NGK INSULATORS

Chip-type ceramic rechargeable batteries

EnerCera®

Li-ion battery with semi-solid state battery technology

The innovation in IoT device power supply.

Realizing high heat-resistance for automotive and industrial applications.

Technological Background

The 1990s brought an upswing in rechargeable Li-ion battery products, which featured higher energy density and power output in comparison to their predecessors. This has led to the realization and spread of smartphones and other wearable devices. Since then, while there have been no paradigm-shifting developments in the field of rechargeable batteries, Li-ion batteries will continue to be utilized in next-generation technology that requires larger-scale batteries such as electric vehicles.
On the other hand, the application of Li-ion batteries in ultra-small devices, for instance in IoT solutions, has seen limited development. This is a bottleneck, the reasons for which include low heat resistance and durability, and the fact that Li-ion batteries can not be installed as an on-board electronic component. In other words, they are difficult to be installed together with other components on the circuit board through reflow soldering, which requires operation in temperatures from -40°C~85°C as well as a life expectancy of over 10 years like other electronic components. This leads to IoT devices relying on primary batteries that have to be replaced, effectively limiting market expansion.

Features

To respond to these needs, NGK Insulators (NGK) has developed the EnerCera series. EnerCera is a Li-ion rechargeable battery with NGK Insulators (NGK) original Crystal Oriented Ceramic Plate as electrodes. EnerCera has two types: “EnerCera Pouch”, an ultra-thin and bendable cell, 0.45 mm thick, for embedding in an IC card, and “EnerCera Coin”, a coin type cell that is 1 mm to 2 mm thick, for mounting on a circuit board. EnerCera’s defining characteristic is its make achieved by adding a small amount of liquid electrolyte to its all-ceramic stacked monolithic body with electrodes and separator, allowing for higher power, heat resistance and durability. NGK defines these unique batteries as “Semi-Solid State Battery”.

Comparison of cross-sectional positive electrode structures

EnerCera Coin	Conventional Lithium-ion Battery
Original technology **Semi-solid state battery** Unique structure, achieved by adding a small amount of liquid electrolyte to its all-ceramic stacked monolithic body **Monolithic ceramic body guaranteeing high heat-resistance** — Positive plate layer — Separator layer — Negative plate layer Formed only with active material by sintering Crystallized ceramic electrode plate Liquid electrolyte ※No binder and conductive aid **High-speed conduction of lithium-ions and electrons**	**Powder-coating type battery** Formed by bonding the active material powder and conductive aid with a binder Binding force decreases under high temperature Liquid electrolyte Conductive Aid Binder
Unique features ☑ High energy density ☑ High heat-resistance ☑ Long lifespan ☑ Low internal resistance	● Limited improvement in energy density ● Low heat-resistance ● High internal resistance

The above strengths in its inherent design allows the EnerCera series to provide practical solutions to pressing issues in the industry. The EnerCera Coin possesses a high discharge current property in an ultra-small frame, allowing it to be used in applications requiring several 10mA such as sensor operation and wireless communications. In addition, it can be mounted to circuit boards using reflow soldering, allowing for operation in temperatures from -40°C~85°C as well as a life expectancy of over 10 years. This allows it to be utilized in the exact same availability as electrical components such as capacitors. It is thus the world's first onboard-type battery, responding to application needs requiring heat-resistance, including in automotive and industrial sectors.

Comparison of small-size power storage devices

		Liquid lithium-ion Battery (Coin type)	Solid-state battery	EnerCera Coin: Semi-solid state battery	Super capacitor
Battery structure	Electrolyte	Organic liquid electrolyte	Solid electrolyte	Organic liquid electrolyte	Organic liquid electrolyte
	Electrode	Powder coating of active material	Mixed ceramics (Active material + solid electrolyte)	Active material ceramics (+ Adding of organic electrolytes)	Powder coating of active carbon
Performance	Energy density	✓ (good)	× (very poor)	✓✓ (very good)	× (very poor)
	Self-discharge	✓ (good)	✓ (good)	✓ (good)	× (very poor)
	Capacity (High-current electrical discharge)	— (poor)	× (very poor)	✓ (good)	✓✓ (very good)
Durability heat-resistance	Lifespan	— (poor)	✓ (good)	✓ (good) ~10 years	✓ (good) ~10 years
	Heat-resistance	× (very poor)	✓ (good)	✓ (good) ~85°C	✓ (good) ~85°C
	Installation by solder reflow	× (very poor)	✓ (good)	✓ (good)	✓ (good)

