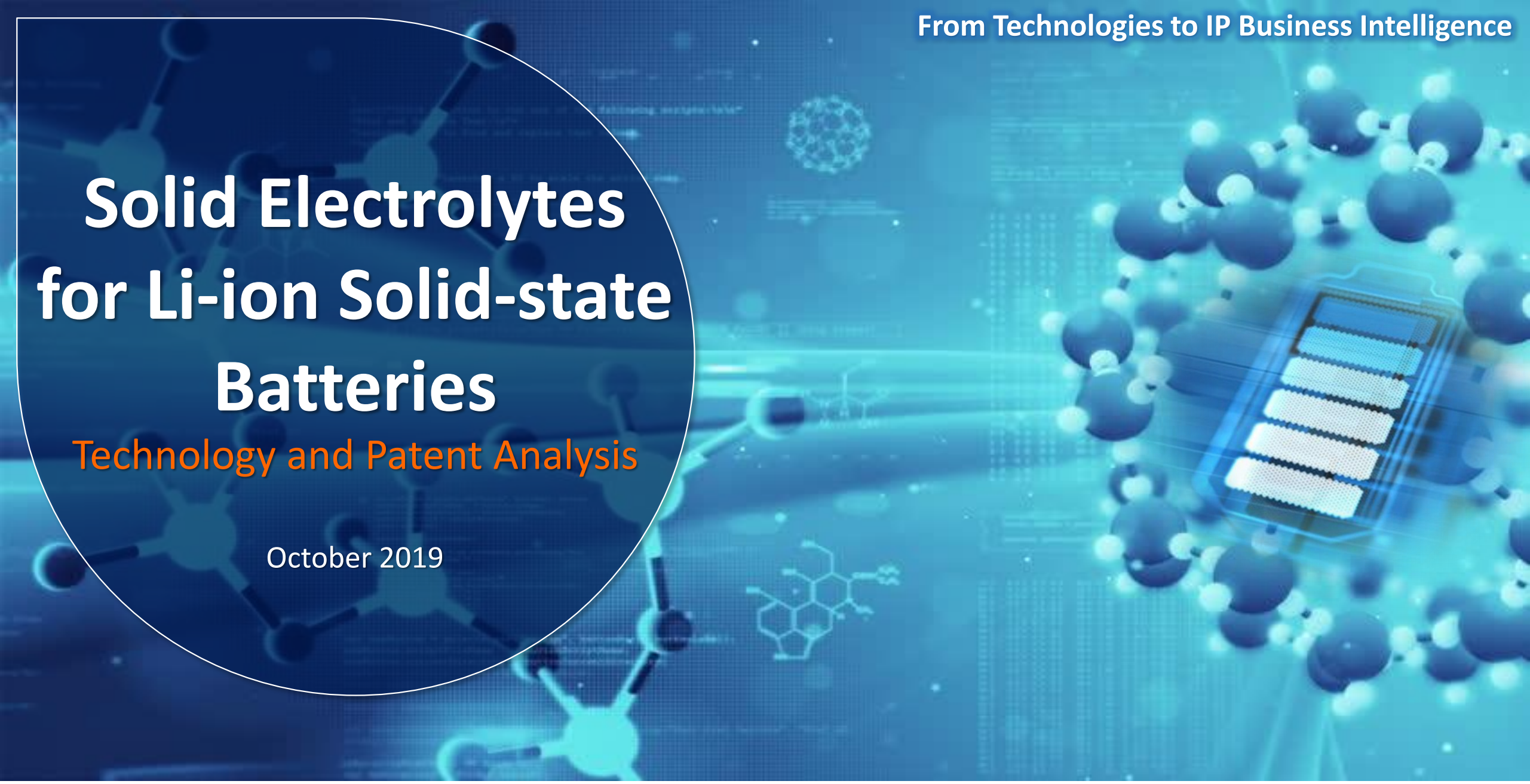
From Technologies to IP Business Intelligence

Solid Electrolytes for Li-ion Solid-state Batteries

Technology and Patent Analysis

October 2019



KnowMade
Patent & Technology Intelligence

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ABOUT KNOWMADE

Knowmade is a Technology Intelligence and IP Strategy consulting company specialized in analysis of patents and scientific information. The company helps R&D organizations, investors and innovative companies to understand their competitive landscape, follow technology trends, and find out opportunities and threats in terms of technology and patents.

Knowmade's analysts combine their strong technology expertise and in-depth knowledge of patents with powerful analytics tools and methodologies to turn patents and scientific findings into business intelligence tools. Our experts provide prior art search, patent landscape analysis, scientific literature analysis, patent valuation, IP due diligence and freedom-to-operate analysis. In parallel the company proposes litigation/licensing support, technology scouting and IP/technology watch service.

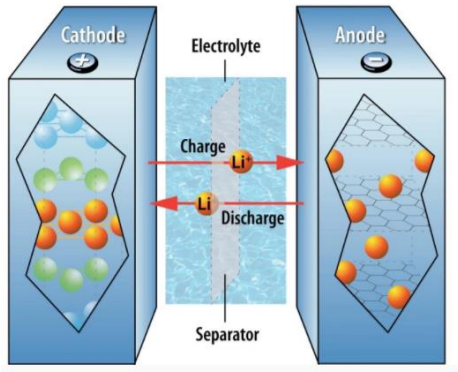
Knowmade has a solid expertise in Compound Semiconductors, Power Electronics, Batteries, RF Technologies & Wireless Communications, Solid-State Lighting & Display, Photonics, Memories, MEMS & Solid-State Sensors/Actuators, Semiconductor Manufacturing, Packaging & Assembly, Medical Devices, Medical Imaging, Microfluidics, Biotechnology, Pharmaceutics, Agri-Food.

INTRODUCTION

Solid-state batteries : Definitions

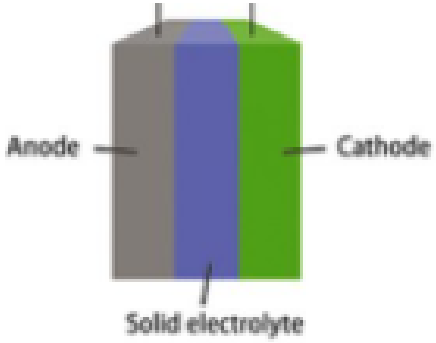
- Solid-state batteries are batteries with **all components in a solid-state** (electrode, electrolyte etc.). They use **same chemistries** than liquid/gelled batteries (i.e. Lithium-ion batteries, Li-Air batteries, Li-S batteries, Na-ion batteries, Mg-ion batteries etc.) but they have a solid electrolyte.
- In a solid-state batteries, two electrodes are separated by a solid-state electrolyte layer instead of a separator impregnated with a liquid of gelled electrolyte. Solid electrolytes allow the movement of ions without the need for a liquid or soft membrane separating the electrodes. Solid electrolytes can be classified in three categories: inorganic, polymer and inorganic/polymer composites.

Conventional liquid battery



Source: Argonne National Laboratory

All-solid-state battery



Source: University of Geneva

- Solid-state batteries have been developed to **enhance battery safety** (not flammable, no leakage, no thermal runaway, restrict dendrites formation etc.) and **enable the use of lithium metal** (improved energy density).

Main advantages and drawbacks of solid-state batteries

Advantages	Drawbacks
• Improved safety (not flammable, no leakage, no thermal runaway, restrict dendrite formation) • High tolerance to high temperature thus less safety protection/cooling systems are needed • Improved energy density: It allows the replacement of conventional anodes with lithium metal (higher capacity), thinner cells, large ESW • No separator membrane required • Simpler cell/pack design	• Lower power density (for the moment) due to lower ionic conductivity of solid electrolyte and resistance induced at electrode/electrolyte interface • Requires different manufacturing processes than liquid batteries • High mechanical constraints in the cell • More expensive • Operation at low temperature may be challenging. • High pressure is required to maintain electrode contact • Electrochemical stability issues with some electrolytes

Today, developed and commercialized solid-state batteries are mainly **Lithium metal and lithium-ion batteries**. This trend is also observed in patents. However, in 2017, some companies published new patent families related to other solid batteries technologies. **Toyota, Denso** and several **Chinese universities** published new patent families related to solid Li-Air batteries (WO2017159420, JP2017168190). **Tokyo Electric Power** and several Chinese universities published new patent families related to solid Li-S batteries (WO2017155011). **Toyota** and **Karlsruhe Institute of Technology** published new patent families related to solid electrolytes for magnesium batteries (US9716289, US9640836) both already granted. **SK Innovation, Toyota, Sila Nanotechnology** and **Foschungszentrum Jülich** published new patent families related to solid-state sodium-ion batteries (WO2017059838, WO2017106563, WO2017102011, KR20170078210).

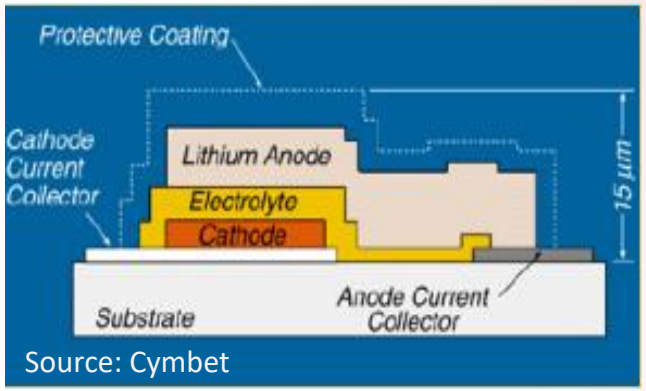
INTRODUCTION

Thin film solid battery *vs.* "Bulk" solid battery

Solid-state batteries can be classified in two categories: Thin Film Solid Batteries and Bulk Solid Batteries. Thin film technology approach proven for thin film battery are not directly applicable for bulk solid-state batteries. Thus, new processes and materials have to be developed to get "bulk" solid batteries reaching market requirements (performances, stability, costs).

