

**Nb based Technology for Clean Energy**

# **Next-generation Li-ion Battery with Niobium-based Anode for Electrified Society**

**Yasuhiro Harada (Ph.D.)**

**Senior Fellow**

**Cooperate Research & Development Centre  
Toshiba Corporation**

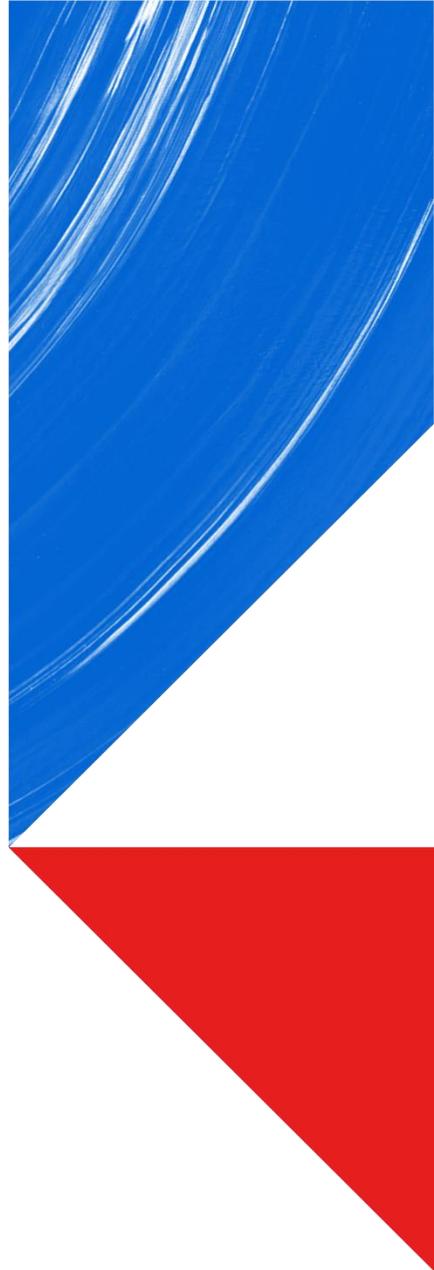
**9<sup>th</sup> November 2021**

# Contents

- 01 Back Ground
- 02 Promising Anode Material NTO for Batteries
- 03 Performances of NTO Anode Battery

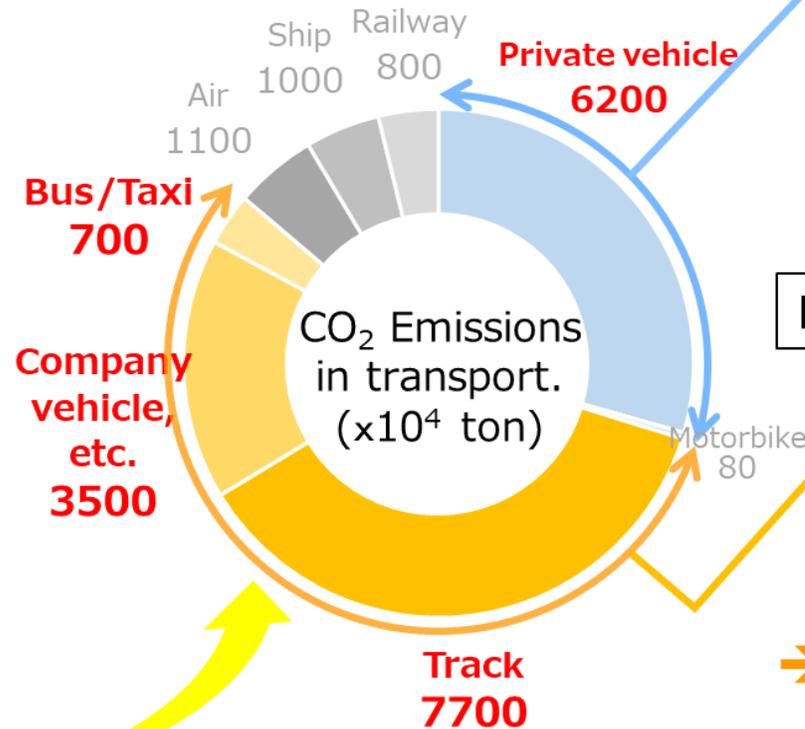
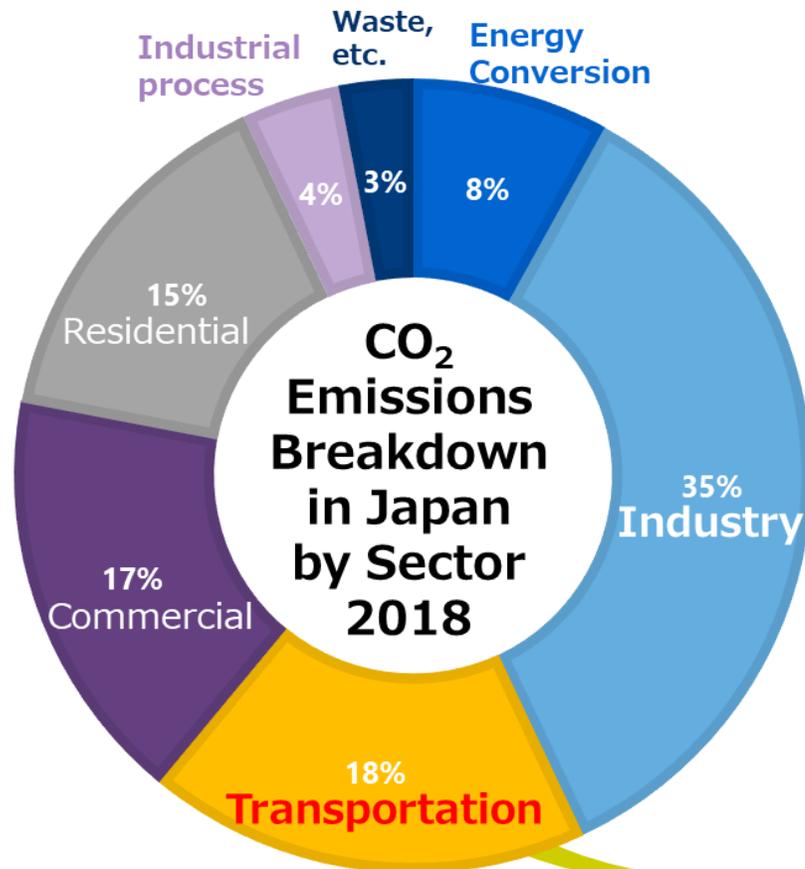
# 01

## Back Ground



# The Challenge of Carbon Neutrality by 2050

Reducing CO<sub>2</sub> gas from industry and transportation is key  
Next generation batteries are required for the electrified society



