

Commercial Power and Energy Technologies approaches to Submarines

Defense & Electronic Systems Div.
Toshiba Infrastructure Systems & Solutions Corporation

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& Solutions Corporation
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01

Toshiba Infrastructure Systems & Solutions Corporation Company Overview

Position of (TISS) in Toshiba group

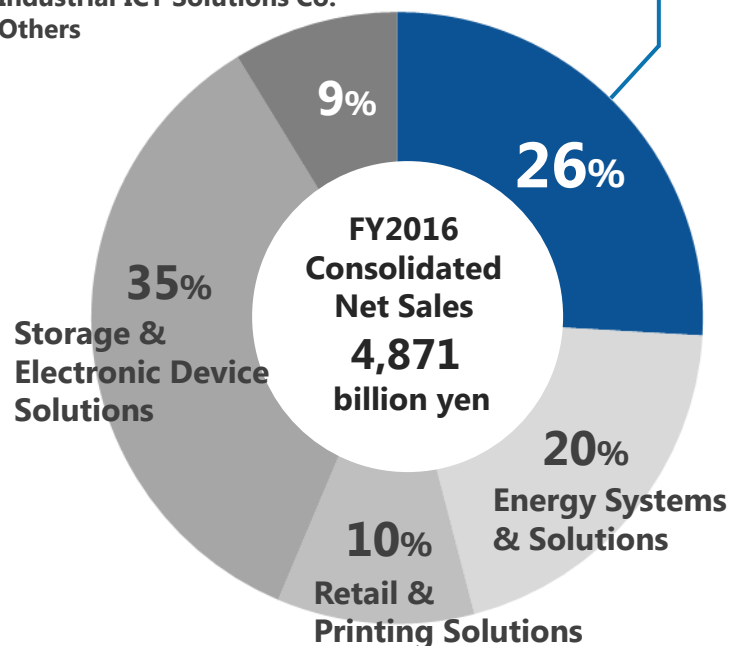
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Responsible for infrastructure business that sustains quality lives

Infrastructure Systems & Solutions Corporation (TISS)

FY2016 consolidated
Net Sales **1,262**
Billion yen

Industrial ICT Solutions Co.
Others



Provide Numbers of Specific Important Customers with the best solutions in three business areas

Public Infrastructure



- Central government
- Roads
- Communications

- Municipalities
- Broadcasting
- Finance

Buildings & Facilities



- Developers
- General contractors & Sub contractors
- Buildings & Facilities owners

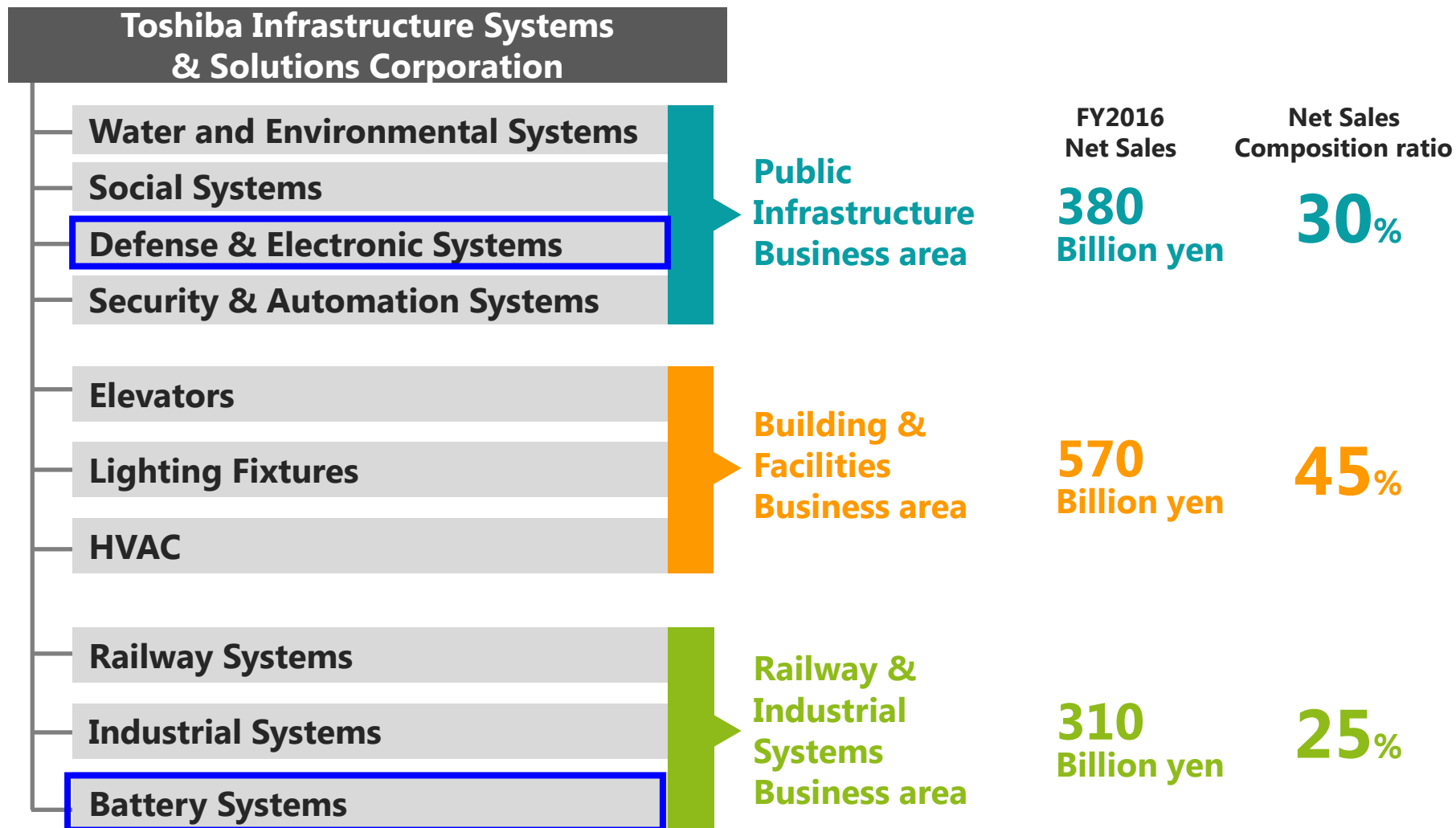
Railway & Industrial Systems



- Railways
- Logistics
- Chemicals

- Automobiles
- Machinery
- Iron & steel, etc.

Our 10 Business Divisions



The HQ function in Kawasaki cooperates with plants and branch offices



Kawasaki Smart Community Center

Head office functions, sales, engineering



Fuchu Complex

Water and environmental systems,
Substation equipment, Disaster
communication systems, Broadcasting
systems, Elevators, Railway systems and
Locomotives



Komukai Complex

Automation equipment
(mail-sorting machines, banknote inspection
machines, public transportation equipment),
Radio wave systems, Highway systems



Mie Operations

Motors and inverters, Small
and medium-sized transformers



Kashiwazaki Operations

Rechargeable batteries (SCiB™)



Fuji Operations

Air-conditioning and
heat source equipment



Kanuma Operations

Lighting Fixtures

* Other plants not shown above : Uenohara, Himeji, Yokosuka, Numazu, Imabari, and Tsuyama

Domestic branches and sales offices

(TISS) **36 locations**, Toshiba Elevator and Building Systems **240 locations**,
Toshiba Lighting & Technology **39 locations**, Toshiba Carrier **40 locations**

Toshiba Infrastructure Systems & Solutions Corporation Proprietary

02

SCiB™ Cell Overview

SCiB™ is a Lithium-ion rechargeable battery
originally developed by TOSHIBA^{*1}
for **civil** and **defence** applications utilizing **LTO^{*2}** technology

LTO anode brings unique and superior characteristics
to **SCiB™** represented by **Six features**

