

SOLID ELECTROLYTES FOR LI-ION SOLID-STATE BATTERIES

Technology and Patent Analysis - October 2019

Solid electrolyte material is the key ingredient in solid-state batteries. This patent analysis will empower your understanding of the main R&D trends and competitors' technological strategies found in the solid electrolyte materials jungle.

REPORT OUTLINE

Solid electrolytes for Li-ion solid-state batteries

- Technology and patent analysis
- October 2019
- Ref: KM19007
- PDF with > 250 slides
- Excel file > 5,800 patents
- €6,490 for a multi-user license

KEY FEATURES

- **IP trends**, including time-evolution of published patents, legal status, countries of patent filings, etc.
- Ranking of **main patent assignees**
- **Patent categorization by type of electrolyte** (polymer, inorganic, inorganic/polymer) and **inorganic electrolyte materials** (sulfide glass ceramics, Thio-LISICON, argyrodite, oxide glass ceramics, NASICON, perovskite, garnet, anti-perovskite, hydride)
- For each technical segment: **IP dynamics**, ranking of **main patent assignees**, **newcomers**, **key IP players** (leadership, blocking potential, portfolio strength), **key patents**, and **recent development trends**
- For each key IP player (100+ companies): Time-evolution of **patenting activity**, **legal status** of patents and **countries** of patent filings, **patent segmentation** by electrolyte material, **IP strengths and weaknesses** by electrolyte material
- **Excel database** containing all patents analyzed in this report, including technology and material segmentations

RELATED REPORTS & MONITORS

- [Solid-state Li-ion Batteries](#) (Knowmade, upcoming)
- [Solid-state Battery](#) (Yole Développement, 2018)
- [Microbatteries](#) (Knowmade, 2016)
- [NMC Li-ion Batteries](#) (Knowmade, 2017)
- [Status of Battery Patents](#) (Knowmade, 2018)

RELATED PATENT MONITOR

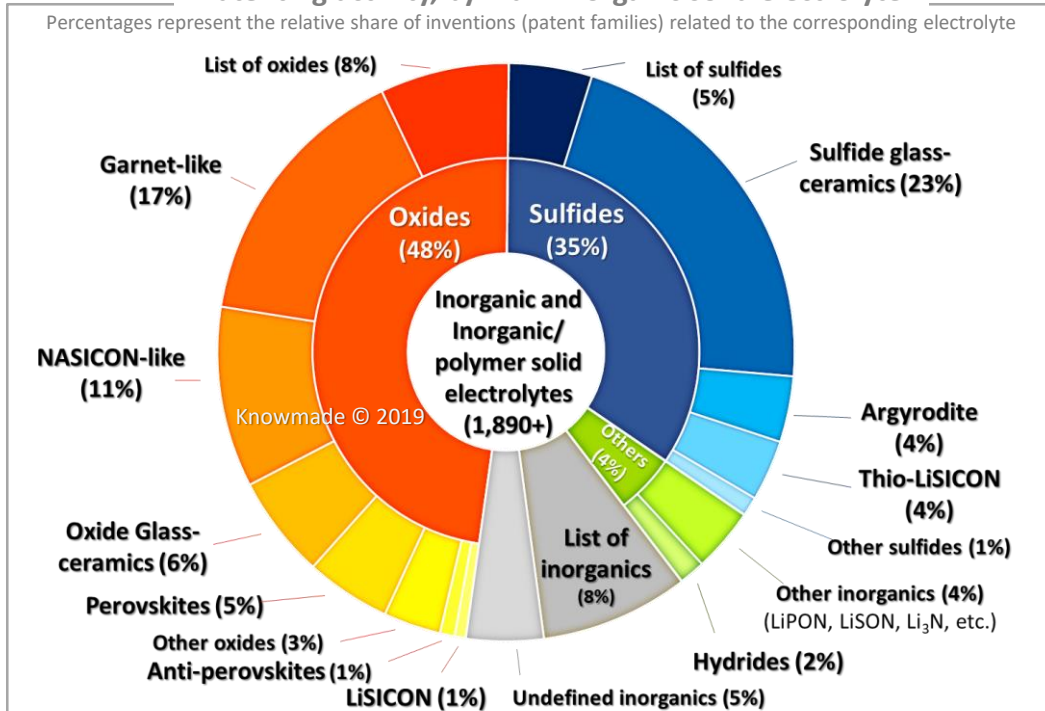
- [Solid-State Batteries Patent Monitor](#)