## Private vehicle

- ✓ Parking time is relatively long
- ✓ Mainly short range driving

→ Li-ion batteries with high energy and long time charging

**Less usability, Short-life of battery**

## Commercial vehicle

- ✓ High operation rate
- ✓ Heavy duty / Long range

→ Next generation batteries with high power & durability

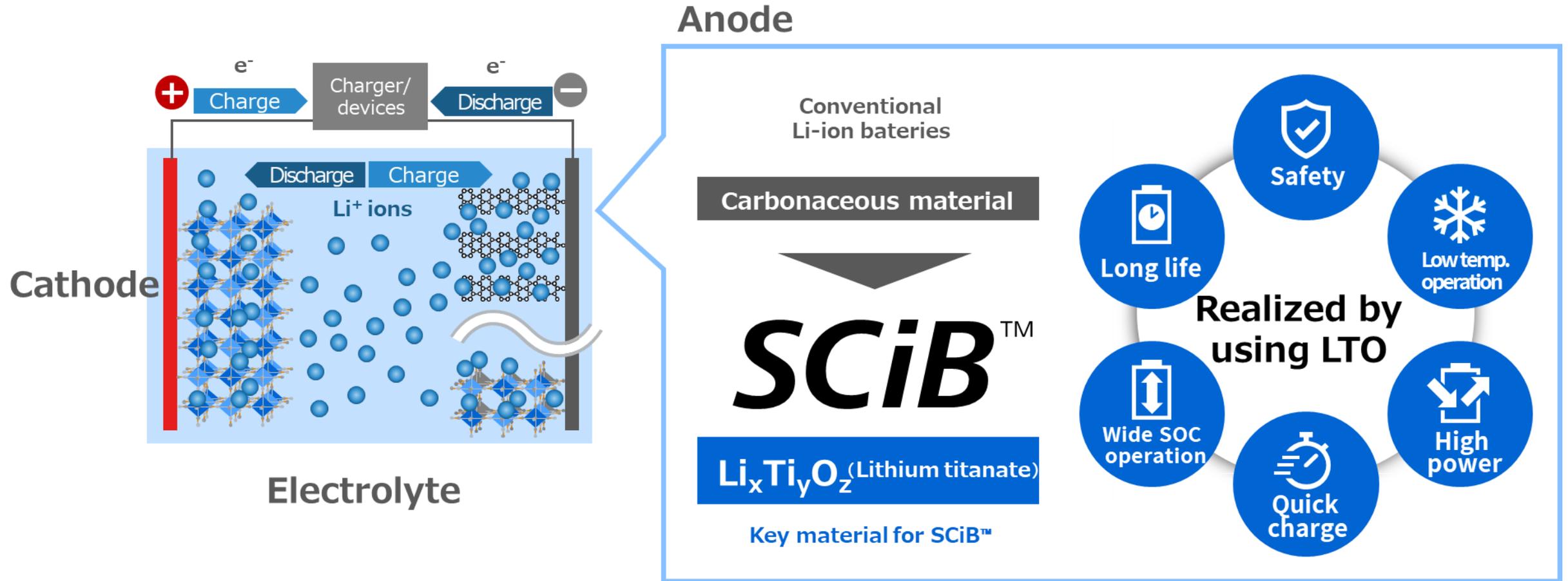
**How to achieve safety & fast-charge operation**

Reference

[https://www.env.go.jp/earth/ondanka/ghgmrv/emissions/results/material/yoin\\_2018\\_2\\_1.pdf](https://www.env.go.jp/earth/ondanka/ghgmrv/emissions/results/material/yoin_2018_2_1.pdf)

# What is SCiB™?

## Unique Li-ion battery having Lithium Titanium Oxide(LTO) anode



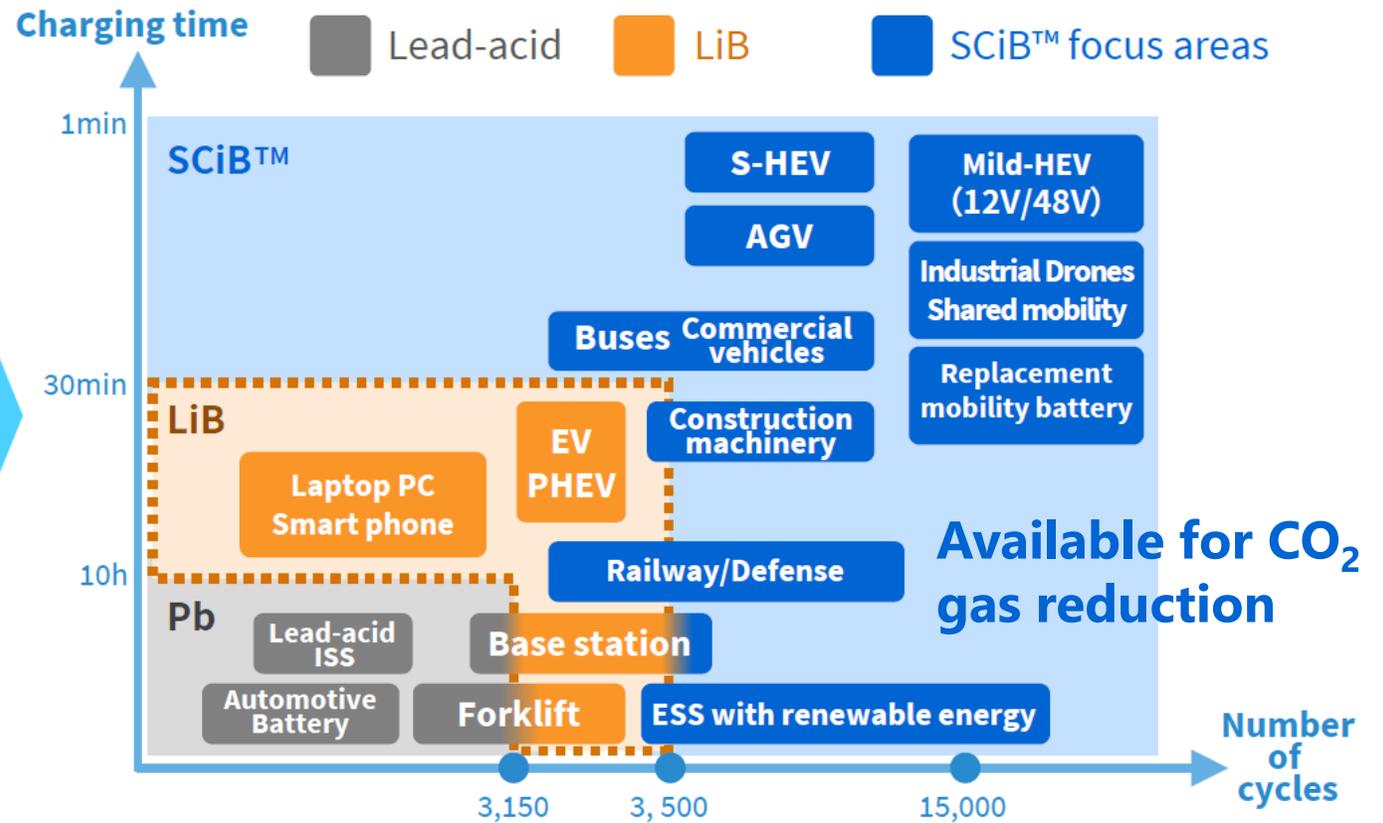
# Target Market Segment for SCiB™

Focus on heavy-duty areas where SCiB™ can be useful, rather than simple energy storage applications