Material of Anode

Conventional LIBs
carbon/graphite



SCiB™
LTO(Lithium Titanium Oxide)



*1 Dual Use and ITAR (International Traffic in Arms regulation) Free products

*2 LTO : Lithium Titanium Oxide

<http://www.scib.jp/en/about/index.htm>

LTO anode provides SCiB™ with six features

- **Safety:**

Uses highly safe lithium titanium oxide (**LTO**)

- **Long life:**

Over **20,000 cycles***

- **Low-temperature operation:**

Can be used at temperatures as low as -30°C

- **Rapid charging:**

Rechargeable in 6 minutes*

- **High input/output:**

Chargeable at large current and provides large current output

- **Wide effective SOC range**:**

Provides a large available capacity

* Measured with a particular single cell under specific conditions

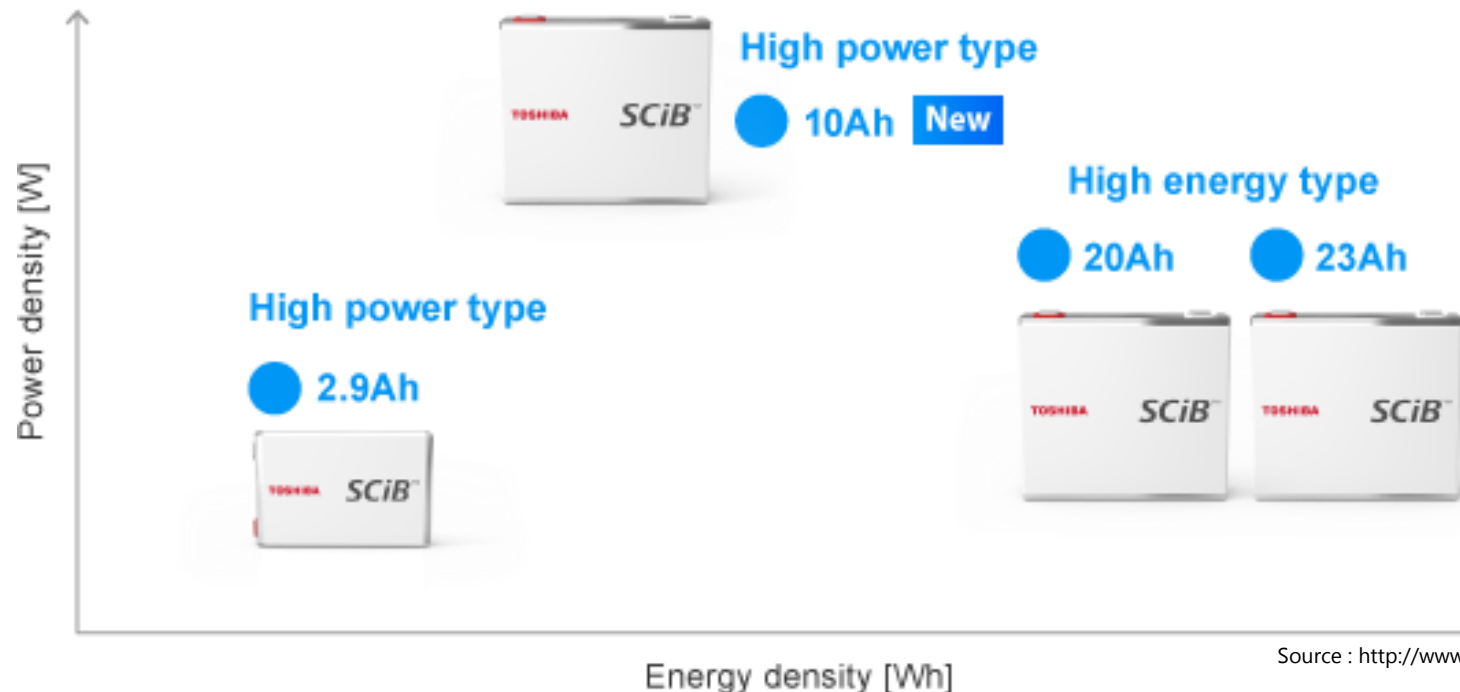
** SOC: State of Charge



<http://www.scib.jp/en/about/index.htm>

SCiB™ rechargeable cells can be categorized into two types

- **The high power type cell** is suitable for applications requiring the charging and discharging of large current in a short time such as regenerative braking in automotive applications
- **The high energy type cell** is suitable for applications requiring large capacity such as electric vehicles and stationary storage systems