Thin film solid batteries

- Miniature batteries with very small energy capacity
- **Maturity:** Commercially available
- **Applications**: Consumer electronics, Microelectronics



Source: Cymbet

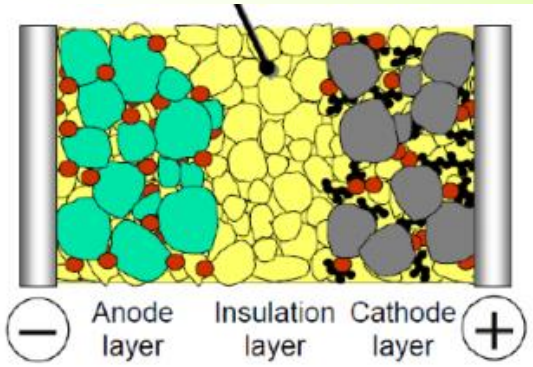
Main market players

cea, CYMBET CORPORATION, POLYPLUS, Infinite Power Solutions, I-TEN, Prieto Battery, Panasonic, Front Edge Technology, Inc., APPLIED MATERIALS, Johnson Battery Technologies, EXCELLATRON, STMicroelectronics, ilika, BRIGHTVOLT SMALL POWERED SOLUTIONS

[Microbattery patent landscape 2016]

"Bulk" solid batteries

- Large batteries such as those used in electric cars
- **Maturity**: Inorganic: Under development; Polymer: Commercialized by Blue Solutions (Operate at 60-80°C)
- **Applications**: Electric vehicles, Consumer devices



Source: Toyota

Potential future market players

BlueSolutions, Panasonic, SAMSUNG, 24M, HYUNDAI, NISSAN, dyson, SAKTI3, TOYOTA, CATL, HITACHI, LG Chem, TOSHIBA, JIAWEI, ProLogium, FISKER, HONDA, TESLA, BMW, ionic MATERIALS, solid energy, PATHION, QuantumScape, nanoOne, Volkswagen, Continental, A123 SYSTEMS, SolidPower, PLANAR Energy Devices, microvast, NGK, Wildcat Discovery Technologies, MITSUI KINZOKU, Empa, KalpTree Energy

This report

INTRODUCTION

Contents of Knowmade's reports related to solid-state batteries

Report	Included	Not included	Technical segments	Technical issues
Microbattery, 2016	• Microbattery • Solid thin film batteries	• Electrodes or electrolytes in which their specific use in micro-batteries or solid thin film batteries is not described. • Thin film batteries with liquid electrolytes • Solid batteries without 3D or thin film electrodes and a thin layer of electrolyte	• Type of claimed invention (product, method, apparatus) • Battery technologies (primary, secondary) • Battery designs (plane, 3D, etc.) • Battery components and their materials (anode: Lithium, Silicon, Carbon, Oxides; cathode: LCO, LFP, etc.; electrolyte: Polymer, LiPON, Li_3N, etc.) • Process methods (CVD, ALD, PVD, sputtering, sol-gel, spray, electrodeposition, printing, electrophoresis, etc.)	• Manufacture thin layer of materials • Improve energy and power densities of very small devices
Solid electrolytes for solid-state Li-ion battery, 2019	• Solid electrolytes for Li-ion batteries* (including polymer, inorganic and polymer/inorganic composite electrolytes)	• Other solid-state batteries (Li-S battery, Li-Air battery, Na-ion battery, Mg-ion battery etc.) • Solid electrolytes without references to their use in Lithium batteries in the patent full text • Gelled electrolytes • Coin-cell solid-state batteries • Thin Film Solid-state batteries • Microbatteries with solid electrolytes	• Type of solid electrolyte (Polymer, Inorganic, Inorganic/polymer) • Inorganic solid electrolytes (Sulfide Glass Ceramics, Thio-LISICON, Argyrodite, Oxide Glass Ceramics, NASICON, Perovskite, Garnet, Anti-Perovskites, Hydrides, others)	• Improve solid electrolyte performances
Solid-state Li-ion batteries, 2019	• Bulk solid-state Li-ion batteries* (with polymer and/or inorganic electrolytes) and their manufacturing methods • Electrodes for bulk solid-state li-ion batteries (core-shell electrode materials / electrodes containing solid electrolyte materials) and their manufacturing methods		• Type of solid electrolyte (Polymer, Inorganic, Inorganic/polymer) • Inorganic solid electrolytes (Sulfide solid electrolytes: Sulfide Glass Ceramics, Thio-LISICON, Argyrodite; Oxide solid electrolytes: Oxide Glass Ceramics, NASICON, Perovskite, Garnet, Anti-Perovskites, Hydrides, others) • Electrode/electrolyte interface (Deposition of a thin coating layer on the electrode, core-shell electrode/solid electrolyte materials, composite electrode containing solid electrolyte) • Manufacturing of battery, electrode layer and electrolyte layer	• Improve electrode/electrolyte interface • Develop manufacturing processes compatible with industrial scale production

* Includes Lithium metal batteries and li-ion batteries

SCOPE OF THE REPORT

Included in the report

Patents related to **solid electrolytes for Li-ion batteries** (including polymer, inorganic and polymer/inorganic composite electrolytes)

The report covers **patents published worldwide** up to **May 2019**

Not included in the report

Patents related to:

- Other solid-state batteries (Li-S battery, Li-Air battery, Na-ion battery, Mg-ion battery etc.)
- Solid electrolytes without references to their use in Lithium batteries in the patent full text
- Gelled electrolytes
- Coin-cell solid-state batteries
- Thin film solid-state batteries
- Microbatteries with solid electrolytes

→ Report: Microbattery Patent Landscape 2016

KEY FEATURES OF THE REPORT (1/2)

- The report provides **essential patent data** for **solid electrolytes for solid-state Li-ion battery**, including **polymer, inorganic and polymer/inorganic composite electrolytes.**

- We have identified more than **40 major patent holders** and the report provides **in-depth patent analyses** of **key technologies** and **key players** including:
  - **IP dynamics** including time evolutions and countries of patent filings for each technological approach.
  - Current **legal status** of patents for each technological approach and for each players.
  - **Ranking** of main patent applicants.
  - **IP position** of key players and **relative strength** of their patent portfolios
  - Joint developments and **IP collaboration** network of main patent applicants.
  - **Key patents** and granted patents near expiration.
  - Matrix patent applicants vs. technologies.

KEY FEATURES OF THE REPORT (2/2)

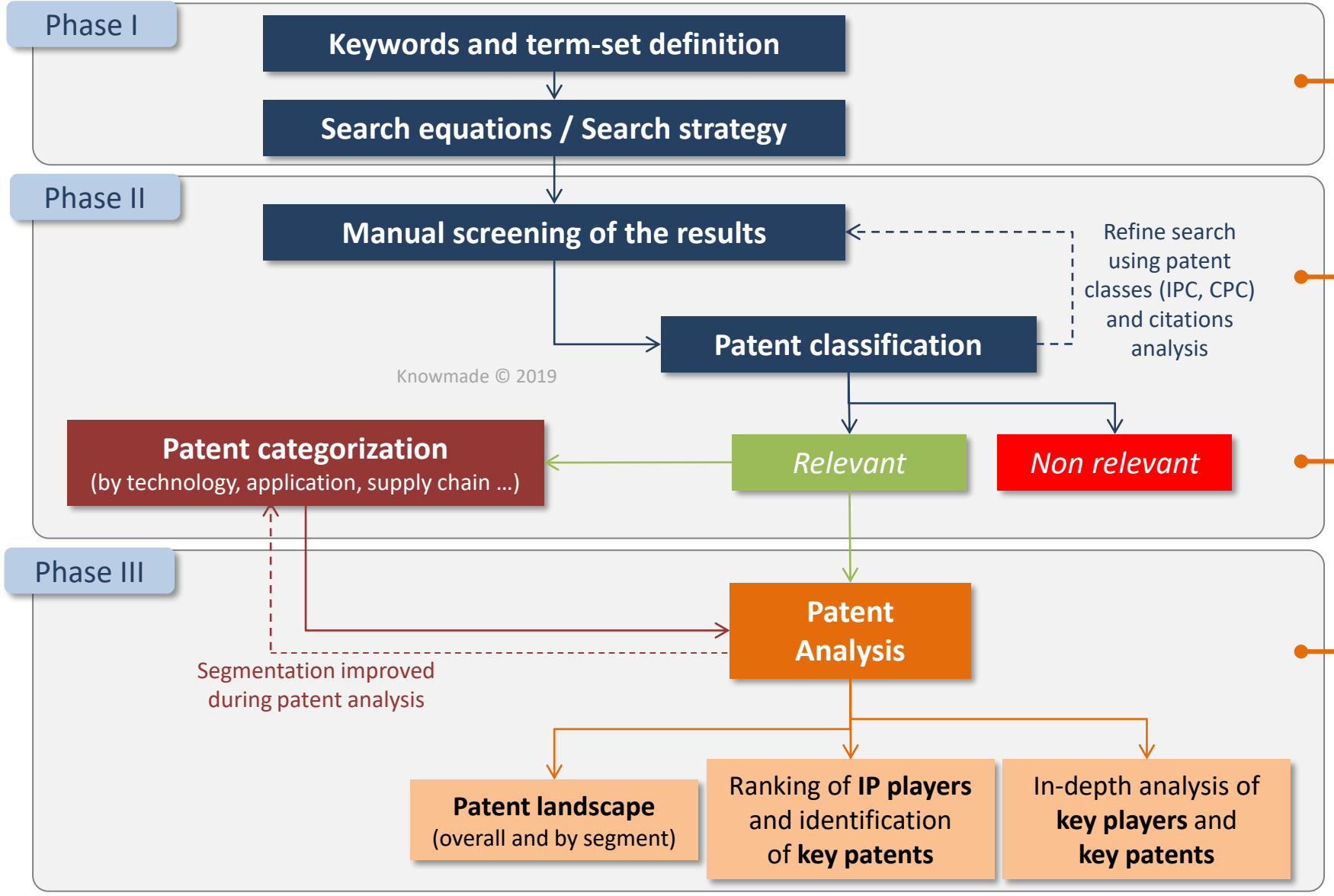
- The report also provides an extensive **Excel database** with **all patents** analyzed in the report (>5,800 patent applications grouped in >2,760 patent families), including application and technology segmentation.

- This **useful patent database** allows multi-criteria searches, including:
  - Patent publication number
  - Hyperlinks to the original documents
  - Priority date
  - Title
  - Abstract
  - Patent assignees
  - Technical 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.

METHODOLOGY

Methodology for patent search, selection and analysis



ORBIT worldwide patent database (Questel)
Provides 100+ million patent documents from 95 offices.

IP analysts with PhD degree combining **technical** and **patent expertise**.

Patents 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.

IP analysts using powerful **analytics tools** and **proprietary methodologies** for **IP business intelligence**.

BENEFITS FOR CUSTOMER

Understanding the **competitive landscape** and **technology developments** from a **patent perspective**

- Know the **key IP players**, their **key patents**, their IP/technology **strategy** and their **future intents** by solid electrolyte materials
- Identify **new entrants**, their **technology** and **market areas** of interest by solid electrolyte materials
- Follow the **technology trends** and identify **emerging technologies** by solid electrolyte materials
- **Benchmark** patent portfolios and know competitors' **strengths** and **weaknesses** by solid electrolyte materials
- Identify the **key patents** (seminal, blocking, valuable) and the **key technical solutions** that address hot technical issues by solid electrolyte materials
- Identify **free technologies** which can be used safely and mitigate the **risks of patent infringement**
- Identify **technologies to acquire** and potential **R&D partners**

Very complementary to market research

Links between patents and

- Key market players
- Supply chain
- Technology Readiness Levels (TRL)
- Market product
- Emerging technologies/applications
- Forecast

INTRODUCTION

Challenges and envisioned technical solutions

INTRODUCTION
Challenges in battery field

Challenges	Improvement solutions
• Increase battery performances (energy and power density, charge duration, life duration, performances in extreme environments)	• **Develop new** electrode materials, **electrolytes** and separators • Decrease cells weight/volume • Improve the battery control by BMS and thermal management
• Improve battery safety (fire/explosion risks, environment contamination)	• Increase the tolerance to overcharging, deep charging, mechanical abuse • **Use solid/non-flammable electrolytes** or fire-retardant in electrolytes • Limit short-circuit risks (ceramic separator etc.) • Use non dangerous materials • Improve cells arrangements in battery packs to avoid fire propagation upon failure • Improve thermal management in battery packs (BMS + cooling systems + fire retardant products) • Improve BMS (circuit protection to maintain safe operations)
• Decrease battery costs	• Use of cheaper materials and processes • Lower the cost due to the increase of production and sales
• Adapt battery morphology to specific applications	• Micro-scale, flexible, cable etc.
• Decrease dependence to scarce materials	• Substitution for lithium, cobalt etc. • Less geopolitical dependence • Especially important for countries with high battery demand and small (no) material resources
• Decrease environmental impact	• No toxic materials, dangerous chemicals, heavy metals • Eco-friendly production • Materials easy to dispose/recycle

