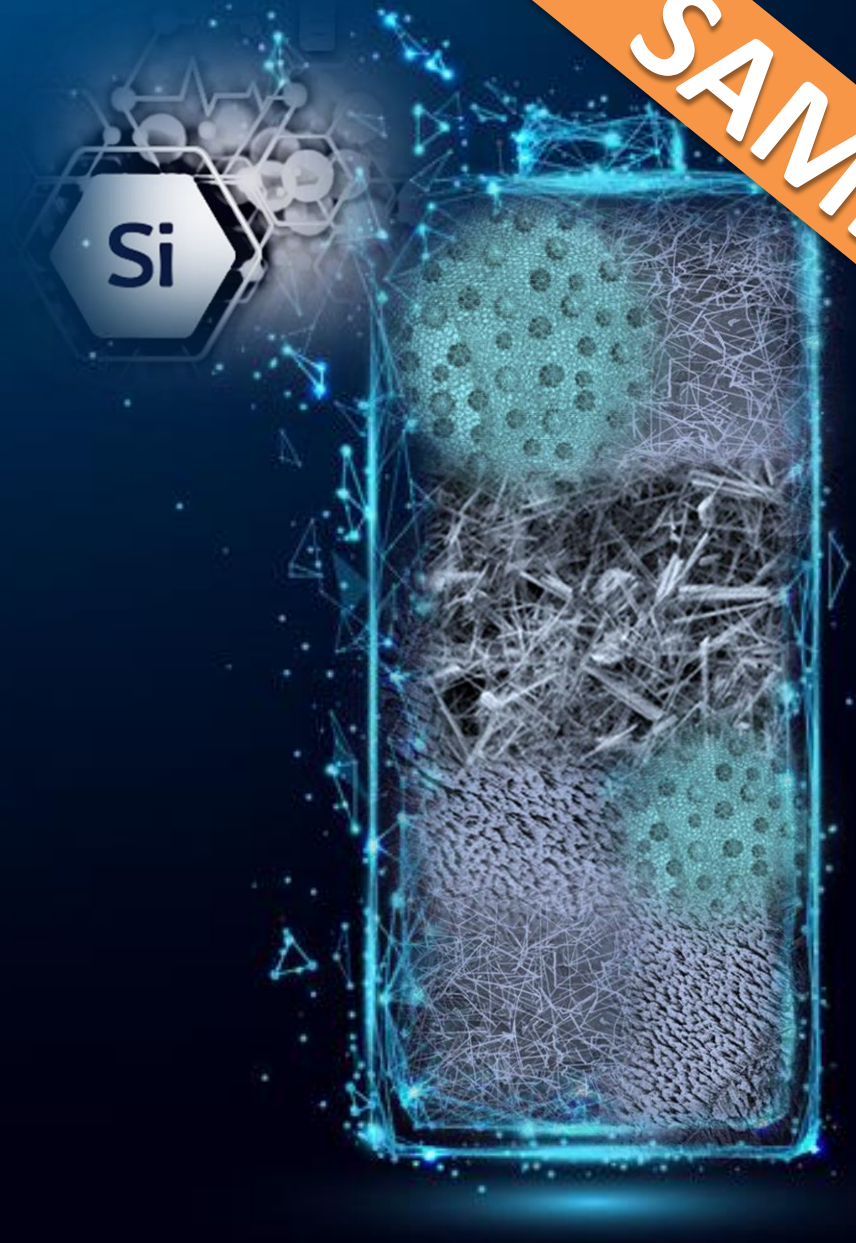
PATENT MONITOR

Silicon Anode Li-ion Batteries

Quarterly Report

Q2 2023



KnowMade
Patent & Technology Intelligence

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KnowMade

KNOWMADE is a technology intelligence and IP strategy consulting company specialized in analyzing patents and scientific publications. The company helps innovative companies, investors, and R&D organizations to understand competitive landscape, follow technological evolutions, reduce uncertainties, and identify opportunities and risks in terms of technology and intellectual property.

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.

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

INTRODUCTION

INTRODUCTION

Context & objectives of the monitor (1/2)

- New rules and regulations on vehicle CO_2 emissions are pushing car manufacturers to accelerate their transition towards electric vehicles. The performance of electric vehicles (including range, speed, and safety) mainly depends on their batteries. The automotive sector represents a vast new potential market for the battery industry, which is why companies in this field are heavily investing to meet these demands. Driven by the need for electric vehicles with greater range, power, and safety, research and development in the battery sector is constantly growing and evolving across all levels of the supply chain (electrodes, electrolytes, separators, cell packs, and systems).
- One promising solution to **improve battery performance** (i.e., energy and power density, charging time, lifespan, and performance in extreme environments) is the development of **new electrode materials** and electrolytes. On the anode side, **silicon is a promising material** to replace graphite and enhance battery performance. **Silicon-based anodes in Li-ion batteries offer superior electrochemical performance**, such as higher energy density, greater gravimetric and volumetric capacity, suitable thermodynamic lithiation potentials, and higher average voltage. Additionally, **silicon is environmentally friendly**, non-toxic, and abundant in the Earth's crust, with its raw material cost remaining relatively low for several years. However, the use of silicon presents **two major challenges**: **poor cyclability** due to the significant volume expansion of silicon during charging and discharging, which generates mechanical stress and leads to the collapse of the electrodes, and silicon's **poor intrinsic electronic conductivity**.
- The main challenges in adopting silicon-based anodes for Li-ion batteries involve **improving the cycling and electrochemical performance** of silicon anode materials, as well as **refining the synthesis process** to increase yields, reduce costs, and lower environmental impact. Key technical solutions under development include **creating various silicon-based materials** (e.g., nanostructured, composite, highly porous, and high-density materials) and **developing electrolytes and binders** specifically suited to silicon anode materials.

INTRODUCTION

Context & objectives of the monitor (2/2)

- R&D laboratories and industrial companies quickly recognized the potentiality of silicon as an anode material for Li-ion batteries, leading to significant investments to bring this technology to market. Today, the use of silicon-based anodes in Li-ion batteries is becoming a reality. In 2021, IDTechEx estimated that **$1.9 billion in funding had flowed into silicon anode start-ups** and forecasted that the demand for silicon anode materials would reach $12.9 billion by 2032. Several material manufacturers, such as **Advano**, **Sila Nanotechnologies**, **Elkem**, **Group14**, **NanoGraf**, **OneD Materials**, and **Nexeon**, have announced the commercial production of silicon active materials for Li-ion batteries. Likewise, several battery manufacturers have announced the commercial availability of silicon anode Li-ion cells, including **Amprius**, **Sionic Energy (formerly NOHMS)**, **Farasis Energy**, **Enovix**, **StoreDot**, **Samsung**, **Panasonic**, **PPES**, **Murata**, and **Enevate/EnerTech**. On the automotive side, we are seeing strategic acquisitions and partnerships. **Tesla** acquired battery manufacturer **Maxwell Technologies** in 2019 and battery startup **SiLion** in 2021. In 2021, **PPES** (joint venture between **Toyota** and **Panasonic**) and **Nexeon** announced a partnership focused on silicon anode development. In the same year, **StoreDot** entered into a strategic framework agreement with **EVE Energy** and partnered with **Group14 Technologies** to accelerate commercialization of **StoreDot**'s XFC lithium-silicon cells for electric vehicles. In 2024, IDTechEx forecasted that the market for **silicon anode material for Li-ion batteries will exceed $24 billion by 2034**. **IDTechEx** also noted that **Sila Nanotechnologies**' materials have been used in the Whoop fitness wearable, **Amprius** has deployed batteries in drones and high-altitude pseudo satellites (HAPS), and **Lightning Motors** plans to offer e-motorcycles using **Enevate**'s technology. Automotive OEMs such as **Daimler**, **Porsche**, and **GM** have taken note of the potential of silicon anodes, investing in and partnering with silicon anode companies.
- In this context, **our patent monitoring service** perfectly complements market research to offer a deep understanding of the competitive landscape, to anticipate changes, detect business opportunities early, get ahead of cutting-edge technology developments, and understand competitors' strategies.

