Sensors Converge

nichicon america

Optimization of Energy Storage in IoT Devices

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Mark Gebbia, Sales Application Engineering Manager

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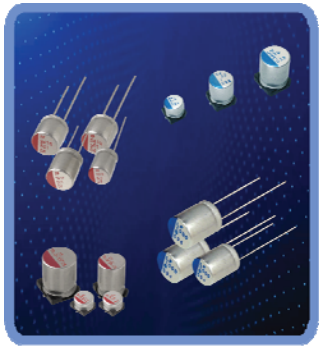
Company Data

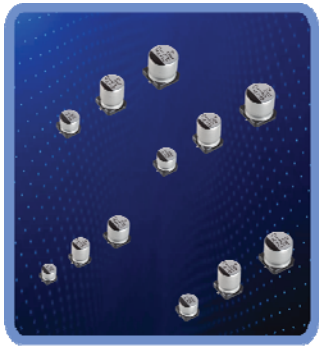
Company Name	NICHICON CORPORATION
Established	August 1, 1950
Employees	5,209
Revenue	184.725 million Yen March 31, 2023
Stock Listings	Tokyo Section 1
Product Lines	Aluminum, Polymer Aluminum, Hybrid Polymer Aluminum, **Small Lithium-Titanate Rechargeable Batteries**, Film Capacitors, EDLC Capacitors, Functional Modules, Positive Thermistors, Switching Power Supplies, ICEL by Nichicon Films, Capacitors for Applied Systems and Equipment

Nichicon Products at a Glance

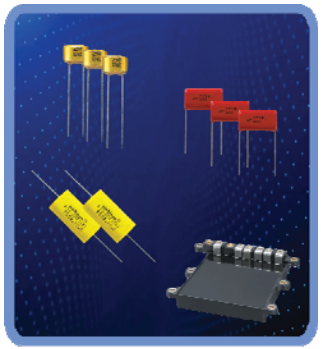
Aluminum Electrolytic Capacitors



Conductive Polymer Capacitors

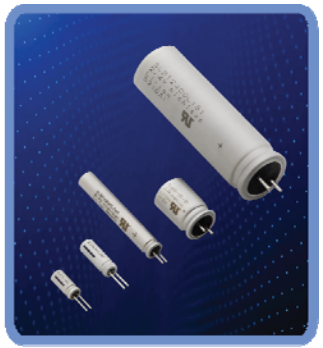


Hybrid Aluminum Polymers



Film Capacitors

Electric Double Layer Capacitors



Small LTO Rechargeable Battery

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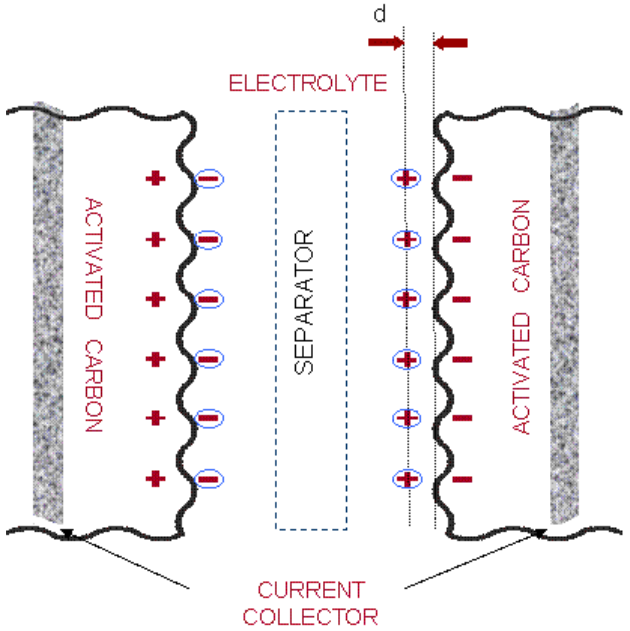
EDLC/Supercapacitors

Electric Double Layer Capacitor's

- Activated Carbon electrodes
  - Extremely large surface area
- No dielectric - unlike standard capacitors
  - Energy stored on surface
- Energy stored in carbon/ electrolyte interface area on both plates.
  (Electric Double layer)
- Environmentally safe electrolyte
  (Nichicon EDLC's)



Electric Double Layer Capacitor's

- ✓Capacitance values up to several thousands of Farads in a single package.
- ✓Voltage limited to 2.7VDC per capacitor cell.
- ✓Maximum temperature 70°C, 85°C with voltage derating.
- ✓Discharge times can be very short (<1second).
- ✓Up to 1,000,000 charge/discharge cycles.

- ✓Applications: Battery backup, Battery alternative, Pulse power, DC-DC converters, Actuators, LED displays, Scanners, Wind power, Audio systems

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Lithium-Ion Rechargeable Batteries

Why Lithium?

- ✓Lightest metal in the periodic table
- ✓Greatest electrochemical potential
- ✓Largest specific energy/kg
- ✓Wider temperature range
- ✓High reliability
- ✓Long cycle life (Compared to other battery types)
- ✓Higher charging/ discharging rate

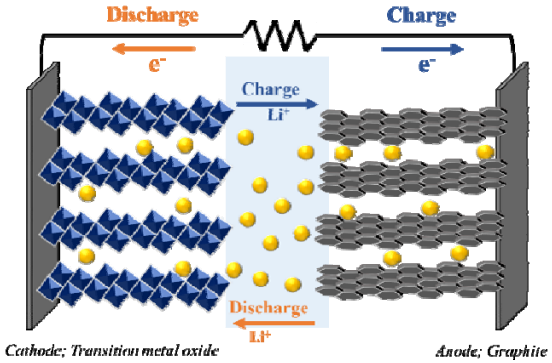
How a Li-ion Battery Works

Charging

Charging current causes Li-ions to be released. Flow from cathode to Anode.