INTRODUCTION
Challenges and improvement solutions for "Bulk" solid-state lithium battery

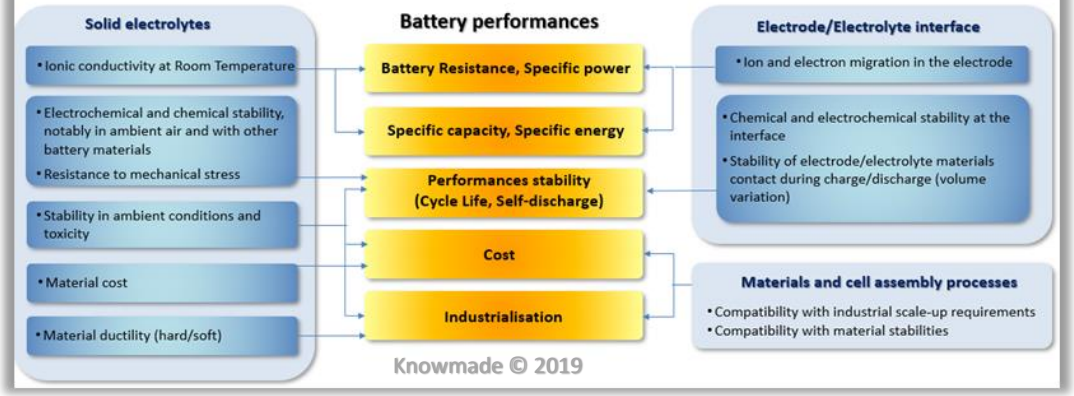
Challenges	Improvement solutions	
• Improve solid electrolyte performances (ionic conductivity at room temperature, electrochemical and chemical stability (notably against Lithium), resistance to mechanical stress induced by volume change during charge/discharge)		Detailed in this report
• Improve electrode/electrolyte interface		Detailed in the report "Bulk solid-state batteries: Technology and Patent Analysis"
• Develop manufacturing processes compatible with industrial production		
• Improve Lithium metal stability		Not detailed in this report
• Decrease battery costs		

INTRODUCTION
Overview of main technical issues for "Bulk" solid-state lithium batteries

Solid Electrolytes	Electrode/electrolyte interface	Battery manufacturing
Improve solid electrolyte performances to improve battery performances (energy and power densities, capacity, maximum voltage) and stability	Improve electrode/electrolyte interface to reduce global battery cell resistance and thus improve its power density and stability	Develop manufacturing processes compatible with industrial production to enable their large scale production and commercialization

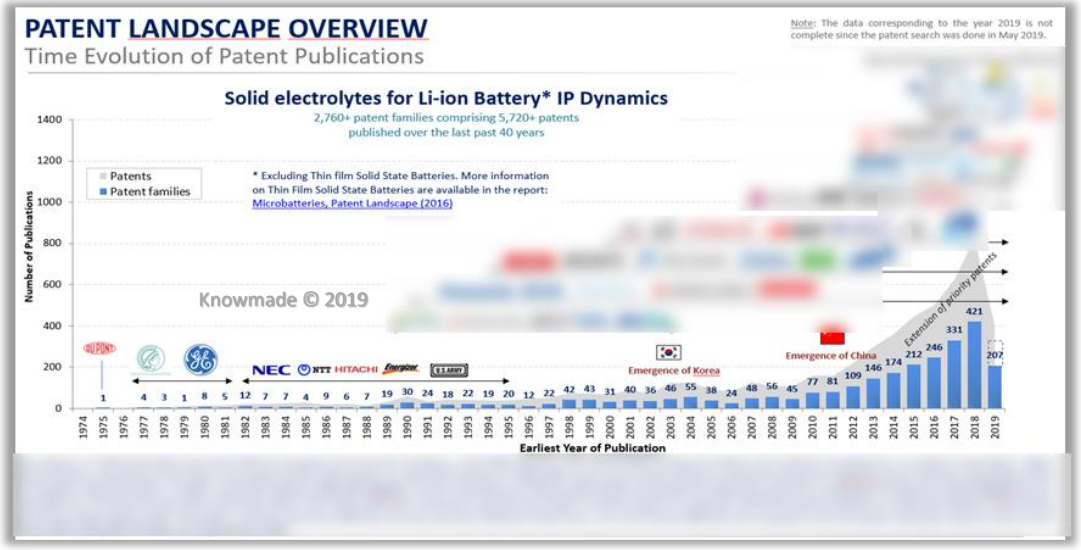
INTRODUCTION
Impact of main "bulk" solid-state battery technical issues on its performances

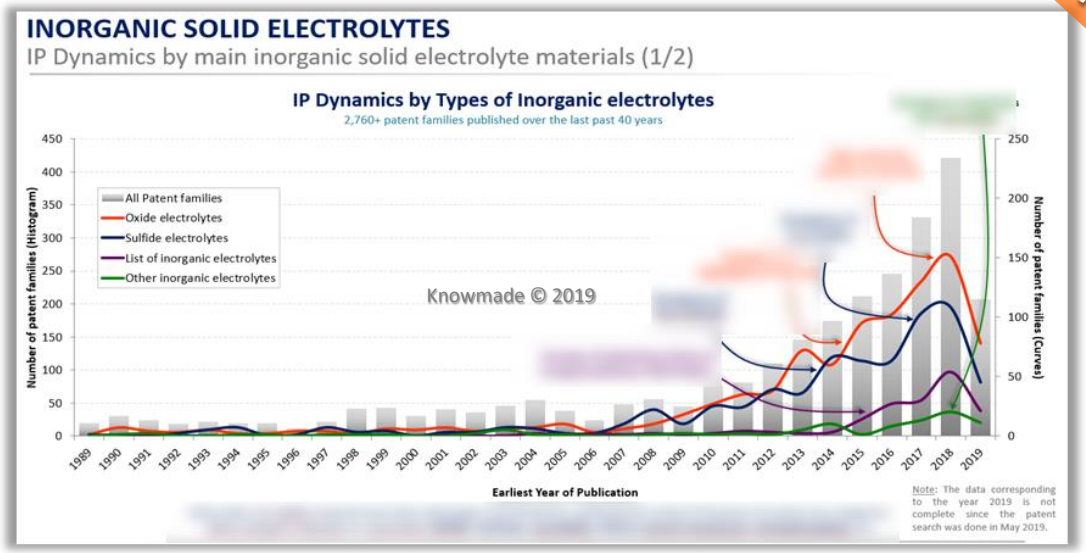
Three main developments axes have been envisioned to improve performances of "Bulk" Solid-state batteries: Solid electrolytes, electrode/electrolyte interface and materials/cell assembly processes. Impact of solid electrolyte properties, electrode/electrolyte interface properties and material/cell assembly processes on battery performances are represented on the scheme below.