INTRODUCTION

Take advantage of quarterly updates on IP activities

ANNUAL SUBSCRIPTION

12 months

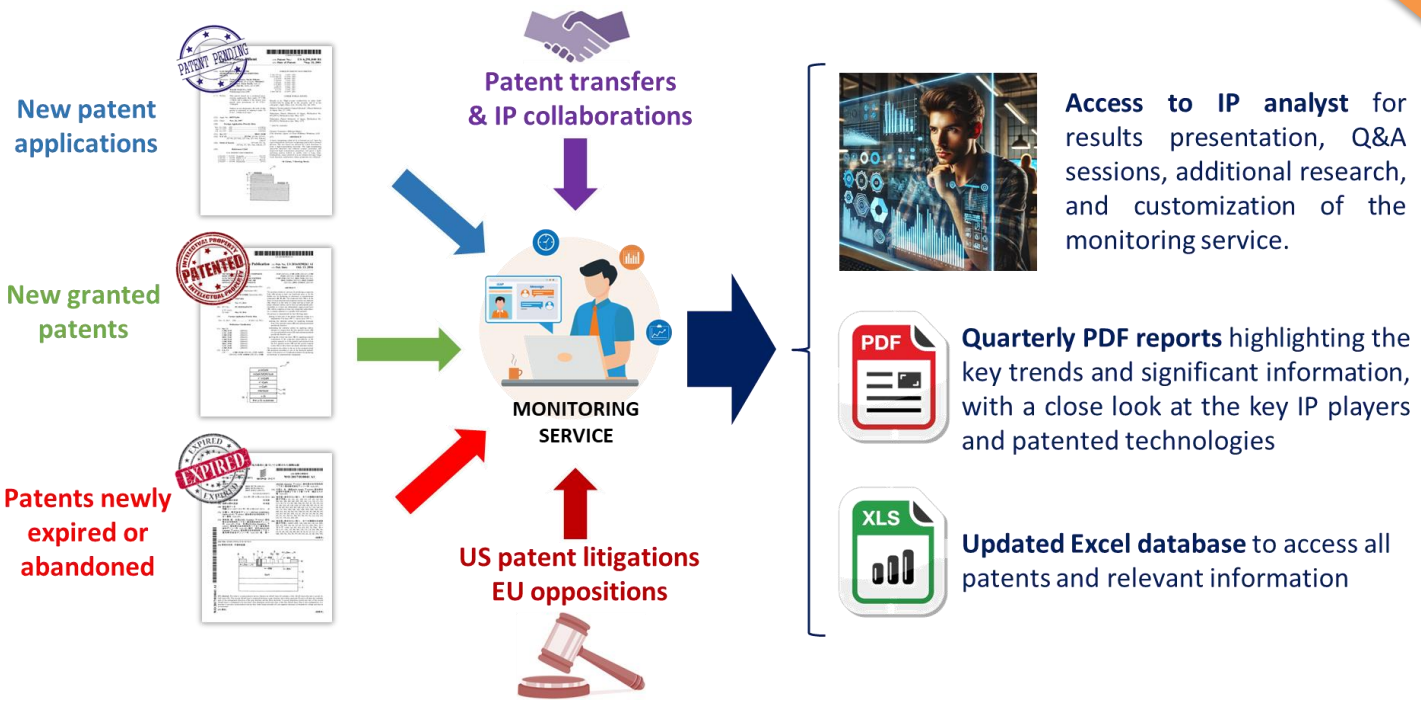
CONTENTS

Every quarter

- One-hour **presentation of results**, Q&A, and discussions.
- **PDF report** highlighting the key trends and significant information, with a close look at the key IP players and patented technologies.
- Updated **Excel database** to access all patents and relevant information (*new patents applications, granted patents, expired or abandoned patents, patent transactions, IP collaborations, patent litigations and oppositions*)

Throughout the year

- **Direct access to the IP analyst**
  - to address any inquiries you may have regarding reports' results.
  - to conduct additional research on specific technologies or companies' patent portfolios.
  - to customize the monitoring service by adding specific players and/or specific segments.



WHY YOU SHOULD SUBSCRIBE

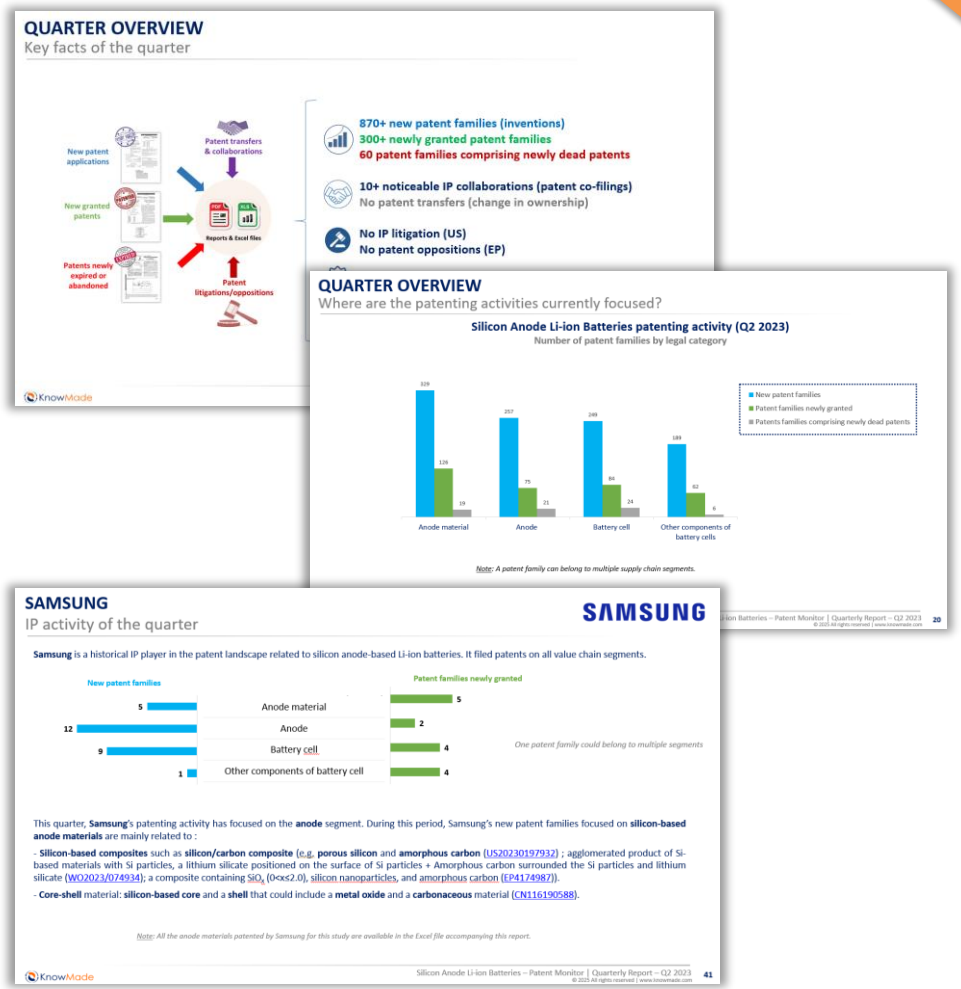
- ✓ Track your **competitors**, partners or clients
- ✓ Identify **newcomers** to your technology field
- ✓ Early detect **opportunities** and **risks** for your business
- ✓ Get a clearer view of the **technology evolution**
- ✓ Identify emerging research areas and **cutting-edge technology** developments
- ✓ Mitigate patent **infringement risks**
- ✓ Take advantage of **free technologies**

