Halide Solid Electrolytes for Li-ion Batteries

Patent Landscape Analysis – April 2024

Patented technologies and nascent IP competition for emerging halide solid electrolyte materials

REPORT OUTLINE

- Halide Solid Electrolytes
- Patent Landscape Analysis
- April 2024
- PDF >90 slides
- Excel file >300 patent families
- Reference: KM24002
- 4,990 EUR for a multi-user license

KEY FEATURES

- **Global patenting trends**, including time evolution of patent publications, countries of patent filings, etc.
- **Main patent assignees** and **IP newcomers** in the different segments of the supply chain.
- Key players' **IP position** and the relative **strength** of their patent portfolio.
- Patents categorized by **material composition** and **technical challenges**.
- **IP profile of key players** (patent portfolio overview, technical coverage, geographical coverage, key patents, etc.)
- **Excel database** containing all patents analyzed in the report, including **patent segmentations** and hyperlinks to an **updated online database**.

RELATED REPORTS & MONITORS

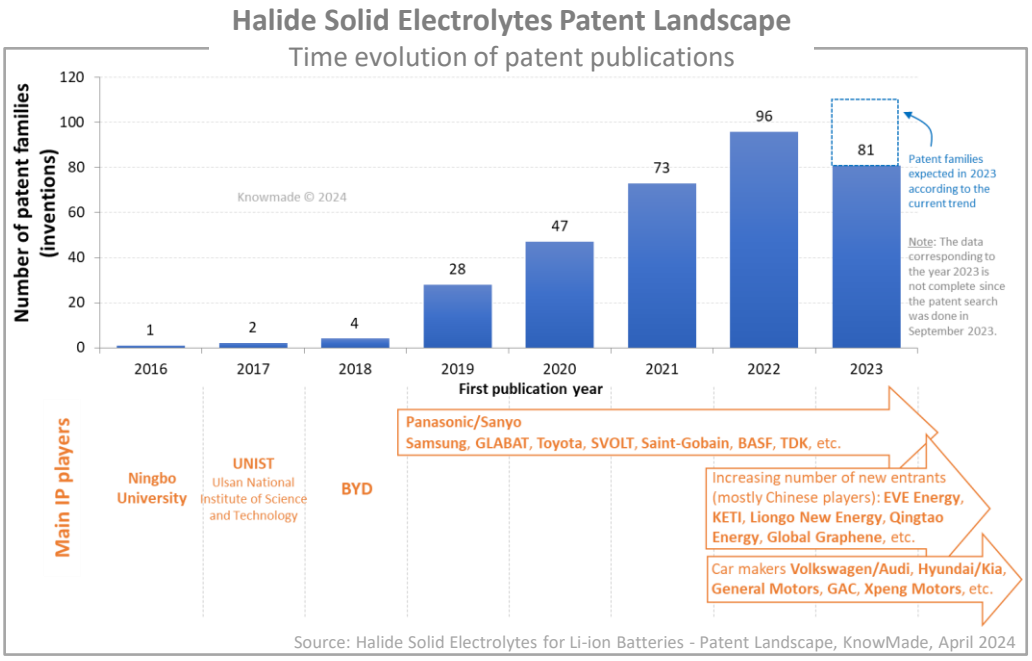
- Solid-State Li-ion Batteries with Inorganic Solid Electrolytes - Patent Landscape Report
- Solid Electrolytes for Li-ion Solid-State Batteries - Patent Landscape Report
- Solid-State Batteries - Patent Monitoring Service (annual subscription)

Halide solid electrolytes are promising options for solid-state batteries

Solid-state Li-ion batteries have garnered significant attention in recent decades due to their notable advantages of safety and potential for high energy density. Solid electrolytes (SE) with rapid ionic transport and excellent stability are essential for the commercialization of this promising next-generation of Lithium batteries. Hence, there has been extensive exploration of inorganic solid electrolytes, including sulfide- and oxide-based electrolytes. Unfortunately, both have been unable to strike an optimal balance between conductivity and stability. Oxides suffer from high impedance of grain boundaries, while sulfides experience poor stability. However, **halide-based solid electrolytes** are increasingly being recognized as one of the most promising options for solid-state Li-ion batteries, owing to their decent room temperature ionic conductivity (>10^{-3} S.cm^{-1}), good compatibility with oxide cathode materials, excellent chemical stability, and scalability.