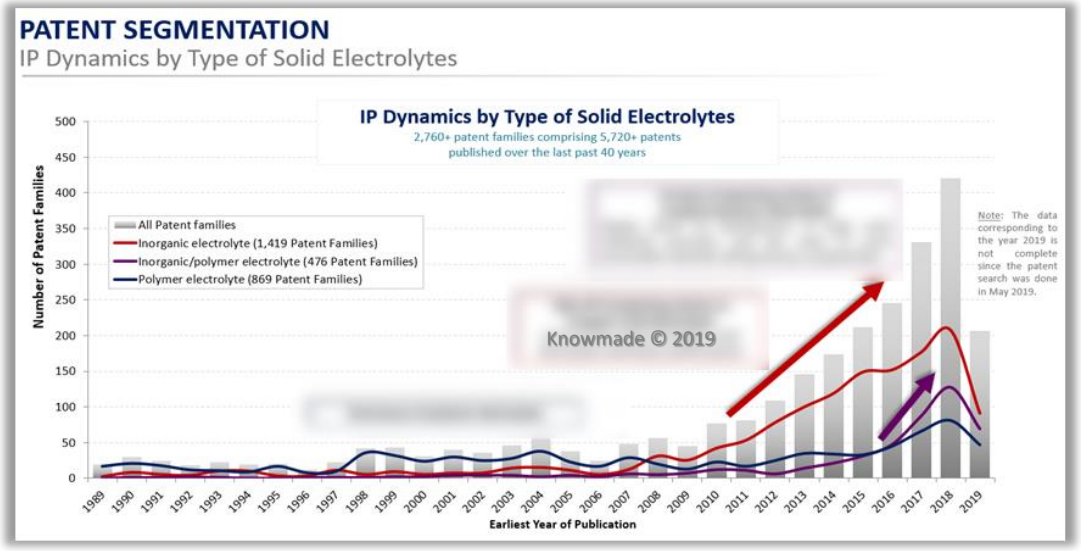


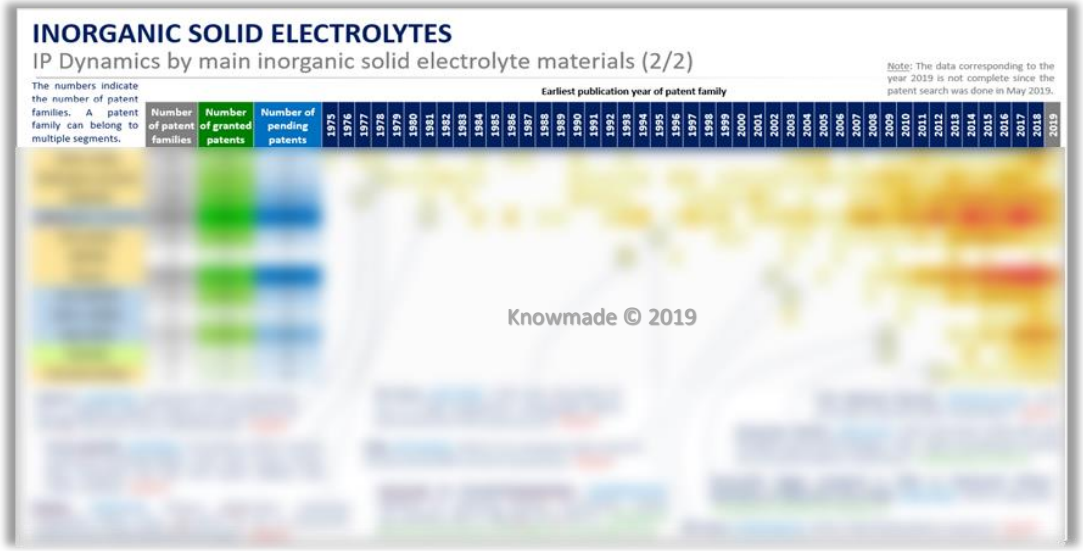
PATENT LANDSCAPE OVERVIEW

IP Dynamics



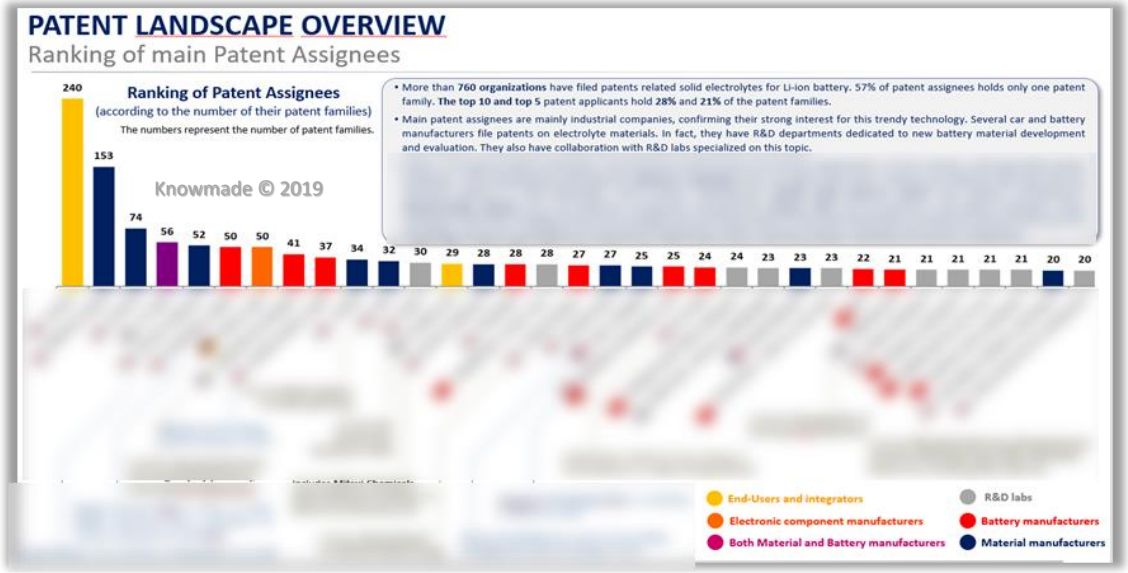


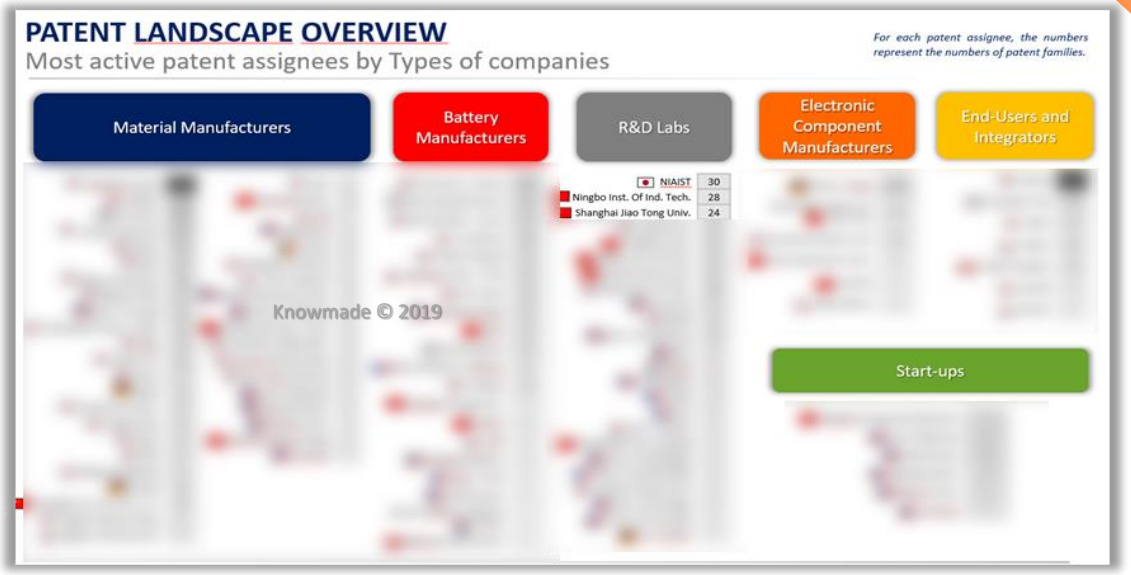


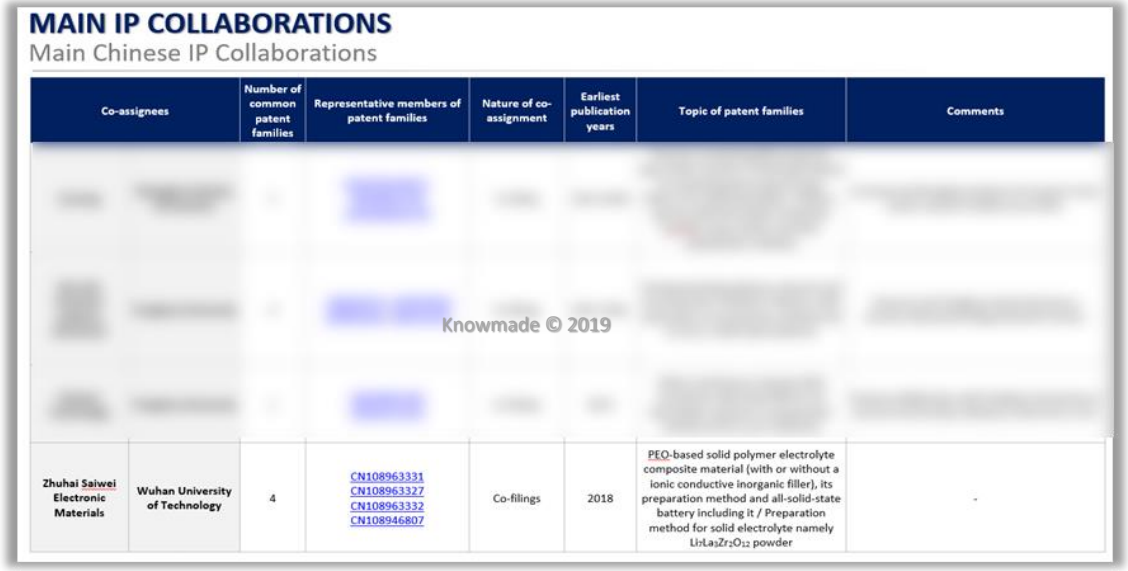


PATENT LANDSCAPE OVERVIEW

Main Patent Assignees



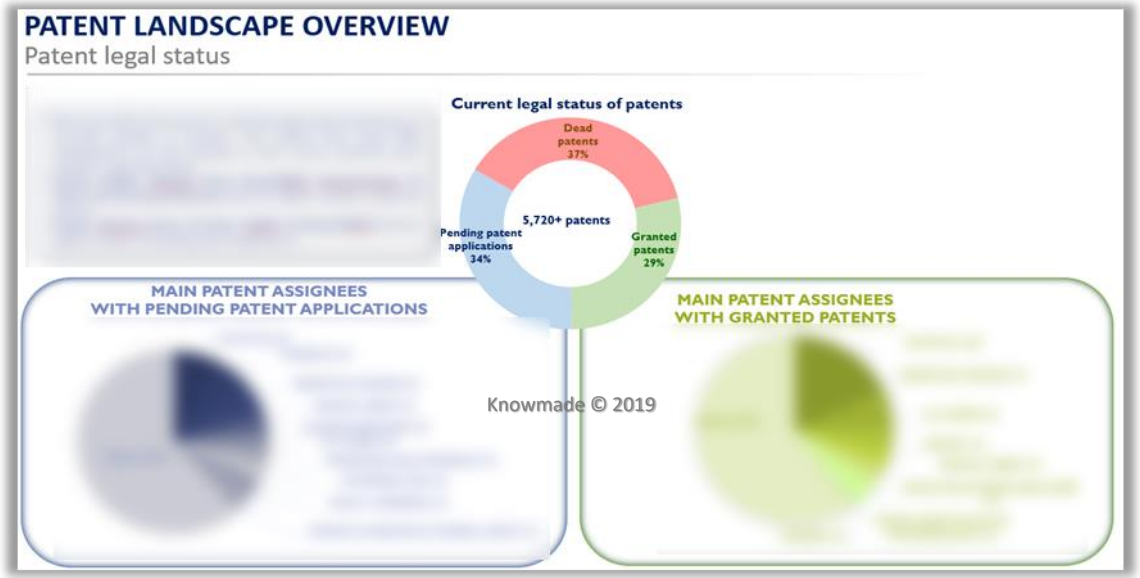


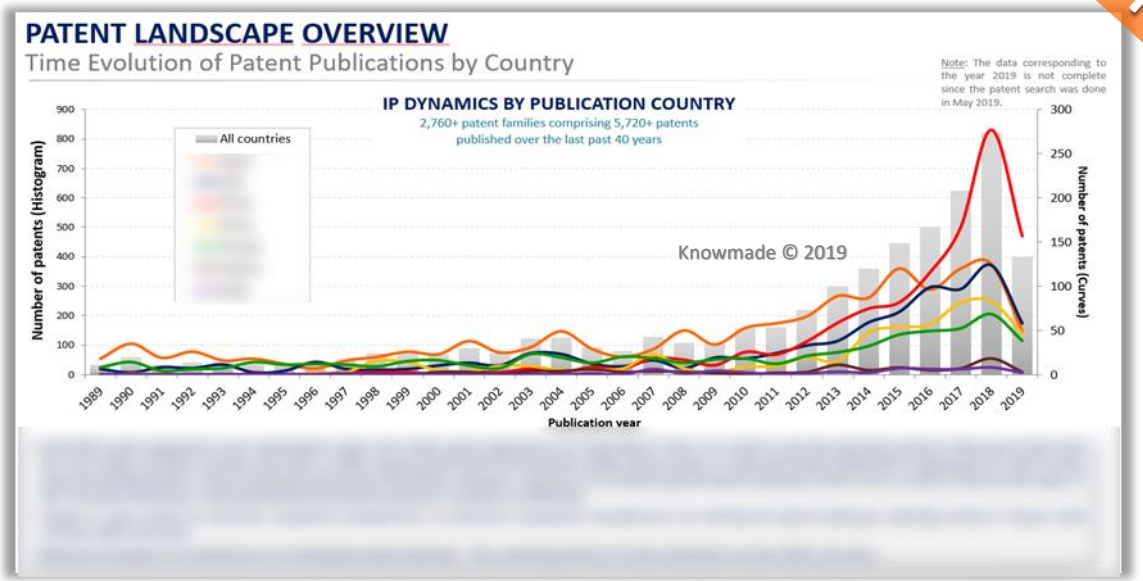


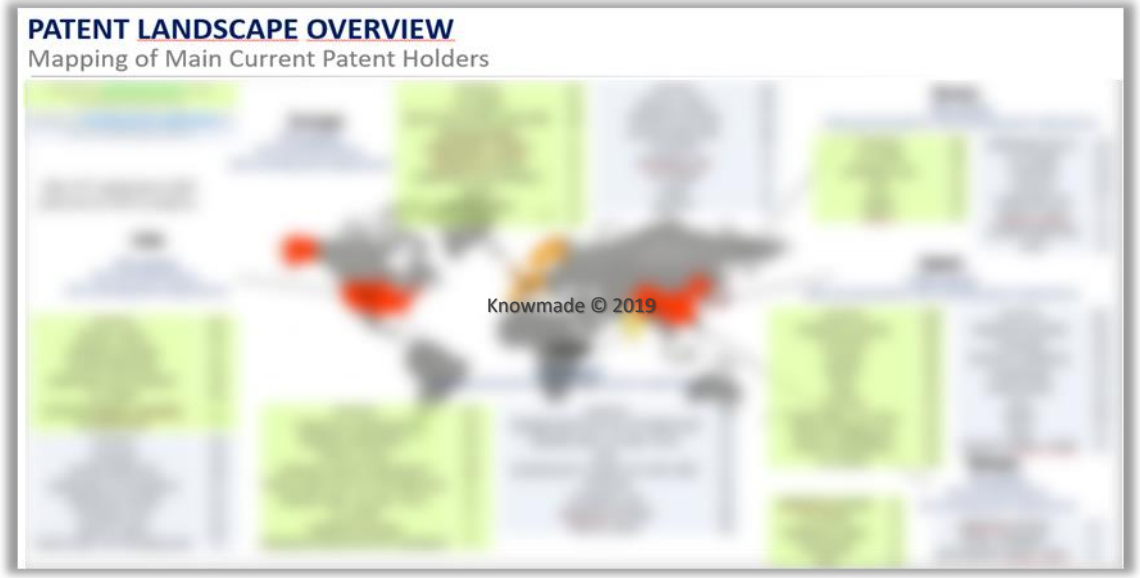
Co-assignees		Number of common patent families	Representative members of patent families	Nature of co-assignment	Earliest publication years	Topic of patent families	Comments
Zhuhai Saiwei Electronic Materials	Wuhan University of Technology	4	CN108963331 CN108963327 CN108963332 CN108946807	Co-filings	2018	PEO-based solid polymer electrolyte composite material (with or without a ionic conductive inorganic filler), its preparation method and all-solid-state battery including it / Preparation method for solid electrolyte namely $Li_7La_3Zr_2O_{12}$ powder	-