INTRODUCTION

Quarterly report

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

- Main patent applicants, their notable patent filings and technologies.
- New entrants and their patents.
- Technology trends and notable patented technical solutions.
- Key patents newly granted, their owners and claimed inventions.
- Main IP right transfers (reassignments, licensing agreements).
- Key patents newly expired or abandoned or revoked, their owners and their potential market impact.
- Noteworthy news on patent litigation and opposition, plaintiffs and defendants, patents and products involved.



INTRODUCTION

Year-round access to an IP analyst

Take advantage of **direct interaction with our analysts** by phone call and/or email for **result presentations**, **Q&A sessions**, **additional research** on specific technologies or companies' patent portfolios, and **customization of the monitoring service** by adding specific players and/or specific segments.

Examples of questions or requests:

- Could you tell me more about the **patent portfolio of this company**?
- What is exactly the **invention claimed** in these patents?
- Can you give me the **patents filed by this company** on these specific technologies?
- Can you shortly **analyze the patents** of this new entrant?
- What are the patents **issued in Japan and Korea** for this application?
- Please give me more details about this **patent litigation**.
- We want to file a new patent. Can you help us to **assess the prior-art** in this field?
- I would like to **invalidate these patents**. Could you do a prior-art search?
- Can you help me to identify in patents the **technical solutions** to solve this issue?
- I would like to assess my **freedom of operating** in USA. Can you provide me with the granted US patents covering this technology?
- I am looking for **free technologies** I could use safely without infringing valid IP rights. Can you provide me with newly expired patents related to this technology?
- I would like to **customize the monitoring service** to track my primary **competitor's IP activities**.
- I would like to **customize the monitoring service** to track patents related to a **specific topic**.

INTRODUCTION

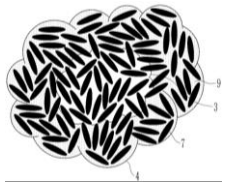
Scope of the patent monitor

- This patent monitor provides a detailed picture of the current IP dynamics related to **Silicon Anode Li-ion Batteries,** covering the whole value chain (anode materials, anode electrode, battery cells, electrolytes, binders, etc.)
- The patent search strategy has been implemented using advanced search equations in the patent database and by a cautious patent selection performed by the analyst to get the most relevant corpus.

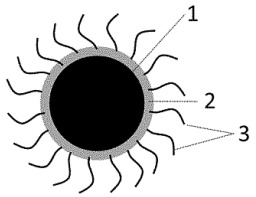
MAIN FOCUS

Anode materials | **Anodes** | **Battery cells** | **Other components** | **Other** *(Packs, Equipments, Charging Technologies, Recycling, etc.)*

All types of silicon-based materials are **included**, **except** for **silicon alloys** and **SiOx** alone.



Silicon/carbon composite with a central void (source: Samsung's patent)



Grafted silicon-based core-shell (source: COSMX's patent)

includes binders, electrolytes, cathode materials & electrodes, current collectors and separators

(*)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.

INTRODUCTION

Excel database

With this report, an **Excel file** is provided that includes 1200+ **patent families** (inventions) selected and analyzed during this quarter. This **useful patent database** allows for **multi-criteria searching** and includes patent publication numbers, **hyperlinks to an updated online database** (original documents, legal status, etc.), priority date, title, abstract, patent assignees and **segments** (anode materials, anodes, battery cells and other components of battery cells such as binders, electrolytes, etc.).

Silicon Anode Li-ion Batteries - Patent Monitor: Q2 2023

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Note : Other components of battery cells can include binders, electrolytes, cathode materials & electrodes, current collectors and separators.