Discharge

Li-ion flow from Anode to cathode. Electrons (Current) flows into circuits.



Anode

$$LiM^*O_2 \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} Li_{1-x}MO_2 + xLi^+ + xe^-$$ M=Metal oxide (Ni, Co, Mn etc)

Cathode

$$6xC + xLi^+ + xe^- \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} xC_6Li$$

Combined reaction

$$LiM^*O_2 + 6xC \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} Li_{1-x}MO_2 + xC_6Li$$

Special “Negative Electrode” of LTO

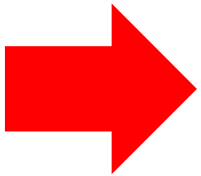
What’s the difference between the LTO and conventional Lithium-Ion Rechargeable Batteries?

Negative Electrode

Conventional Lithium-Ion Rechargeable Battery

LiC_6

(Graphite)



Lithium Titanate Rechargeable Battery

LTO

($Li_4Ti_5O_{12}$)

Li-ion reaction is 0.1V
Thick SEI (solid electrolyte interphase)
Higher electrolyte decomposition
Higher resistance

LTO reaction 1.55V
Thin SEI(solid electrolyte interphase)
Low electrolyte decomposition
Low resistance

Li-ion Batteries vs EDLC

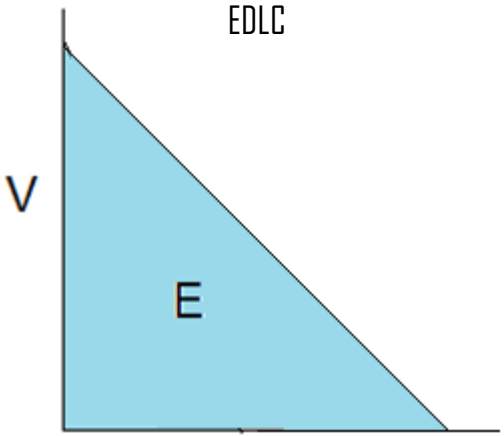
EDLC

- Can be charged/ discharged repeatedly thousands of time
- More stable with temp.
- Higher power density
- Wider temperature range
- Non flammable
- Board mountable

Li-ion Batteries

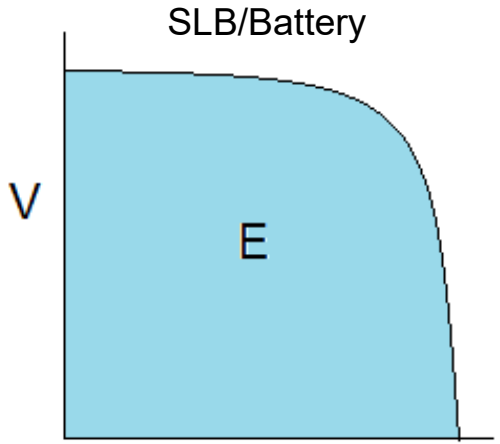
- Higher energy density
- Discharge over a longer period of time
- Smaller in size
- Low cost
- Higher voltage

Discharge (EDLC vs Battery)