PATENT LANDSCAPE OVERVIEW

Legal status and countries of patent filings







PATENT SEGMENTATION BY SOLID ELECTROLYTE MATERIALS

Segmentation by type of solid electrolyte

SOLID ELECTROLYTES

Properties of each solid electrolytes categories

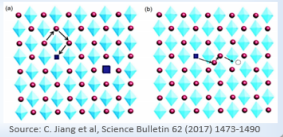
Properties	Liquid organic electrolytes	Inorganic Solid Electrolytes	Polymer Solid Electrolytes	Inorganic/Polymer Solid electrolytes
Ionic Conductivity at 20-25°C (S.cm^{-1})	10^{-2}			
Electronic Conductivity	Negligible			
Electrochemical Stability Window vs Li (V)	<4.5			
Chemical stability				
Thermal stability				
Resistance to mechanical stresses				
Compatibility with large scale manufacture				
Commercialization				
Examples of materials				
Additives (improve their stability, conduction properties and/or mechanical resistance)				

SOLID ELECTROLYTES

Categories of Solid Electrolytes

Inorganic solid electrolytes

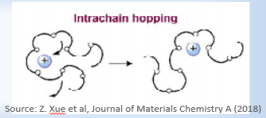
- Crystalline, amorphous, mixed phase inorganic material with can conduct Lithium ions (Sulfur or oxide garnets, oxide-based perovskites, Phosphate-based and sulphide-based glassy or glass ceramics etc.)
- Conductivity of ions across the solid electrolyte takes place usually by migration of mobile ions across vacancies/defects (a) or interstitials in the electrolyte (b).



Source: C. Jiang et al, Science Bulletin 62 (2017) 1473-1490

Polymer solid electrolytes

- Polymers (PEO, PPO, PEG etc.) combined with Lithium salts ($LiCO_4$, $LiPF_6$, LiTFSI etc.) with can conduct Lithium ions.
- Two Lithium ions conduction mechanism have been proposed: Interchain and intrachain Li+ ion hopping, ions (Li+ and anion) transport assisted by polymer chain motion



Source: Z. Xue et al, Journal of Materials Chemistry A (2018)

Inorganic/Polymer solid electrolytes

- Combination of inorganic solid electrolytes and polymer solid electrolytes
- Conductivity of ions across the electrolyte combines all mechanisms involved for inorganic solid electrolytes and polymer solid electrolytes (Ions hopping, migration across vacancies/defects/interstitials and transport across polymer motion chain.

Source: L. Yue, Energy Storage Materials 5 (2016) 139-164

Criteria for soli

- High **ionic conduc** (at least 10^{-4} S.cm^{-1})
- Negligible **electron**
- **Wide voltage win** Stability Window)
- **Chemical compati** materials (especial
- High **resistance** (volume expansion
- Simple to manufa low cost
- Environmentally friendly, non-hygroscopic

Note: Additives can be added to the electrolyt material to improve **their stability, conductio properties and/or mechanical resistance.**

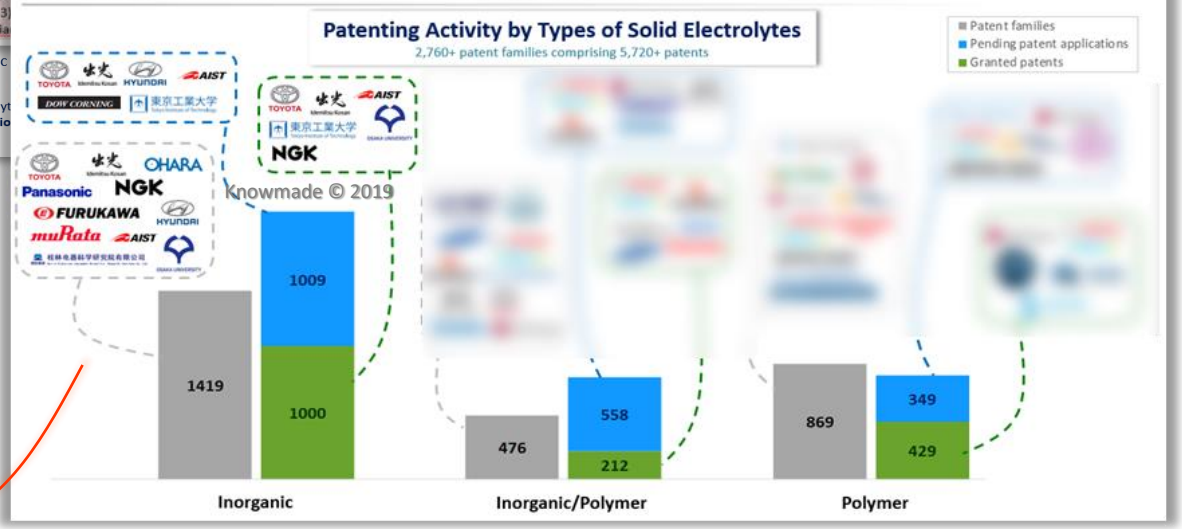
PATENT SEGMENTATION

Main Patent Assignees by Type of Solid Electrolytes

	Inorganic electrolyte	Inorganic/polymer electrolyte	Polymer electrolyte
Main IP players *(Patent portfolio)*	**1,419 patent families** Toyota (219), Idemitsu Kosan (131), Panasonic_Sanyo (37), Ngk (35), Ohara (25), Furukawa (24), Niaist (24), Hyundai_kia (24), Guilin Elect. Equip. Sci. Res. Inst. (23), Murata Man._sony (21), Osaka Univ. (20), Hitachi Chem. (19), Ningbo Univ. (19), Tokyo Inst. Of Tech. (19), Amperex Tech._tdk (18), Samsung Elect. (18), Fujitsu (17)		
Current blocking IP players *(Granted patents)*	**1000 granted patents** Toyota (292), Idemitsu Kosan (90), Tokyo Inst. Of Tech. (41), Niaist (34), Osaka Univ. (30), Ngk (29), Nagata Kazuhiro (25), Fujitsu (24), Panasonic_sanyo (23), Mitsui Chem. (23), Ohara (21), Hyundai_kia (21), Lg Chem (18), Lithium Werks_valence Tech. (17), Basf (16), Arkema (14), Murata Man._sony (13)		
Current active IP players *(High number of patent filings)*	**1009 pending patent applications** Toyota (158), Idemitsu Kosan (96), Hyundai_Kia (37), Dow_Corning (34), Tokyo Inst. Of Tech. (33), Niaist (24), Mitsubishi Chem._mat. (22), Murata Man._Sony (22), Samsung Elect. (21), Seiko (21), Agc (19), Panasonic_Sanyo (18), Guilin Elect. Equip. Sci. Res. Inst. (17), Amperex Tech._Tdk (16), Ngk (15), Quantumscape (15), Hitachi Chem. (14)		
Main new IP players *(First patent publication date on the topic after 2015)*	**170+ new comers** **Numerous Chinese Univ. and small company** Asahi Kasei (11), Qingdao New Energy Tech. (10), RIST(8), Kiit		