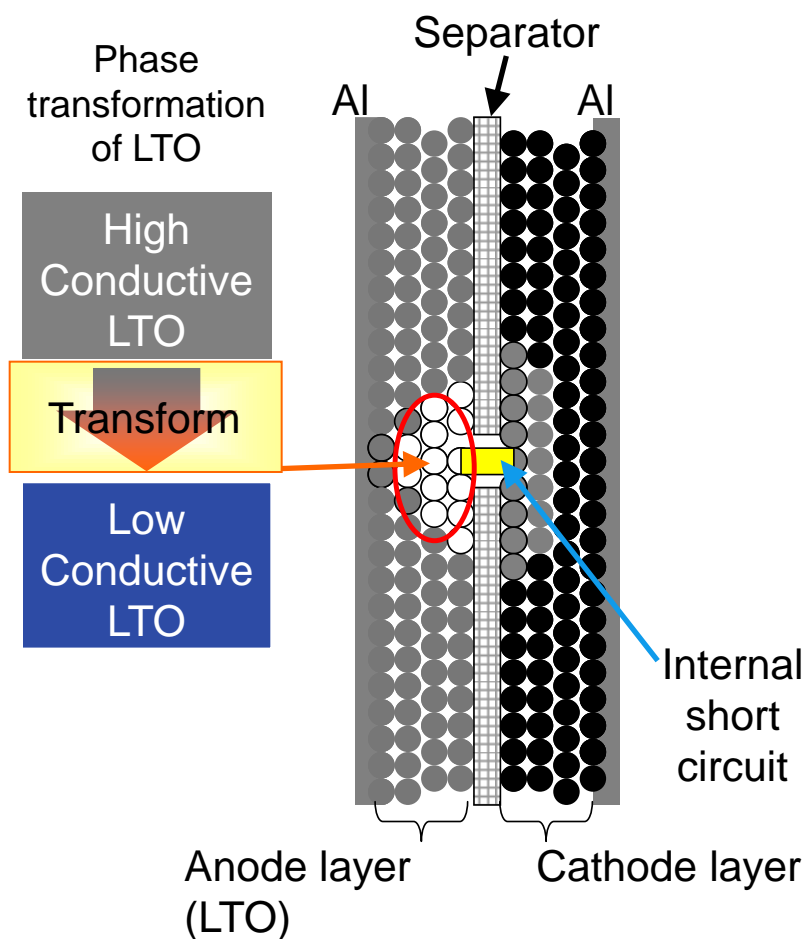
Source : <http://www.scib.jp/en>



Safety - fundamental

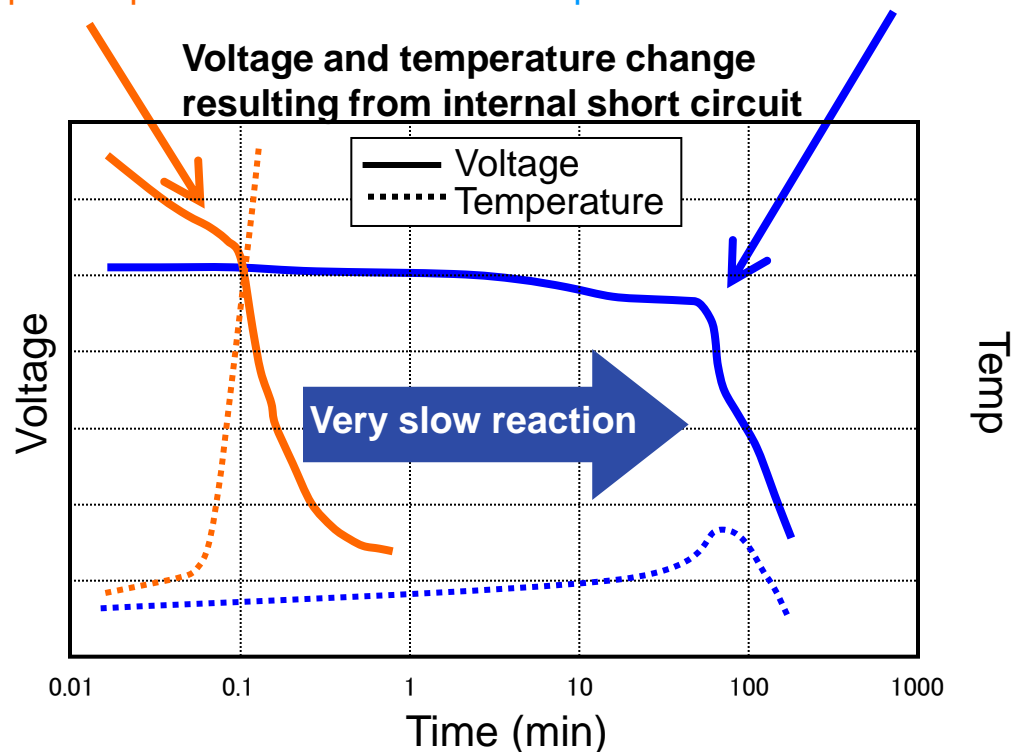
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Phase transformation in the **LTO anode** provides safety **self protection** against **internal short circuiting**



Carbon anode
Sudden discharge causes rapid temperature rise

LTO anode (SCiB™)
Gradual discharge causes low temperature rise

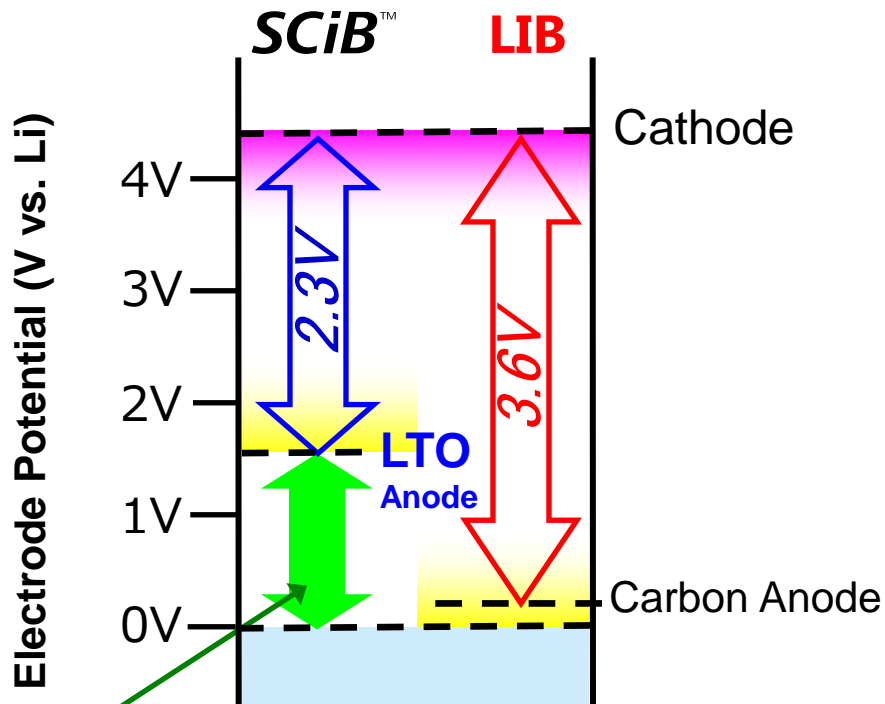




Safety – SCiB™ Design with safety margin

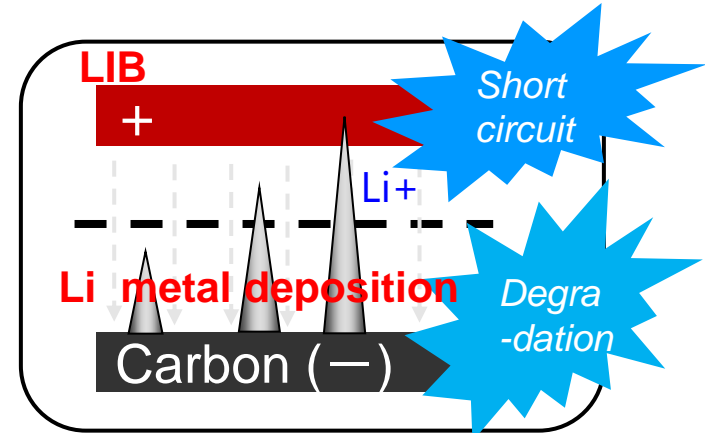
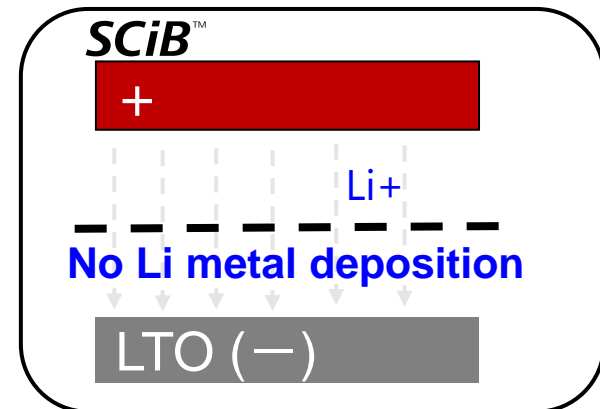
The margin of Electrode potential prevents **Lithium-metal deposition** even **high rate charging** in **cold conditions**