Q=CV

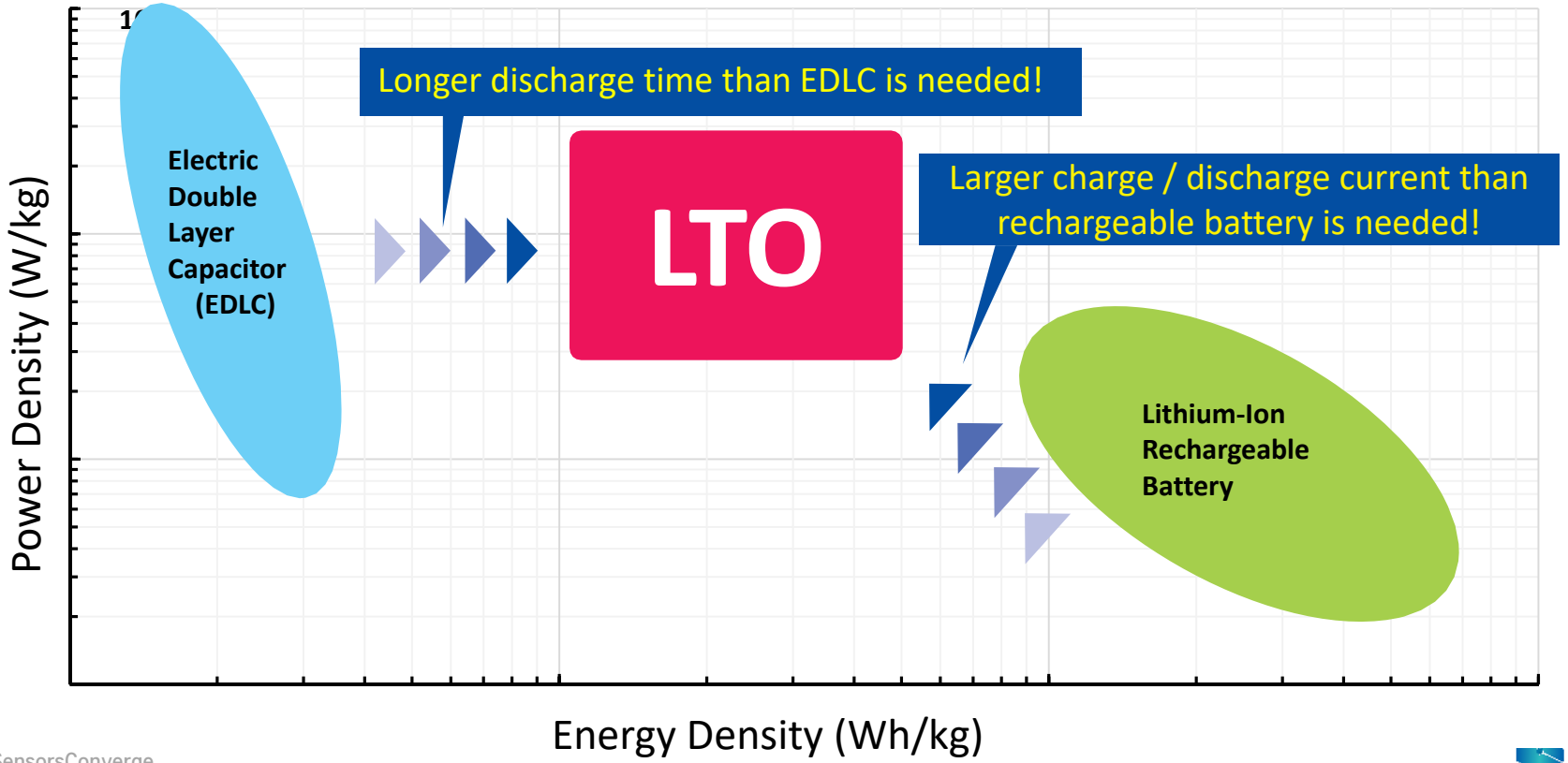
EDLC's – voltage drops as parts discharge



Q=It

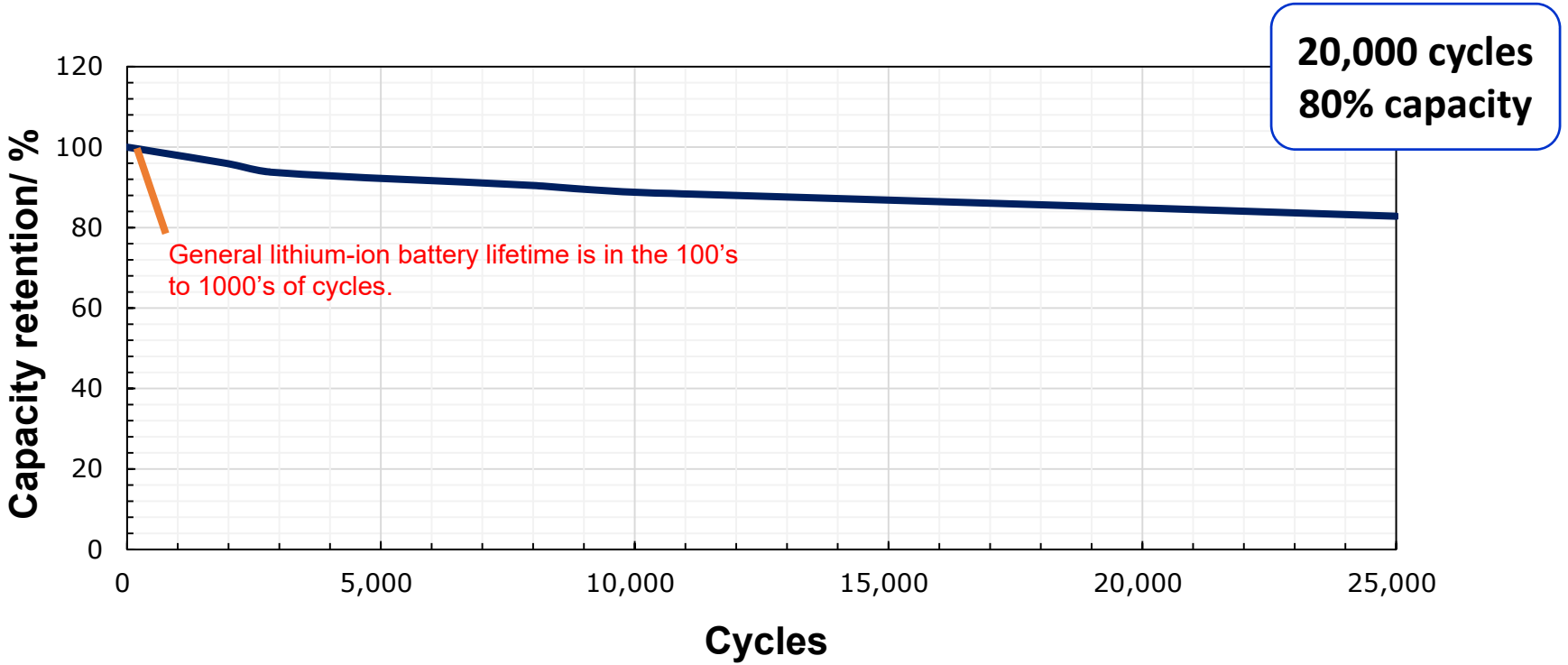
Battery – Voltage constant until discharge complete

Circuit Board Energy Storage Devices



Long Life (LTO vs. Li-ion)

Long Life: Over 80% capacity after 20,000 charge/discharge cycles.