PATENT SEGMENTATION

Overview of Patenting Activity by Types of Solid Electrolytes



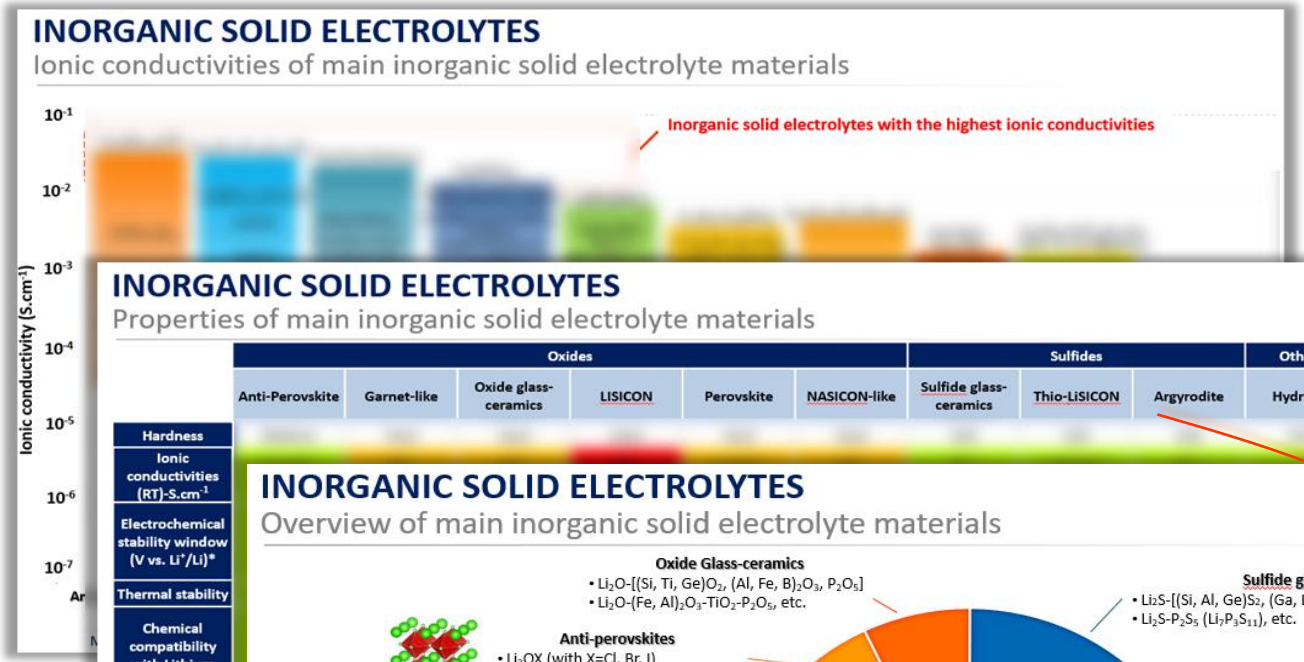
Properties of Materials

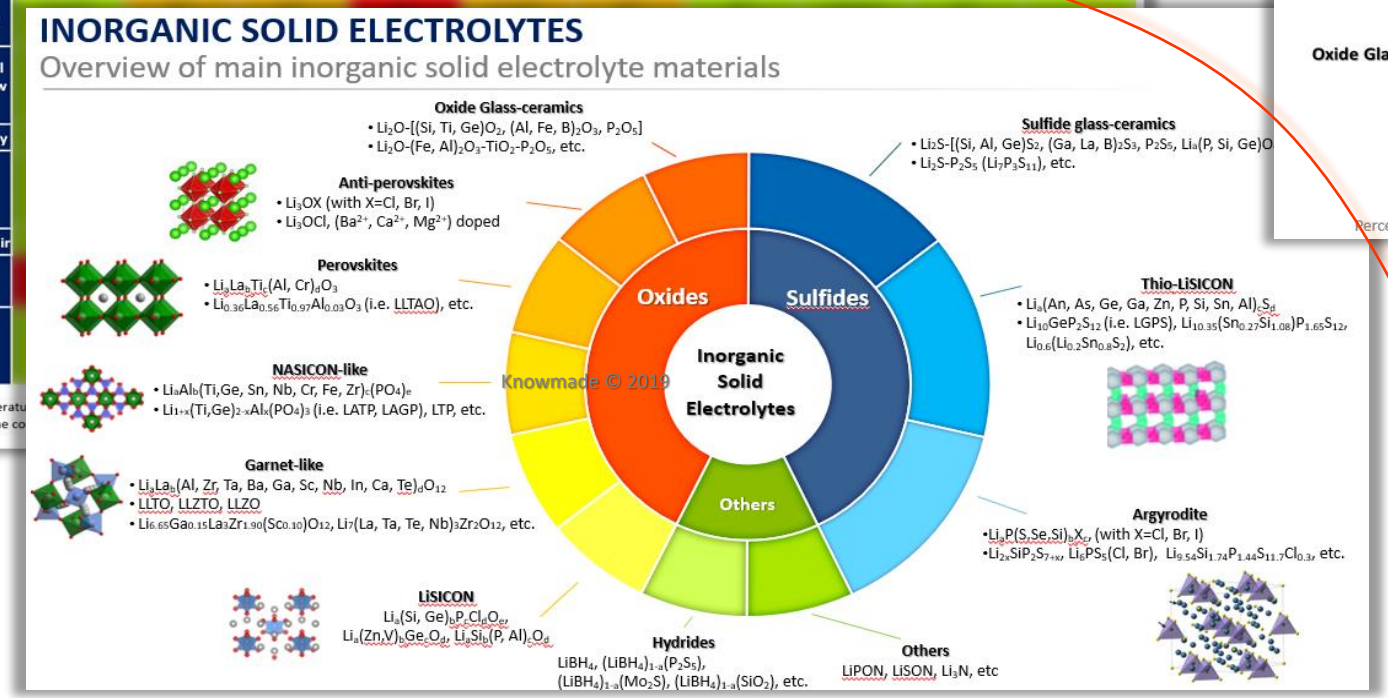
Main IP players according to the number of patent families, granted patents and pending patent applications

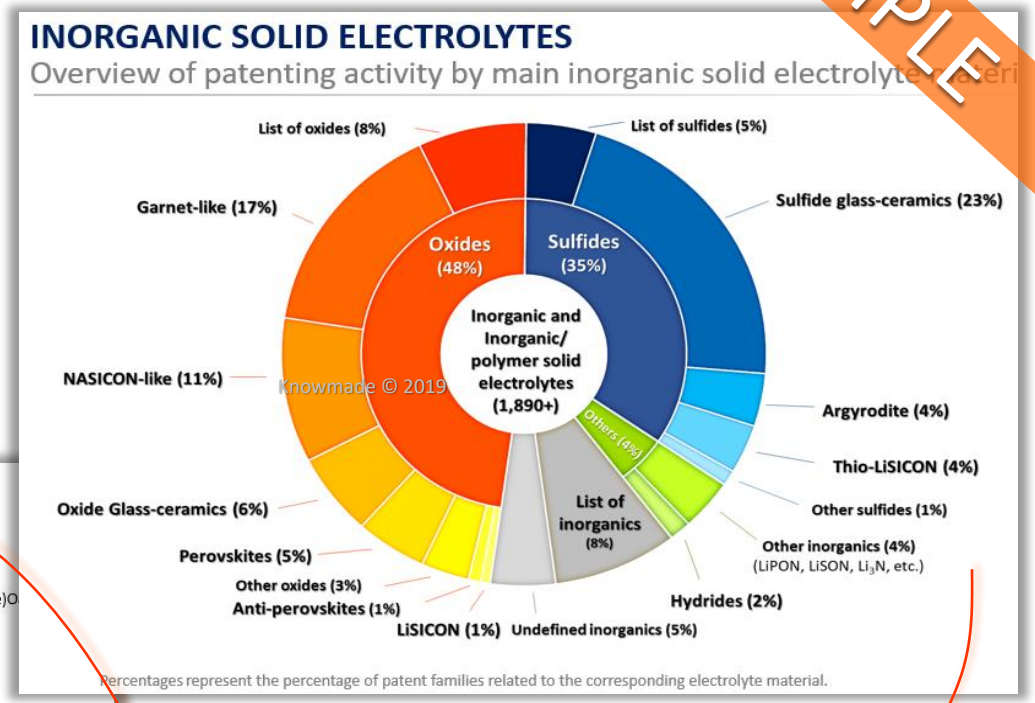
Patenting activity

PATENT SEGMENTATION BY SOLID ELECTROLYTE MATERIALS

Segmentation by Inorganic Solid Electrolyte Materials







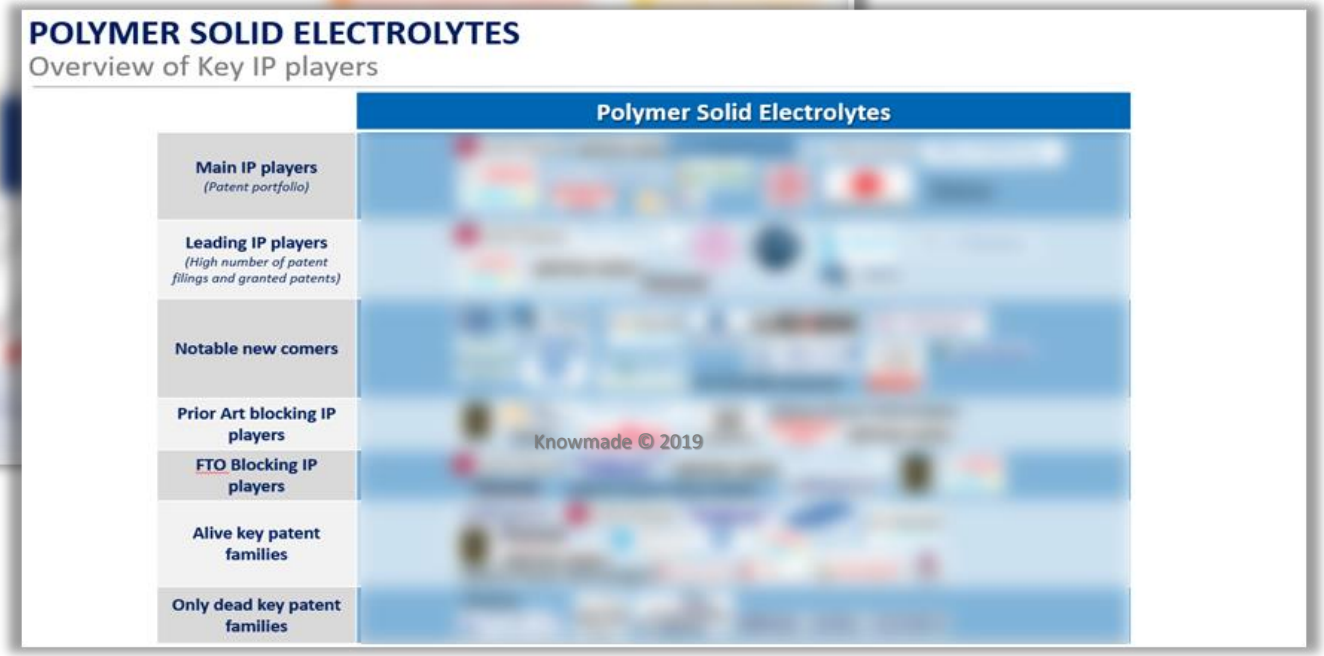
Patenting activity

Categories of inorganic solid electrolytes
Properties of Materials
Ionic conductivities

PATENT SEGMENTATION BY SOLID ELECTROLYTE MATERIALS

Detailed analysis of competitive landscape for main solid electrolyte materials

SAMPLE



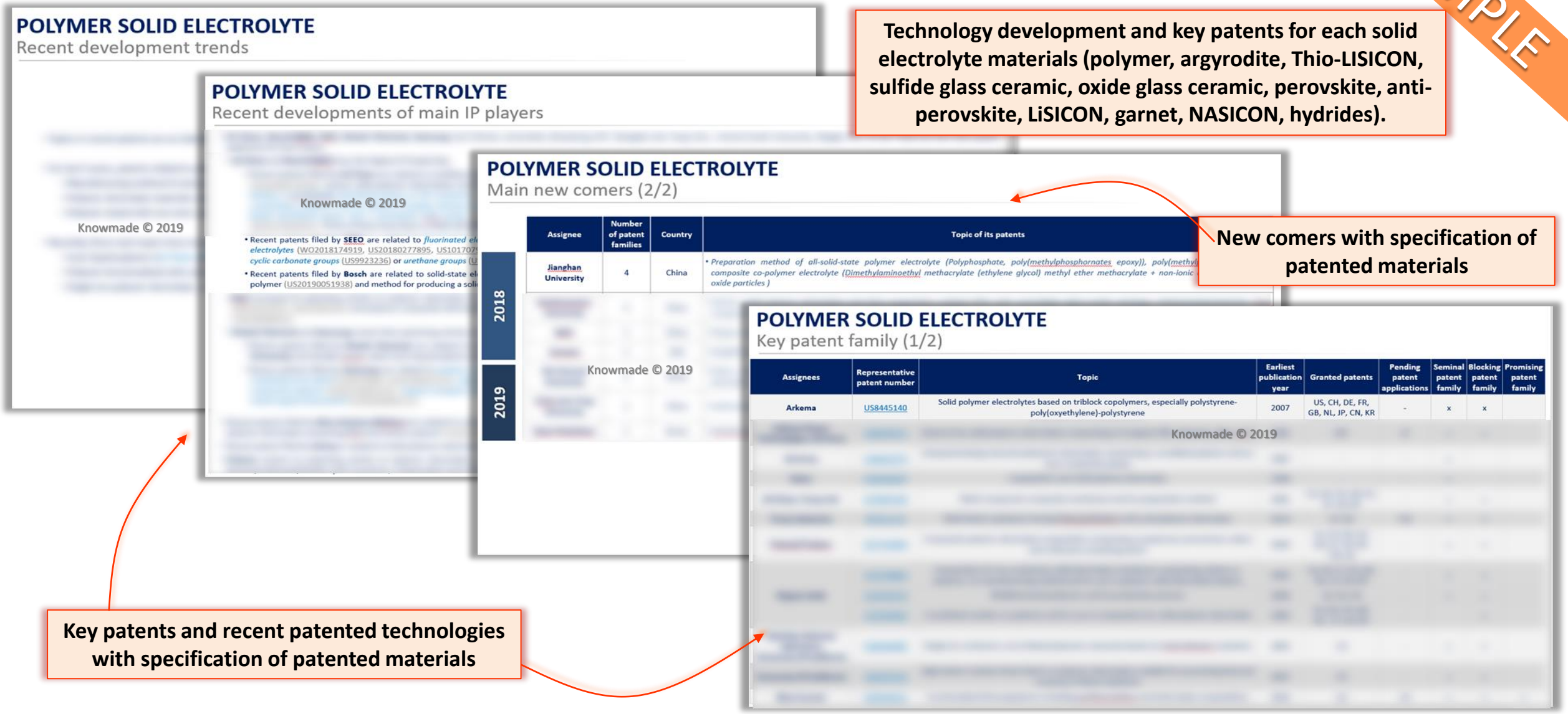
Competitive landscape and key IP players for each solid electrolyte materials (polymer, argyrodite, Thio-LISICON, sulfide glass ceramic, oxide glass ceramic, perovskite, anti-perovskite, LiSICON, garnet, NASICON, hydrides)

PATENT SEGMENTATION BY SOLID ELECTROLYTE MATERIALS

Detailed analysis of technology landscape for main solid electrolyte materials

SAMPLE

Technology development and key patents for each solid electrolyte materials (polymer, argyrodite, Thio-LISICON, sulfide glass ceramic, oxide glass ceramic, perovskite, anti-perovskite, LiSICON, garnet, NASICON, hydrides).