Electrochemical potential of Materials



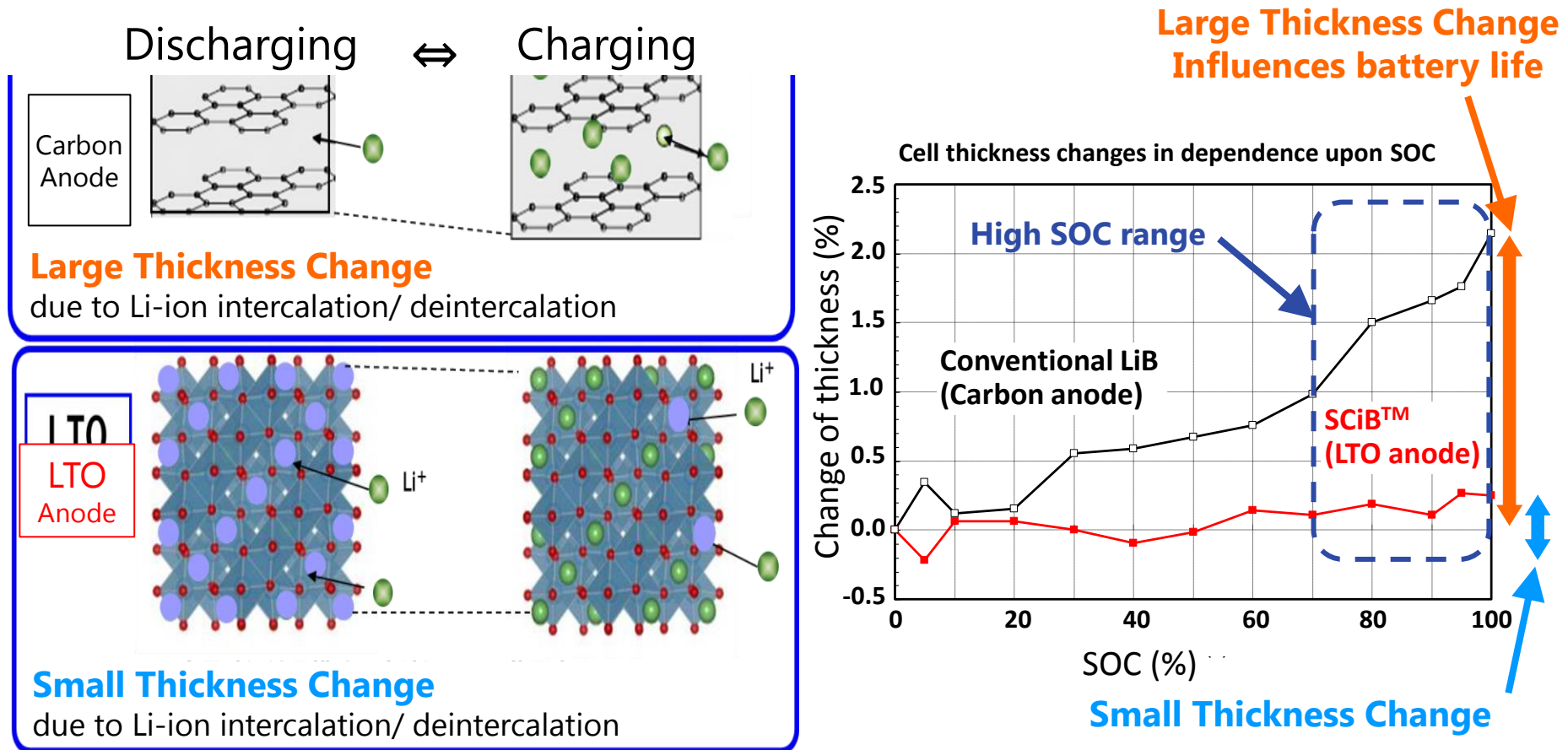
Safety margin against Li-metal deposition

Generation of Li metal deposition



Long Life – Cell Thickness Changes

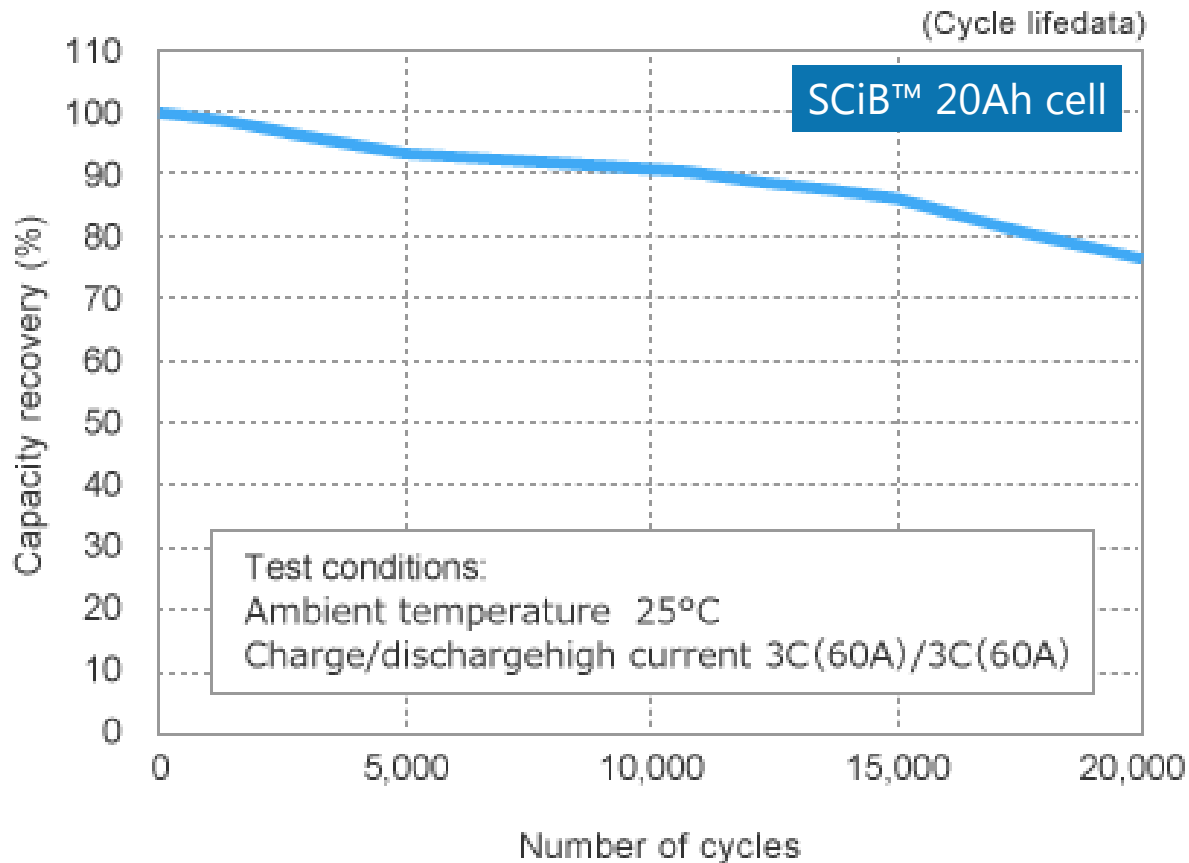
In high SOC range, small cell thickness changes of LTO anode prevents battery capacity degradation





Long Life – Sustaining operation capability

Maintains over 70% of its initial capacity
after **20,000** charge/discharge **cycles** with **3C*** at 25°C



*3C : 20Ahx3C=60A



Long life

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Long Life – High Temperature Cycle Life Test

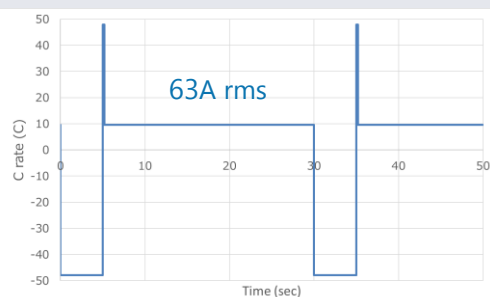
SCiB™ enlarge service life in extremely severe environment

High Temperature Cycle Life Test Result (SCiB™ 2.9Ah Cell)

■ Enlarge a Long service life by Lithium Titanium Oxide (LTO) Anode

SCiB™ 2.9Ah cell

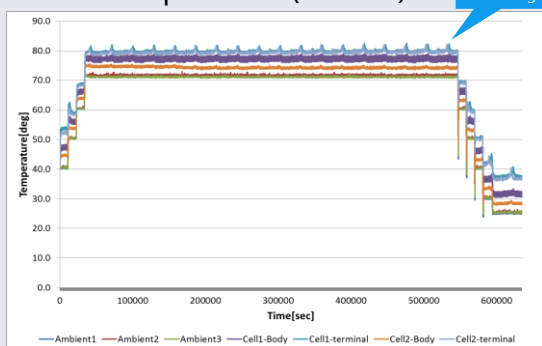
Charge / Discharge waveform



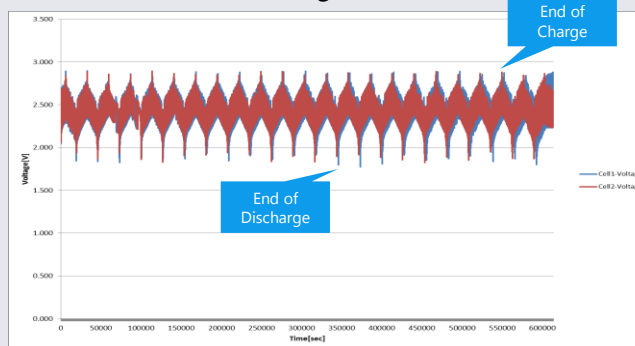
71deg.C
2weeks
(40,320 cycles)