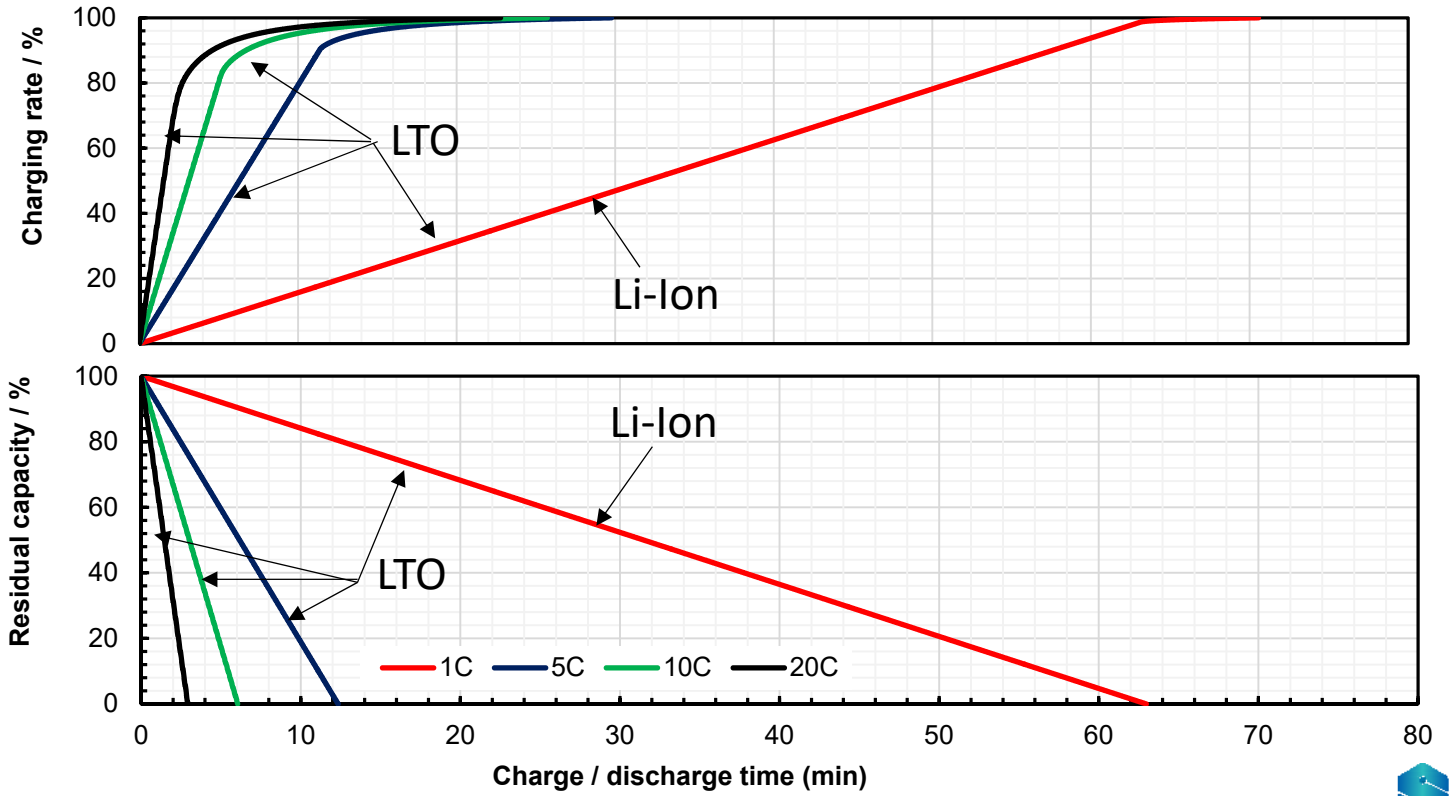
EDLCs can do 1,000,000 charge/ discharge cycles

Charge/Discharge Characteristics

Rapid charge/discharge is possible： Power density similar to EDLC.

