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1 Constitution and Structure

1.1 Constitution Lithium ion secondary battery

Lithium ion secondary batteries charge/discharge electricity by lithium ion absorption and desorption between active materials of positive electrode and negative electrode.

Lithium ion secondary battery consists of positive electrodes and negative electrodes Binder, electrolyte, separators, Outer package and Tab which contributes to conduction path from electrode to outside. The positive electrodes and negative electrodes is consist of activate materials, Electrode collector foil, conductive assistant, the electrolyte consists of lithium salt and organic solvent.

Battery voltage is determined by the reaction potential difference between active materials of positive and negative electrodes at the time of Li-ion absorption/desorption (Fig.1).

Therefore, the using energy is large when the positive activate materials of high reaction potential have high reaction potential.

The higher the reaction potential of the positive electrode active material and the lower the reaction potential of the negative electrode active material, the larger the reaction potential difference between the positive and negative electrode, and the larger energy that can be used. But, the higher the reaction potential of the positive electrode, the electrolyte oxide-decomposition is likely occurred on the surface activate material of electrode. And the lower the reaction potential of the negative electrode, electrolyte reduction-decomposition is also likely occurred on the surface activate material of electrode, the battery degradation will be accelerated.

As the Lithium ion transport medium between positive activate material and the negative activate material the electrolyte solution which the lithium salt is dissolved in organic solvent is used. The organic solvent is designed in considering that the electrolyte is easily dissociated and the electrolyte solution is hardly occurred oxide and reduction-decomposition (potential window is wide) for high reliability. Ensure the lithium ion transportation path between the positive electrode and negative electrode,
The porous material called separator is placed between positive and negative electrode because it is necessary to ensure lithium ion the transportation path between positive and negative electrode and prevent from short circuit by physical collision.

The thinner and higher porosity separator, the high output lithium ion secondary battery will be realized because of effective lithium ion transportation,

However the thinner and the higher porosity, it is necessary to be careful that the short circuit by physical collision will be easily occurred.
1.2 Electrode activate material of CT series

As cathode electrode active material of a lithium ion secondary battery, lithium cobalt oxide, lithium iron phosphate, lithium manganates and so on are known. And, Graphite, amorphous carbon, lithium titanate, and so on are known as negative electrode active materials. The CT series uses lithium cobalt oxide as cathode electrode active material and lithium titanate as the anode electrode active material. The charge / discharge chemical reaction is as shown in Fig.2.

**Positive electrode**

\[
\text{LiCoO}_2 \xrightarrow{\text{Charge}} \text{Li}_{1-x}\text{CoO}_2 + x\text{Li}^+ + xe^- \\
\text{LiCoO}_2 \xleftarrow{\text{Discharge}} \text{Li}_{1-x}\text{CoO}_2 + x\text{Li}^+ + xe^- 
\]

**Negative electrode**

\[
\text{Li}_4\text{Ti}_5\text{O}_{12} + x\text{Li}^+ + xe^- \xrightarrow{\text{Charge}} \text{Li}_{4+x}\text{Ti}_5\text{O}_{12} \\
\text{Li}_4\text{Ti}_5\text{O}_{12} + x\text{Li}^+ + xe^- \xleftarrow{\text{Discharge}} \text{Li}_{4+x}\text{Ti}_5\text{O}_{12} 
\]

**All reaction**

\[
\text{LiCoO}_2 + \text{Li}_4\text{Ti}_5\text{O}_{12} \xrightarrow{\text{Charge}} \text{Li}_{1-x}\text{CoO}_2 + \text{Li}_{4+x}\text{Ti}_5\text{O}_{12} \\
\text{LiCoO}_2 + \text{Li}_4\text{Ti}_5\text{O}_{12} \xleftarrow{\text{Discharge}} \text{Li}_{1-x}\text{CoO}_2 + \text{Li}_{4+x}\text{Ti}_5\text{O}_{12} 
\]

Fig. 2  Chemical reaction formula

On the surface of the anode electrode active material, decomposition products of lithium ions and organic solvents called SEI (Solid electrolyte interface) films are formed. Lithium ions solvated in the electrolyte during charging are desolvated by the SEI film and occluded in the negative electrode active material (Fig. 3). However, thicker SEI coatings make it difficult for lithium ions to pass through, which increases the internal resistance of the battery. One of the factors affecting the thickness of the SEI film is the reaction potential of the anode electrode that absorbs and releases lithium ions. The lower the reaction potential, the thicker the film tends to be formed.