The increasing interest in **halide solid electrolytes** has been observed while **monitoring patents on solid-state Li-ion batteries**. As of September 2023, over 330 patent families have been published on halide solid electrolyte materials for Li-ion batteries. It is now crucial for companies operating in the solid-state battery industry to closely examine these emerging materials from technological, competitive, and intellectual property (IP) perspectives.

In this context, **Knowmade** is releasing a **new patent landscape report** that focuses on **halide solid electrolyte materials for Li-ion batteries**. In this report, Knowmade's analysts have selected and analyzed over **860 patents and patent applications** from more than **330 patent families** (inventions) filed by **110+ different entities**. The report provides a detailed analysis of the **IP landscape** and **noteworthy patents** concerning **halide solid electrolyte materials**. This new IP report is complementary to our previous patent landscape reports and patent monitors on solid-state batteries.



Source: Halide Solid Electrolytes for Li-ion Batteries - Patent Landscape, KnowMade, April 2024

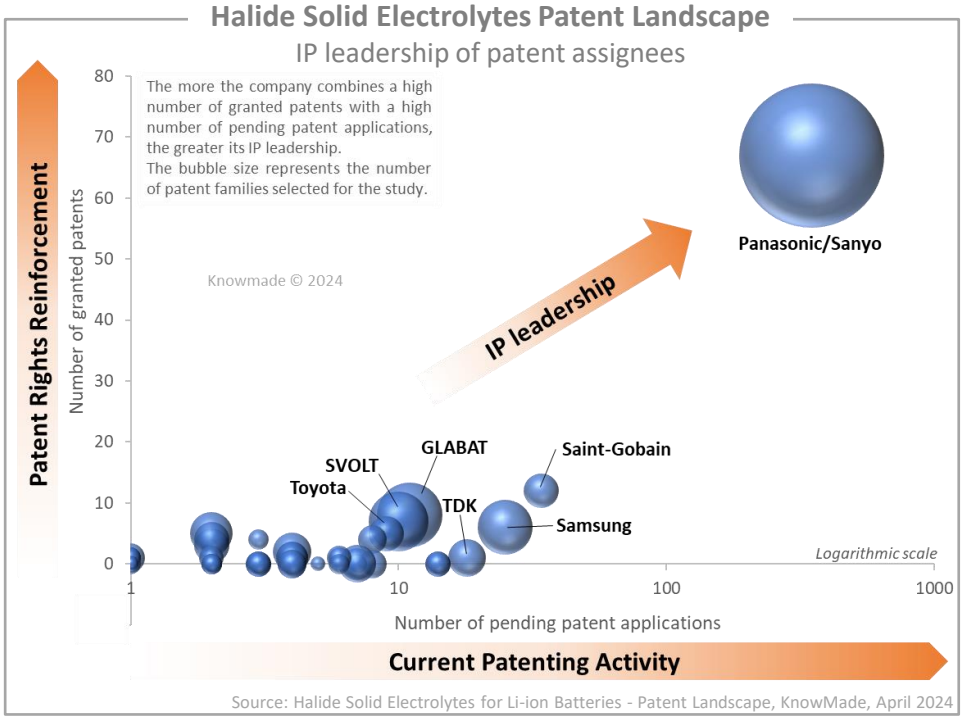
Understanding the main trends, the key players' IP position and IP strategy

IP competition analysis should reflect the vision of players with a strategy to enter and develop their business in the **solid-state Li-ion battery** market. In this report, Knowmade's analysts provide a comprehensive overview of the competitive IP landscape and latest technological developments in this field. The report covers **IP dynamics** and **key trends** in terms of patents applications, patent assignees, filing countries, and patented technologies. It also identifies the **IP leaders**, most **active patent applicants**, and **new entrants** in the IP landscape. The report also sheds light on **under-the-radar companies and new players** in this field.

What are the patented technologies?

In this report, we analyze the **strength of patent portfolios** and the **technology and application focus** of key patent assignees. An overview of the current status and trends of **patented technologies** and their applications is also provided. Furthermore, the report examines the **strategic and technological directions** of both leading companies and newcomers in the field.

The patents have been manually categorized according the claimed **material compositions** (LiMX4, Li3MX6, halide material alone, halide material with a shell, halide material mixed with another material), the claimed **manufacturing methods** (mechano-chemical, co-melting, liquid-phase), as well as the **challenges/solutions** and the **best materials/ionic conductivities** at room temperature disclosed by the inventions.