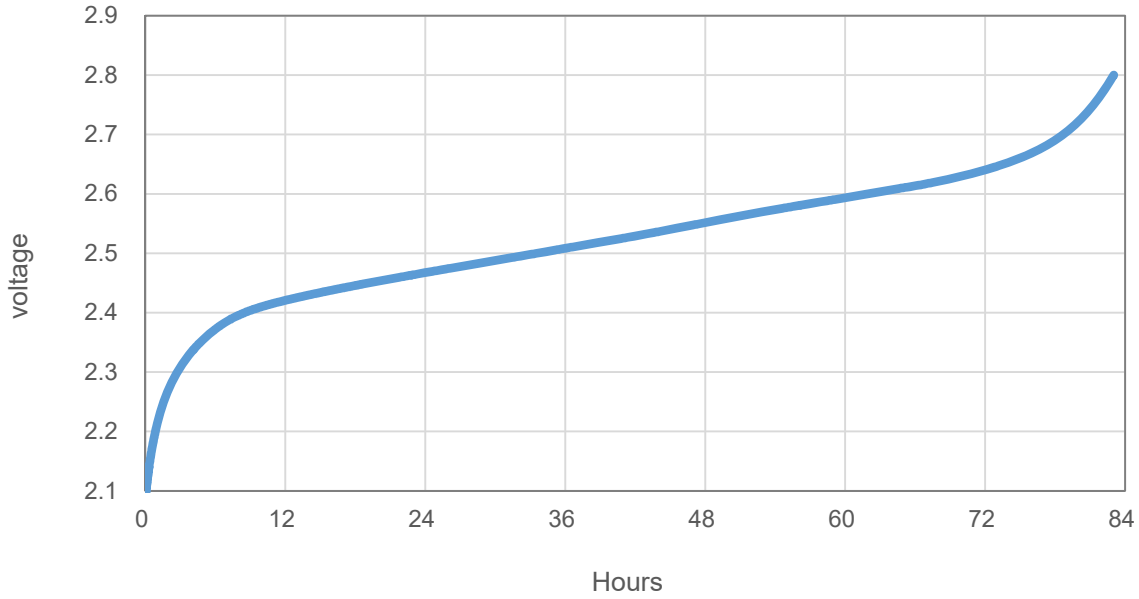
Charge

Discharge



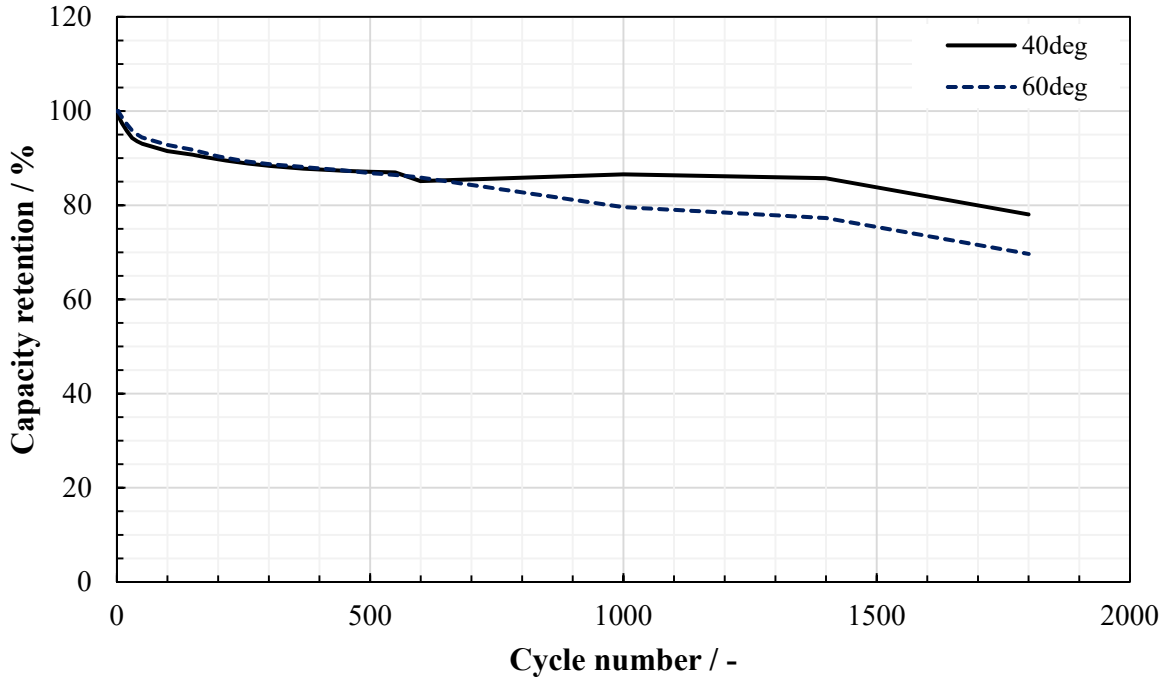
Low-current Charging

Test conditions
Charging current; 5µA (=0.014C)



EDLCs & Li-ion cannot be charged at this low of a charging current

Discharge to 0V (Depth of Discharge)



EDLC not damaged if discharged to 0V

Li-ion can become damaged

Overcharge

LTO battery

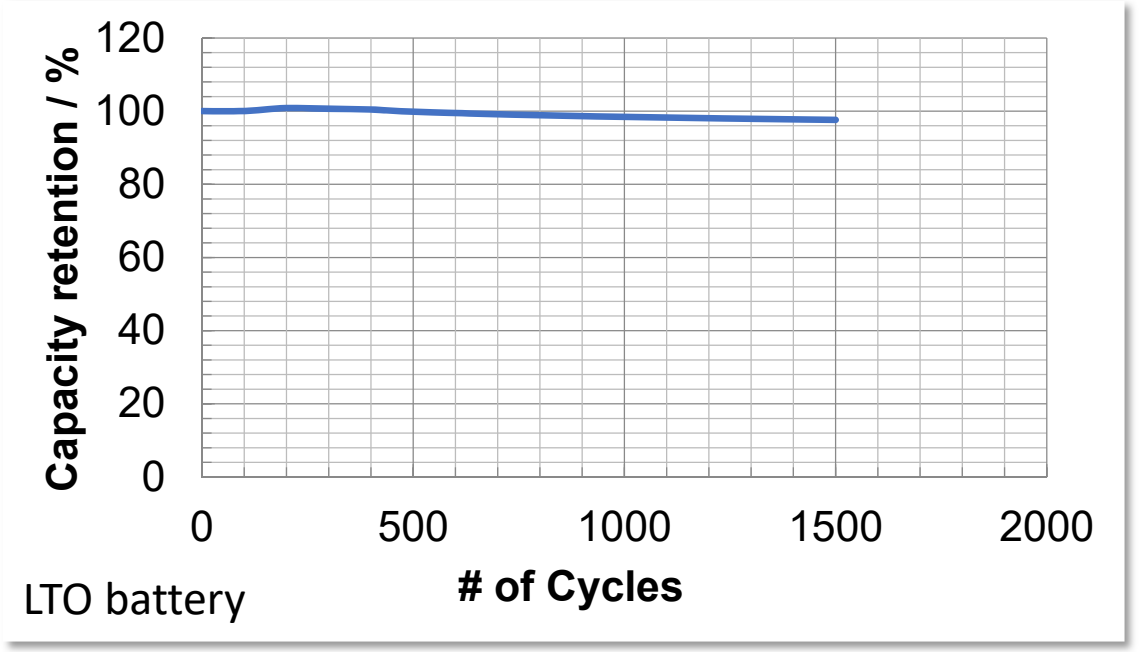
Can withstand up to 20% over rated voltage