In a general lithium ion secondary battery, a carbon material called graphite is used as anode electrode active material, and its reaction potential is 0.1 V vs. Li / Li +. On the other hand, the lithium titanate used in the CT series has a high reaction potential of 1.55V vs. Li / Li +, and is excellent in high-temperature durability and charge-discharge cycle characteristics because the SEI film is not easily thickened.

In addition, since lithium titanate is a highly safe active material, the CT series is a highly safe battery.
1.3 CT series structure

For the cathode electrode and the anode electrode, an electrode mixture layer composed of a positive electrode, a negative electrode active material, a binder, and a conductive additive is formed on an aluminum current collector foil. The wound element inside the battery has a wound structure with a separator interposed between the cathode and anode electrodes and the electrode. The external terminals are welded to aluminum tabs that are conductively connected to the electrodes (Fig.4) The internal element and electrolyte are placed in an aluminum can and sealed with rubber.

Fig. 4 Battery internal element structure
2 Characteristic Overview

2.1 Characteristic Overview

Table 1 shows the characteristics and Fig. 5 shows the outline of the shape.

### Table 1 Characteristics Overview

<table>
<thead>
<tr>
<th>Items</th>
<th>Rated Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>3mAh (+/-20%)</td>
</tr>
<tr>
<td>ESR @1kHz</td>
<td>1000 mΩ (max)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Voltage</td>
<td>2.3V</td>
</tr>
<tr>
<td>Lower limit discharge voltage</td>
<td>1.8V</td>
</tr>
<tr>
<td>Upper limit discharge voltage</td>
<td>2.7V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. continuous discharge current</td>
<td>30mA</td>
</tr>
<tr>
<td>Maximum charging current</td>
<td>150mA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature range</td>
<td>-20℃～+70℃</td>
</tr>
<tr>
<td>Storage temperature range</td>
<td>-20℃～+70℃</td>
</tr>
</tbody>
</table>

![Diagram of battery dimensions](image)

|| φD| 4.0 ±0.0 mm|
|---|------------------|
| L | 12.0 ±0.5 mm     |
| φd| 0.45 ±0.05 mm    |
| F | 1.5±0.5 (Dimensions of terminal root) |

Fig. 5  Shape and its dimensions

2.2 Measuring method, Definition of terminology

◇ Standard capacity measurement method :

[Preprocessing]  Constant current discharge to 1.8V at 1CA and pause for 30 seconds.

After constant current charging to 2.7 V at 1 CA, constant voltage charging at 2.7 V is performed, and charging ends when the charging current reaches 0.05 CA or 30 minutes have passed.

[Measurement] Constant discharge current at 1CA and discharge until 1.8V at 23 ± 2 ℃.

◇ Current Unit CA : Indicates the magnitude of the current when charging and discharging the battery.

The current value that can be completely discharged in one hour when the battery is discharged from the fully charged state is 1 CA. The capacity of CT04120 is 3mAh, so 1CA is 3mA, 10CA is 30mA, and 0.05CA is 0.15mA

◇ Standard ESR measurement method :

[Preprocessing]  After constant current charging to 2.7 V at 1 CA, constant voltage charging at 2.7 V is performed, and charging ends when the charging current reaches 0.05 CA or 30 minutes have passed.

[Measurement] AC current methods  Measurement frequency:1kHz  atmosphere:23±2℃

◇ Nominal voltage : Estimated voltage between terminals when the battery is used under normal conditions
◇Lower limit discharge voltage: Lower limit voltage when discharging battery.
◇Upper limit charging voltage: Upper limit voltage when charging the battery
3  Merit and Applications

3.1  Principle Merit

① Quick charge characteristics
High-rate charging (10C) is possible, and charging IC is not required.