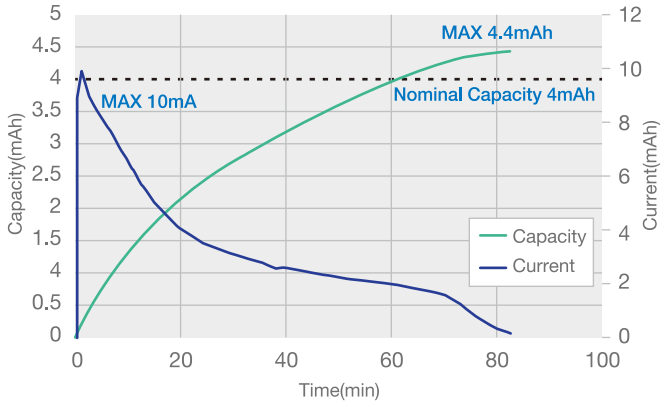
Model featuring heat-resistance of up to 100°C and 125°C under development

Specifications

The EnerCera Coin, as a “Semi-Solid State Battery'' with high heat resistance, has the ability to maintain at least 95% of its capacity after 1,000 charge-discharge cycles, and 90% of capacity after 1,000 hours storage at 100% SOC, when tested at 85 degrees Celsius. Furthermore, due its CV (Constant Voltage)-charging capability, there is no need for a power IC to control the charging current. There are two types, the ET-1210C-H featuring a 12mm diameter and 1.0mm thickness, and the ET2016C-H with a 20mm diameter and 1.6mm thickness. The ET2016C-H has a nominal capacity of 20mAh (when charging at 2.7V), an energy density of 90mWh/cc and a peak discharge current of 45mA.

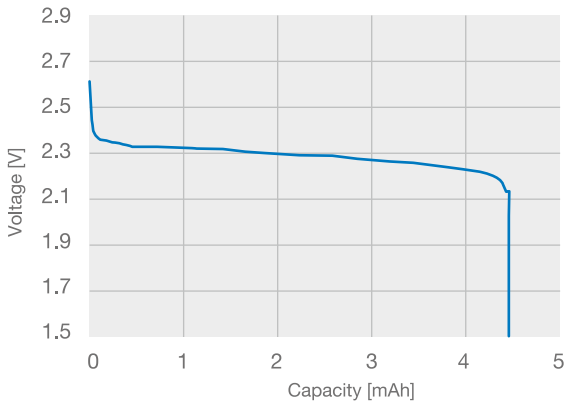
Charge characteristics ET1210C-H

Charge CV : 2.7V (Cut-off 0.05C)
※1C=4mA
Temp.25°C



Discharge characteristics ET1210C-H

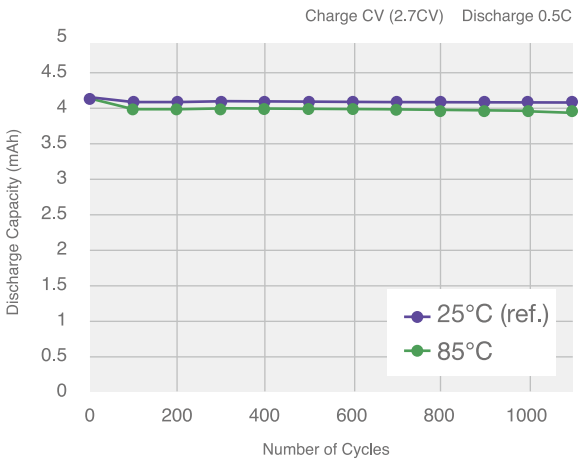
Discharge CC : 0.2C (Cut-Off 1.5V)



