM LEE | US002385 | US002385 | US002385 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Excel worksheet listing the patent newly granted in 2017

▶ Excel worksheet listing the new patent applications published in 2017

ORDER FORM

Status of the Battery Patents 2018

Ref.:KM18004

SHIP TO

Name (Mr/Ms/Dr/Pr):

Job Title:

Company:

Address:

City:

State:

Postcode/Zip:

Country:

VAT ID Number for EU members:

Tel:

Email:

Date:

PAYMENT METHODS

Check

To pay your invoice using a check, please mail your check to the following address:

KnowMade S.A.R.L.
2405 route des Dolines
06902 Valbonne Sophia Antipolis
FRANCE

Money Transfer

To pay your invoice using a bank money wire transfer please contact your bank to complete this process. Here is the information that you will need to submit the payment:

Payee: KnowMade S.A.R.L.
Bank: Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var
IBAN: FR76 1460 7003 6360 6214 5695 139
BIC/SWIFT: CCBPFRPPMAR

Paypal

In order to pay your invoice via PAYPAL, you must first register at www.paypal.com. Then you can send money to the KnowMade S.A.R.L. by entering our E-mail address contact@knowmade.fr as the recipient and entering the invoice amount.

RETURN ORDER BY

E-mail: contact@knowmade.fr

Mail: KnowMade S.A.R.L., 2405 route des Dolines, 06902 Valbonne Sophia Antipolis, FRANCE

PRODUCT ORDER

☐ €6,490 – Corporate license

☐ €5,990 – Single user license*

For price in dollars, please use the day's exchange rate. For French customer, add 20% for VAT.

All reports are delivered electronically in pdf format at payment reception.

**Single user license means only one person at the company can use the report. Please be aware that our publication will be watermarked on each page with the name of the recipient and of the organization (the name mentioned on the PO). This watermark will also mention that the report sharing is not allowed.*

I hereby accept Knowmade's Terms and Conditions of Sale

Signature:

Terms and Conditions of Sales

DEFINITIONS

“Acceptance”: Action by which the Buyer accepts the terms and conditions of sale in their entirety. It is done by signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”.

“Buyer”: Any business user (i.e. any person acting in the course of its business activities, for its business needs) entering into the following general conditions to the exclusion of consumers acting in their personal interests.

“Contracting Parties” or “Parties”: The Seller on the one hand and the Buyer on the other hand.

“Intellectual Property Rights” (“IPR”) means any rights held by the Seller in its Products, including any patents, trademarks, registered models, designs, copyrights, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property rights or similar in any part of the world, notwithstanding the fact that they have been registered or not and including any pending registration of one of the above mentioned rights.

“License”: For the reports and databases, 2 different licenses are proposed. The buyer has to choose one license:

1. One user license: a single individual at the company can use the report.

2. Multi user license: the report can be used by unlimited users within the company. Subsidiaries are not included.

“Products”: Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

“Seller”: Based in Sophia Antipolis (France headquarters), Knowmade is a technology intelligence company specialized in the research and analysis of scientific and technical information. We provide patent landscapes and scientific state of the art with high added value to businesses and research laboratories. Our intelligence digests play a key role to define your innovation and development strategy.

1. SCOPE

1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. ANY ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS IN ANY OTHER DOCUMENTS ISSUED BY THE BUYER AT ANY TIME ARE HEREBY OBJECTED TO BY THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.

1.2 This agreement becomes valid and enforceable between the Contracting Parties after clear and non-equivocal consent by any duly authorized person representing the Buyer. For these purposes, the Buyer accepts these conditions of sales when signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”. This results in acceptance by the Buyer.

1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7 days] from the date of order, to be sent either by email or to the Buyer’s address. In the absence of any confirmation in writing, orders shall be deemed to have been accepted.

2. MAILING OF THE PRODUCTS

2.1 Products are sent by email to the Buyer:

- within [1] month from the order for Products already released; or

- within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.

2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including in cases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.

2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in article 3.

2.4 The mailing is operated through electronic means either by email via the sales department. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be

sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

2.6 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer’s risk.

3. PRICE, INVOICING AND PAYMENT

3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmade, PayPal or by electronic transfer to the following account:

Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var

BIC or SWIFT code: CCBPFRPPMAR

IBAN: : FR76 1460 7003 6360 6214 5695 139

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

4. LIABILITIES

4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement

4.3 In no event shall the Seller be liable for:

a) damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller’s website or the Products, or any information provided on the website, or in the Products;

b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of

saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

6. PROTECTION OF THE SELLER’S IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;

- Recordings and re-transmittals over any network (including any local area network);

- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;

- Posting any Product to any other online service (including bulletin boards or the Internet);

- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

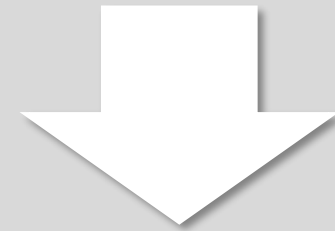
9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.



