Who is KRI?

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KRI
Your Innovation Partner

Establishment: February 20, 1987

KRI was founded on a 100% investment from Osaka Gas Co., Ltd.
modeled after SRI in USA. Osaka Gas still have 100% share.

Location: Kyoto (Head-quarter, Labs) and Osaka (Branch, Labs) in Japan

Sales: $ 30M (FY2023)

Almost all income are contracted project fees from private companies.
No governmental subsidy.

Employees: 180

Business field: Contract Research and Development
Scientific analysis, testing and evaluation
Technology survey and consulting

Osaka Gas (Daigas Group)

★ Second largest city gas utility (7M customers) in Japan,
within ten largest gas utilities in the world.
★ Group: 140 companies, Employees: 20,000 (consolidated)
★ The most aggressive gas utility company for R&D all over the world.

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We solve your technical issue/challenges together

Research & Development/Evaluation/Analysis /Investigation

If you have any technical problems, please contact us first.

Let's think together and find a solution.

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What can KRI provide?

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KRI is not a consulting firm, nor an analysis & testing center, but a contract research company which provides not only proposal of solution to clients' technological issue but also executing its experimental verification to move clients' R&D forward.

You can outsource R&D under the same conditions as in-house R&D

Outcomes belong to clients

All outcomes/inventions obtained by contract research belong to clients, in principle.

Strict Confidentiality

Confidentiality of information is strictly maintained before, midst and after the completion of the contract research project including information disclosed by clients.

We propose and verify accurate solutions to client's technological issue

Highly experienced researchers

Researchers with various background and experience to solve technological issues during industrial R&D day by day mainly on chemical field propose, experiment and verify the solution optimal to the client goal.

Full complement of research equipment/facility

We install a full complement of experimental equipment including preparation, analysis and evaluation and can execute various experiment and verification corresponding to the purpose of clients. We also have partners to support us with further experimental facility , if necessary.

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Secondary battery field of KRI

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Energy Conversion Research Laboratory since 1998

Advanced Battery and Capacitor Laboratory

Solving research and development problems related to materials and electrodes within 5 years.

Main research themes	Composite materials, technologies to **reduce resistance**, pre-doping technology, capacitor-related development, **electrode formation technology**, development of **tip evaluation** methods
Main clients	Material developers, trading companies and public research institutes

Evaluation of the potential of your own products as a material in a battery — Materials

Performance improvement of batteries — Battery Design

Battery System Laboratory

Supporting device development through the study of device principles as well as formulation and verification of hypotheses

Main research themes	Development of new devices (including design and prototyping), safety element technology development, **device design and prototyping**, development of **life analysis methods**, development of methods for evaluating tip safety, assistance with **module and system development**
Main clients	Device developers, system developers

Life Prediction — SOH diagnosis, LIFE estimation

Safety — SAFETY

Modules/packs — BMS

Next-generation Batteries Research Laboratory since 2016

Achieving practical use of next-generation materials and batteries in compliance with the principles based on material technologies such as quantum and solid state chemistry

Main research themes	**Research on next-generation active materials**, **solid electrolytes**, molten salts, development of technologies beyond LIB

Material Informatics / AI

Solid electrolyte battery

We discuss the possibilities of next-generation materials and pursue the feasibility of their creation at our clients' side.

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KRI's One-Stop Service for Battery Technologies

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Coherent development structure capable of R&D, evaluation and analyses of technologies ranging widely from materials to systems – including next-generation technologies

Investigation of technological trends → Development of materials → Process design and development of electrodes → Development of devices → Design and development of batteries and capacitors → Design and development of module systems

Investigation of technological trends
Evaluation of novelty

Structure, deterioration and tip analyses

Basic characteristic evaluations, input and output characteristic evaluations, reliability evaluations, life prediction analyses, and safety evaluation analyses

Support in design and development

Material field

Advanced technology research dept.

Material design & application research lab.

Intelligence & energy materials lab.

New functional materials research lab.

Advanced battery & capacitor lab.

Next-generation batteries lab.

Energy field

Energy conversion research lab.

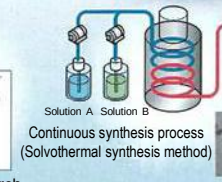
Battery evaluation & analysis Lab.

Analysis and solution fields

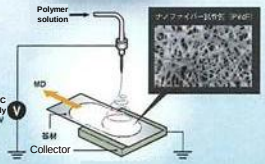
Analysis research center

Micro & nano structure analysis lab.

Prior art research (patents and literature)



Continuous synthesis process (Solvothermal synthesis method)

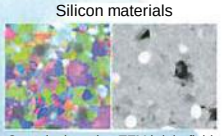


Nanofiber synthesis (electrospinning method)

Design and experimental production of medium- and large-size batteries (Note-shaped LIB)

Development of safety evaluation technology (New forced internal short-circuit)

How long will this battery work when used in this way under this environment?

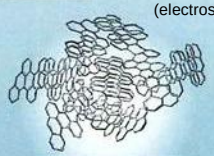


Silicon materials

Crystal orientation mapping
TEM bright-field image

Cutting-edge analysis and analysis technology (TEM precession crystal orientation mapping)

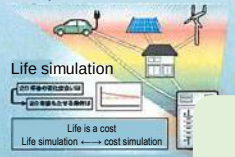
Design and syntheses of next-generation battery materials (positive and negative electrode materials and electrolyte solution)



Next-generation negative electrode material (Polyacene series material)

Design and experimental production of electrodes (Continuous electrode coating device)

Battery material evaluation technologies (materials and components)



Life and cost analysis technology (On-site life prediction)

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Collaboration with KRI: accelerate R&D, new ideas, solve problems

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Evaluation of the potential of your own products as a material in a battery

Positioning

- Fabricate battery that incorporates your own products
- Extract issue or characteristics of your own products
- Clarify positioning of your own products for the industry, draw up the effective sales data

Performance improvement of batteries

Development

- Improve electrode output etc., capacity, rapid charge, life, safety, cost
- Improvement guidelines by separation of resistance components, analysis, deterioration analysis etc.
- Prototype battery

New battery materials and components development (advanced, next-generation, all-solid-state)

All solid state battery

- Apply to all-solid-state batteries / to prototype all-solid-state batteries
- Search new battery material by Materials Informatics
- Develop new battery components (electrode, electrolyte, separator etc.)