② Excellent discharge characteristics
Continuous discharge with a maximum discharge rate of 10C is possible. In addition, since the internal resistance is low and the voltage drop is small, stable discharge is possible even under a large peak load or low temperature.

② Long cycle life
Charge (capacity) recovery rate keeps over 80% even after 5000 cycles.

③ High Security
No thermal runaway occurs because of using chemically stable lithium titan.

3.2  Principle Applications

① Small power equipment
Applications: Electric pen, wearable Equipment
- Quick charge with High rate charge (10C) is available
- Constant voltage charge is available
- High safety and small weight saving
- Able to use many times due to long cycle life

② Backup Power Supply
Applications: Handy Terminal/ barcode reader/ POS / RTC Back up etc.
- High output, long time backup possible
- Constant voltage charge is available
- Charge control IC is not required
- Resistant to over discharge

③ Energy Harvesting System
Applications: Solar battery charger equipment • Sensor node with wireless sensor network in combination with micro and macro energy harvesting systems
- Chargeable in wild rate range (μA～)
- Long operating time due to low leakage current
- High Power output is available
- Resistant to over discharge
- Operation temperature is wide
4 Use method and characteristics

4.1 Charge method

In addition to CC-CV charging, which is a general lithium-ion secondary battery charging method, charging starts with constant current control, and after reaching the charging voltage, transitions to constant voltage control. Charging using only voltage control (CV charging) is also possible. Therefore, charging circuit can be configured simply by combining USB or alkaline batteries with a DC/DC converter. (This usage way is not guaranteed.) When using the battery with constant voltage charging, use it with care in a high temperature environment, as current exceeding the maximum charging current (150 mA) may flow continuously and cause a failure.

4.2 Charge Voltage and Charge Rate

Fig. 6 shows the relationship between charging voltage and charging capacity. The lower the charging voltage, the lower the available capacity. However, there is a merit that deterioration is suppressed as the battery is used at a lower charging voltage. Therefore, it is necessary to study and set the optimal charging voltage for each device.

4.3 Discharge method

The lower the voltage at which discharge ends, the faster the deterioration when charging and discharging is repeated. Therefore, it is necessary to set the voltage at which discharge ends in consideration of deterioration. In the CT series, the discharge voltage at the lower limit of 1.8V that can fully exhibit the characteristics is set to 1.8V.

However, when the voltage is set to 1.8 V or less, the deterioration does not accelerate rapidly, and details will be described in the following chapter (5.2.4). There is no significant deterioration even if the battery is discharged to the maximum (* If the discharge current is large, the battery will deteriorate significantly).

Depending on the device, it may be possible to simplify the circuit etc. by devising the voltage and method of terminating discharge. Fig. 7 shows a graph of discharge time and voltage change when CT04120 is discharged at 1CA, 5CA, and 10CA. Fig. 8 shows the ratio of the capacity when discharging at each discharge current to the capacity when discharging at 1CA discharge current. Due to the internal resistance of the battery, the higher the discharge current, the bigger the voltage drop of the battery and the smaller the available capacity.
4.4 Temperature Dependence

4.4.1 Temperature dependence of charging characteristics

The moving speed of lithium ions in the electrolyte contained in the battery and the resistance for inserting and extracting lithium ions with the cathode electrode active material and the anode electrode active material have temperature dependence. The lower the temperature, the higher the internal resistance of the batteries affected by them tends to be. Therefore, the charge and discharge characteristics differ depending on the used temperature. Fig.9 shows the change over time of the charging rate when CC-CV charging the CT04120 at -20 °C, 0 °C, 25 °C, 45 °C, and 70 °C with a charging current of 1CA and a voltage of 2.7V. When the temperature is as low as -20 °C, the internal resistance of the battery rises greatly, and the time until the battery is fully charged becomes longer.