FOR GOING
EVEN FURTHER



PATENT WATCH
SERVICE

FOR GOING EVEN FURTHER

Patent Watch Service (1/2)

Get updated data on battery patent activity

Keep a watch on your competitors' IP activities and their future intentions.

With the help of the patent watch service, you will be aware of your competitors' current patenting activities, their IP dynamics, patent transfers including acquisitions and licenses, patent litigation, technology development and R&D strategies. You will also be able to rapidly detect new entrants in your business area .

Keep track of the latest technology developments and follow technology trends.

By keeping note of any recent patent filings, you can track the newest innovations in the battery field. You will get details on claimed inventions and you can follow technology developments. New technical solutions could inspire and improve your R&D activity.

Prevent registration of IP rights that may be harmful to your business.

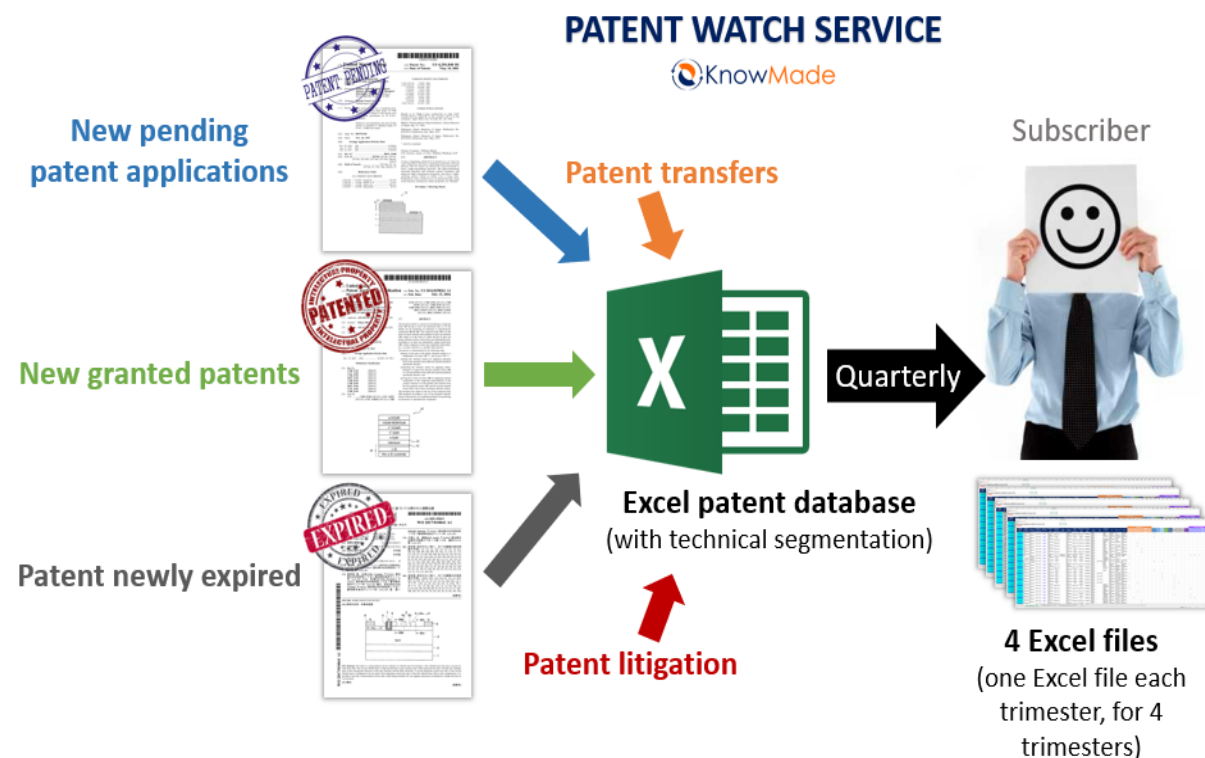
You will obtain information on patent applications filed even before exclusive rights have been granted and you can react in time to prevent registration of IP rights that may be harmful to your business.

React in time to infringements and mitigate legal risks.

Monitoring both newly-issued patents and patent litigation allows you to regularly assess your freedom-to-operate, ensuring your products or processes are not covered by granted patents and thus they can be manufactured, sold or used safely without infringing valid IP rights owned by others.

Take advantage of free technologies and decrease R&D project risks.