	Start	After 1 week	After 2 weeks
Capacity	3.17Ah	2.89Ah(91%)	<u>2.75Ah(87%)</u>
AC impedance	0.96mΩ	1.03mΩ(107%)	1.14mΩ(119%)
DC impedance (Discharge)	3.28mΩ	4.66mΩ(142%)	5.73mΩ(175%)
DC impedance (Charge)	3.14mΩ	4.38mΩ(139%)	5.31mΩ(169%)
Thickness	12.1mm	12.1mm(0mm)	12.4mm(+0.3mm)

Cell temperature (1 week)



Cell voltage (1 week)





High input/output - SCiB™ Cell Benchmark

High input/output

Symmetric of Input and Output Power of SCiB™

- **low input power density** are not appropriate for High Power Battery System
- **SCiB™ 10Ah cell** (**Best of Input Power density**) and **SCiB™ 23Ah cell** (**Symmetric of Input and Output Power density**) will be fit for High Power Battery System

Items	SCiB™*1 10Ah (LTO)	SCiB™*1 20Ah (LTO)	SCiB™*1 23Ah (LTO)	Li-ion*2 (NCA)	Li-ion (LiFePO ₄)	
Manufacturer	TOSHIBA	TOSHIBA	TOSHIBA	A	A*2	B*4
Energy density (Wh/kg, Wh/L)	47 91	89 175	96 202	120 280	89 189	104 218
Output Power density (kW/kg, W/L)	4.4*3 8.6*3 (SOC90%, 10sec)	1.9*3 3.7*3 (SOC90%, 30sec)	2.5*3 5.2*3 (SOC90%, 10sec)	7.2 16.8 (SOC100%, 2sec)	4.4 9.3 (SOC100%, 2sec)	1.1 2.3
Input Power density (kW/kg)	3.3*3 (SOC10%, 10sec)	2.7*3 (SOC90%, 30sec)	2.4*3 (SOC90%, 10sec)	0.06 (SOC0%, cont.)	Unknown	0.208

*1 : <http://www.scib.jp/>*2 : <http://www.saftbatteries.com/>

*3 : The data was calculated without current limitations

*4 : <http://www.cotac.co.jp/pdf/battery.pdf>

: Best

: Fair

Successfully adopted in Commercial Applications

The Proven SCiB™ cells and modules are widely adopted in high reliability commercial systems

- SCiB™ has been applied to following platforms
 - ◆ EVs/PHEVs ◆ EV-Buses ◆ Hybrid electric boats
 - ◆ Emergency-Running Battery System for metro
 - ◆ Battery powered locomotive
 - ◆ General battery-driven industrial equipment

<http://www.scib.jp/en/index.htm>
- JR central and Toshiba are jointly developed the power supply which adopted lithium ion battery for New Shinkansen N700S

https://jr-central.co.jp/news/release/_pdf/000030982.pdf
- SCiB™ is also adopted to the world-largest class(40MW/40MWh) stationary battery energy storage systems (BESS)

<http://www.scib.jp/en/applications/index.htm>

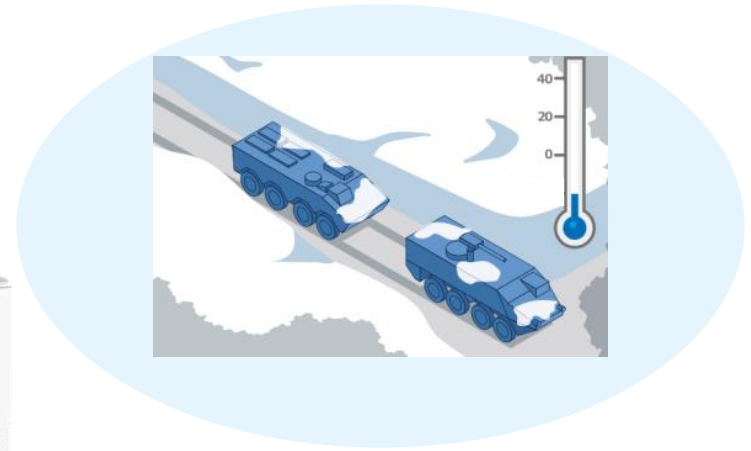
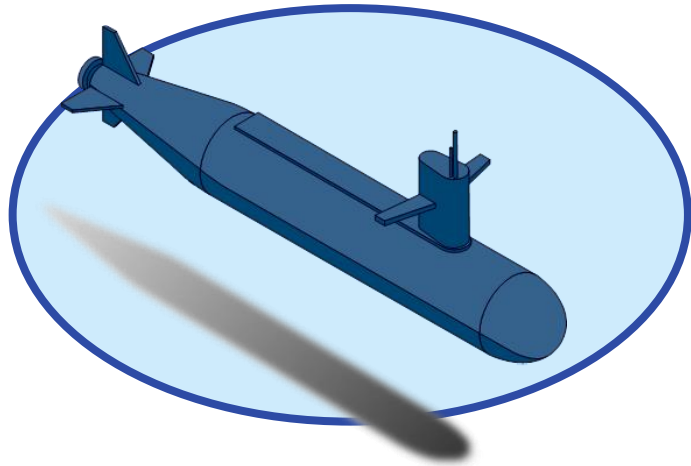
03

SCiB™ Main Storage Battery System(MSBS)

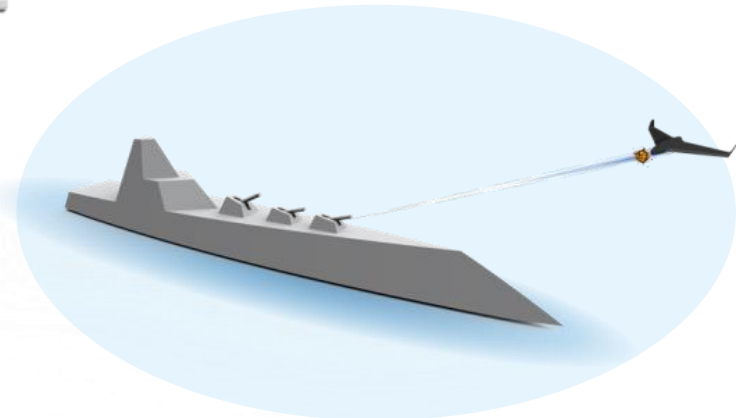
Potential advantages for military operation

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SCiB™ technology will enforce military operations