													REASON OF SELECTION					SUPPLY CHAIN			
Questel unique family ID	Publication numbers	Title	Abstract	Legal status (Pending, Granted, Revoked, Expired, Lapsed)	Current assignees (Orbit extraction)	Current assignees (Knowmade treatment)	Inventors	Earliest application date (yyyy-mm-dd)	Earliest publication date (yyyy-mm-dd)	Earliest grant date (yyyy-mm-dd)	Expected expiry dates (yyyy-mm-dd)	Link to Original Document	New inventions	New granted patent families	Patent families comprising newly dead patent	Patent transfers	Patent litigations	Anode material	Anode	Battery cell	Other components of battery cells
80197378	EP3557662 EP3557662 CN108475773	(EP3557662) Negative electrode for lithium ion	(EP3557662) A lithium-ion secondary battery	(EP3557662B1) LAPSED (US20190326595A1)	KEIO UNIVERSITY KYOCERA	KyoceraKeio University	TERASHI YOSHITAKE YAN JIWANG	2017-12-19	2018-06-28	2019-06-12	(EP3557662B1) 2024-09-30 (US20190326595A1	Open			X				X		
104756289	CN116053587	(CN116053587) Electrolyte for lithium ion battery	(CN116053587) The electrolyte for the lithium ion	(CN116053587A) PENDING	A123 SYSTEMS	,123 Systems (Wanxiang grou	SHI LANLAN ZHOU XIAOCHONG	2023-02-23	2023-05-02		(CN116053587A) 2043-02-23	Open	X							X	X
101592999	CN115000407 CN115000407	(CN115000407) Silicon-based negative pole	(CN115000407) The invention relates to the field	(CN115000407BB) GRANTED	A123 SYSTEMS	,123 Systems (Wanxiang grou	ZHANG XIAOZHU SU MIN CHEN YUN	2022-06-13	2022-09-02	2023-06-09	(CN115000407BB) 2042-06-13	Open		X					X		
104893625	WO2023/081524 WO2023/081523 WO2023/081523	(WO2023081532) Slot electrode stack and	(WO2023/081530) The present disclosure	(WO2023081530A1) PENDING (WO2023081532A1)	ADVANCED CELL ENGINEERING	Advanced Cell Engineering	KAUFMAN JOHN ZAGHIB KARIM MANIVANNAN	2022-11-08	2023-05-11		(WO2023081530A1) 2025-05-08 (WO2023081532A1)	Open	X							X	X
105001347	US20230163281	(US20230163281) Lithiated silicon/carbon	(US20230163281) The invention relates to	(US20230163281A1) PENDING	ALBEMARLE	Albemarle	WIETELMANN ULRICH EMMEL UTE	2023-01-06	2023-05-25		(US20230163281A1) 2036-01-27	Open	X					X			
105447713	CN116314793	(CN116314793)	(CN116314793)	(CN116314793A)			SUN DAN YAN TAO HUANG XIN	2023-02-09	2023-06-23		(CN116314793A) 2043-02-09	Open									
105427927	CN116314716					Anhui University	FANG DAOLAI LIU WEISHAN YANG	2023-04-12	2023-06-23		(CN116314716A) 2043-04-12	Open									
105426420	CN116314714						FANG DAOLAI LIU WEISHAN YANG	2023-04-11	2023-06-23		(CN116314714A) 2043-04-11	Open									
104457316	CN115939532					Anhui University	HE YITAO DONG YUJIE LI HAIJIN	2023-03-02	2023-04-07		(CN115939532A) 2043-03-02	Open									
104773959	CN116053708 CN116053708	Lithium supplement	The invention provides a lithium	(CN116053708BB) GRANTED	ANMAITE TECHNOLOGY BEIJING	MAITE TECHNOLOGY BEIJ	SUN XINSEN FAN WEICHAO LI YONGWEI	2023-03-29	2023-05-02	2023-07-04	(CN116053708BB) 2043-03-29	Open	X								X
104892897	WO2023/080367	(WO2023080367) Slurry composition for negative	(WO2023/080367) The present invention relates	(WO2023080367A1) PENDING	ADVANCED NANO PRODUCTS	NP (Advanced Nano Produc	Kwak Woo-heon YOON, Kee Bong KOAK,	2022-04-29	2023-05-11		(WO2023080367A1) 2025-05-03	Open	X						X		
105554557	CN219286445	(CN219286445U) Electrode structure and	(CN219286445) The utility model discloses an	(CN219286445UU) GRANTED	DONGGUAN AOZON NEW MATERIAL TECHNOLOGY	Aozon	ZHANG ZHANGYU LIU TAO	2022-12-20	2023-06-30	2023-06-30	(CN219286445UU) 2032-12-20	Open	X	X					X		
104820940	CN116072878 CN116072878	(CN116072878) Electrode, preparation	(CN116072878) The invention provides an	(CN116072878BB) GRANTED	DONGGUAN AOZON NEW MATERIAL TECHNOLOGY	Aozon	ZHANG ZHANGYU LIU JING	2023-04-06	2023-05-05	2023-06-30	(CN116072878BB) 2043-04-06	Open	X	X					X		
104580651	CN115966665	(CN115966665) Carbon-silicon composite	(CN115966665) In order to improve the problem of	(CN115966665A) PENDING	DONGGUAN AOZON NEW MATERIAL TECHNOLOGY	Aozon	ZHANG ZHANGYU LIU TAO	2022-12-07	2023-04-14		(CN115966665A) 2042-12-07	Open	X					X			
105332319	WO2023/113961 US20230197922 WO2023/113961	(US20230197922) Cold spray deposition for	(US20230197922) Embodiments of the present	(US20230197922A1) PENDING (WO2023113961A3)	APPLIED MATERIALS	Applied Materials	SONAL ISHIKAWA DAVID MASAYUKI	2022-11-15	2023-06-22		(US20230197922A1) 2042-11-15	Open	X						X		
105394203	WO2023/118674 FR3130820	(WO2023118674) Anode composition with	(WO2023/118674) The invention relates to an	(WO2023118674A1) PENDING (FR3130820A1)	COATEX	Arkema	CORFIAS ZUCCALLI CATHERINE	2021-12-20	2023-06-23		(WO2023118674A1) 2025-06-20 (FR3130820A1)	Open	X						X		
105318467	TW202335336 WO2023/108106	(WO2023108106) Composite materials providing	(WO2023/108106) Provided herein are composite	(WO2023108106A1) PENDING (TW202335336A)	ASPEN AEROGELS	Aspen Aerogels	BEGAG REDOUANE LEVENTIS	2022-12-09	2023-06-15		(WO2023108106A1) 2025-06-09 (TW202335336A)	Open	X					X			
90361075	US20230294061 RU2801325 US11648521	(EP3931894) Carbon aerogel-based electrode	(EP3931894) Nanoporous carbon-based	(EP3931894A1) PENDING (US11648521B2)	ASPEN AEROGELS	Aspen Aerogels	ZAFIROPOULOS NICHOLAS TRIFU ROXANA	2020-02-27	2020-08-27	2023-05-16	(EP3931894A1) 2040-02-27 (US11648521B2)	Open		X					X		
		(CN116344766)	(CN116344766)	(CN116344766A)	NINGDE AMPEREX																

INTRODUCTION | PATENT LIST | +

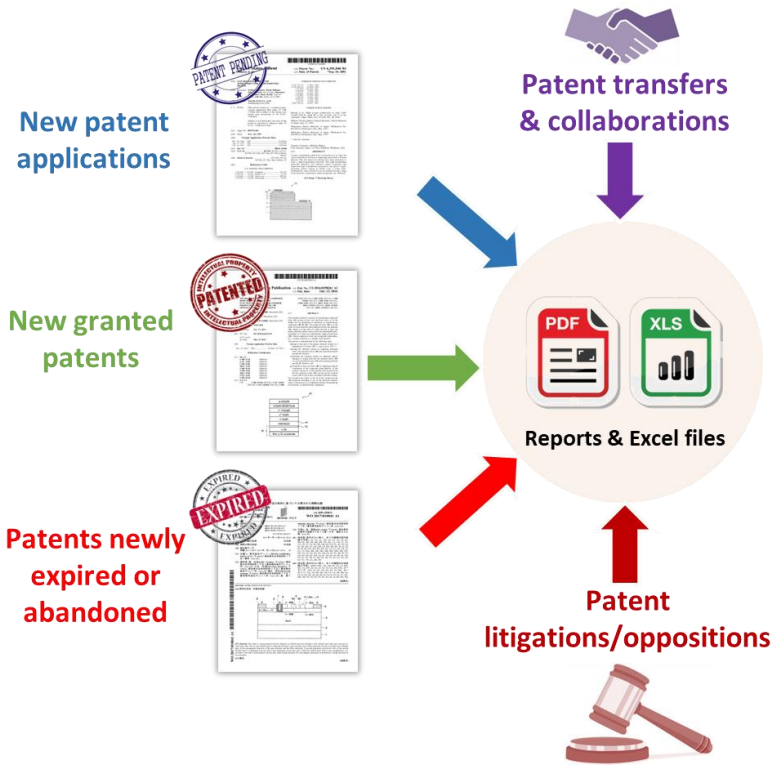
Patent information
(Assignees, numbers, dates, title, abstract, legal status, original document etc.)

Patent segmentation
(Reason of Selection, Supply Chain Position: Anode material, Anode, etc.)