CAR AND BATTERY MANUFACTURERS ALSO HAVE A NOTABLE IP POSITION IN SOLID ELECTROLYTE MATERIALS

Everyone still recalls the drama surrounding the Samsung Galaxy Note 7 smartphone, which revealed a major drawback for today's Li-ion batteries: the safety risk induced by the use of liquid-flammable electrolytes. One technical solution envisioned for improved safety is to replace the liquid electrolyte with a **solid electrolyte**. **Solid-state batteries** can be categorized in two categories: thin-film solid batteries and bulk solid batteries. The thin-film technology approach, proven for thin-film batteries, is not directly applicable for bulk solid-state batteries. Thus, new processes and materials must arise to ensure "bulk" solid batteries meet market requirements (performance, stability, cost). Three main development axes are envisioned for enhancing "bulk" solid-state battery performance: improve solid electrolyte performances and electrode/electrolyte interface, and develop materials/cell assembly manufacturing processes compatible with industrial production.

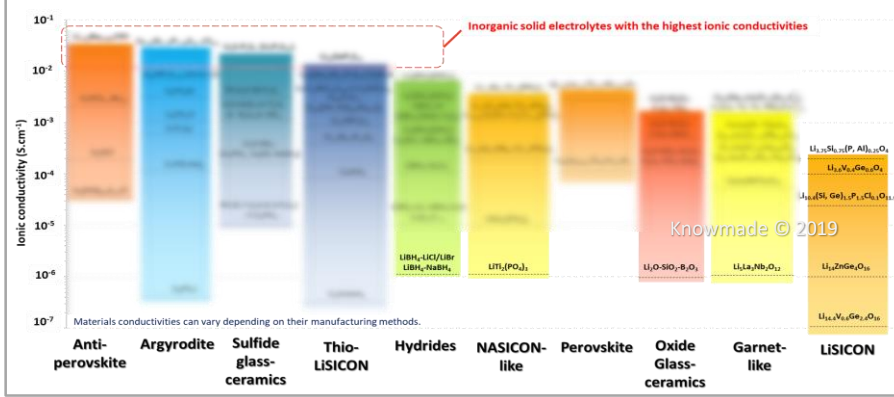
Many companies have recently announced the commercialisation and integration of batteries with solid electrolytes (solid-state batteries) by 2020 - 2025. However, many questions remain: which **solid electrolyte** exhibits the most promising performance? What are the most recent **technology developments** for solid electrolyte materials? Who has the **best IP position** in solid electrolyte materials? In this context, a **patent analysis** is a complementary approach to market research in order to fully comprehend the **competitive landscape** and **technology roadmap**; stay abreast of cutting-edge technology developments; **anticipate future technological consolidation**; and understand competitors' strategies. This patent analysis also reveals the **companies, technical solutions, and strategies not identified by a market analysis**.

Patenting activity, by main inorganic solid electrolyte



This report focuses on **solid electrolyte materials**. More than 5,800 patents grouped in 2,760 patent families are related to solid electrolytes for solid Li-ion batteries. In this report, we reveal the main IP trends, key patented technologies, recent development trends, key IP players and newcomers and their IP strategies/strengths by solid electrolyte material (polymer, polymer/inorganic, inorganic, argyrodite, Thio-LISICON, sulfide glass ceramic, oxide glass ceramic, perovskite, anti-perovskite, LiSICON, garnet, NASICON, hydrides, etc.).