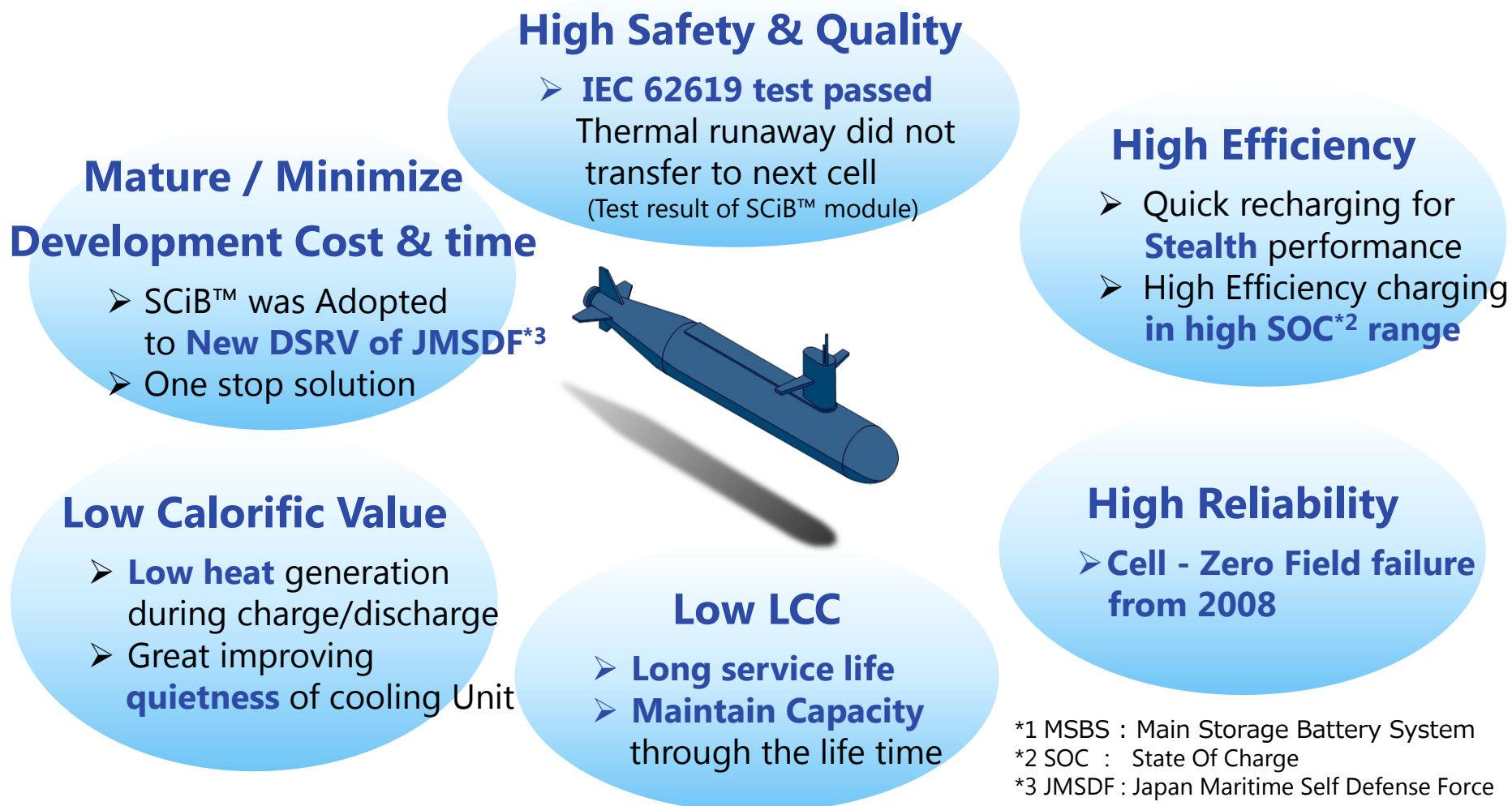


SCiB™



Advantages of SCiB™ MSBS*1

A fusion of high level Safety and Quality Performance realize high reliability Battery System for Naval Applications



*1 MSBS : Main Storage Battery System

*2 SOC : State Of Charge

*3 JMSDF : Japan Maritime Self Defense Force

SCiB™ MSBS for New DSRV*1 of JMSDF*2

The first Li-ion Battery System for submersible vessel of the JMSDF*

SCiB™ realizes;

✓ Safety

- Cabin installed battery system
- High flexibility of layout (vertical and horizontal plane)

✓ Repeated Rapid Recharging(R³)

- Shorten total rescue time

✓ Long life

- Low battery replacement cost

- And more advantages -

◆ Cell/module are expected upgrading
By the demand of the market in the future

New DSRV delivered

Successfully delivered
from Kawasaki Heavy Industries, Ltd.
to JMSDF on 23 Mar, 2018

*1 Deep Submergence Rescue Vehicle

*2 Japan Maritime Self Defense Force

SCiB™ MSBS for New DSRV of JMSDF

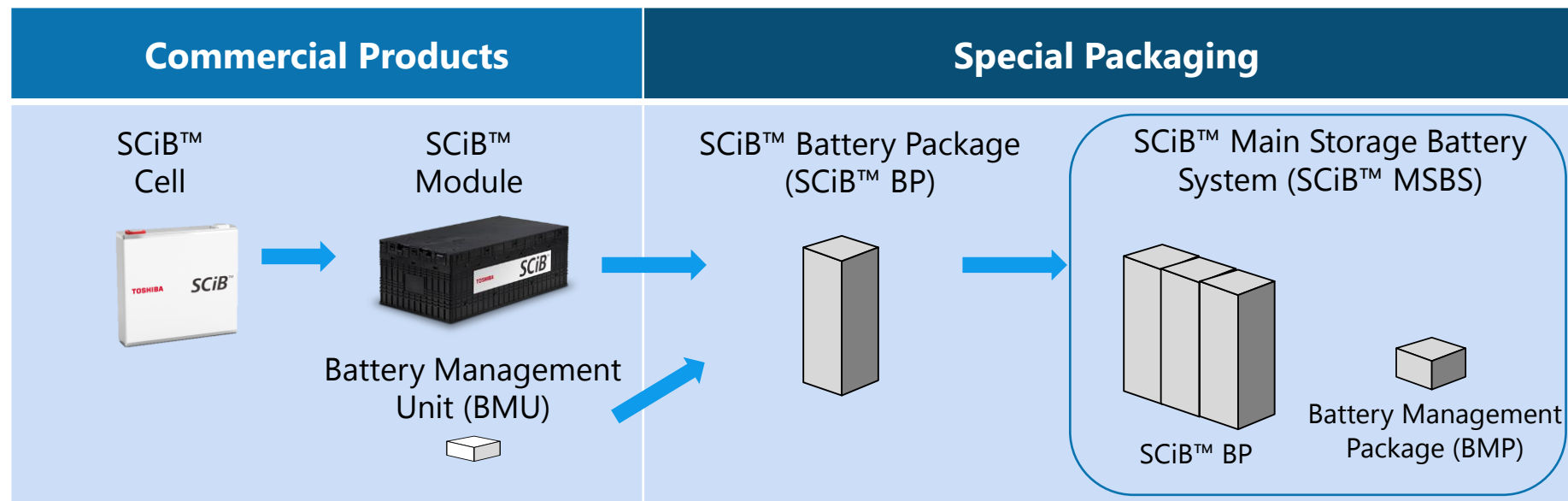
Product cost and development time are reduced by adoption of mature commercial products