EDLC

Can withstand up to SVDC (~8%)

Li-ion

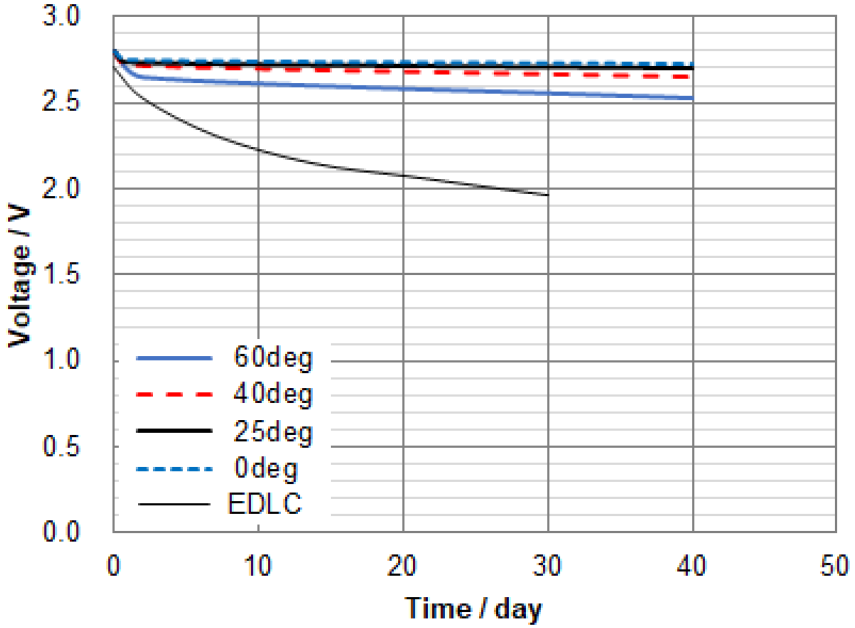
Can become damaged



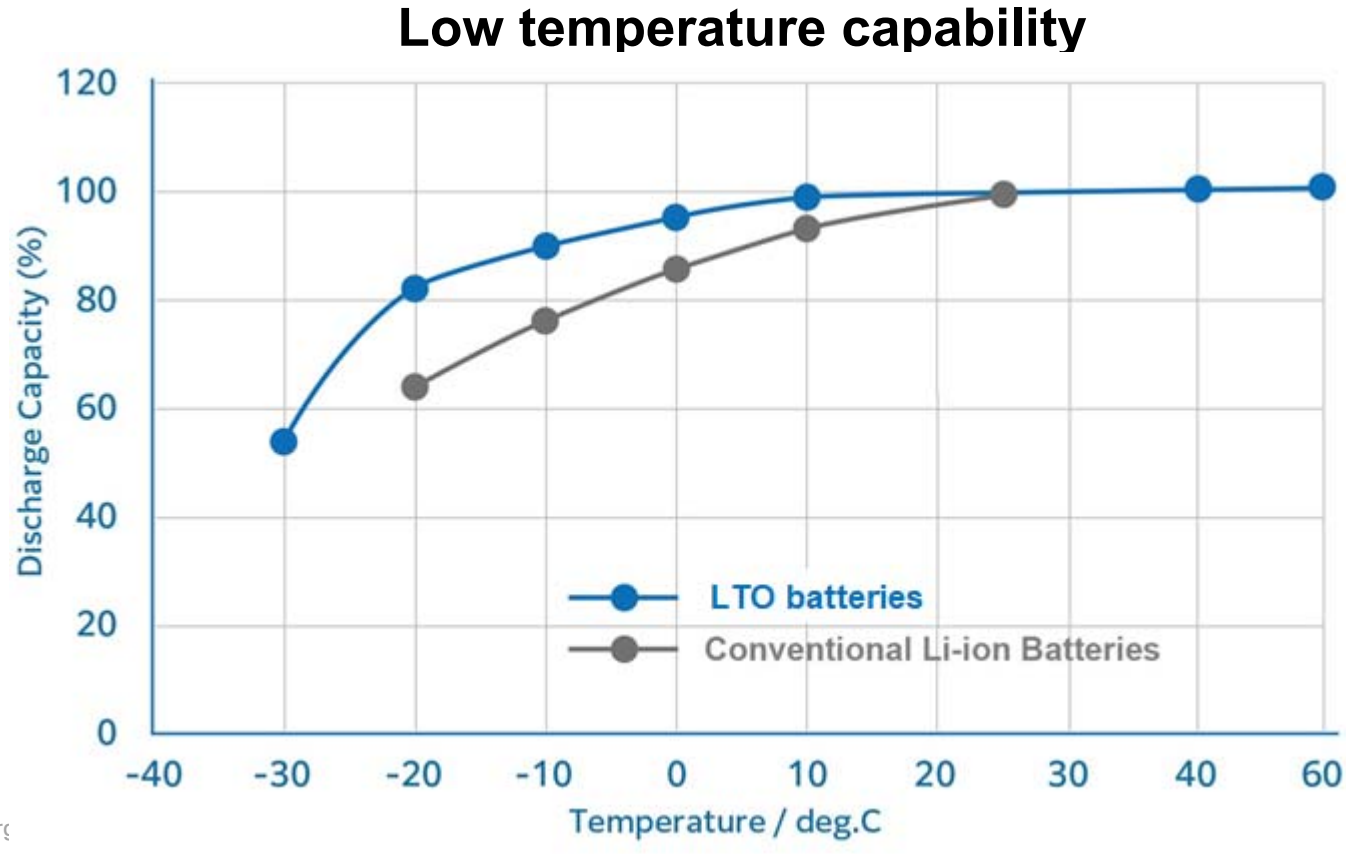
Self Discharge (EDLC vs LTO)