QUARTER OVERVIEW

QUARTER OVERVIEW

Key facts of the quarter



870+ new patent families (inventions)
300+ newly granted patent families
60 patent families comprising newly dead patents

10+ noticeable IP collaborations (patent co-filings)
No patent transfers (change in ownership)

No IP litigation (US)
No patent oppositions (EP)

10+ noticeable Newcomers identified

4 Key IP players selected and analyzed

SAMSUNG LG Chem LG Energy Solution

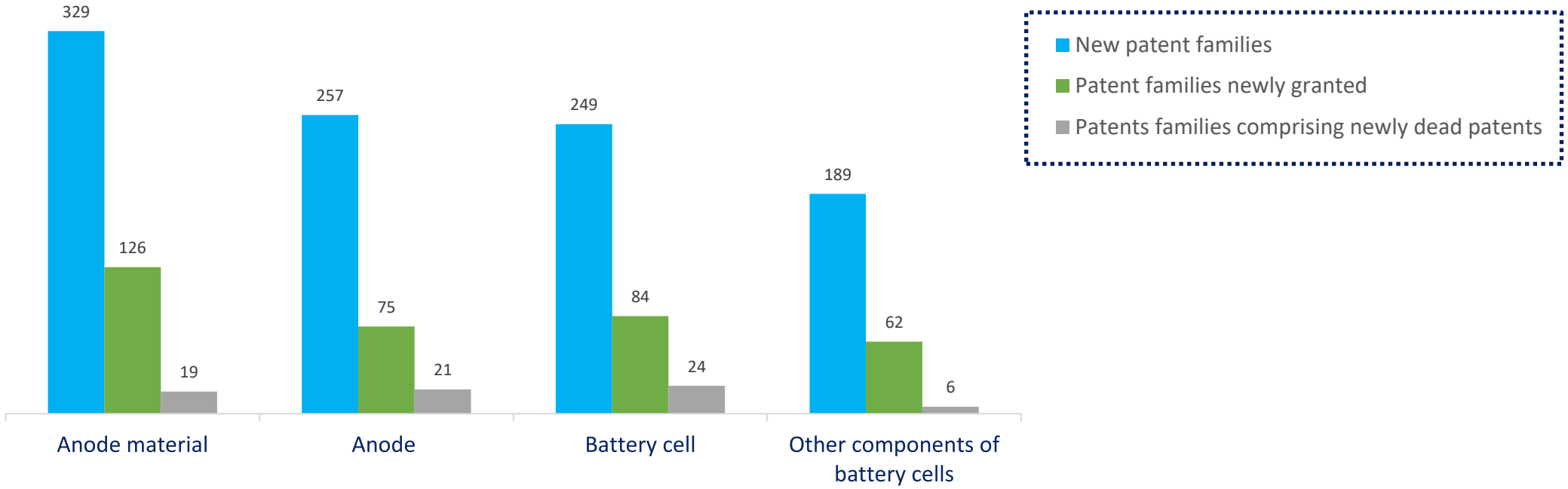
Clickable logo to IP profiles

QUARTER OVERVIEW

Where are the patenting activities currently focused?

Silicon Anode Li-ion Batteries patenting activity (Q2 2023)

Number of patent families by legal category



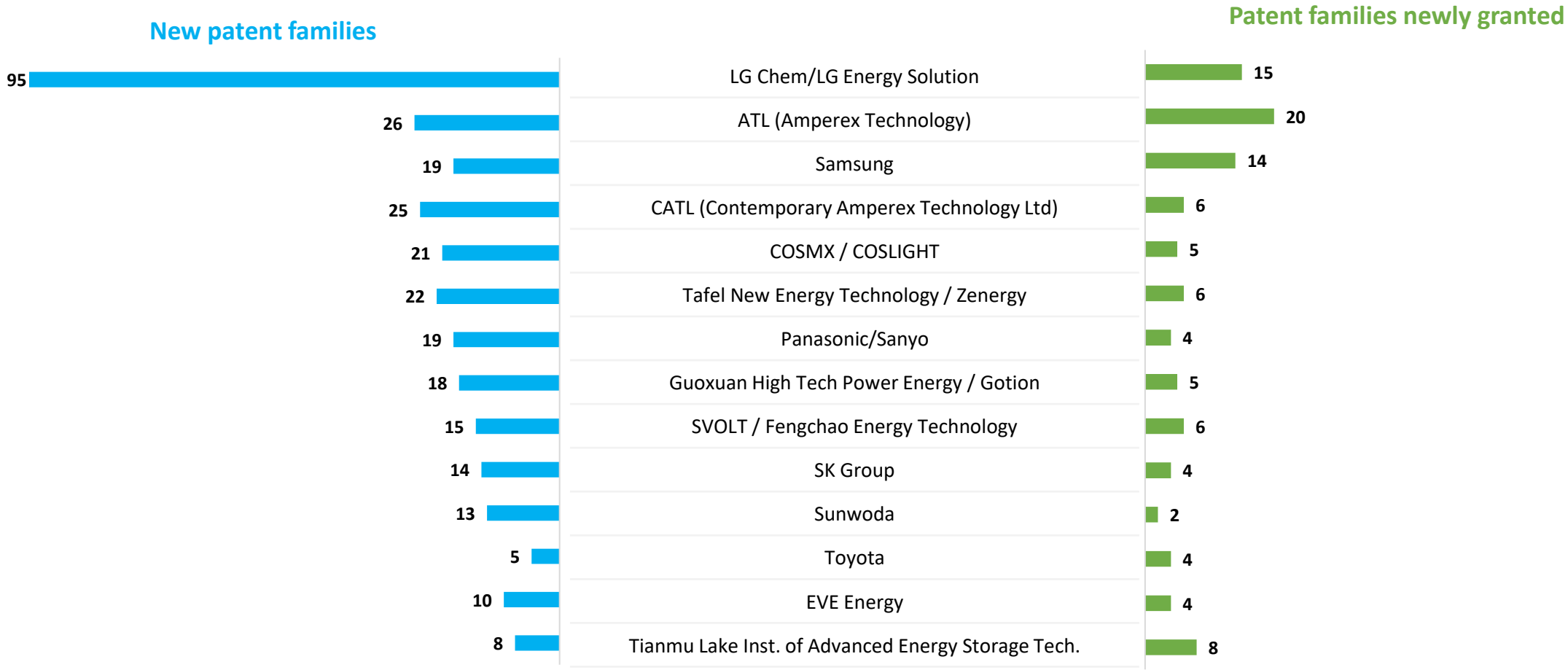
Note: A patent family can belong to multiple supply chain segments.

QUARTER OVERVIEW

Main Silicon Anode Li-ion Batteries IP players during this quarter

Silicon Anode Li-ion Batteries patenting activity (Q2 2023)

Number of alive patent families



This ranking identifies players focused on Silicon Anode Li-ion Batteries technology based on their IP activity.