Customer satisfaction

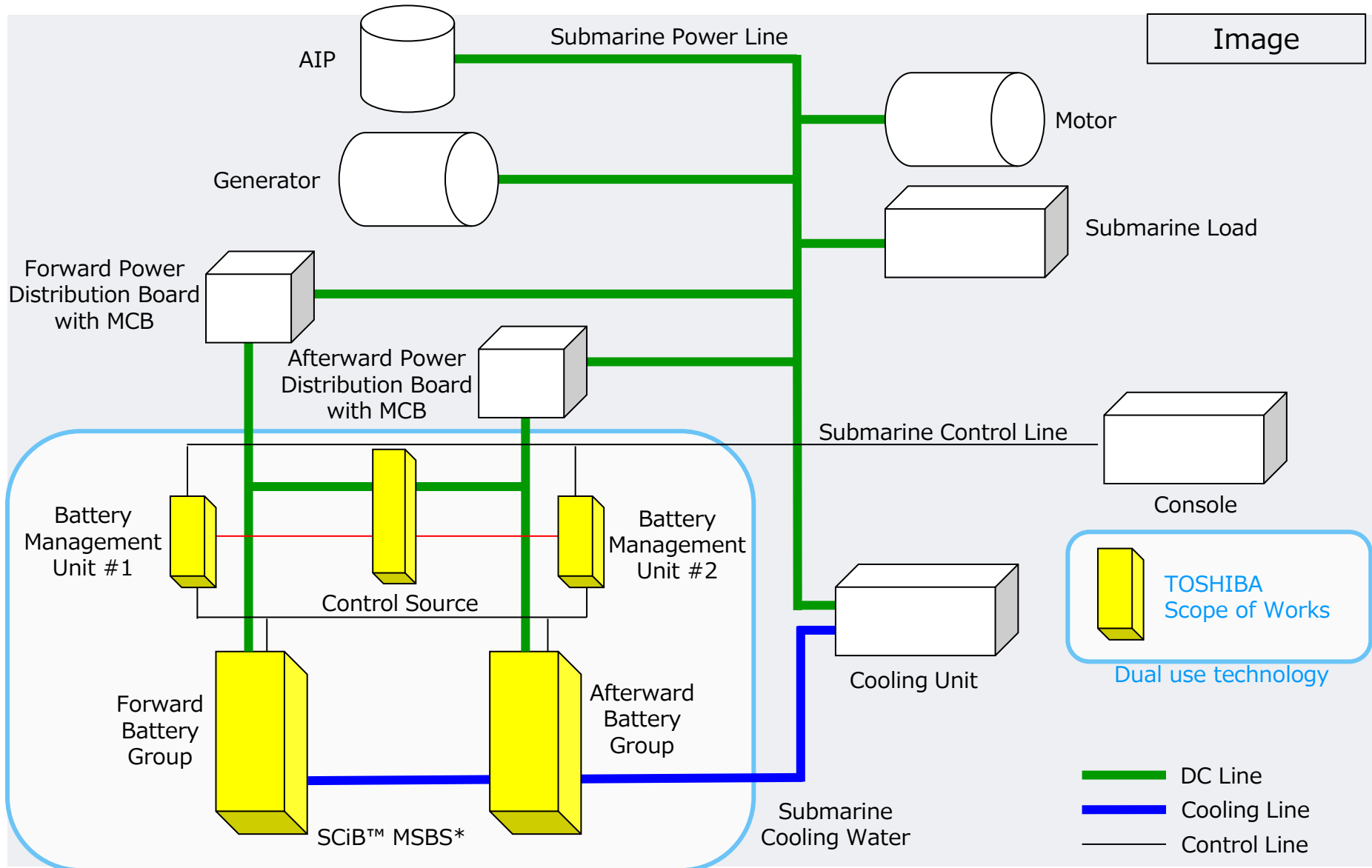
- **Safety** : Actual operational safe record of SCiB™ in commercial platforms
- **Repeated Rapid Recharging (R³)** : low internal resistance and liquid-cooled package

Adopt Mature Commercial Products

- **Product cost and development time reduction** by the use of mature commercial products (SCiB™ Cell/Module/Battery Management Unit(BMU))



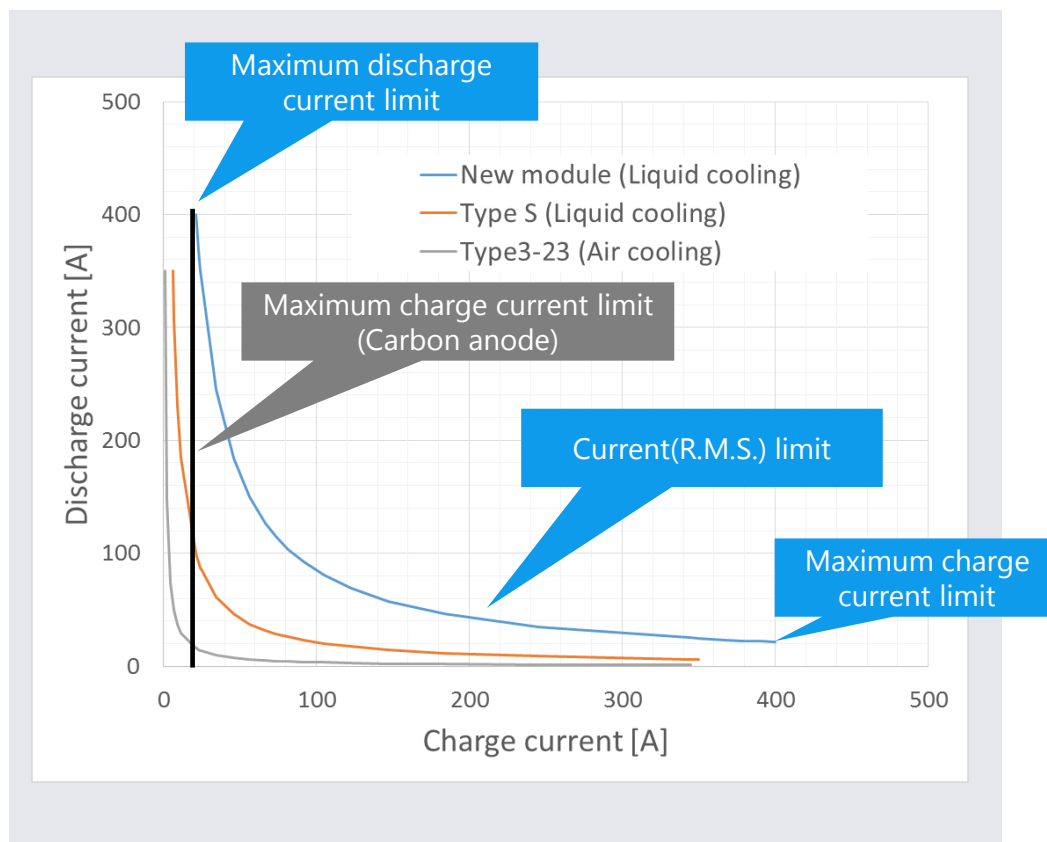
Toshiba scope of works for submarines MSBS



04

SCiB™ High Power Battery System(HPBS)

Improvement cooling efficiency is key technology for HPBS



1 SCiB™ Cell

High charge and
discharge current

10Ah

20Ah

23Ah

X Ah

2 New Module*1

Improvement
Cooling efficiency

Type-1

Type-3

Type-S

New

3 New System

Optimize high power
applications

*1 : The specifications and others may change without notice for development

SCiB™ Type S module for high reliability - high power system

Specifications

Description	Type S Module
Applicable cell	SCiB™ 20Ah
Cell configuration	2 in parallel x 12 in series
Nominal Voltage(Voltage range)	27.6V (18V – 32.4V)
Rating Capacity	40Ah
Maximum Number of connection/ Nominal voltage(Voltage range)	28 modules in series 772.8V (504V – 907.2V)
Maximum continuous current	160A
Maximum inrush current	350A
Dimensions	W187×D358×H130mm
Weight	Approx. 15kg
Functional safety	EN:50126-1:1999 with SSU(Safety Supervisor Unit)

* HPBS : High Power Battery System

05

Next-Generation SCiB™

Next-Generation SCiB™

Press Release 3 Oct, 2017

Toshiba Develops Next-Generation Lithium-ion Battery with New Anode Material

➤ New Anode Materials : **Titanium Niobium Oxide (NTO)**

- ✓ Toshiba has developed a titanium niobium oxide anode that has **double the capacity by volume** of the graphite-based anodes generally used in lithium-ion batteries
- ✓ Excellent characteristics, such as **Safety and Long life are same** as current SCiB™

➤ 50Ah prototype cell

- ✓ The **energy density by volume is twice** that of the LTO anode
- ✓ Maintains over **90%** of its initial capacity after being put through **5,000 charge/discharge cycles**
- ✓ **Ultra-rapid recharging** can be done in cold conditions, with temperatures as low as minus 10°C, in only 10 minutes