LTO self discharge superior to EDLC

	EDLC	LTO
Temp(°C)	25	25
Charge Voltage (VDC)	2.7	2.8
Time (days)	30	40
Final voltage (VDC)	1.97	2.66
ΔVDC	-27.04	-5

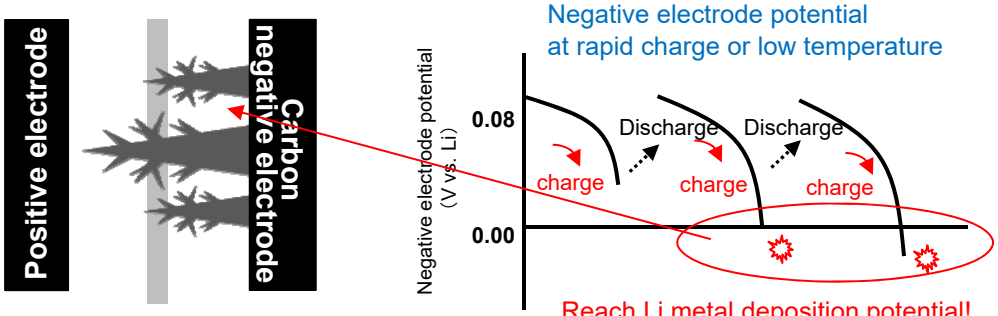


Temperature Characteristics



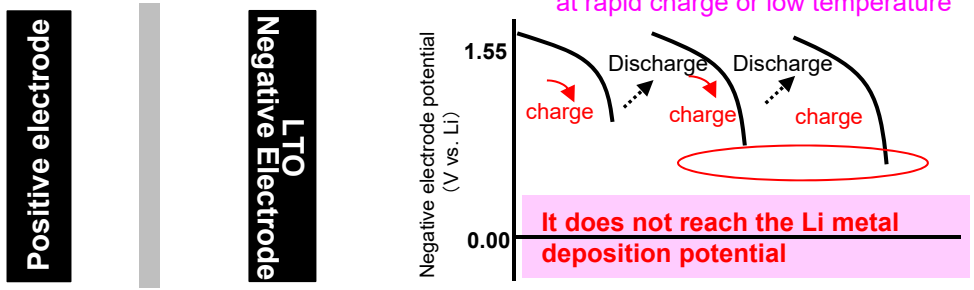
LTO No Lithium Deposition

General Lithium-Ion Batteries



In addition to the separator breaking during charging a short circuit may occur due to Li-Ion Metal deposition.

SLB Series (LTO)



Safety

Extremely low risk of **rupture or ignition** from internal short circuit (LTO).

No.	Test Item	Result (Li-ion)	Result (LTO)
1	Crushing	ignition	Extremely low risk of rupture or ignition
2	Nail penetration test	ignition	Extremely low risk of rupture or ignition
3	Blunt nail test	ignition	Extremely low risk of rupture or ignition
4	External short circuit	ignition	Extremely low risk of rupture or ignition
5	Over charge	ignition	Extremely low risk of rupture or ignition
6	Forced discharge	ignition	Extremely low risk of rupture or ignition

LTO Rechargeable Battery

Safe

Crush Test

Nail penetration test

JIS C 8712 test criteria

Comparison (EDLC vs Li-ion vs LTO)

	EDLC	Li-ion	LTO
# of cycles	>500k	<5k	20k+
Widest Temp Range (without de-rating)	-40/70°C	-20/60C	-30/80°C
Max Voltage	3.8V	3.7V	2.8V
Board-mountable (solderable)	Yes	no	Yes
Energy Density	Lowest	Highest	Middle
Safe to use	No fire	Fire	No fire
Abuse (over voltage/ Discharge)	SVDC	none	Yes
Low charging current (<1C)	None	None	0.01C
Discharge rate	1C	5C	20C (100C)