Storage system best suited for your application

System development

- Design outline of the system according to usage conditions, select a suitable battery
- Design module considering durability, safety, cost and prototype/evaluate storage system

Accurate evaluation on durability, reliability and safety

Life prediction

- Evaluate and predict durability under actual use conditions
- Know the mechanism and make it a development guideline
- Evaluate the safety to the world standard and directly connected to the phenomenon

Opinions from experts because you have problems with batteries

Opinions from experts

- Hear opinions because you have trouble with product problems in market
- Hear opinions because development guidelines are not clear, eventually from third parties

Receive support because development does not progress with just your own resources

- Compensate for unavailable resources: staff, technology accumulation, equipment

Trend of the secondary battery industry

- Know the trend of the world secondary battery market / battery maker
- Know the latest technology development trends

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Establishment of Battery Ecosystem

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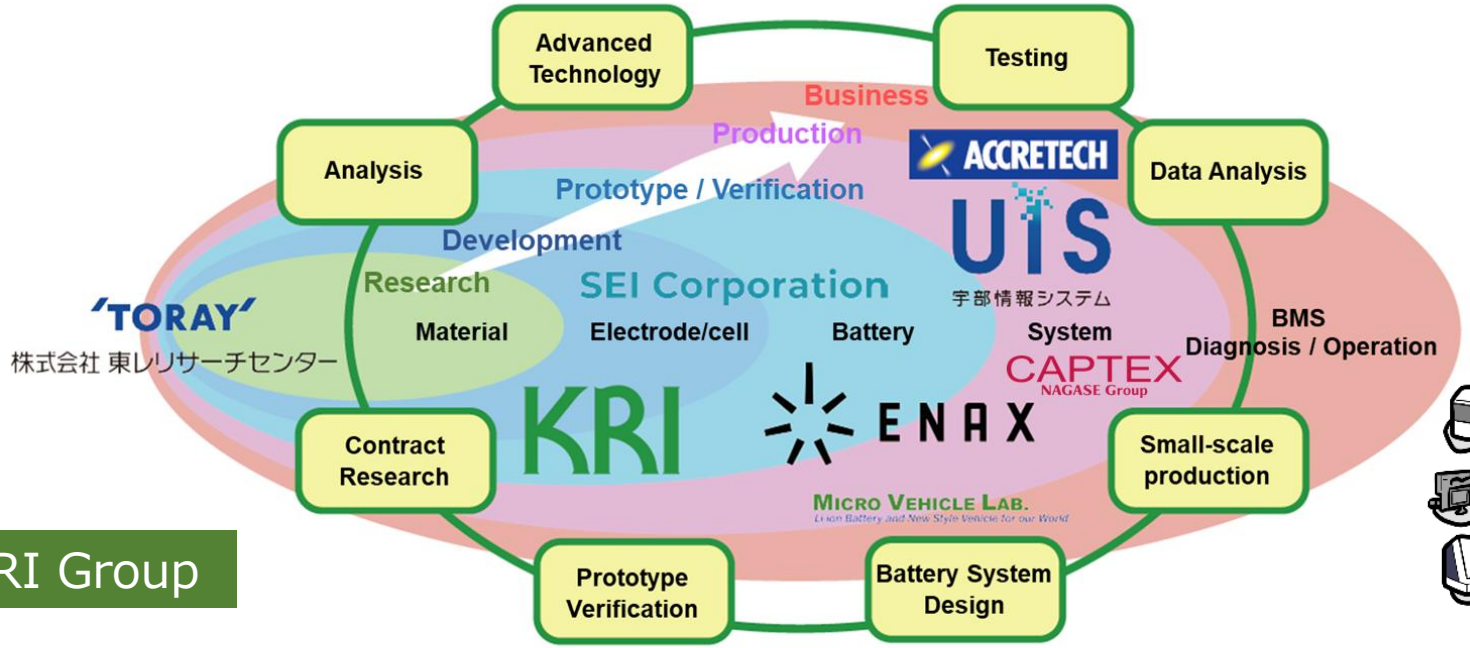
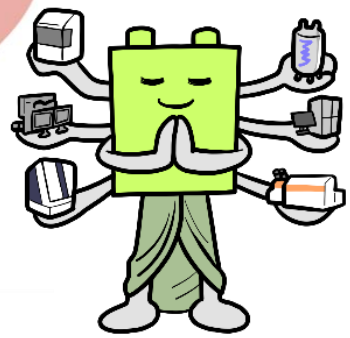
KRI selected to collaborates with companies and research institutions rather than competing in the fields of technology development, advanced analysis/analysis, prototype demonstration, small-volume production, data analysis, product implementation, and measurement.

Therefore, KRI has built a “Battery Ecosystem" that provides all the resources necessary from research and development to commercialization.





KRI Group

SEI Corporation | Battery Speciality Company

ENAX, Inc. - Making the World Sustainable with Batteries

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Secondary battery field : Past Record and Trends

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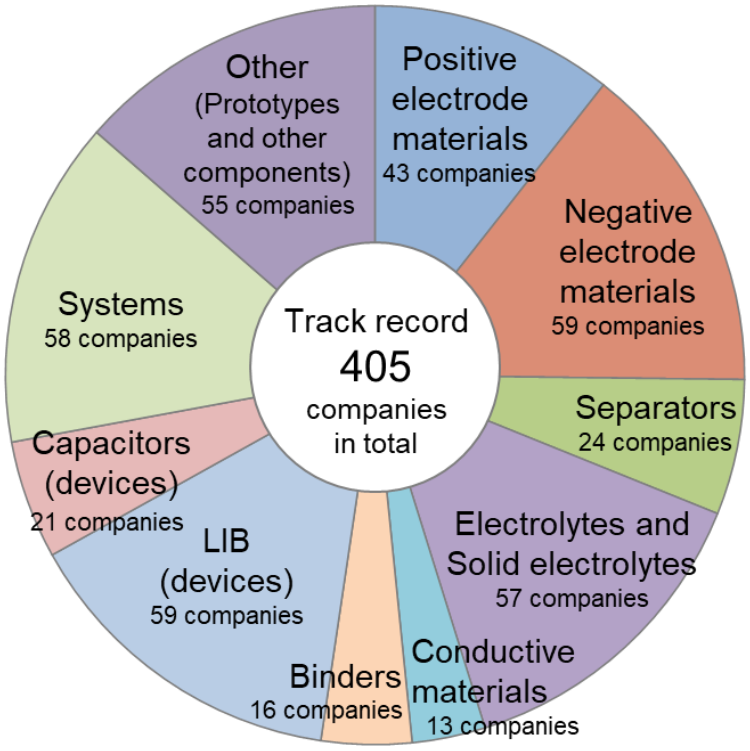
Research and development services
based on lithium-ion battery and capacitor technology

Over 25 years of accumulated experience and know-how
Approximately 1,000 research and development projects

Safety & Life
BMS



Orders for evaluations in different categories are counted individually.