High Heat-Resistance Capacity ET1210C-H

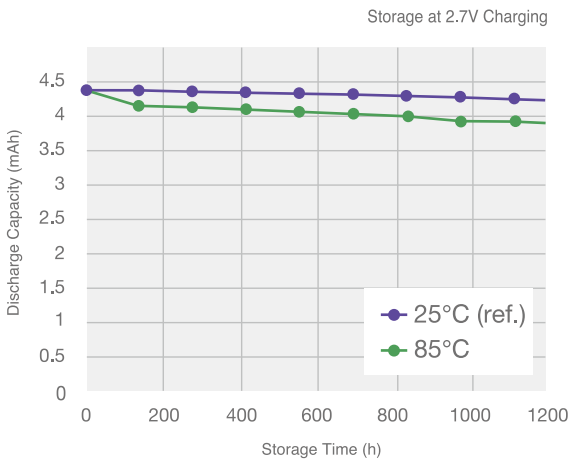
Charge/Discharge Cycle

Charge CV (2.7CV) Discharge 0.5C



High-temperature Storage Test

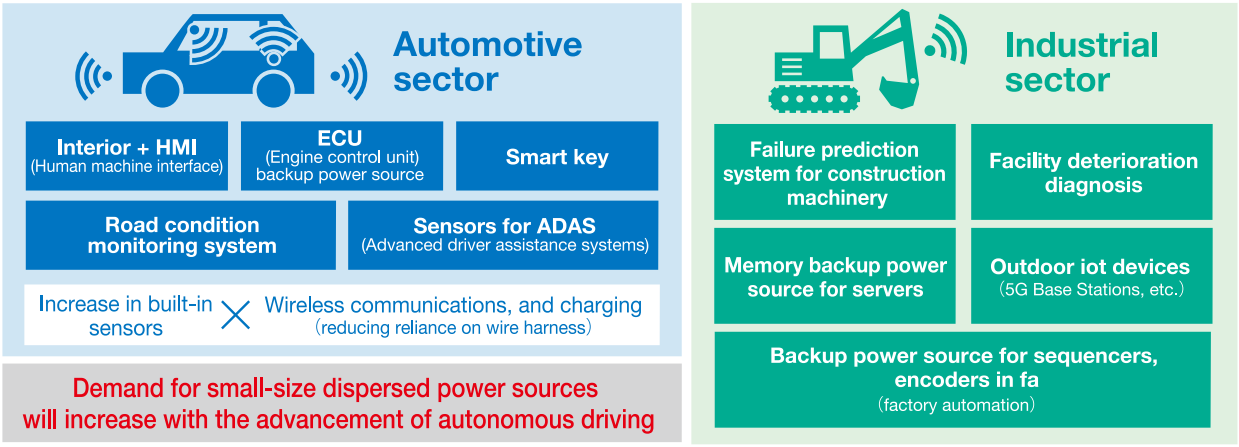
Storage at 2.7V Charging



Potential Demand for EnerCera

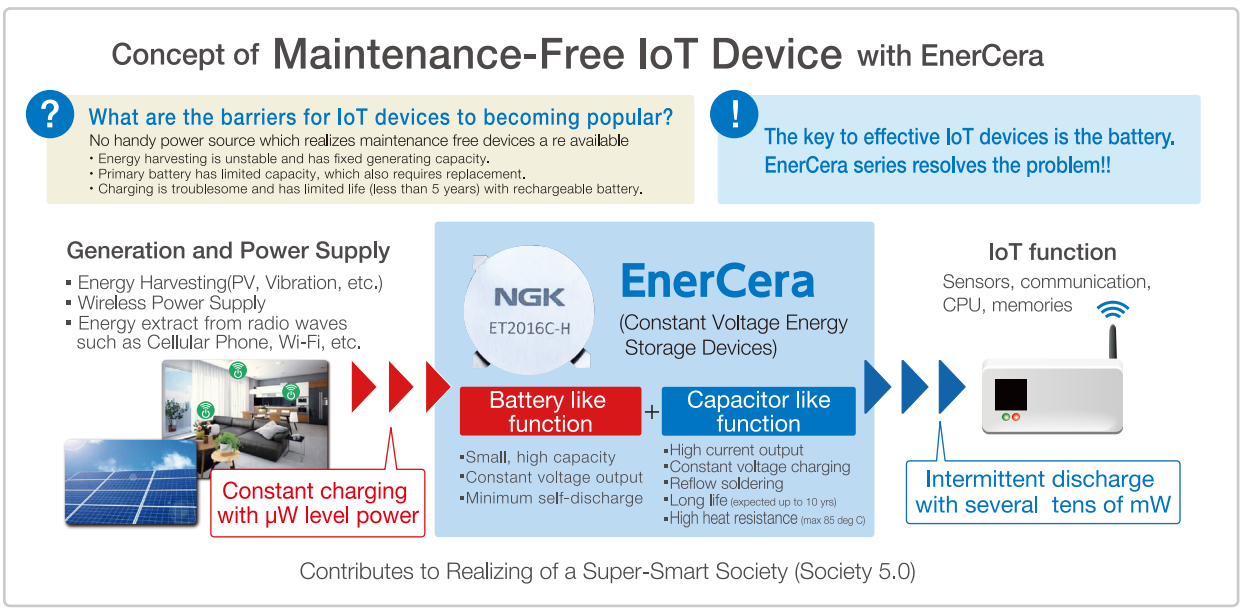
The EnerCera Coin is set to be adopted as a power source in a variety of small-size IoT devices, especially in applications requiring high heat-resistance, such as the automotive and manufacturing industries. In the automotive sector specifically, the series is already under consideration for use as a power source for smart keys, tire sensors, interior and HMI (Human Machine Interface), as well as a backup power source for ECUs. In the future, as progress in autonomous driving technologies leads to an increase in built-in sensors, wireless communication and charging (i.e. the spread of wire harnessless) devices in the automobile will multiply, resulting in an increase in demand for small-size dispersion type power sources. In the industrial sector, potential applications including as a high-reliability backup power supply system for FA devices and servers, among others, are currently being examined.
Finally, installation in the engine room of a car and around high temperature semiconductor substrates is another immediate goal. To that end, NGK is currently developing a line-up that can realize heat-resistance at 105°C and 125°C in the near future.

Potential applications in the automotive and industrial sectors using the high heat-resistance EnerCera line



Potential as a maintenance-free power supply solution for IoT devices

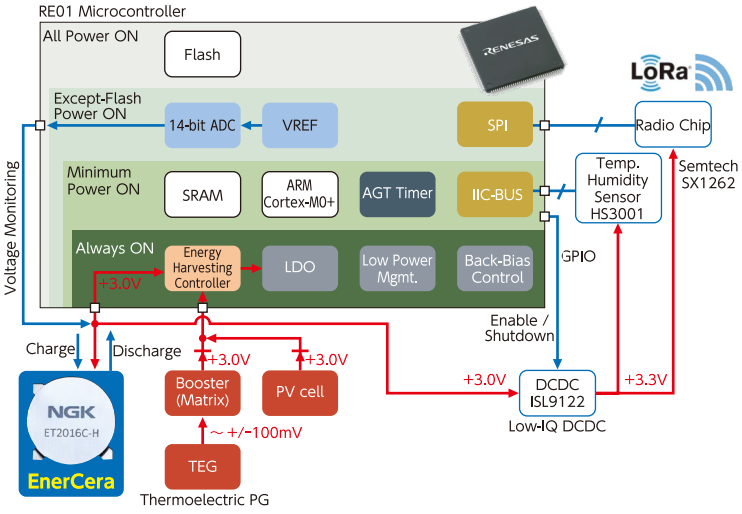