New patent families

QUARTER OVERVIEW

Main players driving the patenting activity across the supply chain

Anode material	Anode	Battery cell	Other battery components
Tafel New Energy Technology / Zenergy	LG Chem LG Energy Solution	LG Chem LG Energy Solution	LG Chem LG Energy Solution
LG Chem LG Energy Solution	SAMSUNG	CATL	ATL
Gotion	ATL	ATL	COSMX
SVOLT	Tafel New Energy Technology / Zenergy	Panasonic SANYO	SK
BTR	EVE	SAMSUNG	SVOLT

Main IP players driving the IP activity in each segment of the supply chain have been identified according the number of their new patent families (inventions) published during the quarter

QUARTER OVERVIEW

Notable new inventions across the anode material segment

Anode material

LG Chem
LG Energy Solution

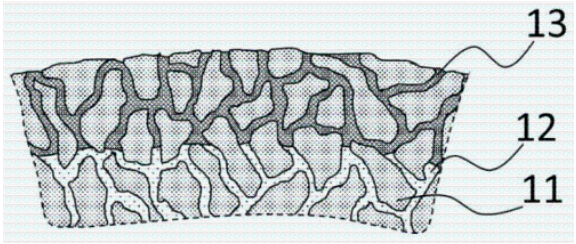
KR10-2023-0081674

***Composite** material : Core = **Si** or SiOx (with 0 ≤ x ≤ 2) with **a** lithium-containing compound + a **graft layer** (**sulfonic acid group**) surrounding the core. This material could provide high initial capacity, capacity retention rate. It could also provide stable viscosity and suppress volume expansion of the anode.*

COSMX

CN116130636

***Composite** material comprising a part with a **porous carbon** as a skeleton structure and containing **fillers** such as **silicon** and **fluorine** (F), **phosphorus** (P) and **sulfur** (S) elements.This material could provide enhanced **interfacial** and **electrochemical stability**.*

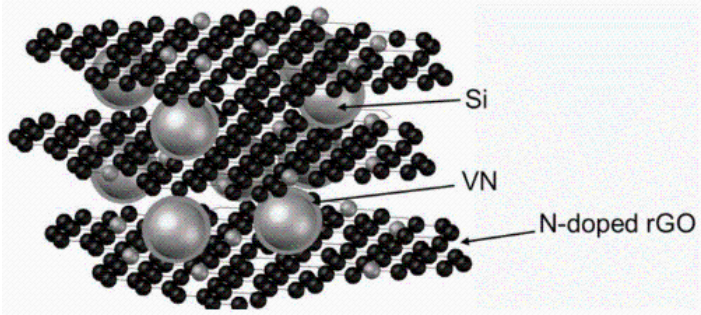


13: Outer layer comprising F, P, S elements
12: Inner layer comprising silicon
11: Porous carbon

SVOLT

CN116344768

***Composite** material : A **nano silicon core**, and a **vanadium nitride (VN)** coating layer and a **nitrogen-doped reduced graphene oxide (N-doped rGO)** coating layer which are sequentially laminated on the surface of the nano silicon core.
This material could provide a battery cell with enhanced **cycle performance** and **rate capability**.*



Note: The full-texts of patents mentioned in this slide are available in the Excel database provided with the present report

QUARTER OVERVIEW

Main non-Chinese IP players & IP newcomers

Patent assignee	SEGMENTS (number of new patent families)				
	Nb of new patent families (inventions)	Anode Material	Anode Electrode	Battery cell	Other components of battery cell
All Players	**876**	**329**	**257**	**249**	**189**
LG Chem/LG Energy Solution	95	9	37	42	12
Samsung	19	5	12	9	1
Panasonic/Sanyo	19	3	4	10	2
SK Group	14		7	6	6
Toyota	5	4		1	
Murata Manufacturing/Sony Battery	5			5	
OCI	4	3	1		
Posco	4	4			
Hyundai/Kia	3		1	1	2
General Motors	3	1	1	2	2
Seoul National University	3		2	3	1
Ionobell	3	2		1	
Daejoo Electronic Materials	3	3			
Global Graphene	3	2	1	1	
KIER (Korea Institute of Energy Research)	3	1	1	1	
Sumitomo Chemical / Tanaka Chemical	3		3		
RIST (Research Institute of Industrial Science and Technology)	3	3			
Solvay	3		1		3
Wacker Chemie	3	3			
KICET (Korea Institute of Ceramic Engineering & Technology)	3	1	3	1	
PPG Industries	3		3		2
Resonac (Showa Denko / Hitachi Chemical)	3	3		1	
TDK	3			3	

Main IP players

New IP players

(1st silicon anode-related patents published during this quarter)

Clickable logo to corporate websites

QUARTER OVERVIEW

Main Chinese IP players & IP newcomers

Patent assignee	SEGMENTS (number of new patent families)				
	Nb of new patent families (inventions)	Anode Material	Anode Electrode	Battery cell	Other components of battery cell
All Players	876	329	257	249	189
ATL (Amperex Technology)	26	2	12	10	7
CATL (Contemporary Amperex Technology Ltd)	25	5	5	15	3
Tafel New Energy Technology / Zenergy	22	10	11	3	2
COSMX / COSLIGHT	21	6	4	6	7
Guoxuan High Tech Power Energy / Gotion	18	9	7		2
SVOLT / Fengchao Energy Technology	15	9	2	1	5
Sunwoda	13	2	1	7	5
Tianmu Energy Anode Material	10	10			
EVE Energy	10		8	1	3
Shinghwa Advanced Material	10	10			
JEVE (Tianjin EV Energy)	9	3	4	1	2
Beijing Institute Of Technology	8	1		2	6
Cornex New Energy	8	2	4	2	3
WeLion New Energy Technology	8	2	5	1	1
BTR New Energy Material	7	7			
Shanxi Wote Haimer New Materials Technology	7	7			
Veken	6	1	1	1	3

Main IP players

Tafel New Energy Technology / Zenergy

New IP players

(1st silicon anode-related patents published during this quarter)

青岛新泰和纳米科技有限公司
QINGDAO XINTAIHE NANO TECHNOLOGY CO., LTD

LEAPMOTOR

Clickable logo to corporate websites

Newly granted patent families

QUARTER OVERVIEW

Main players reinforcing their IP position across the supply chain

Anode material	Anode	Battery cell	Other battery components
SAMSUNG	Tianmu Lake Inst. of Adv. Energy Storage Tech.	ATL	LG Chem LG Energy Solution
Tafel New Energy Technology / Zenergy	ATL	LG Chem LG Energy Solution	SAMSUNG
清華大學 Tsinghua University	LG Chem LG Energy Solution	SVOLT	ATL
Gotion	COSMX	SAMSUNG	广汽集团 GAC GROUP
BTR	SAMSUNG	CATL	HYUNDAI KIA

Main players reinforcing their IP position in each segment of the supply chain have been identified according the number of their patent families (inventions) firstly granted during the quarter

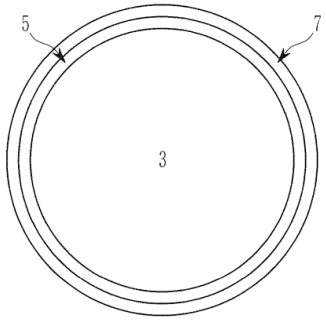
QUARTER OVERVIEW

Notable new granted patents across the anode materials segment

Anode material

SAMSUNG **US11670762**

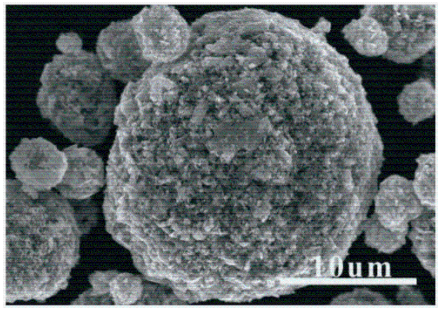
Core-shell *material comprising a silicon particle* ***core*** *(particle size = 1 µm to about 10 µm) + an* ***oxide layer*** *(may include silicon oxide) + a* ***conductive layer****.This material could provide* ***high initial efficiency*** *and* ***stable cycle-life*** *characteristics.*