Materials
Battery Design

KRI supports many companies in Japan, the US and Europe.

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Categories of Contract Research and Development in Secondary Battery Field

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We consider clients' development and support needs from every angle to propose the most appropriate projects

Contract research and development

KRI makes proposals to solve clients' problems

Investigation into and deliberation on commercialization

Experimental production of electrodes and devices

Customized experimental production according to the clients' development objectives

Contract evaluation and analyses

Clarification of features and challenges
Positioning in the market
Third party evaluation

Source: Shizukuni Yata, "Practical Evaluation Technologies for Li-ion Batteries and Capacitors," Technical Information Institute, September 2006

Contract evaluation research

Degree of freedom of evaluation
Development support with close cooperation with clients
Marketing assistance

- **Contract research category: to meet clients' needs for new technologies that clients cannot achieve by themselves ⇒ new technological development**
- **Prototyping category: to meet clients' needs for commoditizing their own technologies as electrodes or batteries ⇒ high level prototyping**
- **Evaluation and analysis category: to meet clients' needs for clarifying the characteristics of and problems with their own technologies ⇒ support for matching their technologies to market trends and market research**
- **Evaluation research category: to meet clients' needs for researchers with consulting ability in evaluation in their own development**

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Collaboration with KRI: Confidentiality and IPRs

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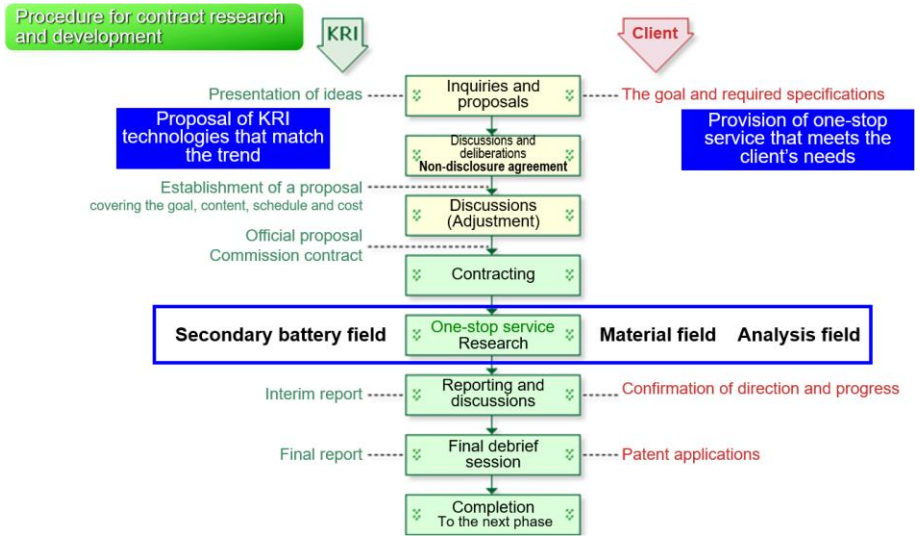
Outline and Flow of Contract Research

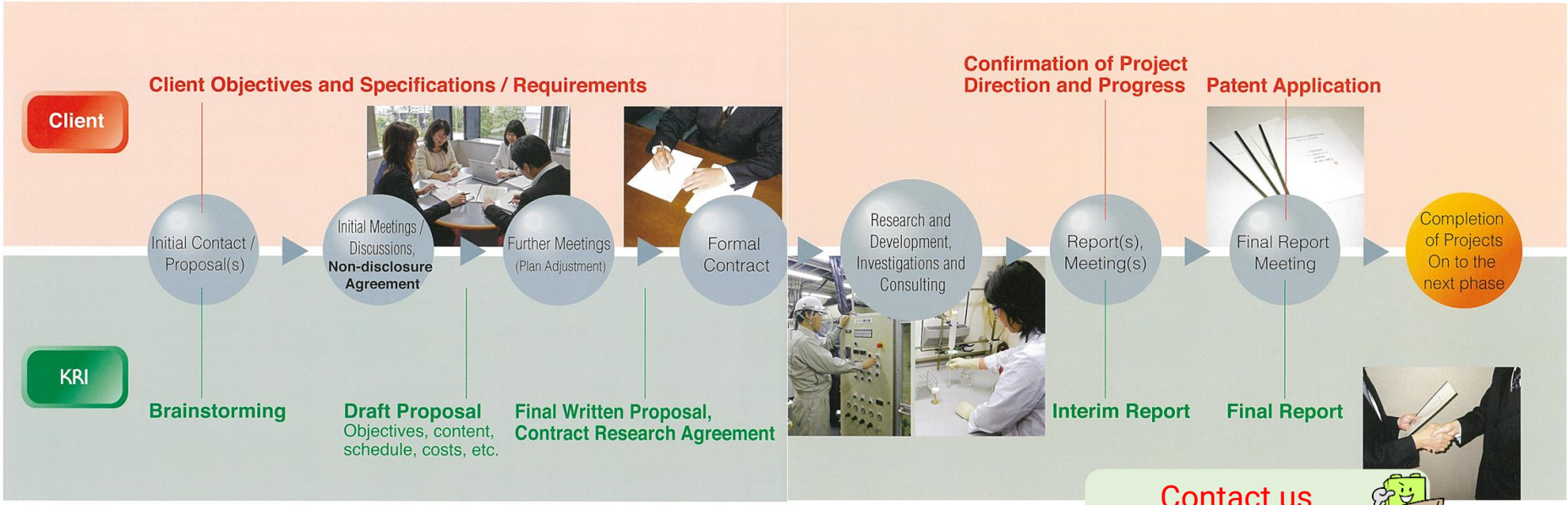


[Non-disclosure policy:](#)

All information disclosed by clients is kept strictly confidential.

[Results of projects:](#)

Unless agreed otherwise, results from work performed under consulting and research contracts belong to the respective client(s).