## SCiB™ Characteristics



## Target Markets



# Battery Demand Trend for MaaS

**Toward realization of a highly mobile society (MaaS),  
create value that expands the battery business**

## Value Change

### **Mobility as a Service: MaaS**

- Increased vehicle ownership by service providers

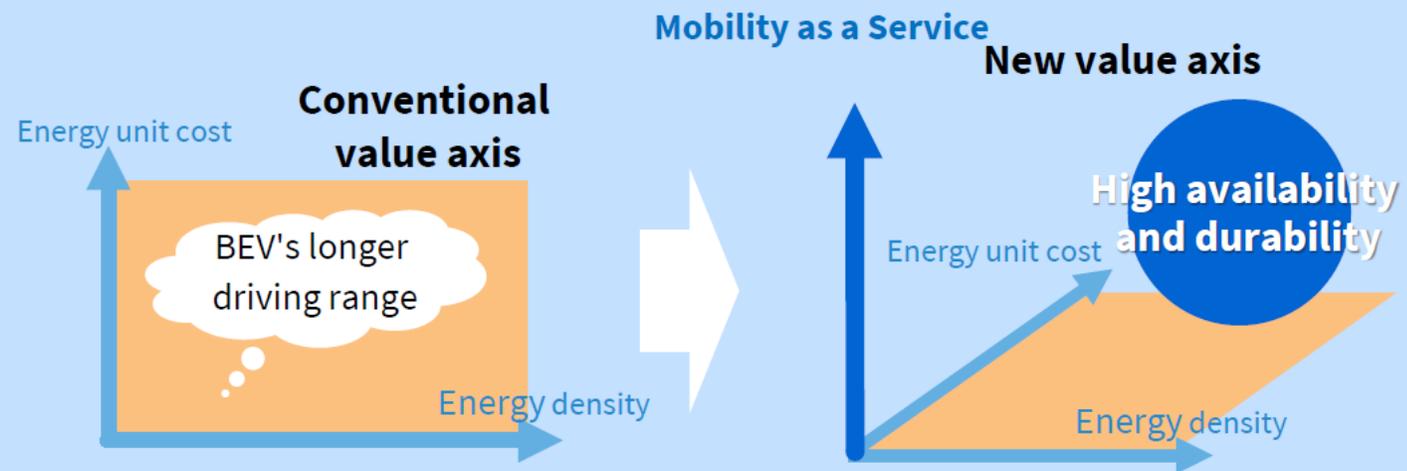


Ride Sharing



**Public transport**  
(Buses, Trains, etc.)

## Performance required for batteries



- **High availability combined with ultra-fast charging**
- **long-term stable usage based high durability**

# Environmental Impacts by Battery Waste

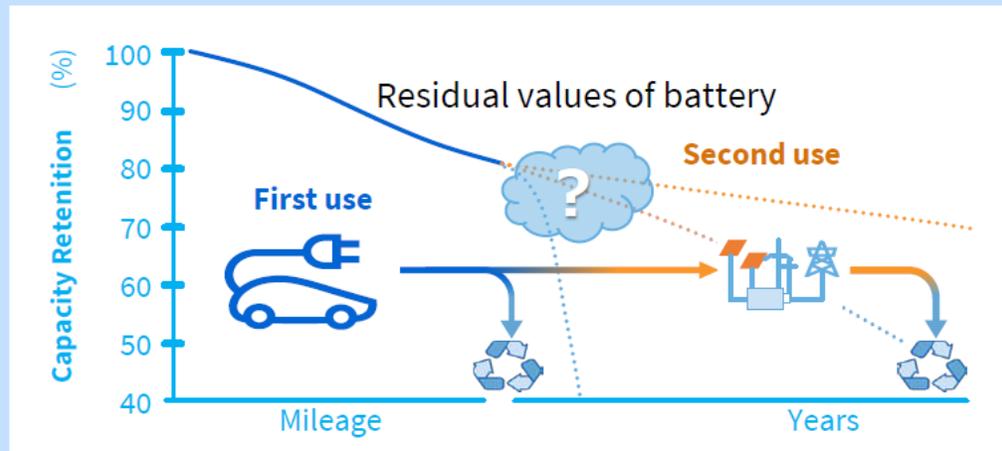
## Long life characteristic contributes to lower environmental impacts

Increased battery use and environmental considerations

- Battery production will reach 1000GWh equivalent in 2030
- In a few years later, 5 million tons of battery waste is discharged every year