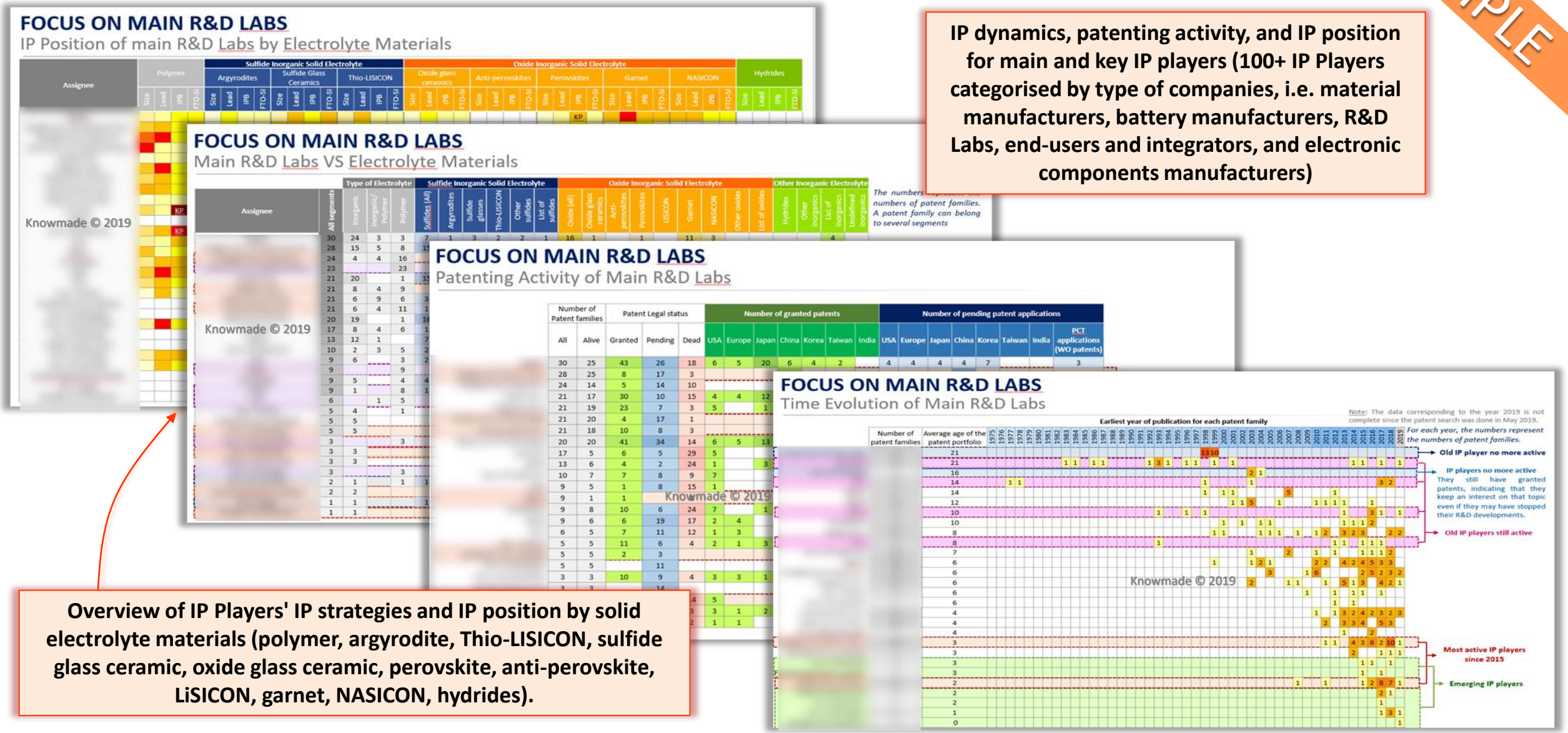


New comers with specification of patented materials

Key patents and recent patented technologies with specification of patented materials

FOCUS ON KEY IP PLAYERS

IP Profiles of key IP players



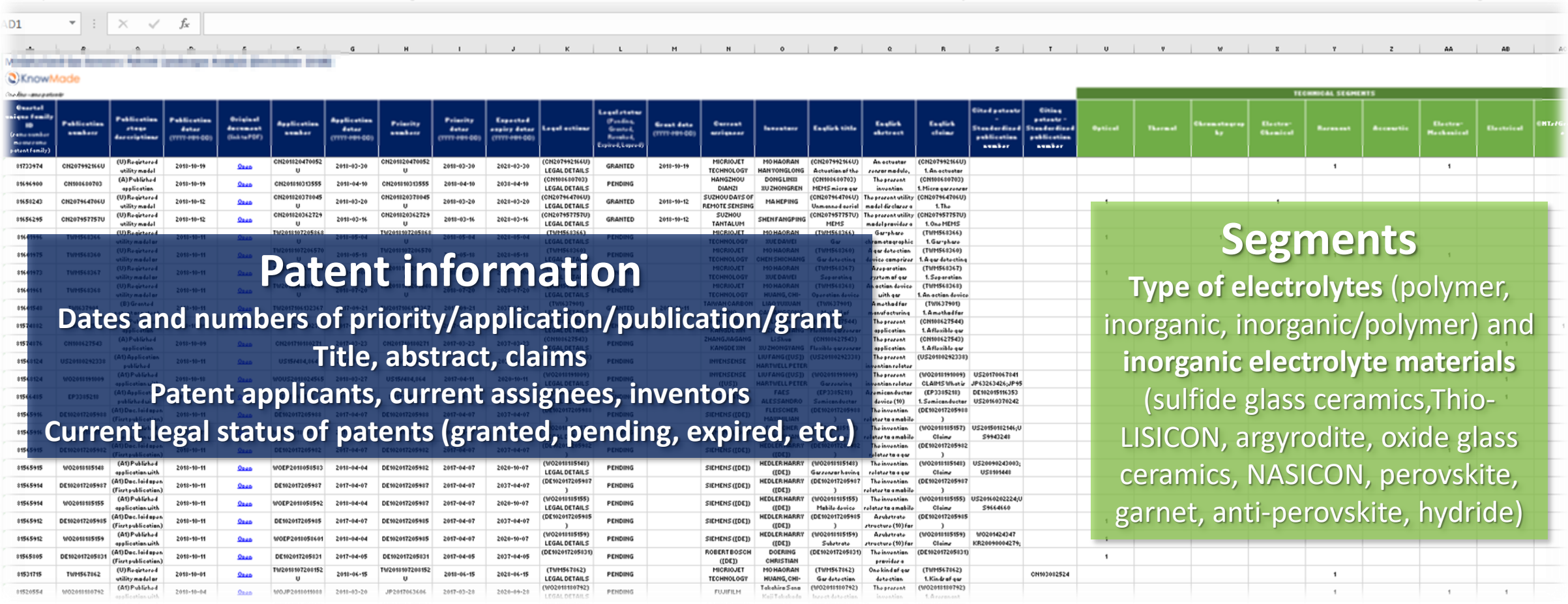
IP dynamics, patenting activity, and IP position for main and key IP players (100+ IP Players categorised by type of companies, i.e. material manufacturers, battery manufacturers, R&D Labs, end-users and integrators, and electronic components manufacturers)

Overview of IP Players' IP strategies and IP position by solid electrolyte materials (polymer, argyrodite, Thio-LISICON, sulfide glass ceramic, oxide glass ceramic, perovskite, anti-perovskite, LiSICON, garnet, NASICON, hydrides).

EXCEL PATENT DATABASE

Useful Excel file containing all the patents analyzed in this report with corpus segmentation

SAMPLE



Patent information

Dates and numbers of priority/application/publication/grant

Title, abstract, claims

Patent applicants, current assignees, inventors

Current legal status of patents (granted, pending, expired, etc.)

Segments

Type of electrolytes (polymer, inorganic, inorganic/polymer) and **inorganic electrolyte materials** (sulfide glass ceramics,Thio-LISICON, argyrodite, oxide glass ceramics, NASICON, perovskite, garnet, anti-perovskite, hydride)

ORDER FORM

Solid Electrolytes for Solid-state Li-ion Batteries

Patent Landscape Analysis – October 2019

Ref.:KM19007

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, Le Drakkar
06560 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, France
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, Le Drakkar, 06560 Valbonne Sophia Antipolis, FRANCE

PRODUCT ORDER

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☐ **€5,990 – Single user license***

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

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Signature:

Terms and Conditions of Sales

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"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.

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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.

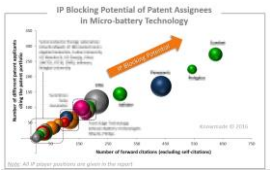
FOR GOING EVEN FURTHER

KnowMade
Patent & Technology Intelligence

FOR GOING EVEN FURTHER

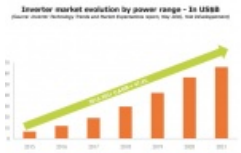
Related Reports

You may also be interested in our other reports:



- Solid-state Li-ion Batteries, technology and patent analysis (Upcoming)
- Microbattery Patent Landscape (September 2016)
- NMC Lithium-ion Battery Patent Landscape (July 2017)
- Status of Battery patents (May 2018)

You may also be interested in those market analysis reports of our partner Yole Développement:



- Solid-state Battery Market (Yole, 2018)

FOR GOING EVEN FURTHER

Patent Monitor on Solid-state Batteries

CONTENTS

Monthly IP database (Excel file)

- New patent applications
- Patents newly granted
- Patents expired or abandoned
- Transfer of IP rights (re-assignment, licensing)
- Patent litigation & opposition
- Patent categorization by:
  - Supply Chain: Electrolyte, Electrode, Battery, Pack
  - Type of electrolyte materials: Inorganic, Inorganic/polymer, Polymer
  - Inorganic electrolyte materials: Sulfide Glass Ceramic, Thio-LISICON, Argyrodite, Oxide Glass Ceramic, NASICON, Garnet, Perovskite, Anti-Perovskite, LISICON, Hydride, etc.

Quarterly report (PDF slide deck)

On a quarterly basis, this report will provide the IP trends over the three last months, with a close look to key IP players and key patented technologies.