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Support for Technological Trends Investigation and Commercialization

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Clarification of the developmental directions of technologies related to next-generation electrical energy storage by utilizing the expertise of researchers who have abundant experience in battery and capacitor development

Support scheme for research and development and business development on the basis of the investigation into technological trends

Clients' needs and problems

Expertise of researchers	Several analyses conducted by researchers
● Abundant research experience ● Connoisseur of technologies ● Know-how on electrical energy storage ● Networks, etc.	● Patents and literature investigation and analyses ● Market trend investigation ● Interviews with intellectuals

High added value that only KRI can realize

Clarification of the approaches to issues and methods for solving them with added value such as business plans of developed technologies

Proposals for concrete methods (proposals for contract research)

Material development | Design and development of batteries | Evaluation of batteries | Experimental production of devices | Design and development of systems

Analyses and evaluation of batteries | Evaluation of entries in patent applications | Verification of new methods and ideas | Identification of potential issues for higher added value

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- Trends investigation of next-generation secondary batteries
- Investigation into the development trends overseas secondary battery technologies
- Feasibility study on next-generation technologies for secondary batteries
- Battery performance analyses using disclosed information:
- Investigation into patents and literature about battery systems and components (separators, negative and positive electrodes, etc.)
- Investigation into market trends and needs related to secondary batteries
- Support for the research and development and business development of next-generation secondary batteries
- Consultation on secondary battery technologies, etc.

Evaluation and Analyses Associated with Electrical Energy Storage Devices

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Evaluation is the compass of technology. Why not discuss the directions of technological development and possible markets for your technologies with us?

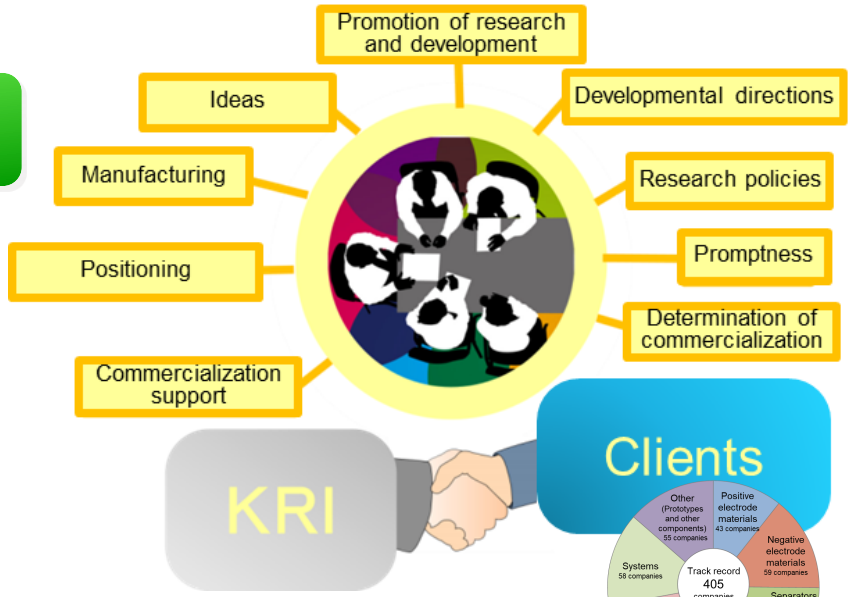
KRI's evaluation is not simple routine work starting with the prototyping of electrodes followed by the prototyping of batteries and ending with data acquisition and provision.

Although planning and manufacturing are important factors in the research and development of a device, having quick and appropriate evaluation technology and know-how is considered to be the more important factor that determines whether a device will be able to survive in what is expected to be an intense research and development race. *

* Shizukuni Yata, "Practical Evaluation Technologies for Li-ion Batteries and Capacitors," Technical Information Institute, September 2006

Features of KRI's evaluation and analyses associated with electrical energy storage devices

- Clarification of the features and challenges with materials and devices, understanding of their positions in the markets, and developmental directions of the technologies
- Discussions with clients about the materials and devices from the viewpoints of an evaluator and analyzer
- Abundant past records of evaluations and analyses of materials, components and devices for batteries and capacitors.



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Outline of KRI's Evaluation Associated with Electrical Energy Storage Devices

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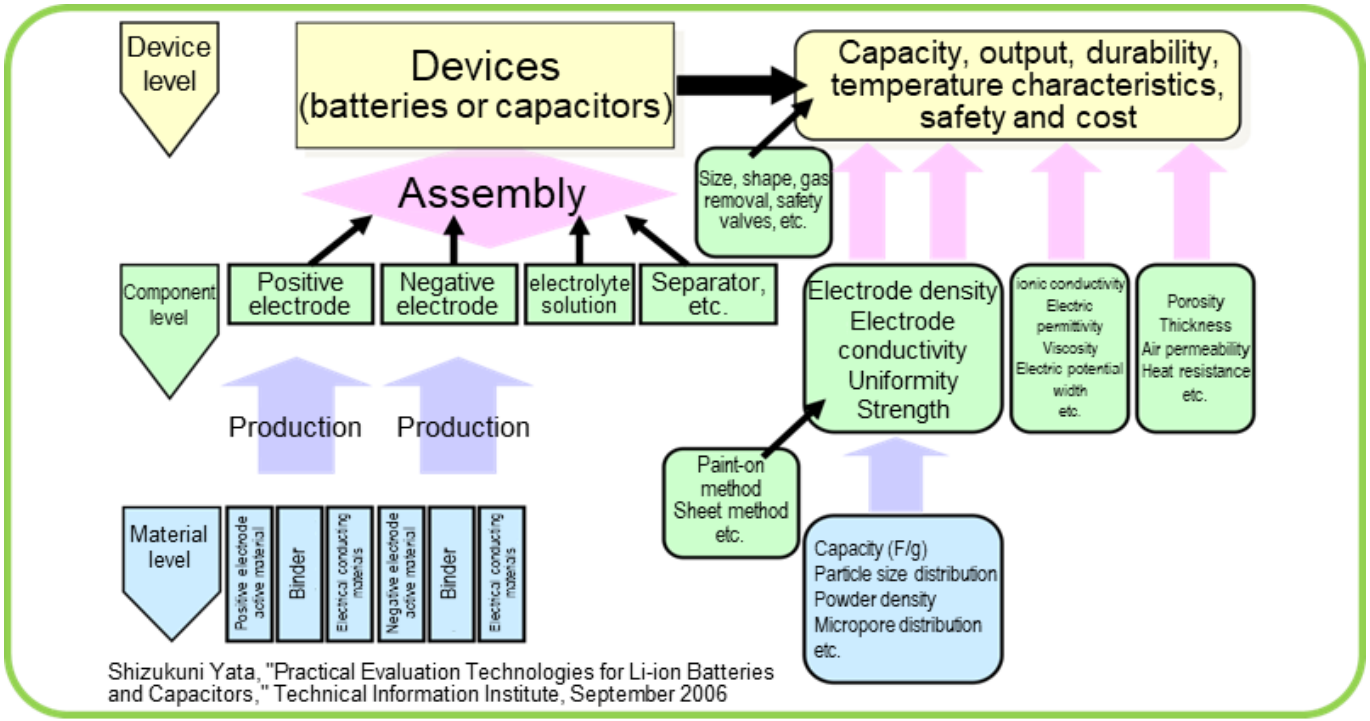
For battery-related evaluations, it is important to comprehensively analyze each level of evaluation data.