Reuse model to conserve resources and reduce waste



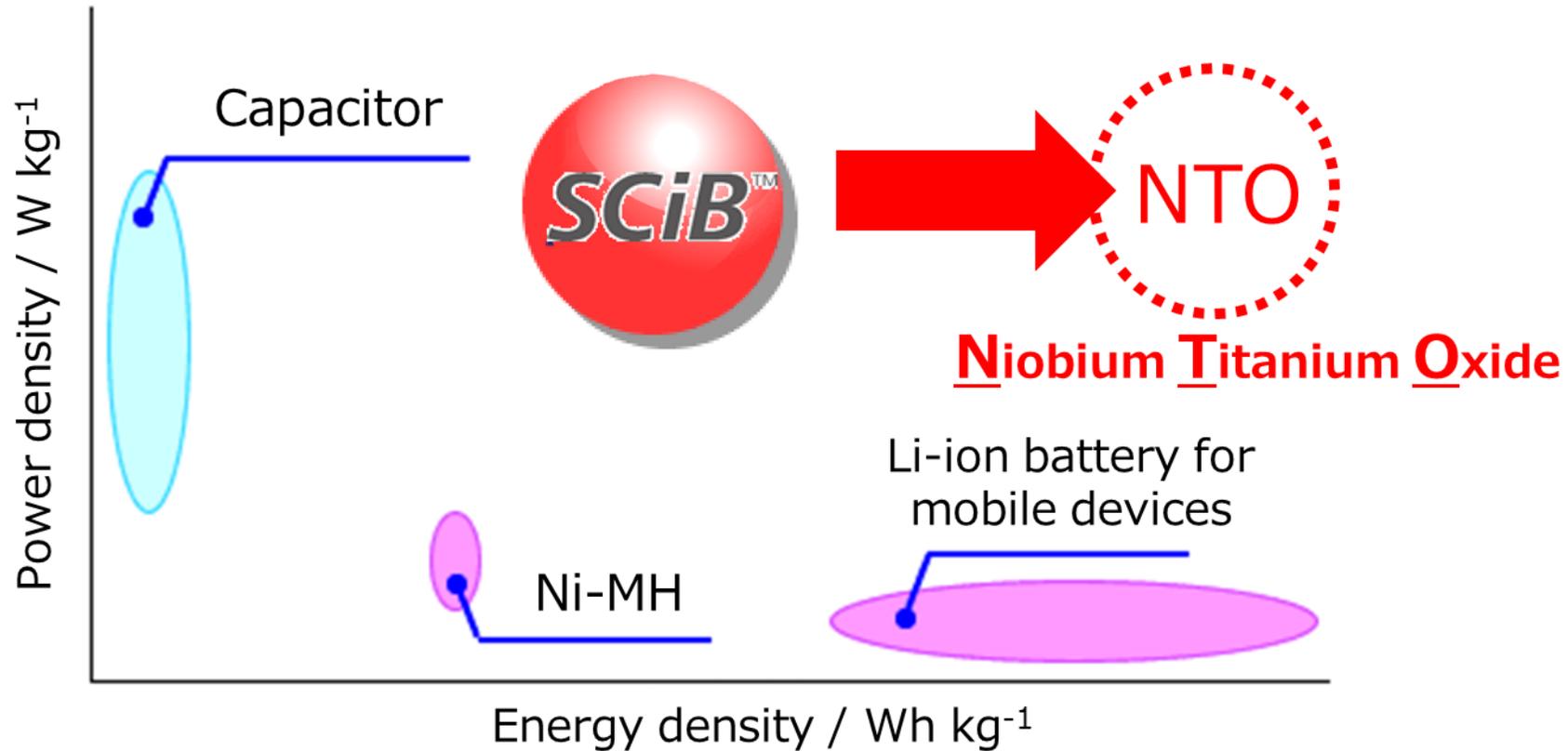
- **Key point:** Battery residual value diagnostic technology



# 02

## Promising Anode Material NTO for Batteries

# Target Energy Density for Next Generation Battery



**Lack of sufficient energy density is the biggest weakness of Toshiba's battery.**

**Toshiba's challenge is to enhance the energy density with keeping attractive advantages of SCiB™ having LTO anode**

# What is Niobium?, What is NTO ?

Niobium Nb Atom. No. 41



Heat resistant special alloy



Steel pipes



Civil construction materials



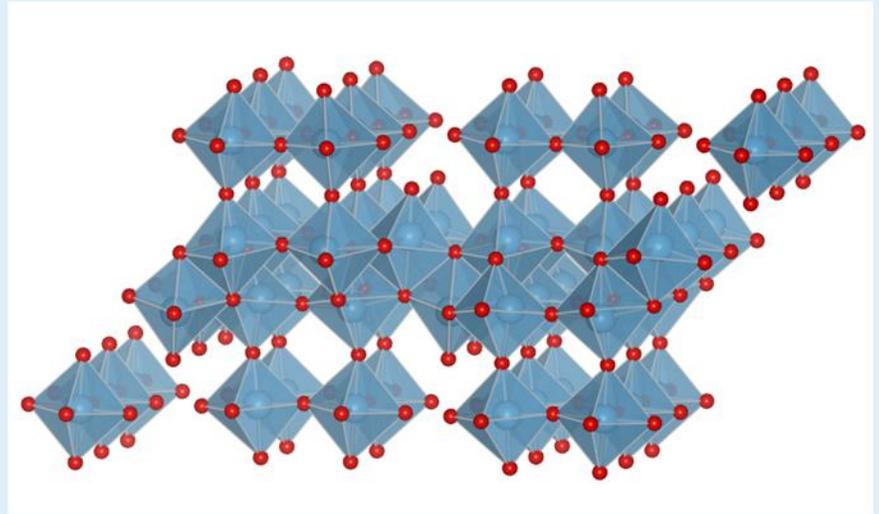
Vehicles



Opticals

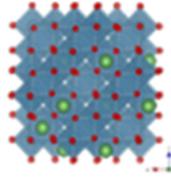
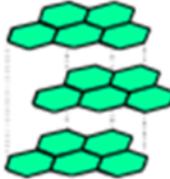
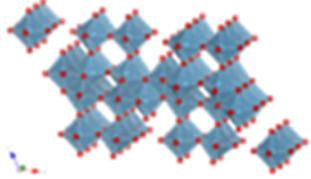


## Niobium Titanium Oxide



- ✓ Rigid framework consisting of Nb
- ✓ Large spaces for Li ion storage
- ✓ Harmless and stable compound

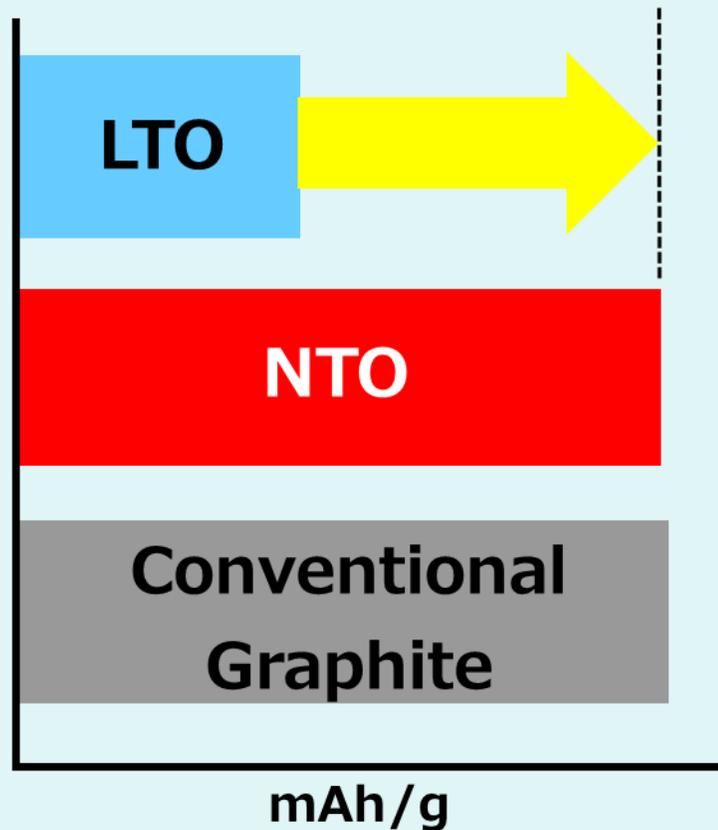
# Features of NTO Anode

	SCiB™	Conventional LIB	NTO
<b>Anode Materials</b>	 <b>L</b> ithium <b>T</b> itanium <b>O</b> xide	 <b>G</b> raphite	 <b>N</b> iobium <b>T</b> itanium <b>O</b> xide
<b>Weight Capacity (mAh/g)</b>	<b>170</b>	<b>372</b>	<b>387</b>
<b>Volume Capacity (mAh/cm<sup>3</sup>)</b>	<b>580</b>	<b>837</b>	<b>1680</b>
<b>Electrode Potential (V vs. Li<sup>+</sup>/Li)</b>	1.55	0.2	1.6