4.4.2 Temperature dependence of discharge characteristics

In the case of discharging, the lower the temperature, the higher the internal resistance of the battery. Therefore, the voltage drop of the battery increases even at the same discharge current. Since the lower limit discharge voltage 1.8V is reached quickly, the available discharge capacity is reduced.

Fig.10 shows the ratio of the discharge capacity when discharging at -20 °C, 0 °C, 45 °C, and 70 °C
to the discharging capacity when discharging CT04120 to 1 CA, until 1.8V at 25 °C.

Fig.10 Relationship between temperature and discharge capacity

4.5 Reliability

Lithium titanate, which has a higher reaction potential for absorbing and releasing lithium ions than graphite, is used as the anode electrode active material in CT series. Since the SEI film is not easily formed thick, it has low resistance and shows excellent characteristics of high temperature durability and charge / discharge cycle characteristics.

4.5.1 Storage characteristic (charged)

Storage characteristic (Full charged CT04120 before testing) expresses the retention capacity after CT04120 for several months at each temperature without being connected load. After charging, the retention capacity that is maintained during storage is called the retention capacity. The bigger the self-discharge of the battery, the faster it drops. In addition, the capacity measured by the standard capacity measurement method after charging is called the recovery capacity, which indicates the degree of battery deterioration. Fig.11 shows the transition of the ratio of the retention capacity to the initial value when the CT04120 is fully charged and left at 0, 25, 45, and 70 °C, and the transition of the recovery capacity to the initial value is shown in Fig.12. The higher the temperature, the lower the retention capacity (self-discharge) and the faster the recovery capacity (battery degradation).

Fig. 11 Retention capacity transitions  Fig.22 Recovery capacity transitions
4.5.2 Storage characteristic (Float)

Float characteristics are the reliability characteristics of a battery when voltage is continuously applied to the battery. The recovery capacity measured by the standard capacity measurement method after continuous application of voltage indicates the degree of battery deterioration. For example, in backup applications, voltage is often applied to the battery while the device is operating, and the result of the float test is an index for estimating the deterioration and life of the battery when incorporated in the device.

Fig. 13 shows the transition of the ratio of the recovery capacity to the initial value when the voltage of 2.7V is continuously applied to the CT04120 at 0 °C, 25 °C, and 70 °C. After 1000 hours, no significant deterioration was observed at 0 °C and 25 °C, and it was about 70% even at 70 °C. However, no significant deterioration is found at 25 °C for 1000 hours, but the deterioration is definitely progressing. If the product to be used has a long product life, it is important to consider the deterioration.

![Fig. 3  Float test of Recovery capacity ratio](image)

4.5.3 The charge-discharge cycle characteristics

The charge-discharge cycle characteristics are the reliability characteristics of the battery after repeated charge-discharge. The recovery capacity measured by the standard capacity measurement method after repeated charge-discharge cycles indicates the degree of battery deterioration.

Fig. 14 shows the transition of the recovery capacity when the CT04120 is cycled at 25 °C. Even with constant voltage charging without current control, the recovery capacity after 5000 cycles is more than 80% of the initial value.

![Fig.4 Constant voltage charge / discharge cycle recovery capacity (%)](image)
5 Comparison another storage device

5.1 Merit in case of comparison between Supercapacitor and CT series

5.1.1 High energy density

CT04120 has 40 times higher energy density than same size supercapacitor (Murata’s product). Because of this ultra-high energy density, CT04120 can run devices for a longer time than a supercapacitor.

5.1.2 Hard to lose energy during storage

Lithium-ion secondary batteries absorb and release lithium ions as an active material through an electrochemical reaction, and retain energy in a state where a chemical change has occurred, resulting in less self-discharge than Super capacitors. In addition, since lithium titanate is used for the negative electrode, it has the characteristic of high capacity retention especially at high temperatures. When the CT04120 and Super capacitor that have been fully charged are left at 25 °C, the retention capacity is shown in Fig.15 as a transition of the ratio to the capacity before the test.