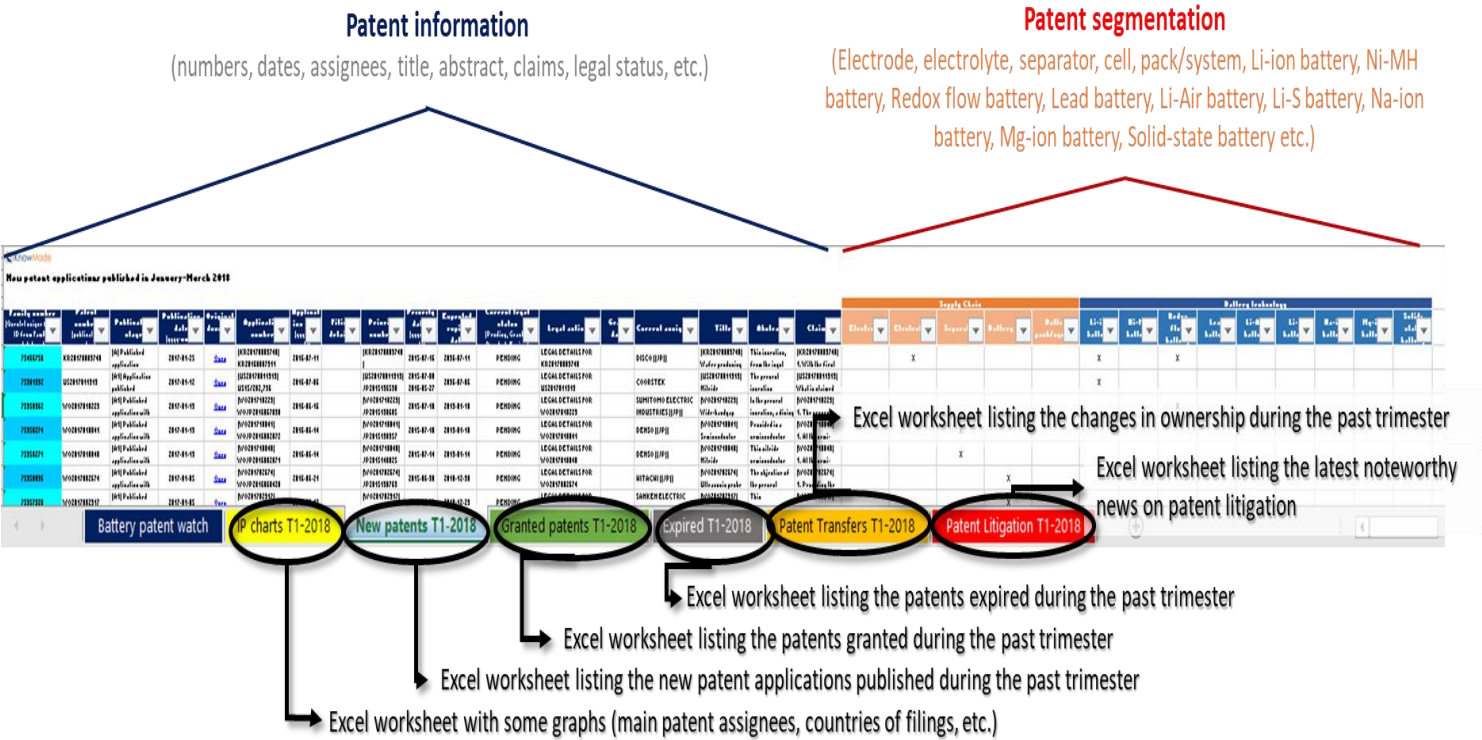
By tracking both expired patents and abandoned patents, you will be able to identify inventions entering the public domain that you can use safely for your development.



FOR GOING EVEN FURTHER

Patent Watch Service (2/2)

- With the **booming number of companies** involved in battery IP and the **proliferation of battery technologies**, take advantage of **quarterly updated Excel file** including the patents newly **published, granted** or **expired** during the past **3 months**, plus the latest **patent transfers** and noteworthy news on **patent litigation**.
- The patents will be **categorized** by supply chain segments (**electrode, electrolyte, separator, battery cell, battery pack/system**) and battery technologies (**Li-ion, Ni-MH, Redox flow, Lead, Li-Air, Li-S, Na-ion, Mg-ion, solid-state, thin film/flexible, lithium metal electrode, NMC cathode for Lithium battery, Silicon anode for Lithium battery**). This useful patent database allows for **multi-criteria searches** (patent numbers, priority dates, patent assignees, titles, abstracts, claims, legal status of patents, hyperlinks to original documents). This quarterly updated Excel file also includes graphs highlighting the **main IP trends of the past 3 months** for each technical segment (patent applicants, countries of patent filings, IP dynamics, etc.).



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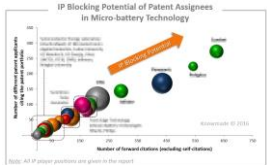
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