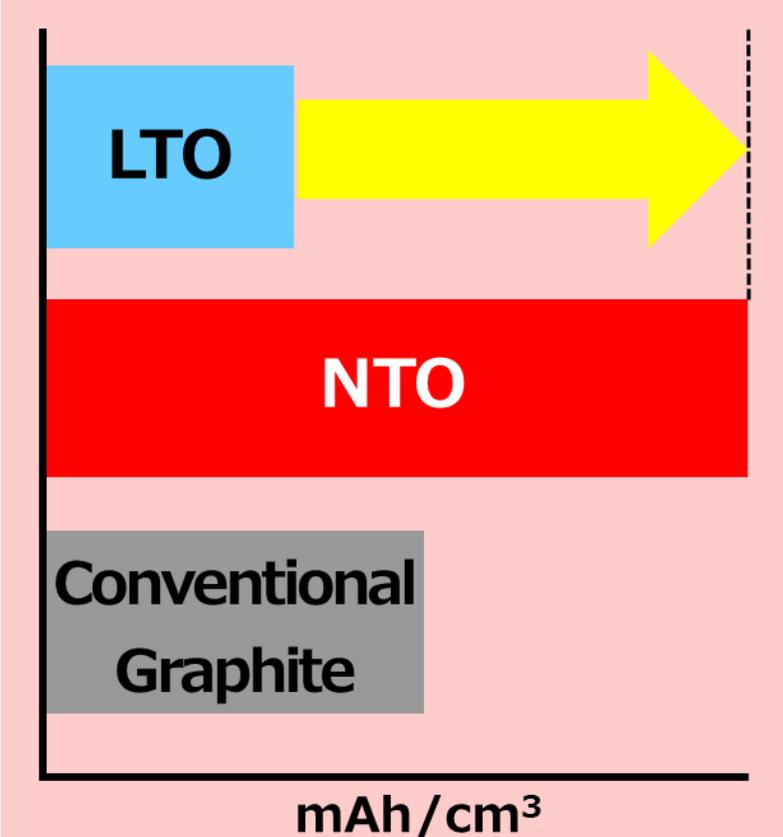
**NTO shows theoretical capacity in volume of Graphite x2, LTO x2.75**

# Comparison of Energy Density on **Anode** Materials

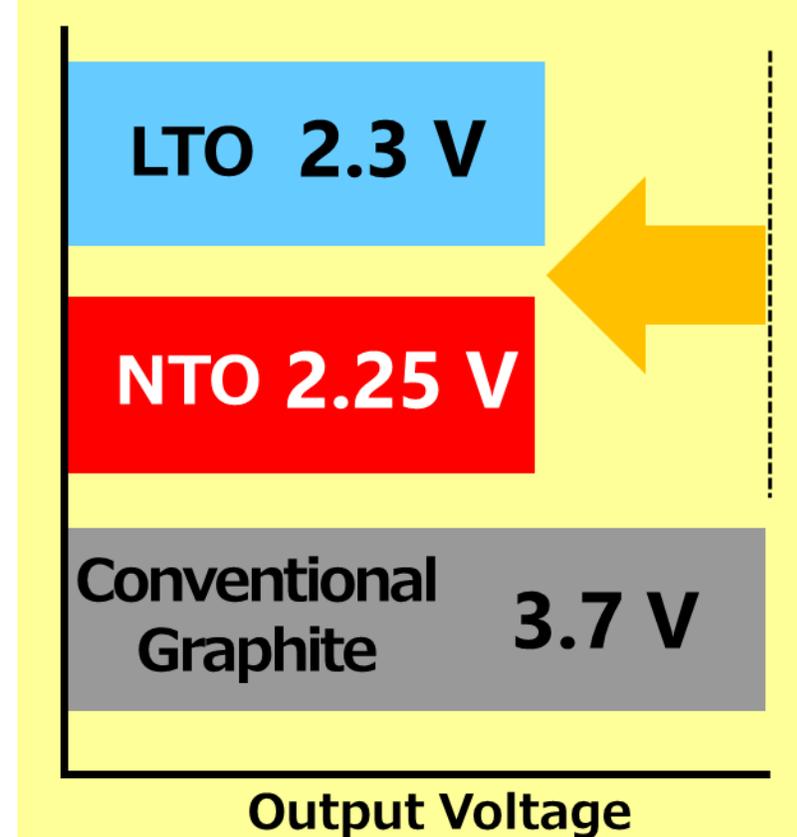
## Mass energy density



## Volume energy density



## Battery voltage

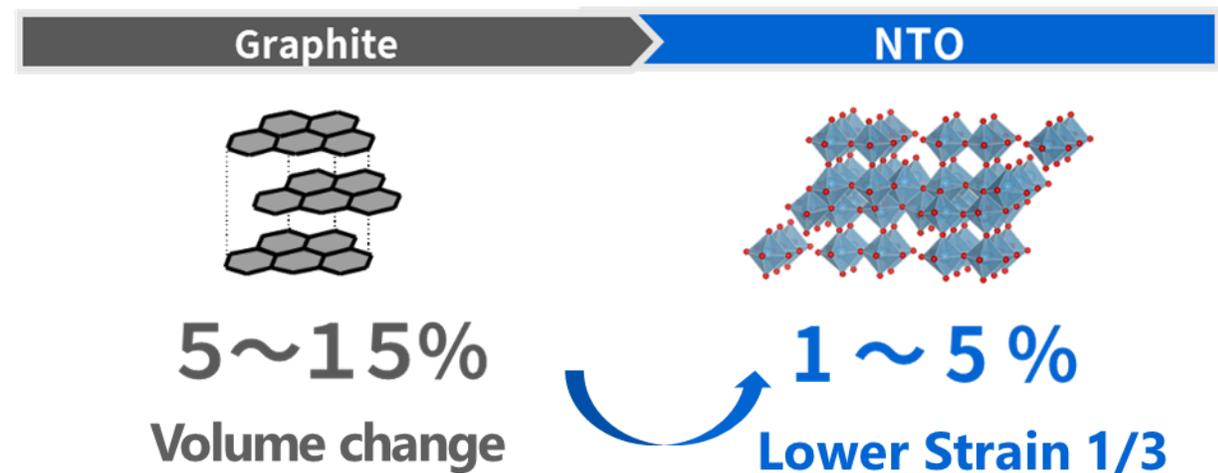


$$\text{Battery Energy (Wh)} = \text{Capacity (Ah)} \times \text{Battery Voltage (V)}$$