✓What characteristics do the materials used for the devices need to have?
✓ What are the key points in electrode development that would enable us to take advantage of the material's characteristics?
✓ What are the material and electrode factors that determine device characteristics?



The characteristics of electrical energy storage devices result from a complex and multilayered relationship among the component level characteristics of electrodes, electrolyte solution and separators as well as the material level physicality of the materials used as positive and negative electrodes. We clarify the problems specific to the electrical energy storage devices after comprehensively analyzing and understanding the complex and multilayered relationships by utilizing KRI's accumulated know-how.

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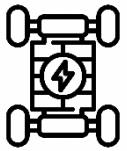
Our 30 Years of Battery's R&D Insights help your innovation

New Product, R&D support, Prototyping, Benchmarking, System design, BMS, Life Safety

Material Testing & Material development
Applying AI and technology in material analysis and testing

Cell Assembly & Testing support
Cell assembly & testing - For different applications including EV , ESS & CS

Battery Testing, R&D
Research and development evaluation and analysis on battery and capacitors



Battery material solutions (R&D and production)
Battery failure analysis and solutions,
new companies can expedite their establishment process

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Advanced Battery and Capacitor Laboratory
Holding Technologies and Facilities

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- Support for problem-solving research and development of materials, components and electrodes of secondary batteries (LIB, etc.) and capacitors
  Supporting solutions of development problems that clients cannot solve by themselves.
- Developmental support through evaluation research
  Supporting clients' development from the standpoint of evaluators, provision of directional guidelines for technological development and marketing support.
- Contract evaluation and analyses of materials and components for batteries and capacitors
  Clarifications of challenges and futures as well as identification of positioning in the market
- We own all types of facilities necessary to develop the materials and components associated with electrical energy storage devices.

☞ Please consult us for a tour of these facilities.

- Synthesis furnaces of several types of atmospheres and CHNSO microelement analysis device
- Pulverization, classification and particle distribution measuring devices
- Pore distribution measuring and analyzing device: QSDFT method analysis
- Planetary mixer, rotation and revolution type mixing and deforming device, nano disperser, etc.
- Thin film revolution type high-speed mixer and roll kneader
- Continuous electrode coating device and (cold and hot) rolling press machines
- Ar atmosphere dry box capable of vacuum drying process at 600℃
- Dry room Ⅱ for prototyping and analyses of electrodes at low dew points
- High speed data logging charge-discharge test machine
- High precision charge-discharge test system for "current-rest-method" and deterioration analysis
- XPS (non-exposure), XPD, (In-situ) EF-SEM (non-exposure), IR (non-exposure), AFM, DSC, 3-D thermal diffusion coefficient, etc.




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Facilities (Kyoto)

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➢ We own many types of facilities

☞ Please consult us for a tour of these facilities.

- Synthesis furnaces of several types (Max1700℃)
- CHNSO microelement analysis device
- Pulverization, classification and particle distribution measuring devices
- Pore distribution measuring and analyzing device: QSDFT method analysis (N2, Co2, O2)
- Planetary mixer, rotation and revolution type mixing and deforming device, nano disperser, etc.
- Thin film revolution type high-speed mixer and roll kneader
- Continuous electrode coating device and (cold and hot) rolling press machines
- Ar atmosphere dry box capable of vacuum drying process
- Dry room Ⅱ for prototyping and analyses of electrodes at low dew points
- High speed data logging charge-discharge test machine
- High precision charge-discharge test system for "current-rest-method" and deterioration analysis
- XPS (non-exposure), XPD, (In-situ) FE-SEM (non-exposure), IR (non-exposure), AFM, DSC, 3-D thermal diffusion coefficient, etc.

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Battery System Laboratory
Holding Technologies and Facilities

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- Structural design of medium and large-size lithium ion batteries and research and development of processes
- Prototyping of electrodes, devices and systems
- Life evaluation and analyses of electrical energy storage devices (algorithm for analyzing
- Safety evaluation and analyses as well as safety mechanism analyses of lithium ion
- Technological support for development of battery modules, packs and systems (system design support, utilization of base battery technologies and evaluation support)

- We own all types of facilities necessary to develop the materials and components associated with electrical energy storage.
  ☞ Please consult us for a tour of these facilities.

- Prototyping facilities for small, medium and large-size batteries (for cylindrical, laminated and hard case types)・・・**SEI**
- Ultrasonic and resistance welders
- Vacuum immersion device
- Dry room, Ar atmosphere dry box (prototyping of batteries and dismantling of medium and large-size batteries)
- Charge-discharge test system: 5 to 72 V/μA to 400 A maximum
- Module charge-discharge test building (Osaka)
- Several constant temperature tanks: from −40 to 100°C, anti-explosion type
- Small-size battery safety evaluation and analysis device (Kyoto)
- Medium and large-size battery safety evaluation and analysis device(Osaka)

SEI







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Facilities (Osaka)

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KRI's New Safety Test Facilities: Large cell, Module, ASSB, etc.

Completion: August 2024

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When to use KRI

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When you face some technical issue, try KRI.

- **You lack the in-house experts and equipment to solve technical issues.**
  KRI's expert researchers find out the essential issue using their specialty background through hearing, and propose its solution and verification approach thereof. You can utilize KRI's researchers and facilities temporally as if you conduct in-house without arranging researchers and equipment.
- **You cannot find a way to resolve technical troubles.**
  Many contract researches are aimed to resolve technical troubles during not only R&D but production and commercial services. Therefore, KRI's researchers experienced much cases. Even when you face unexperienced troubles and have no idea how to deal them, you can find an appropriate way to resolve them by KRI's trouble shouting know-how and accurate analysis.
- **You need to find a breakthrough for in-house R&D.**
  In KRI, researchers of various technical fields are ordinarily searching and generating new ideas. You can find a breakthrough for in-house R&D by discussing with KRI's researchers.
- **You want to start research right away and you want results fast.**
  KRI retains experienced researchers and facilities, and so proposes an appropriate plan immediately and readily executes experiments to provide accurate results soon. You can shorten your in-house R&D period cost-effectively, even when your research resources are fully occupied.
- **You find risks are too high to invest a large cost without reliable data.**
  Since the cost of KRI's contract research is based on sold time (occupied time) of researchers and facilities, you can try a high risk R&D project at a limited cost. Most clients divide R&D project into several phases, and contract and execute the R&D project step by step for cost-effective risk-taking.