Ionic conductivities of main inorganic materials - overview



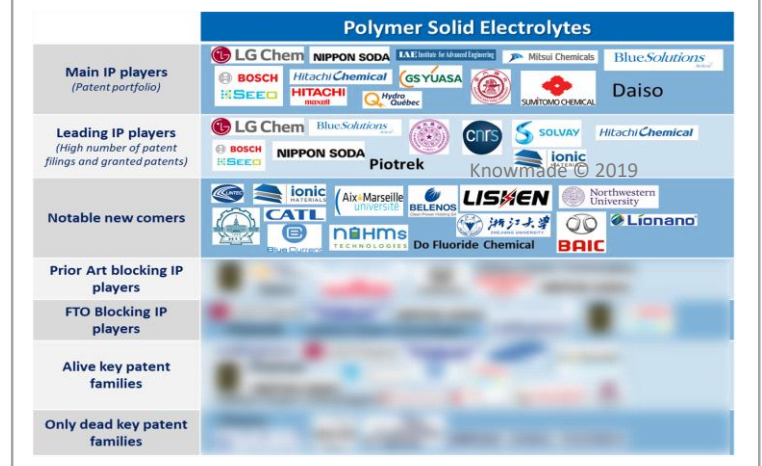
GET AN OVERVIEW OF SOLID ELECTROLYTE MATERIAL PROPERTIES

This report provides an overview of the electrochemical and chemophysical properties, as well as the advantages and drawbacks of the main solid electrolyte materials developed for solid-state Li-ion batteries - with a special focus on their ionic conductivities.

UNDERSTAND PATENTED TECHNOLOGY AND THE COMPETITIVE LANDSCAPE

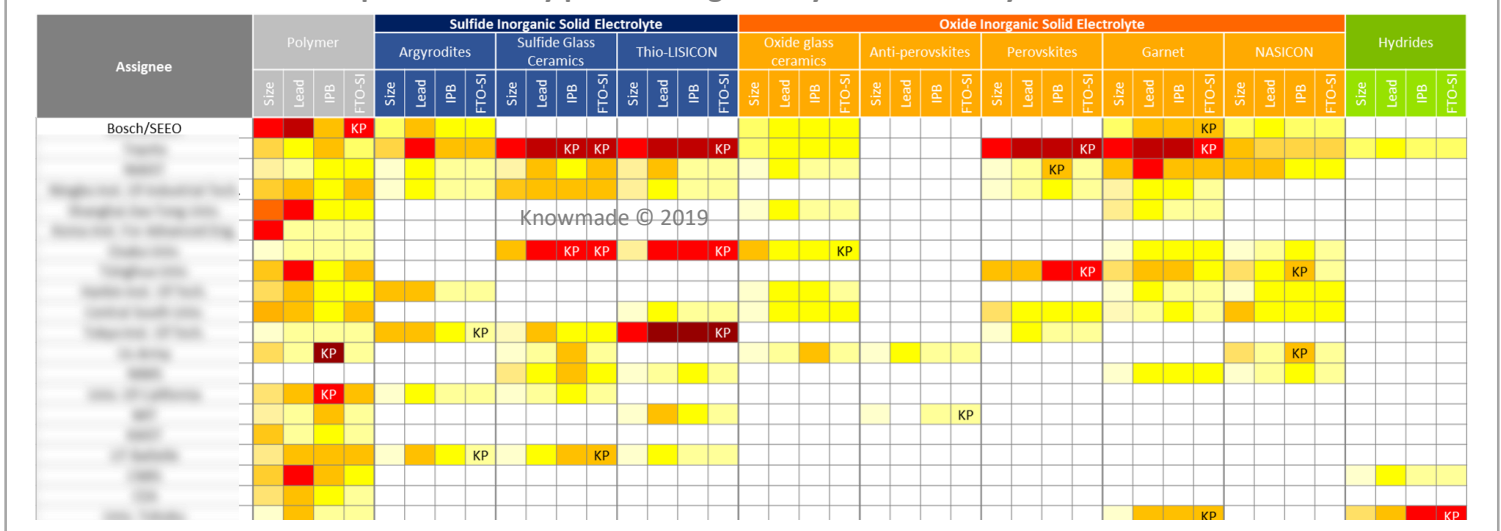
The 2,760+ patented inventions selected for this study are categorized by **type of electrolyte** (polymers, inorganic/polymer, inorganic) and **inorganic electrolyte materials** (argyrodite, Thio-LISICON, sulfide glass ceramic, oxide glass ceramic, perovskite, anti-perovskite, LiSICON, garnet, NASICON, hydride). For **each electrolyte material**, this report includes a time-evolution of **patent applications**, main and **key patent assignees**, **newcomers**, and a description of **key and recently patented technologies**. An understanding of the **current technical challenges** addressed in the patents is also presented. Key IP players in solid electrolyte materials are not only material manufacturers and R&D labs, but also electronic component manufacturers, battery manufacturers, and end-users.