# Why NTO can deriver ultra-quick chargeability?

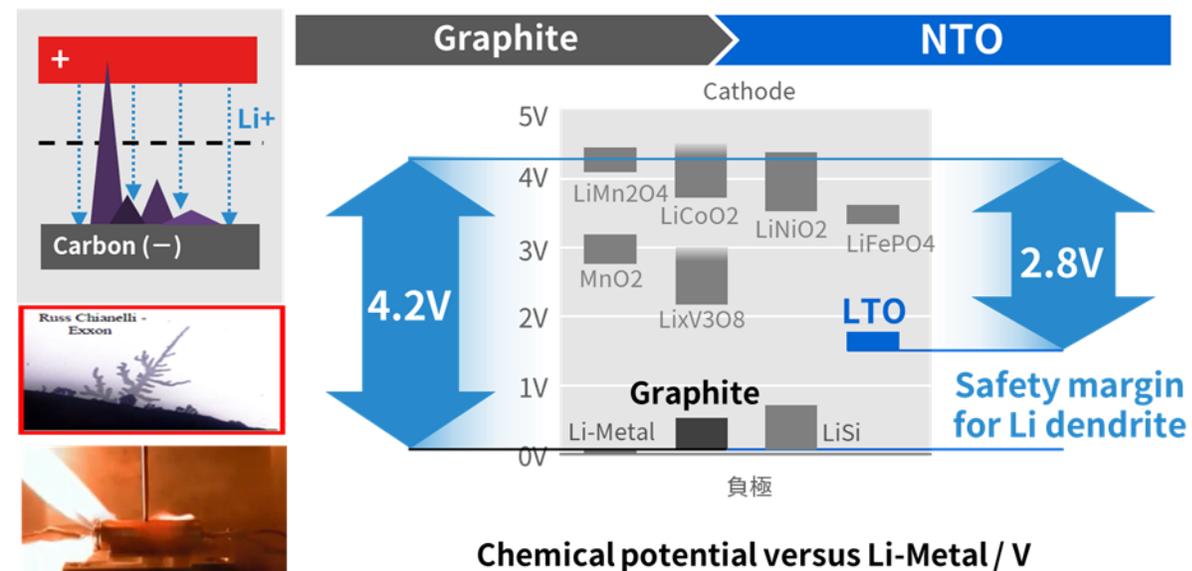
## 1. Lower strain during charging

- ✓ Rigid framework of NTO
- ✓ Almost no structural change



## 2. Safety margin for Li<sup>+</sup> dendrites

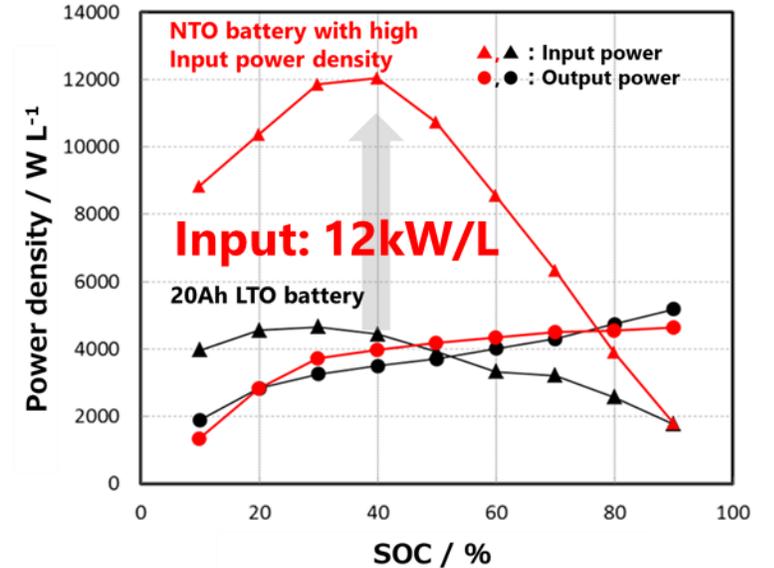
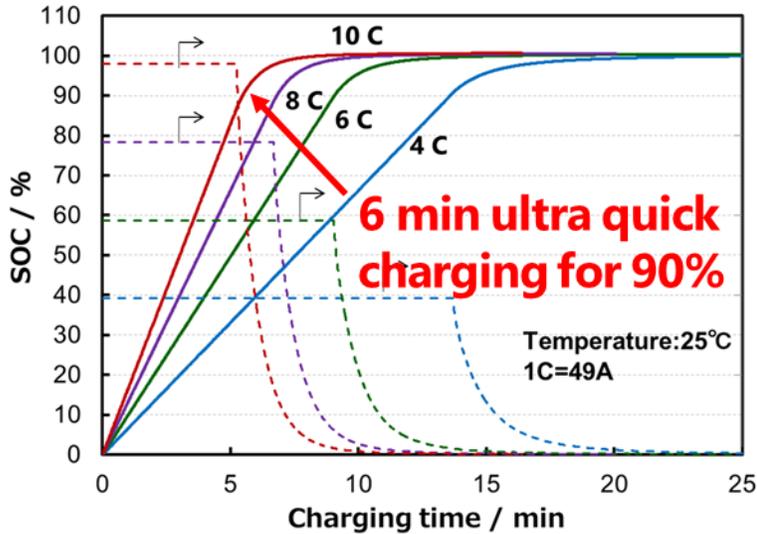
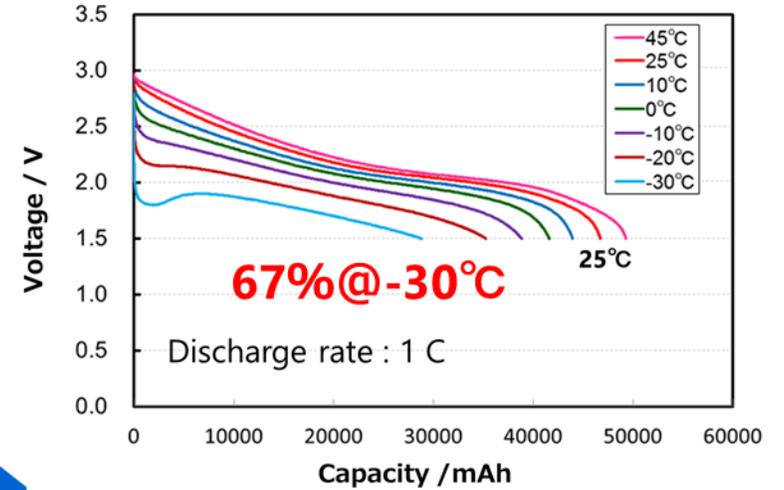
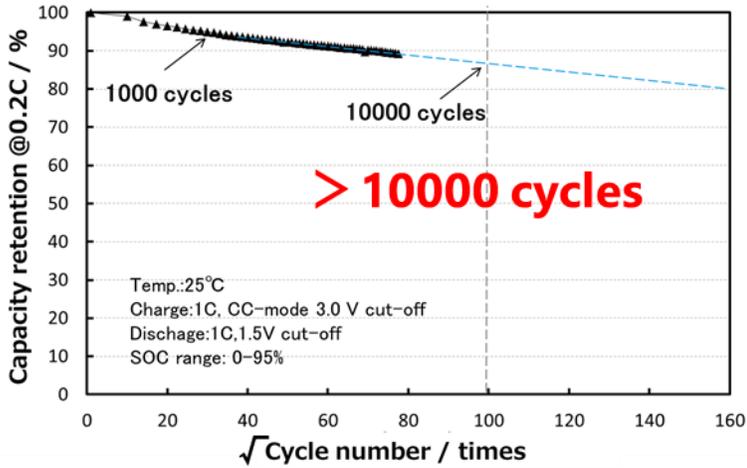
- ✓ Stable even under quick charging
- ✓ Lower safety risk at end of life
- ✓ No damage at low temperature