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Roadmap for the development of next generation LIBs

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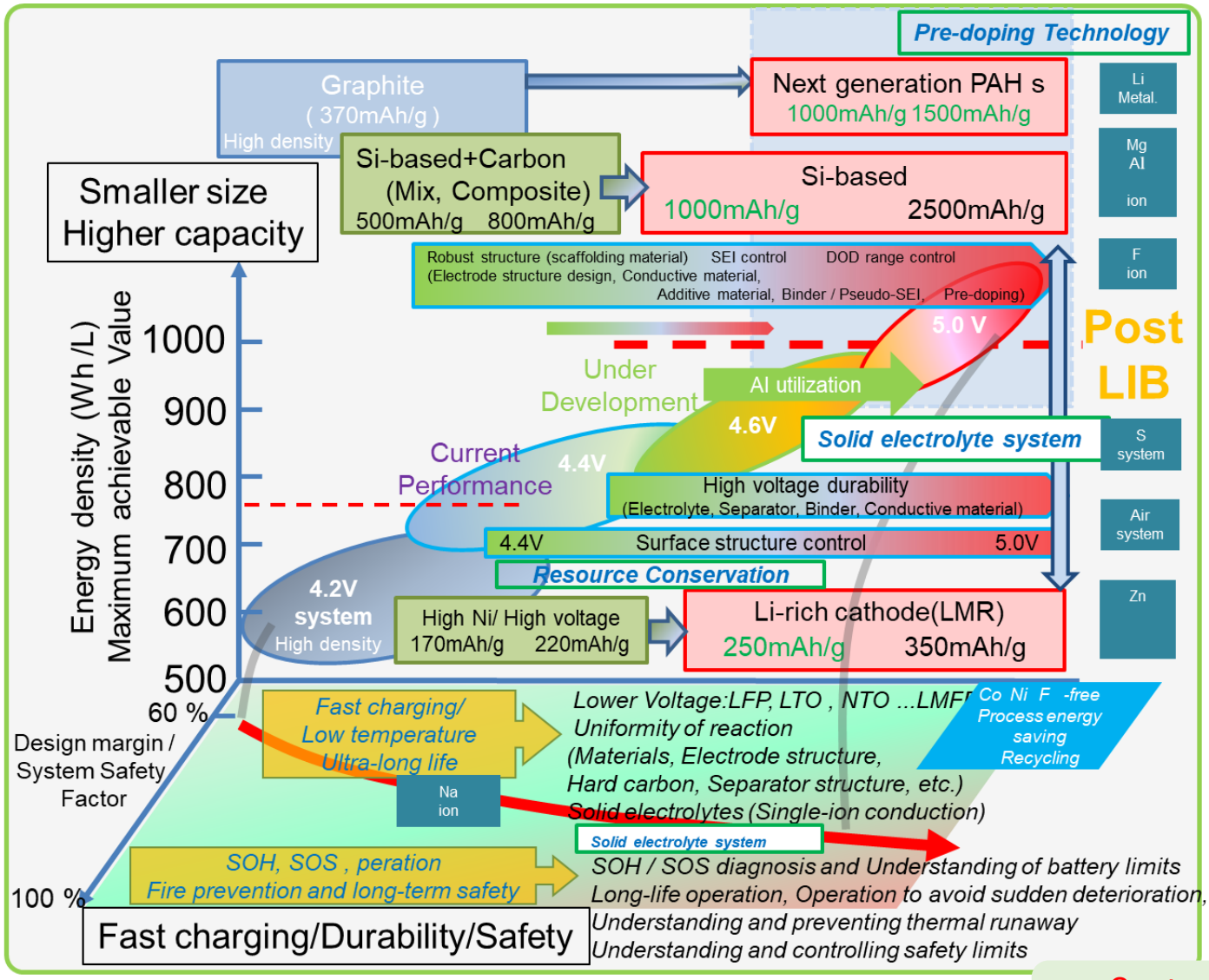
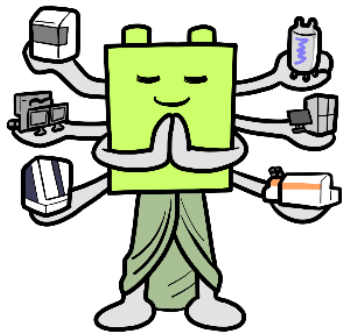
Development Roadmap (KRI 2025 Edition)





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Life Estimation

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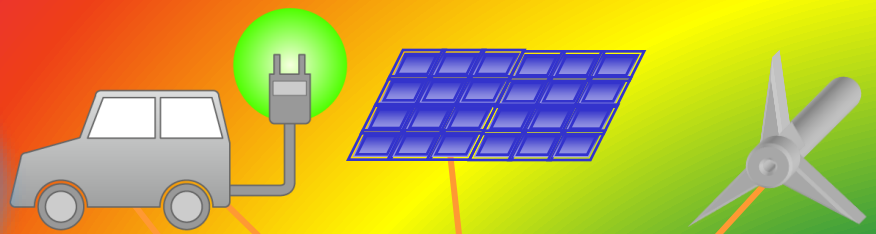
Required life of small batteries used in small devices: 3 to 5 years ⇒ Required life of large batteries used in mobile and stationary bodies: 10 to 20 years

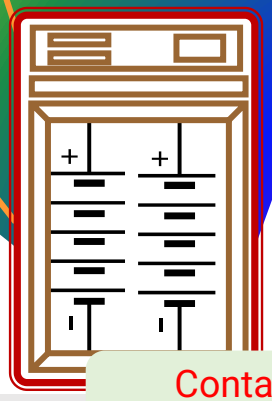
On-site life: How long will this battery work when used in this way under this environment?

Life
simulation



What will the degree of deterioration be 20 years from now?

What conditions would enable the battery to work for 20 years?



Secondary battery

Life is cost.
Life simulation ⇔ Cost simulation

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Safety Evaluation and Analysis Technologies for Electrical Energy Storage Devices

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KRI has been helping to analyze and resolve lithium-ion battery safety issues for over 25 years.

Repeated ignition events!!, Modularized cells ignite even though they do not ignite individually

Is it enough to repeatedly test whether or not cells ignite?