Energy harvesting is defined as gathering forms of energy that are generally thrown away, such as solar power, thermal energy, wind energy, salinity gradients, and kinetic energy, but re-use them. While its potential has been widely discussed in recent years, the needs for power in communications between devices have made its realization difficult by its small current. EnerCera has special characteristics to make it uniquely suited for energy harvesting. In addition to the feature to store small amounts of electrical current, acting as a rechargeable battery, it can also release large current when needed, acting similar to capacitors. This unique feature allows EnerCera to be used as a maintenance-free power supply solution in an ultra-small/ultra-thin package.
At CES 2020, to show the potential of maintenance-free power solutions for IoT devices, NGK collaborated with other companies to showcase numerous applications using EnerCera. For example, the company introduced a wireless agriculture monitoring system based on energy harvesting together with Renesas Corporation. With regards to the efficiency of the battery used, Renesas gave high praise: “We have tried a multitude of products, but EnerCera outclasses them all.” NGK is also advancing technology to increase power generation through energy harvesting by using the EnerCera Pouch in a collaborative project with Ricoh Company. Furthermore, together with Ricoh Electronics Devices, NGK is working on a maintenance-free environmental sensor based on Indoor Photovoltaics.
The future of agriculture is one where managing a field and its crops through IoT devices that no longer require the changing or replacing of batteries, thus lowering maintenance costs, is possible. In the field of wireless power supply, NGK has already announced partnerships with leading companies such as Ossia and Powercast, and is expected to develop maintenance-free wireless power solutions.