A few IP leaders and numerous IP newcomers

Panasonic/Sanyo is leading the halide solid electrolytes patent landscape, challenged by **Samsung, GLABAT**, **SVOLT**, **Saint-Gobain**, and **TDK**. Additionally, the IP analysis allowed us to pinpoint over 60 IP newcomers who filed their first halide-related patents in 2022 or after: **EVE Energy**, **Korea Electronics Technology Institute** (KETI), **Liongo New Energy**, **Qingtao Energy Development**, **Global Graphene**, etc. 80% of new entrants in the patent landscape come from China. In a dedicated section, we focus on the **IP portfolios held by key players** (Panasonic, Samsung, Saint-Gobain, GLABAT, SVOLT, EVE Energy, University of Western Ontario, TDK, Toyota, etc.). For each, we provide an **overview of their patent portfolio** related to halide solid electrolytes and a description of their **key patented technologies**.

Halide Solid Electrolytes Patent Landscape

Material composition and technical challenges mentioned in patent portfolios

Patent owner	Material composition										Manufacturing			Challenges						
	LiMeX4	Li3MeX6	Other liMeX	X=Cl, Br, I	X=F in a list	X=only F	X + F	Halide alone	Core-shell	Other composites	Mechano-chemical	Co-melting	Liquid-phase	Improve ionic conductivity	Improve moisture/ air stability	Improve stability with high voltage cathode	Improve process	Improve mechanical properties of the solid electrolyte layer	Improve interfaces with electrodes	Improve thermal and fire stability
Panasonic/Sanyo	x	x	x	x	x	x	x	x		x	x	x		x		x	x		x	x
Samsung	x	x	x	x	x		x	x		x	x			x	x	x			x	
Saint-Gobain		x		x	x			x		x				x			x			
GLABAT		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	
Univ. of Western Ontario		x	x	x	x		x	x	x		x	x	x	x	x	x	x		x	
SVOLT		x		x	x		x	x	x	x	x	x	x	x	x		x	x	x	x
EVE Energy		x		x			x	x	x	x	x			x	x	x	x	x	x	
TDK	x	x		x	x		x	x						x		x			x	
KETI	x	x		x				x	x	x	x			x	x					x
Toyota	x	x	x	x		x		x						x						
USTC		x	x	x	x			x			x			x	x		x	x		
Liongo New Energy	x	x	x	x	x	x		x	x	x	x	x		x	x			x	x	x
QingTao Energy		x		x	x			x		x		x		x			x	x	x	

Source: Halide Solid Electrolytes for Li-ion Batteries - Patent Landscape, KnowMade, April 2024

Useful Excel patent database

This report also includes an extensive **Excel database with** all patents analyzed in this study. This useful patent database allows for **multi-criteria searches** and includes patent publication numbers, **hyperlinks to an updated online database** (original documents, legal status, etc.), priority date, title, abstract, patent assignees, and **segments** (challenges/solutions, material composition, halide formula, synthesis methods, etc.).

Companies mentioned in the report (non-exhaustive)

Baoneng Group, Baowu Steel Group, BASF, Beijing Institute of Technology, BYD, China Automotive Battery Research Institute, China Electrics, Corning, EVE Energy, FAW (China First Automobile Works), Global Graphene, GRINM (General Research Institute for Nonferrous Metals) / GRIMAT, GRIREM Advanced Materials, GTC Power, Guolian Automobile Power Battery Research Institute (GLABAT), Guoxuan High Tech Power Energy / Gotion, Hanyang University, Hyundai / Kia, Institute of Chemistry – Chinese Academy of Sciences, Korea Electronics Technology Institute (KETI), Liongo New Energy Technology, Nankai University, Nanmu Nanotechnology, Nichia, Panasonic / Sanyo, QingTao Energy Development, Rare Earth Functional Materials Innovation Center, Saint-Gobain, Samsung, Shenzhen University, Silver Leaf Element, Solvay, South University of Science & Technology of China (SUSTech), SVOLT / Fengchao Energy Technology, TDK, Toyota, Tsinghua Shenzhen International Graduate School, University of Maryland, University of Waterloo, University of Western Ontario, University of Science and Technology of China (USTC), Xi'an Jiaotong University, Yonsei University, Zengzhou New Century Materials Genome Institute, Zhejiang University, and more.

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ABOUT KNOWMADE

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KnowMade's analysts combine their strong technology expertise and in-depth knowledge of patents with powerful analytics tools and methodologies to turn patent information and scientific literature into actionable insights, providing high added value reports for decision makers working in R&D, innovation strategy, intellectual property, and marketing. Our experts provide prior art search, patent landscape analysis, freedom-to-operate analysis, IP due diligence, and monitoring services.

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