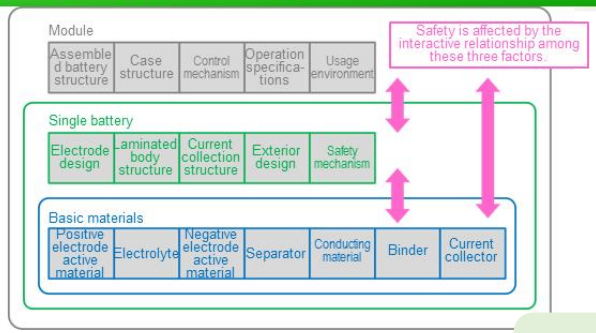
Causal analyses
Verification of hypotheses
Improved design

Generation of hypotheses for possible causes based on causal analysis (data analysis, dismantling investigation, chemical analysis, FTA analysis, etc.)

Verifications of hypotheses through model tests and small scale cell tests (under special conditions)

Problem solving by feedback of the verification results to design

Battery design: capacity and energy density
Battery shape: materials, strength and heat radiation properties
Cell structure: lamination or coils, current collection and safety mechanism
Electrode design: weight per area, specific heat and volume of electrolyte solution (porosity)
Separator: thermal physicality, strength and dendrite inhibition
Active material: thermal characteristics, conductivity and surface treatment



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Development Support through Analysis for Electrical Energy Storage Devices

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Provision of accurate analysis results using data analyzed from different angles

Full range of sophisticated and speedy support of battery-related development in collaboration with analysis, material and battery engineers

Proposal for appropriate analysis methods according to analysis objectives

We can propose appropriate analysis methods depending on the objectives of example solutions of development problems or product troubles.

[Image of our proposals for analysis]

	Analyses of detail structures of positive and negative electrodes	Analyses of chemical structures of electrolytes	Analyses of the states of interfaces between electrode materials and electrolytes	Analysis of constituent material deterioration
Analysis objective	High potential and high capacity material development, high input and output material development	Improvement in input, output and durability	Improvement in efficiency, input and output (Side reaction inhibition and interface resistance reduction)	Improvement in life and safety
Item to be analyzed	Clarification of the effects of shapes, ultrastructure and interface structure on electrode characteristics (potential and capacity)	Clarification of the effects of complex structure, binding strength between Li^+ and counter ion on Li-ion conductivity and transference number.	Clarification of the relationship of the interface states with lithium ion insertion or desorption reaction Clarification of the effects of SEI formation state	Chemical alteration of constituent materials such as positive and negative electrodes and electrolytes Relationship between material quality changes and battery life Analysis of deterioration mechanisms Dismantling and deterioration analysis of large batteries
Analysis method	XRD, Raman SEM, TEM (Precession, 3D) TEM-EDX, FE-EPMA (Mapping) DSC/TG-DTA $^{7}Li/^{13}C/^{29}Si$-NMR, ESR, XAFS	$^{7}Li/^{13}C$-NMR (Li-ion diffusion speed) ^{1}H-DOSY-NMR (coordination structure and temperature change) IR/NIR, Raman (Mapping) UV-vis-NIR, XAFS, Terahertz spectroscopy	XPS, AES, TOF-SIMS AFM Terahertz spectroscopy	In-site XRD, Raman XPS, AES, TOF-SIMS SEM, TEM TEM-EDX, FE-EPMA TG-GC/MS, DSC/TG-DTA $^{7}Li/^{13}C/^{29}Si$-NMR
Analysis device	 FE-EPMA (Chemical state mapping)	 TEM Precession (Crystal orientation mapping)	 XPD (Powder, thin film, In-situ)	 NMR (Multiple nucleus, low temp	 Raman

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Surface Analyses of Secondary Battery Materials (XPS, FT-IR, SEM: Non-exposure)

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Surface analysis technology is a key factor for future battery material development

Our researchers who have expertise in battery and materials and abundant experience in contract research will support the analyses of the changes in surfaces and interfaces of battery constituent materials.

—Comprehensive support for problem solving—

Analyses of material surfaces (XPS)

- We analyze the elemental composition of the surface layer to a few nanometers in depth, the binding (oxidation) state, and the film formation state mainly with XPS and with the materials unexposed to atmosphere. (Improved accuracy is available by combining TOF-SIMS or FT-IR analyses.)
- We clarify state changes including chemical reactions on the surfaces and interfaces of constituent materials from the viewpoint of material chemistry in addition to charge-discharge profiles and electrochemical analysis data.

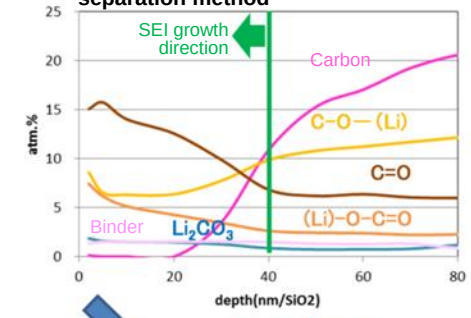
■ Features of our surface analysis technology

⊙Sampling without exposing materials to atmosphere
⊙ Capable of obtaining SEI film thickness and composition information (Depth profile analysis)
⊙ Capable of obtaining information on the surface structure of electrodes

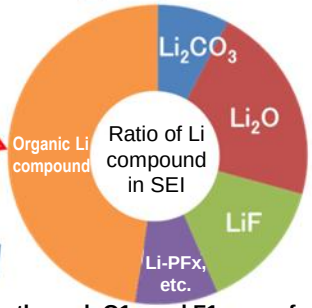
● Comprehensive analyses by analysis and battery engineers

- Comprehensive analyses of information on the changes in material and electrode structures as well as electrochemical characteristics
- Examination of how to solve problems on the basis of estimated deterioration mechanisms
- Advanced battery evaluation and analyses such as capacity and resistance behavior analyses
- Discussions on material surfaces that improve battery life and safety

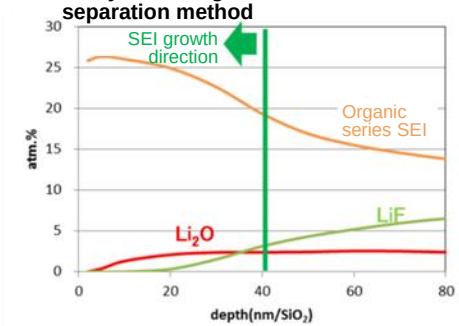
Analysis through C1s waveform separation method



Combined analyses including:
IR
Raman
NMR
TOF-SIMS
TEM



Analysis through O1s and F1s waveform separation method



Example of negative electrode SEI component separation of KRI standard NMC/Black lead series cell (after 250 cycles at 50°C)