# 03

## Performances of NTO Anode Battery

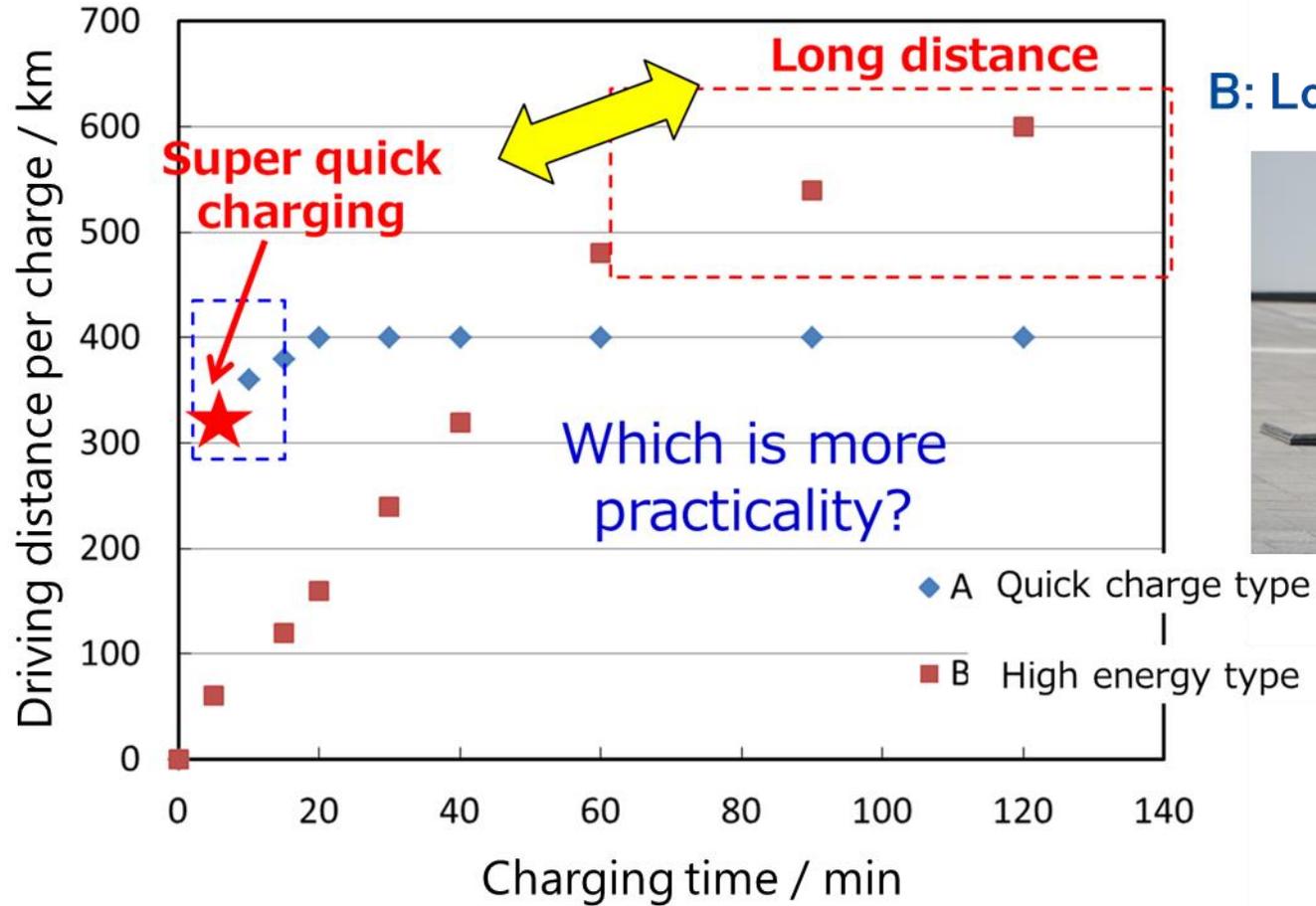
# Performances of Trial Produced 49Ah NTO Battery