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LTO

Applications

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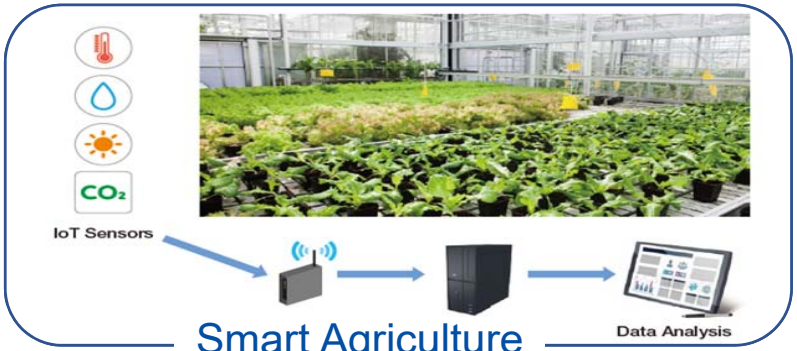
IoT Applications

Smart Home

Disaster Prevention

Smart Building

Smart Agriculture

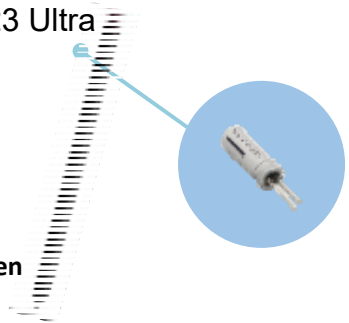


Stylus Pen – Samsung

Galaxy

Samsung Electronics Co., Ltd.

Galaxy Series S Pen
Galaxy Note 10 / Note 10+
Galaxy Note 20 / Note 20 Ultra
Galaxy S22 Ultra
Galaxy S23 Ultra



*

* Previous smartphone models used EDLC capacitors. The EDLC has been replaced with the Nichicon LTO battery in a φ3x7Lmm case size.

The key for Samsung adoption was the LTO ability to handle the increased power consumption that is required due to new S Pen functions.

Source: https://www.ifixit.com/Teardown/Samsung+Galaxy+Note10++5G+Teardown/125590

Maintenance Free Sensor Network

Ricoh
By
Nisshinbo

LTO battery is used by Ricoh for their environmental sensing device – EH Environmental Sensor D201/D202. Monitoring of refrigerated, high temperature and high humidity environments with wireless and maintenance-free.

- Long-life cycle batteries for maintenance-free operation!
- Rapid discharge (20C) for wireless (e.g. BLE) is possible!
- Low current charging (0.01C) with environmental power generation!
- Can be charged and discharged at low temperatures (-30°C)

Advantages of adopting LTO

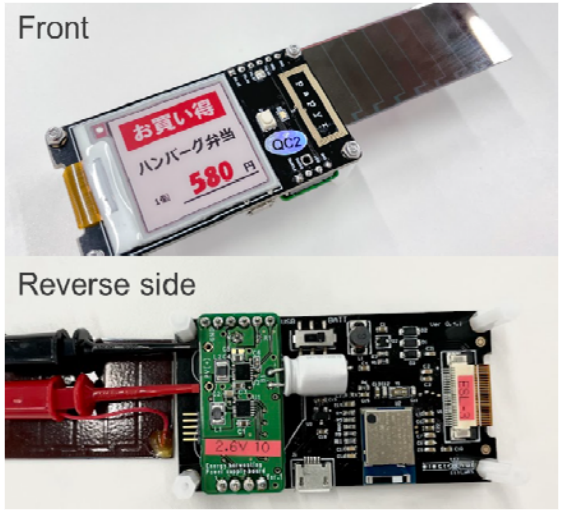
Advantages of installing environmental sensors:

- Visualization of the work environment comfort level.
- Significant reduction in record and management
- Cost reduction in product management

Electric Shelf Label - Prototype

Maintenance-free ESL

Electronic Shelf Tag, which is maintenance-free and can be updated frequently. Powered by in-store lighting and can be updated by using a PC or mobile device



NISSHINBO

Three advantages of maintenance-free electronic shelf tag.

Can be frequently rewritten because it is powered by solar cells
Electricity is generated by the light energy obtained from the store lighting, allowing you to eliminate the limitation on the number of rewrites available.

Power saving circuit and rechargeable battery for maintenance-free operation.
Driven by energy harvesting, no battery replacement is required!

BLE / NFC communication allow for management and promotional updates on the fly.
Rewriting the shelf tag data in the application and guiding the user to the link via NFC communication.

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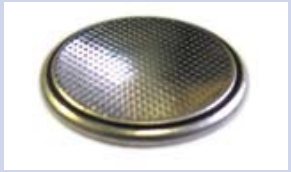
Small Lithium-Titanate Rechargeable Battery

Wound vs Coin Cell Battery

Specification	Coin cell	Through hole
Image		
Chemistry	Lithium nickel manganese cobalt dioxide	LTO
Capacity (mAh)	150	150
Voltage (VDC)	3.7	2.8
Dimensions (DxL)	24.5x4.3 mm	12.5x40 mm
Temp Range	-20°C to 80°C	-30°C to 60°C (80°C)
Charge rate	0.5C (~3 hours)	20C (3 minutes)
Discharge rate	0.2C	20C (100C)
Weight (grams)	5.4	9

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Booth 729

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