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Examples of Material Analyses Associated with Electrical Energy Storage Devices

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Performance development and mechanism analyses of electrical energy storage devices

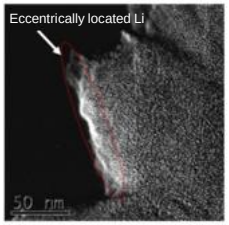
Clarification of structural characteristics affecting charge-discharge characteristics and causing deterioration by utilizing original analysis technologies

Analysis of charge-discharge mechanism of carbon negative electrodes

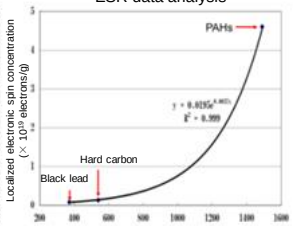
Multidirectional analysis and evaluation using various analysis methods

- RAMAN, TEM and ESR

Mapping of Li in negative electrode by TEM-EELS



Correlation between Li doping amount and spin concentration obtained from ESR data analysis

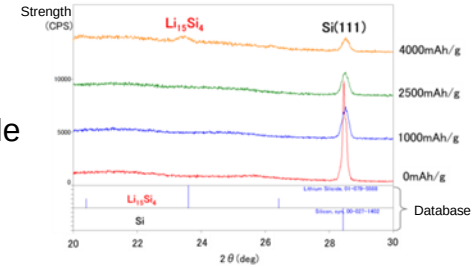


Analysis of deterioration mechanism of Si negative electrodes

Structural analysis with a multi-functional X-ray diffractometer

- Capable of tracking structural changes at variable temperature settings
- Capable of atmospheric control

Li insertion into Si negative electrode by charging



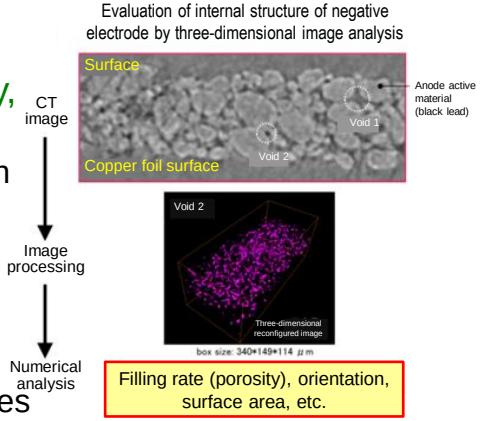
In-situ XRD spectrum of Si negative electrode being charged

Numerical analysis of three-dimensional structure of electrodes and separators

X-ray computed tomography method, electron beam tomography, image analysis

- Quantitative determination of filling rates and porosities of electrodes and separators
- Numerical conversion of particle diameters and diffusion states of structural component particles

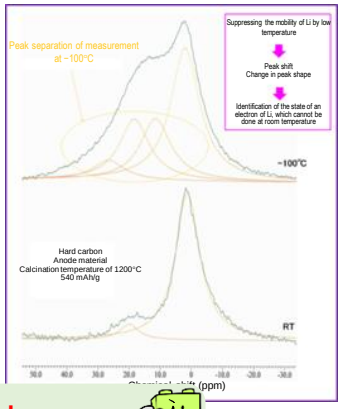
Evaluation of internal structure of negative electrode by three-dimensional image analysis



State analysis of secondary battery materials with NMR

State analyses of ions by NMR

- Analyses of Li insertion states by solid NMR low temperature measurement
- Analyses of electrolytes by molecular diffusion measurement



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Support for Safety Development of Batteries

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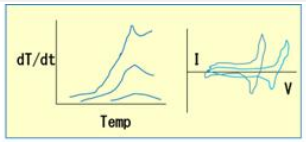
Causal analyses of hazardous events and proposals to improve safety

Development of safety: Evaluation and analyses of degree of influence of each step

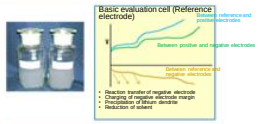
- Step 1: Effects of materials

Material physicality
Equipment analyses
Electrochemical evaluation

Thermal behavior (exothermic temperature, impetus, calorific value)
Redox properties (reaction voltage and current)



Influence rates of respective events → Improved measures Condition changes

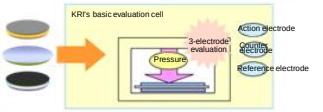


- Step 2: Examination of the effects of electrode design

Active materials and their compositions

Overcharge of basic evaluation cell
Voltage behavior at positive and negative electrodes

Oxidation side voltage behavior
Negative electrode side reaction step



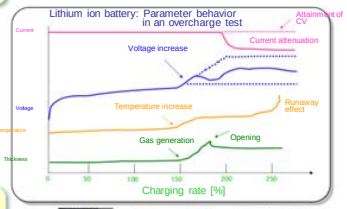
- Step 3: Examination of the effects of battery basic design

Separators, electrolyte solution, additives, etc.

Influence rates of each event → Improved measures Condition changes

Evaluation of material structure system
Characteristics of each abnormality mode
State analyses by dismantlement
Estimation of the effects on actual battery capacity

Parameter behavior (voltage, current, temperature, gas)
Internal state

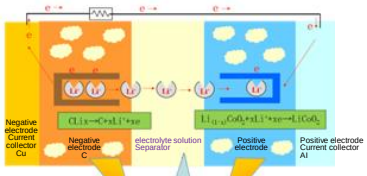


- Step 4: Evaluation and analyses of actual capacity cells

Influence rates of respective events → Improved measures Condition changes

Evaluation and analyses of battery safety
Electrode design: effects of weight per area, porosity and conductivity
Electrode body: effects of lamination, coils and WDH ratio
Constituent components: effects of separators and electrolytes
Exterior design: effects of cylindrical shape, square shape and lamination
Safety mechanism: effects of safety valves and CID effects.

Specific heat, thermal distribution, volume of electrolyte solution
Thermal dispersion, gas passage, heat storage property
Heat resistance, shut-down, flame resistance
Gas generation deformation, restraint, heat radiation property
Control condition, opening pressure, discharge rate

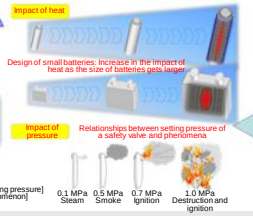


Electrolyte solution
Class 4 hazardous material
Class II petroleum

- Deliberation of the effects of increased size

Study on the effects of increased size through original model tests
Study on the effects of heat radiation and pressure

Improved measures Condition changes



Burning ignition

- Deliberation of the effects of modularization

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