# Suitable for High Rate Operation / Heavy Duty Application

A: Super quick charge

Max. 6 min for 90% charging 🎵



B: Long distance per charge

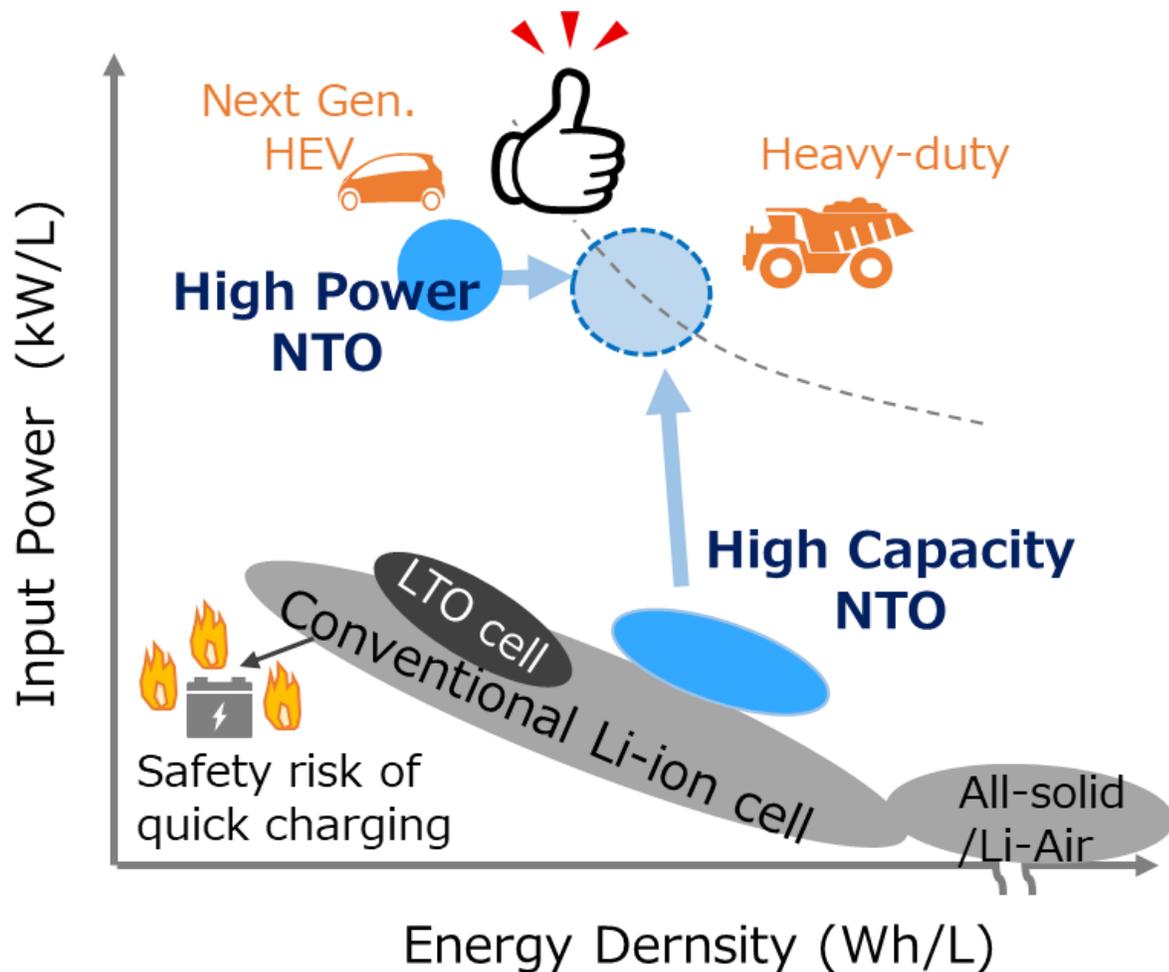


I am waiting for 45 min.....

High-rate operation and long-life with ultra-quick charging are very important to expand electrification in transportation and industrial sector

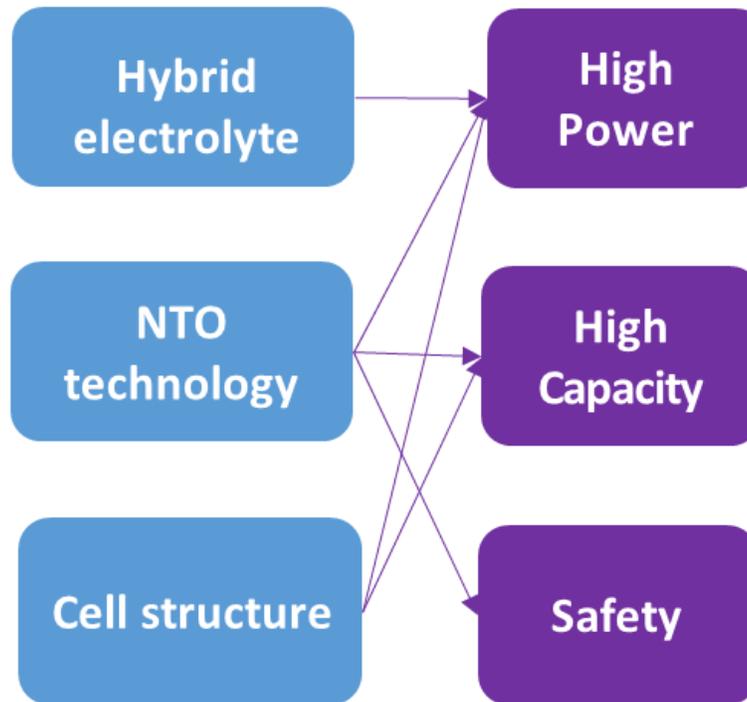
# Future Initiatives for NTO Battery

## Toshiba's technology × NTO brings outstanding battery



### Toshiba's technologies

### Performance



# Summary of NTO Battery

Type of cell	Conventional Li-ion (NCM)*	Conventional Li-ion (LFP)*	NTO**	SCiB™
Voltage	★★★ 3.6 V	★★ 3.2V	★ 2.3~2.4V	★ 2.3~2.4V
Energy density	★★★ ~500Wh/L	★★ ~300Wh/L	★★ ~300Wh/L	★ 100~200Wh/L
Cycle life (25°C)	★ Poor	★★ Fair	★★ Good	★★★ Excellent
Quick charging	★ 30 min	★ 30 min	★★★ 6 min	★★★ 6 min
Low temperature	N/A	N/A	★★★ -30°C~	★★★ -30°C~
Safety (Li-dendrite)	Li-dendrite risk	Li-dendrite risk	★★★ No dendrite	★★★ No dendrite
Environmental Performance	★ Recycle	★ Recycle	★★ Reuse/Recycle	★★ Reuse/Recycle

\* Benchmarked by Toshiba, \*\* Performances of trial produced cell

**NTO can improve energy density comparable to LFP Li-ion battery**

## Toshiba, Sojitz and CBMM Partner to Commercialize Next-Generation Lithium-ion Batteries

- ✓ **Joint development agreement has been concluded between 3 companies.**
- ✓ **This agreement is for the commercialization of next generation lithium-ion batteries using NTO as the anode material.**
- ✓ **This time, NTO battery will be installed on new electric vehicle designed by Volkswagen Caminhões e Ônibus as a pilot project and parties will collect the valuable vehicle operation data.**



# TOSHIBA

***“No Nb, No NB, then No NB ! ”***

*No Niobium, No New Battery, then No New Business*



**Thank you for your attention!!**

**e-mail: [yasuhiro3.harada@toshiba.co.jp](mailto:yasuhiro3.harada@toshiba.co.jp)**