Overview of key IP players, by solid electrolytes



KNOW KEY PLAYERS' IP POSITIONS AND IP STRATEGIES

IP position of key patent assignees by solid electrolyte materials



More than **1,140 patent applicants** are involved in the **solid electrolyte for Li-ion solid-state battery** patent landscape. This report reveals the **IP position of key players, by solid electrolyte materials** (polymers, argyrodite, Thio-LISICON, sulfide glass ceramic, oxide glass ceramic, perovskite, anti-perovskite, LiSICON, garnet, NASICON, hydride) through a detailed analysis of their patent portfolios. We also provide insights regarding these players' **patented technologies**, their **IP strategy**, and their **ability to limit other firms' patenting activity and/or freedom-to-operate**. The **benchmarking** of patent assignees is evaluated **by solid electrolyte materials**, on the basis of their IP portfolio size, prior-art contribution, geographical coverage, and enforceability of patents. A special focus is placed on the main **IP collaborations** (co-assignment, licensing, IP transfer) related to **solid electrolytes for Li-ion solid-state battery**.

USEFUL EXCEL PATENT DATABASE

This report also includes an **Excel database with the >5,800 patents and patent applications** analyzed in this study. This useful patent database **allows for multi-criteria searches** and includes patent publication numbers, hyperlinks to the original documents, priority date, title, abstract, patent assignees, patent's current legal status, and technological and application segments.

COMPANIES MENTIONED IN THIS REPORT (NON-EXHAUSTIVE)

AGC, Albemarle, Alps Electric, Amperex Tech. / TDK, Asahi Kasei, BASF, Belenos Clean Power, Blue Solutions / Bolloré, Bosch / Seeo, BYD, Daiso, DKS, Dow / Corning, FDK, Fujifilm, Fujitsu, Furukawa, GS Yuasa, Guilin Elec. Equip. Sci. Res. Inst., Hitachi Chemical, Hitachi Maxell, Honda, Honeycomb Ener. Tech., Huawei, Hydro Quebec, Hyundai / Kia, Idemitsu Kosan, Ionic Materials, Johnson Matthey, JSR, LG Chem, Lionano, Lishen, Lithium Werks / Valence Tech., Mitsubishi Chem. / Mat., Mitsui Chemicals, Murata Man. / Sony, Nakajima Industry, NGK, Nippon Chemical Ind., Nippon Electric Glass, Nippon Shokubai, Nippon Soda, Nissan, NOF, Nohms Tech., Ohara, Optimumnano Energy, Panasonic / Sanyo, Polyplus Battery, Qingtao Energy Dev., Quantumscape, Saft / Total, Samsung Electronics, Samsung SDI, Schott, Seiko, Shin Etsu Chemical, Sila Nanotech., Solid Power, Solvay, Sumita Optical Glass, Sumitomo Chem Sumitomo Metal Min., Toho Titanium, Toray Ind., Toshiba, Toyota, Wildcat Discovery Tech., Yuhuang Chem., Zeon, CEA, CNRS, FZ. Juelich, KAIST, MIT, NIAIST, NIMS, Osaka Univ., Tokyo Inst. Of Tech., Univ. Of Chicago, Univ. Of Colorado, Univ. Of Michigan, Univ. Tohoku

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SOLID ELECTROLYTES FOR LI-ION SOLID-STATE BATTERIES

Technology and Patent Analysis – October 2019

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Signature:

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