3: silicon particle (core)
5: oxide layer
7: conductive layer

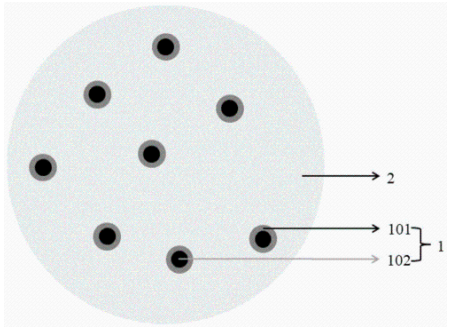
Gotion **CN114914418**

Silicon*-based* ***nanocomposite*** *material jointly coated by a* ***graphene-based compound*** *and* ***Mg-doped ZnO****. This material could* ***inhibit volume expansion*** *of the nano-silicon material and could have* ***improved electrochemical performances****.*



BTR **CN111463409**

Composite material *comprising a* ***carbon*** *material and a* ***supramolecular polymer cracking carbon-coated nano silicon*** *material dispersed in the carbon material.*
This material could have higher first reversible capacity and first coulomb efficiency.



2: carbon material

1 : nano-silicon material
101: supramolecular polymer cracking carbon coating
102: nano-silicon

Note: The full-texts of patents mentioned in this slide are available in the Excel database provided with the present report

QUARTER OVERVIEW

Main non-Chinese players strengthening their IP position across the supply chain

Patent assignee	SEGMENTS (number of patent families newly granted)				
	Nb of patent families (inventions) newly granted	Anode Material	Anode Electrode	Battery cell	Other components of battery cell
All Players	302	126	75	84	62
LG Chem/LG Energy Solution	15	2	3	7	4
Samsung	14	5	2	4	4
SK Group	4	2	2		
Panasonic/Sanyo	4		1	2	1
Hyundai/Kia	4	1	1	1	2
Toyota	4	1	1	1	1
KICET (Korea Inst. of Ceramic Engineering & Tech.)	4	3	2	1	
Murata Manufacturing/Sony Battery	3		1	1	1
Fujifilm	3		1		2
Global Graphene	3	1		2	
Enevate	3	1	2	1	
General Motors	3			3	
Seoul National University	3	2		1	
Resonac (Showa Denko / Hitachi Chemical)	2		1	1	2
Fraunhofer	2		2		2
UNIST (Ulsan National Institute of Science & Technology)	2				2
LeydenJar Technology	2	2		1	
BioGeneSys	2	1		1	2

Main IP players

QUARTER OVERVIEW

Main Chinese players reinforcing their IP position across the supply chain

Patent assignee	SEGMENTS (number of patent families newly granted)				
	Nb of patent families (inventions) newly granted	Anode Material	Anode Electrode	Battery cell	Other components of battery cell
All Players	302	126	75	84	62
ATL (Amperex Technology)	20	2	5	11	3
Tianmu Lake Inst. of Adv. Energy Storage Tech.	8	2	6	1	1
CATL (Contemporary Amperex Technology Ltd)	6	1	1	4	
SVOLT / Fengchao Energy Technology	6	1		5	
Tafel New Energy Technology / Zenergy	6	5	2		
Guoxuan High Tech Power Energy / Gotion	5	4	1	1	
COSMX / COSLIGHT	5		3	2	1
Institute of Physics - CAS	5	1	3	1	
Tsinghua University	5	5			
Cornex New Energy	4	1	2	2	1
EVE Energy	4	2	2		
Yangtze River Delta Physics Research Center	4	1	3		
Kunming University of Science & Technology	4	4			
Qingchuang Silicon Valley Technology	4	4			
BTR New Energy Material	3	3			
CALB (China Aviation Lithium Battery)	3			3	
Shaanxi University of Science and Technology	3	3			
Shandong University	3	2			1
Sinopec	3	1			2
Songshan Lake Materials Laboratory	3	3			
WeLion New Energy Technology	3	1		1	1

Main IP players

ATL

Tianmu Lake Inst. of Adv. Energy Storage Tech.

CATL

SVOLT

Tafel New Energy Technology / Zenergy

Gotion

COSMX

Patents newly expired or abandoned

QUARTER OVERVIEW

Dead patents: new IP in the public domain?

	SEGMENTS (number of patent families comprising newly dead patents)				
Patent assignee	Nb of patent families comprising newly dead patents	Anode Material	Anode Electrode	Battery cell	Other components of battery cell
All Players	60	19	21	24	6
SEL (Semiconductor Energy Laboratory)	12	1	8	9	
Toyota	5	3	1		1
GS Yuasa	3		2	1	
Samsung	3	2		1	1
Nexeon	2	1	1		
Kalptree Energy_Adavolt	2			2	
Nissan	2		1	1	
Murata Manufacturing/Sony Battery	2		2	2	
BYD	2	2			
NEC	2	1	1		
Resonac (Showa Denko / Hitachi Chemical)	2	2			
Jinruichen Science & Technology	2	2			
China Energy Guosheng Power Battery Technology	2		1	1	
Yunli Technology	2		1	1	

If a patent is dead (expired or abandoned or revoked), is it possible to make the formerly patented product?

An expired patent cannot be asserted against competitors. However, other alive patents may still cover different parts, features or combinations described in the expired patent. Moreover, in some countries, a lapsed patent can be reinstated/restored by paying an additional fee plus the maintenance fee, and reasoning that delay or nonpayment of the maintenance fee within the prescribed period was unintentional.

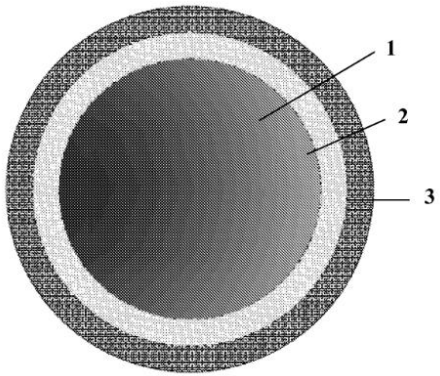
QUARTER OVERVIEW

Notable dead patents

Anode material

US9029020

Core-shell *material with two different layers around the core part.*
This material could improve the performances and stability of the Li-ion battery.

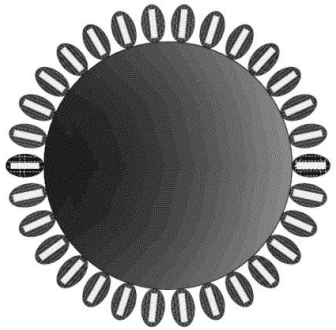


1: Core (carbon material)
2: Intermediate layer that could include Si element.
3: Outermost layer that could include transition metal oxides, transition metal nitrides and transition metal sulfides.