Maintenace-Free Wireless Soil Monitor System with EnerCera Coin

Ultra low-power consumption IoT system with LPWA communication and Energy Harvester by EnerCera

Provided by RENESAS ELECTRONICS AMERICA INC.

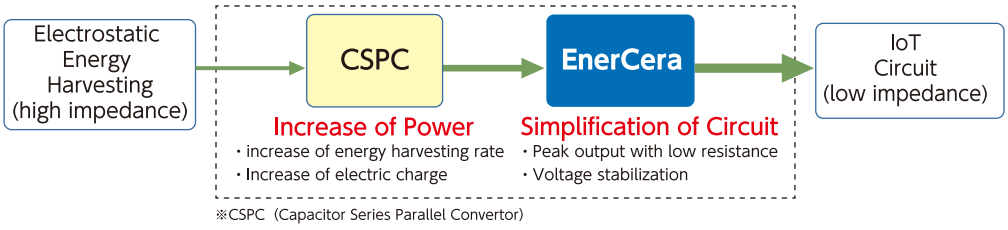


Product Prototype Image

Power Source for IoT Devices:Capacitor Series Parallel Converter(CSPC)

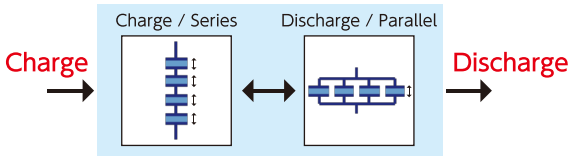
Simple and high efficiency power system.

Provided by RICOH COMPANY, LTD.



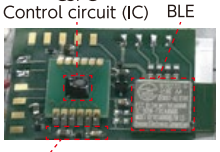
※CSPC (Capacitor Series Parallel Convertor)

Concept of CSPC (Consists of 4 capacitors)



• Operation : Automatic switching between Series and Parallel
• Effect : Increase of energy harvesting rate