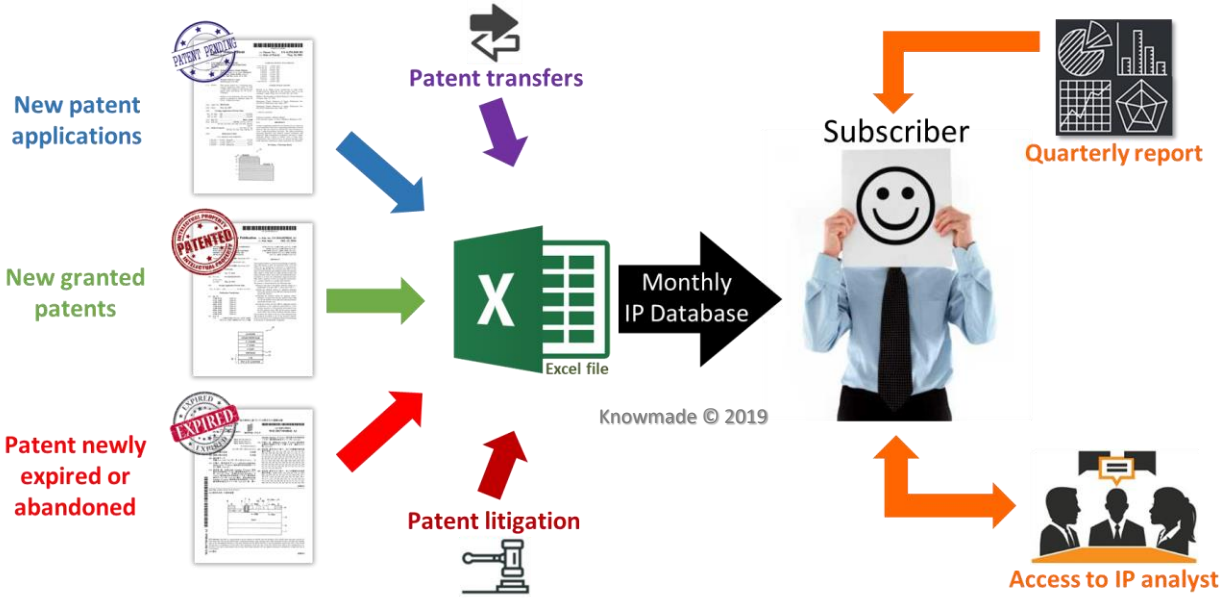
Access to IP analysts (100h a year)

On-demand Q&A and discussion session with our analysts on specific patented technologies or company IP portfolios

ANNUAL SUBSCRIPTION

WHY YOU SHOULD SUBSCRIBE

- ✓ Track your **competitors**, partners or clients
- ✓ Identify **newcomers** to your technology field
- ✓ Early detect **opportunities** and risks for your business strategy
- ✓ Be ahead of **technology trends**
- ✓ Identify emerging research areas and **cutting-edge technology** developments
- ✓ Mitigate patent **infringement risks**
- ✓ Take advantage of **free technologies**



More information: www.knowmade.com/downloads/solid-state-batteries-patent-monitor/

FOR GOING EVEN FURTHER

Which topics can we investigate in battery field?

Battery supply chain

Composition and manufacturing methods

- Battery materials
- Electrode
- Electrolyte
- Separator
- Battery Cell
- Battery Pack (BMS, thermal management, etc.)
- Equipments (manufacturing, testing, etc.)
- Recycling

Battery cell design

- Microbattery, Thin film battery
- Flexible battery
- Solid-state battery
- Prismatic battery
- Cylindrical battery, etc.

Battery materials

Cathode materials:
NMC, NCA, LFP, LMO, etc.

Anode materials:
Graphite, Silicon, LTO, etc.

Electrolytes:
Liquid, gelled, solid, ionic liquids, solvents, salts, additives, etc.

Other materials:
Additives, binders, current collector, etc.

Applications

- Automotive
- Consumer
- Medical
- Stationary, etc.

Battery Technologies

- Li-ion battery
- Lithium metal battery
- Ni-MH battery
- Zn-Air battery
- Lead-Acid battery
- Na-S battery
- Redox flow battery
- Li-Air battery
- Li-S battery
- Na-ion battery
- Mg-ion battery
- Al-ion battery

KNOWMADE

Patent and Technology Intelligence

WHAT WE DO

Knowmade helps customers to understand

the **competitive landscape**, follow **technology trends**, and find out **opportunities** and **threats** in terms of **technology** and **patents**.

- Interpreting the **competitive landscape** and **technology developments** throughout **patents** and **scientific information**.
- Turning **patents** and **scientific information** into **business intelligence tools** that give you the capability to
  - Understand your **competitive environment**
  - Be ahead of **technology trends**
  - Identify patent & technology **opportunities**
  - Assess patent & technology **risks**
  - Define your **IP** and **R&D strategy**
  - Monetize your **technologies** and know-how
  - Defend your **business**
- Strong **technology expertise** with an in-depth **knowledge of patents** and **scientific information**.
- Highly **specialized** analysts in the following sectors:

  Electronics, **Photonics** and **Wireless communications**

  Compound semiconductors, Power electronics, Batteries, Memories, RF devices & technologies, Wireless communications, Solid-state lighting & display, Photonics, MEMS, Sensors and Actuators, Semiconductor manufacturing and Advanced packaging.

  Life Sciences, **Healthcare** and **Agri-Food**

  Medical devices, Medical imaging, Microfluidics, Biotechnology, Pharmaceutics, Food-processing

Patents
Technologies
Prior art
Scientific findings
Opportunities
Partners
Competitors
Newcomers
M&A targets

Patent landscape analysis
Scientific review
IP portfolio assessment
Patent valuation
Freedom-to-operate analysis
Litigation & licensing support
Patents linked to products
Technology scouting
Technology trends
Competitive IP landscape
Market trends
Reverse engineering

Make strategic decisions
Sustain competitive advantages
Speed R&D and enhance innovation process
Align R&D and IP with key business objectives
Strengthen IP portfolio and acquire technologies
Anticipate risks and defend core businesses
Explore new opportunities and monetize IP

WHAT IS OUR ADDED VALUE

Patent Search

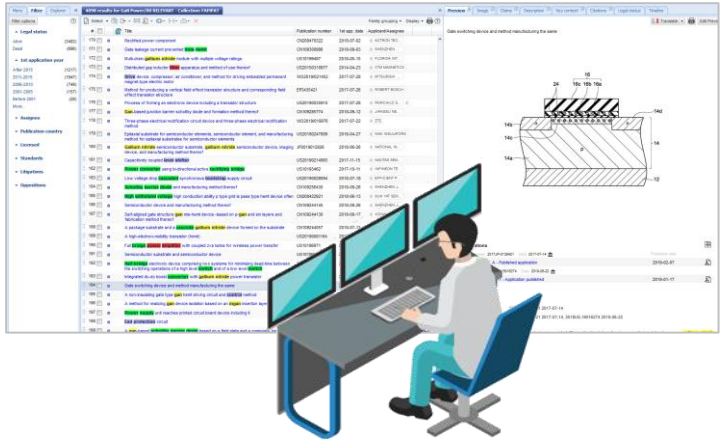
- ✓ **Strong technical expertise of our analysts with PhD degree**
  - Comprehensive search queries and keywords
  - Manual selection of relevant and related patents
  - Manual segmentation by technology & application

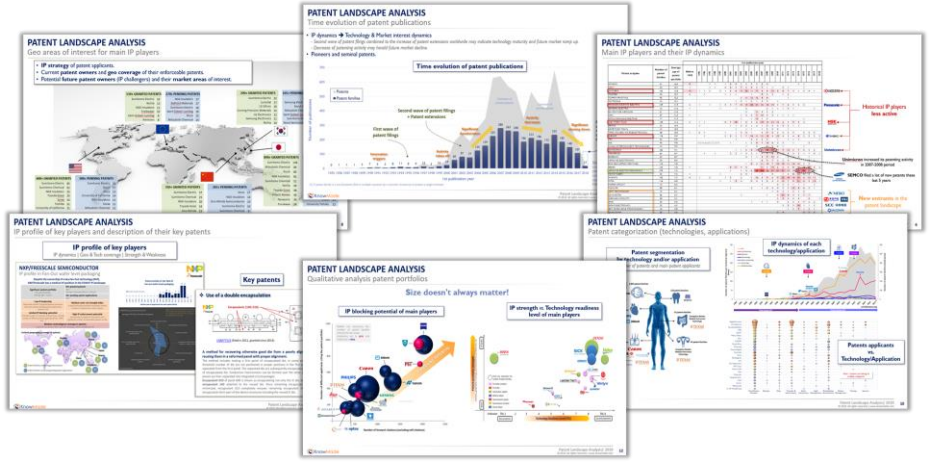
Analytics

- ✓ **State of the art statistical tools**
- ✓ **Innovative methodologies to deliver relevant IP analysis**
- ✓ **Business oriented data representation and graphics**

Results Analysis

- ✓ **Technical expertise**
  - Highly specialized analysts in your field
  - Benefit from knowledge capitalization
- ✓ **In-depth IP analysis combined with market data and reverse engineering ***
- ✓ **Customer support**

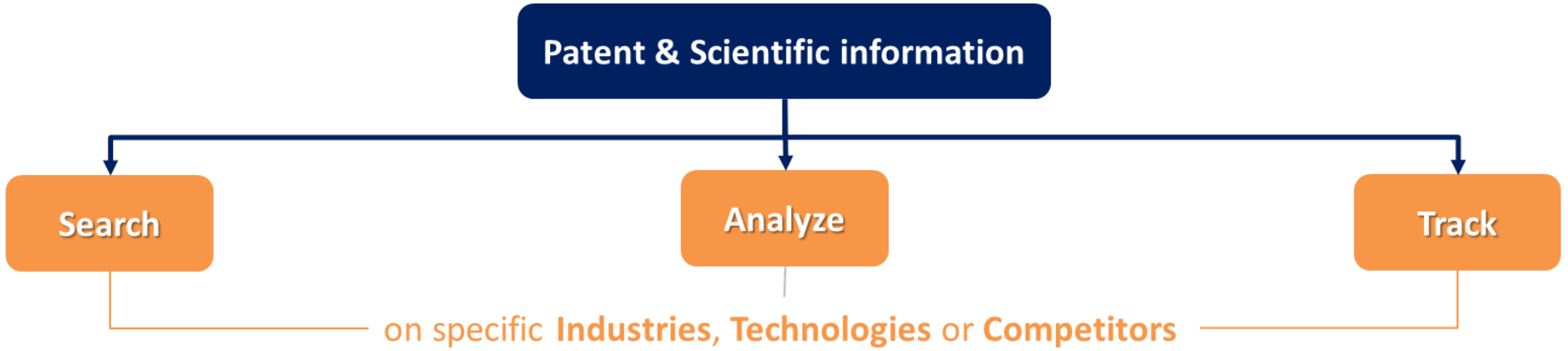




*** Our partners**

YOLE Développement | SYSTEMPlus CONSULTING | PISEO light.innovation.lab.services | BLUMORPHO

KNOWMADE ACTIVITIES



Prior-art search
Is my invention novel?

Technology scouting
Are there patents or technologies to acquire? … that could be drawn on to improve R&D?

Patent landscape analysis
Competitive & technology landscape analysis through patents: Who? What? Where? Since when? With who?

Freedom-to-operate
Am I free to sell my product without infringing third-parties IP rights?

Evidence of use (litigation/licensing)
Make the link between patents and product features

Patent valuation
What are the most valuable patents and what is their financial value?

Patent monitoring service
Monitor the IP activity: new applications, new granted patents, patents newly expired

Scientific watch
Monitor the Scientific activity

Competitor watch
Monitor the competitors R&D activities

KnowMade
Patent & Technology Intelligence

KnowMade SARL
2405 route des Dolines
06902 Sophia Antipolis, France

www.knowmade.com
contact@knowmade.fr