Prototype of 50Ah next-generation SCiB™
111mm x 194mm x 14.5mm

Source: https://www.toshiba.co.jp/about/press/2017_10/pr0301.htm

appendix

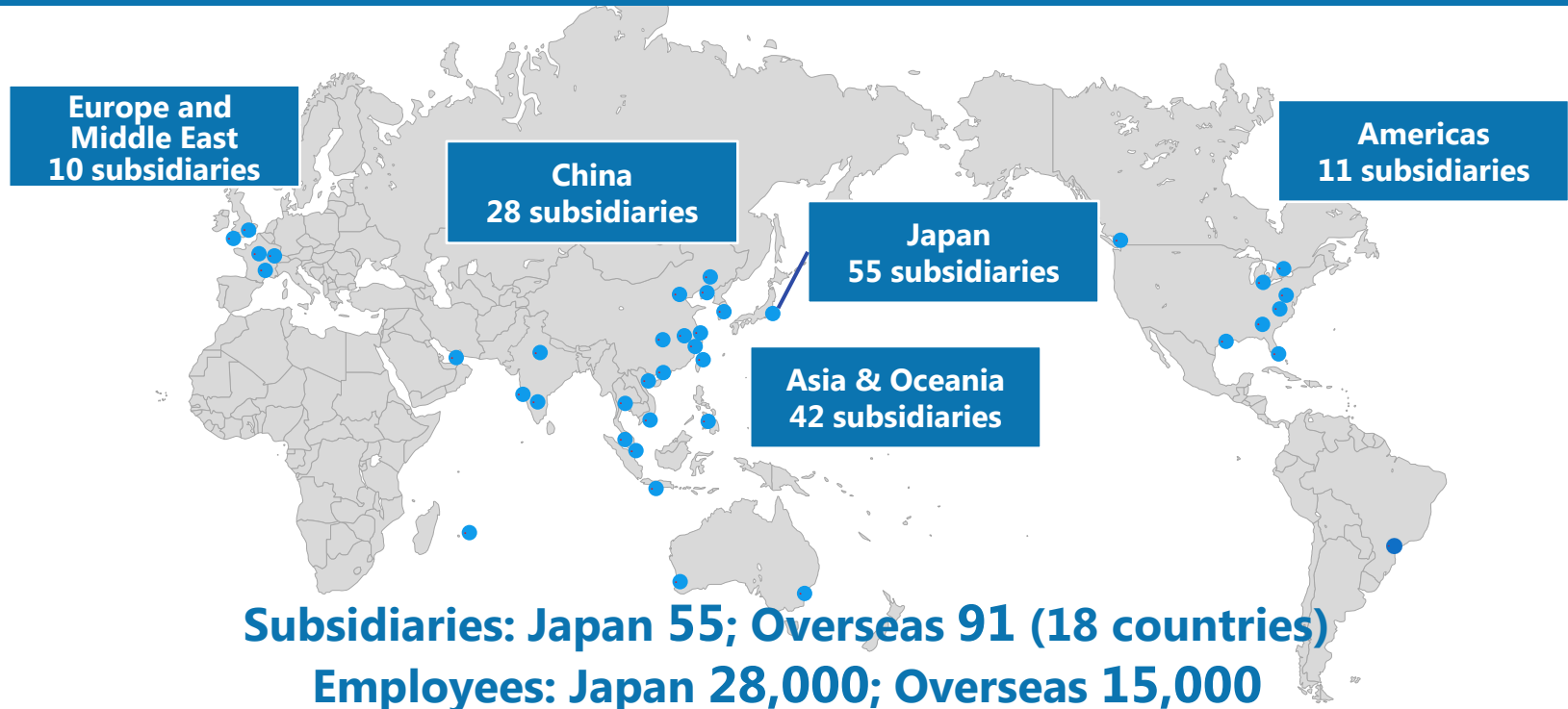
Provide products and services based on strengths in each of the 3 business areas



Major customers

- Central government
- Municipalities
- Broadcasting stations
- **Electrical Equipment Constructor**
- General Contractors
- Japan Post Holdings
- Bank of Japan
- **Railway operators**
- **Automobile manufacturers**

Take advantage of the overseas branch network to accelerate global growth



Overseas sales ratio 26%



**UEM India
Pvt. Ltd.**
Water treatment
systems (EPC*)



**TOSHIBA ELEVATOR
(CHINA) CO., LTD.**
Elevators



**Dalian Toshiba Locomotive
Electric Equipment Co., Ltd.**
Railway systems



**Thai Toshiba
Lighting Co., Ltd.**
Industrial lighting



**Toshiba Carrier (Thailand)
Co., Ltd.**
Air conditionings



**Toshiba Industrial Products
Asia Co., Ltd. (Vietnam)**
Industrial motors




**Toshiba International
Corporation**
Industrial motors and
inverters
Automotive motors

Photos of Major Global Manufacturing Sites

Company Profile

Company Name	Toshiba Infrastructure Systems & Solutions Corporation
Common stock	10 billion yen
Number of Employees	7,700 (Consolidated) 43,000
Foundation	July 1, 2017 (Business succession) May 11, 1987 (Establishment of Toshiba Electric Service Corporation) July 1875 (Establishment of Toshiba Corporation)
Name and Title of Representatives	President and CEO Shinichiro AKIBA
Headquarters Address	72-34, Horikawa-cho, Saiwai-ku, Kawasaki-shi, Kanagawa, Japan

	High Power Type		High Energy Type	
Cell Type				
Nominal voltage	2.4v		2.3v	
Nominal capacity	2.9Ah	10Ah	20Ah	23Ah
Output power	420W (SOC 50%, 10sec, 25℃)	1800W (SOC 50%, 10sec, 25℃)	460W (SOC 50%, 10 sec, 25℃)	460W (SOC 50%, 10sec, 25℃)
Input power	480W (SOC 50%, 10sec, 25℃)	1500W (SOC 50%, 10sec, 25℃)	460W (SOC 50%, 10sec, 25℃)	460W (SOC 50%, 10sec, 25℃)
Energy density	81Wh/L	92Wh/L	176Wh/L	202Wh/L (213Wh/L*)
Dimension	W63 x D14 x H97 mm	W116 x D22 x H106 mm		
Weight (Approx.)	150g	510g	515g	550g

*1 Calculated by test data of 0.01 C discharging

Source : <http://www.scib.jp/en/product/cell.htm>

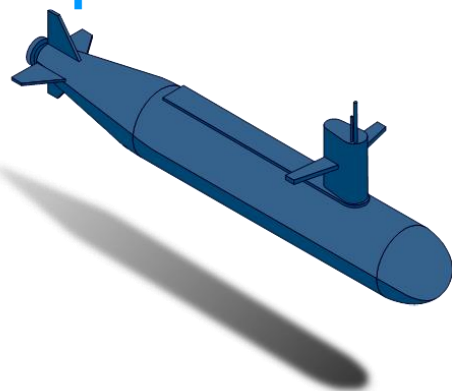
Potential advantages for military operation

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SCiB™ technology will enforce military operations

✓ Zero Field failure from 2008

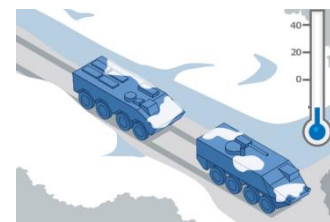
- ✓ **Lower maintenance**/replacement
- ✓ No agitation/No water refill
- ✓ **Environmentally friendly**
- ✓ Low degradation in **high temperature condition**



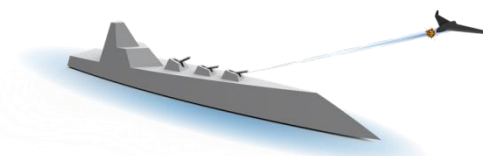
- ✓ **No 2/3 stage charging**
- ✓ **Durational silent operation**



- ✓ **Arctic climate** operation
- ✓ No-preheating required before charging in **0deg.C or below**



- ✓ **Capability for High duty operation**



- ✓ **Quick Ready** for next demand
- ✓ **Minimized standby time**
- ✓ **Overcharge protection** with LTO characteristic

TOSHIBA

Leading Innovation >>>