US9005812

Composite material *with a* ***core*** *comprising a* ***carbon material*** *and a plurality of* ***composite material*** *particles* ***attached*** *to a surface of the core. Each of this composite material particles contains a* ***1st material*** *(that could include* ***Si element****) and a* ***2nd material*** *(that could be transition metal oxides, transition metal nitrides and transition metal sulfides) coated on the 1st material.*

This material could provide improved cycling performance and chemical stability.



Note: The full-texts of patents mentioned in this slide are available in the Excel database provided with the present report

IP transfers & collaborations

QUARTER OVERVIEW

Main IP transfers (patent reassignment)

No significant IP transfer (patent reassignment) was identified this quarter.

QUARTER OVERVIEW

Main IP collaborations (patent co-filings)

Note: The full-texts of patents mentioned in this slide are available in the Excel database provided with the present report

Anode material | Anode | Battery cell | Others

WO2023/092096

Silicon-carbon composite *material comprising a* ***multimodal particle size distribution*** *and an* ***anode*** *incorporating this type of material. It could provide improved electrochemical properties.*

KR10-2023-0068666

A ***battery cell*** *that could have an anode with* ***silicon-based material*** *and a* ***liquid electrolyte*** *with a* ***specific additive combination****. This invention could have improved lifetime characteristics and fast-charging performance.*

CN115986061

A method of manufacturing an anode (that could include a silicon-based material) for a ***solid-state battery****. This invention could solve the problem of* ***volume expansion*** *inherent in* ***silicon-based*** *anodes.*

US litigations & European oppositions

QUARTER OVERVIEW

US litigations & European oppositions

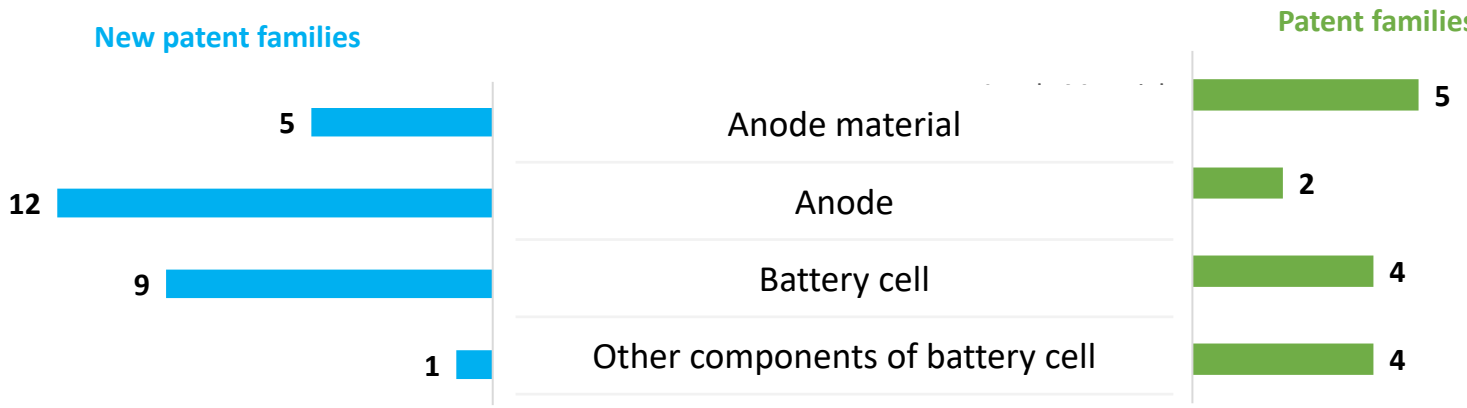
No US litigation or European opposition was opened or closed this quarter.

FOCUS ON KEY PLAYERS OF THE QUARTER

SAMSUNG

IP activity of the quarter

Samsung is a historical IP player in the patent landscape related to silicon anode-based Li-ion batteries. It filed patents on all value chain segments.



One patent family could belong to multiple segments

This quarter, **Samsung**'s patenting activity has focused on the **anode** segment. During this period, Samsung's new patent families focused on **silicon-based anode materials** are mainly related to :

- **Silicon-based composites** such as **silicon/carbon composite** (e.g. **porous silicon** and **amorphous carbon** (US20230197932) ; agglomerated product of Si-based materials with Si particles, a lithium silicate positioned on the surface of Si particles + Amorphous carbon surrounded the Si particles and lithium silicate (WO2023/074934); a composite containing SiO_x ($0<x\leq2.0$), silicon nanoparticles, and amorphous carbon (EP4174987)).

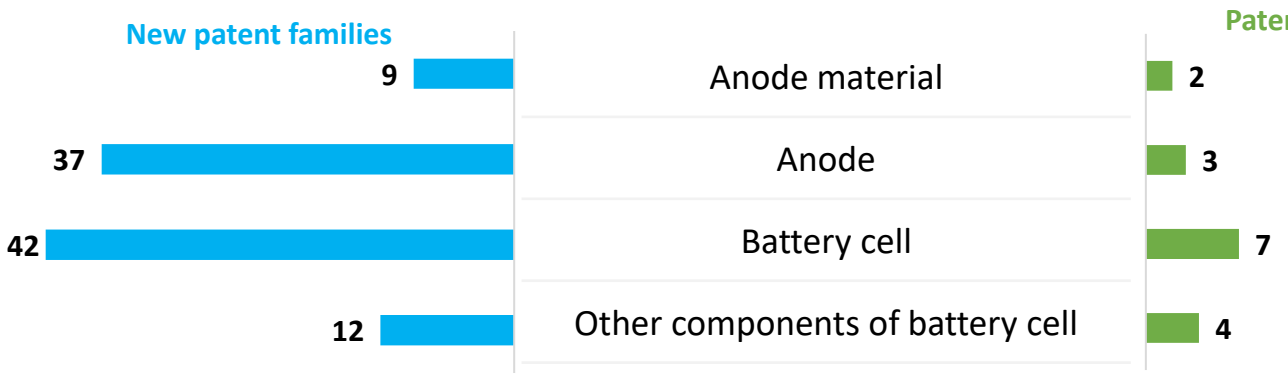
- **Core-shell** material: **silicon-based core** and a **shell** that could include a **metal oxide** and a **carbonaceous** material (CN116190588).

Note: All the anode materials patented by Samsung for this study are available in the Excel file accompanying this report.

LG CHEM/LG ENERGY SOLUTION

IP activity of the quarter

LG Energy Solution was spun out from **LG Chem** in December 2020. LG is a **historical IP player** in the patent landscape related to silicon anode-based Li-ion batteries.



This quarter, **LG Chem/LG Energy Solution**'s patenting activity has focused on the **battery cell** and the **anode** segments. During this period, **LG Chem/LG Energy Solution**'s new patent families focused on silicon-based anode materials are mainly related to :

- **Silicon-based composites**: Si grafted with a sulfonic acid group (KR10-2023-0081674), Si-based core and carbon nanotubes (CNTs) positioned on a surface of the Si-based particles (KR10-2023-0068328), etc.

- **Doped silicon-based particles** (boron and phosphorus distributed in the silicon-based particles) – (WO2023/090911).

Note: All the anode materials patented by LG Chem/LG Energy Solution for this study are available in the Excel file accompanying this report.

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