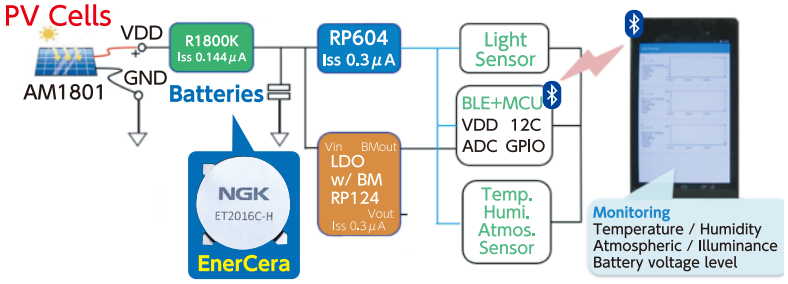
■ BLE with piezoelectric element



Maintenance-Free Environment Sensor with EnerCera Coin

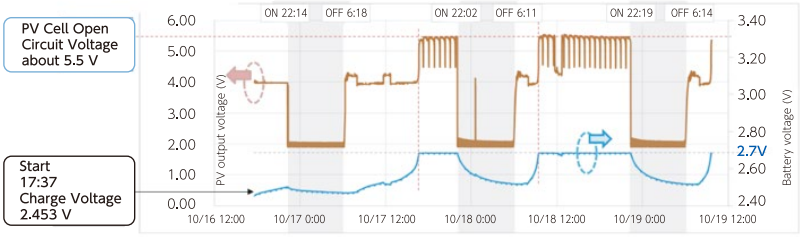
Continuous sensing and BLE communication by Energy Harvesting (Indoor photovoltaics) and EnerCera

Provided by RICOH ELECTRONIC DEVICES CO., LTD.



Tested results with…
・Indoor room light
・Monitoring every 5 sec

Demonstrates sensing and BLE with energy harvesting (room light)
Generated Capacity > Consumed Power

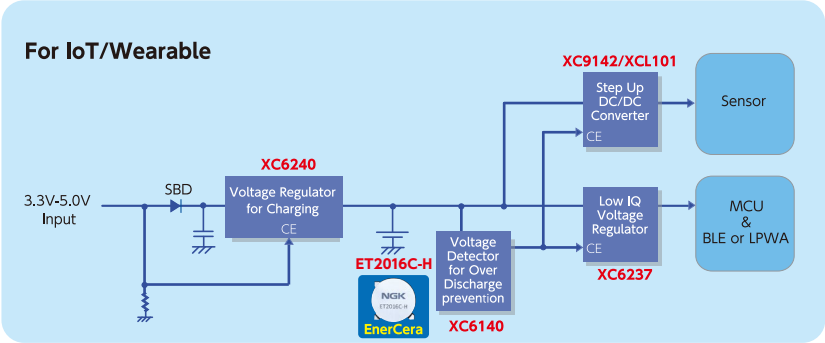


Commercialization Plan

Presently, samples of the EnerCera Coin have been shipped to over 100 companies worldwide, to high praise. In the near future, mass production is scheduled to commence.
In cooperation with TOREX Semiconductors, NGK has prepared Evaluation Boards and Modules, and are expecting the adoption of the EnerCera Coin in a wide variety of IoT devices.

EnerCera® Module with TOREX Power Management ICs

EnerCera Coin Module
with TOREX Power Management ICs
High capacity battery integrated
with LDO for charging: XC6240,RESET
for over discharge prevention XC6140
and Step up Micro DC/DC:XCL101



Specification

Model number	SMD type		High capacity type [Under development]	
	ET1210C-H	ET2016C-H	ET920C	ET1616C
Dimension	Φ12×1.0㎜	Φ20×1.6㎜	Φ9×2.0㎜	Φ16×1.6㎜
Nominal capacity	9 mWh (4 mAh)	46 mWh (20 mAh)	25 mWh (11 mAh)	51 mWh (22mAh)
Energy density	80 mWh/cc	90 mWh/cc	190mWh/cc	150mWh/cc
Nominal voltage	2.3V			
Peak discharge current *	20 mA	50 mA	20mA	60mA
Operating temp.	-40～85 °C Model featuring heat-resistance of up to 125°C under development		-40～60 °C	
Mounting	Reflow soldering		Battery folder	

* Maximum Current within 0.5V drop for 1 sec. (@25°C)

About leading ceramics manufacturer NGK

NGK Insulators is the world's largest manufacturer of electrical insulators and has developed numerous products in the electronics and automotive sectors with top shares globally. The company has recently celebrated its 100th anniversary. NGK is also the world's leading manufacturer succeeding in the commercialization of large-capacity energy storage systems (NAS batteries), which has overturned the conventional wisdom that power cannot be stored. These have been installed in over 200 different locations worldwide.

contacts

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