Since the electric double layer capacitor has a large self-discharge, the retention capacity ratio drops to 20% when left for 30 days. On the other hand, the CT04120 has a retention capacity ratio of about 85% when left for 90 days, which is a low value of about 200 nA when converted to leakage current. Even if the battery cannot be charged for a long time due to energy harvesting, etc., or if it has been stored for a long time without being used in a charging device, the device retains energy until it is used again, making it easier to restart the device.

![Retention capacity rate vs. Elapsed time](chart.png)

Fig. 5 Temperature dependence of retention capacity

5.1.3 Charge-discharge characteristic having stable voltage range

Fig.16 shows the discharge curve of the CT04120 and 3F(capacity) electric double layer capacitor and Fig. 17 shows the charge curve of the CT04120 and 3F(capacity) electric double layer capacitor. When used for equipment with a drive voltage of around 2.0 V, CT04120 has a discharge curve with a flat voltage region at about 2.3 V, so that the equipment can be operated stably without boosting by a DC / DC converter etc.

Also, when the energy supply source is a small power device such as an energy harvest, the voltage of the electric double layer capacitor rises to 2.0 V or more in order to restart the device after the power storage device has once been discharged. It takes a considerable amount of time to reach this point, but the CT series reaches a flat voltage range of about 2.3 V with a short charge, and can operate the equipment.
Fig. 6 Discharge curve of CT04120 and 3F(capacity) electric double layer capacitor

Fig. 7 Charge curve of CT04120 and 3F(capacity) electric double layer capacitor

5.2 Merit in case of comparison between general Lithium ion secondary battery and CT series

5.2.1 Quick charge

In general lithium ion secondary batteries, rapid charging causes accelerated deterioration and breakdown. On the other hand, the CT series uses lithium titanate as the anode active material, so there is no such concern. Fig.18 shows the charging characteristics of the CT04120. In the case of constant voltage charging, charging of 90% or more is possible in 5 minutes.

Utilizing such characteristics that can be charged in a short time, it is possible to realize a device that can be used immediately when the battery capacity is exhausted or when charging is forgotten.
5.2.2 Long charge/discharge cycle life

The CT series has the feature that it is less likely to deteriorate when it is repeatedly charged and discharged compared to general lithium ion secondary batteries. In addition, in the case of a general lithium ion secondary battery, the charge and discharge cycle under a high load (large current) rapidly deteriorates the battery. However, the CT series does not have this concern, and has the feature that rapid charge and discharge can be repeated.

Fig.19 shows the charge / discharge cycle characteristics of the CT04120 at a constant voltage charge / 5CA discharge current, and the charge / discharge cycle characteristics of a typical lithium ion secondary battery at 0.5CA charge current and 0.5CA discharge current.
5.2.3 Resistant to low and high temperatures

Fig. 20 shows the discharge curve when CT04120 was discharged at 0 °C, 25 °C, 45 °C, and 70 °C with 1 CA, Fig. 21 shows the charge curve when 1CA was charged, and Fig. 22 shows the discharge curve when 0.2CA was discharged at -20 °C. Fig. 23 shows the discharge curve when 10CA (30mA), 10msec pulse discharge at -20 °C is repeated at 15sec intervals. 80% or more capacity can be used even at -20 °C, depending on pulse discharge conditions, compared to 3mAh capacity under standard discharge conditions.

The CT series can be available in a wide temperature range from -20 °C to 70 °C, compared to general lithium ion secondary batteries.

![Fig.20: Discharge curve at each temperature](image1)

![Fig.21: Charge curve at each temperature](image2)

![Fig. 22 Discharge curve at -20°C](image3)

![Fig. 10 Pulse discharge by the cycle of (1)30mA, 10msec discharge (2) Rest 15sec. at -20°C](image4)
5.2.4 Resistant to over-discharge

CT04120 has higher resistant to over-discharge compared to conventional Li-ion secondary batteries. Recommended cut-off voltage of CT04120 is 1.8V. No significant degradation after dozens of charge / discharge cycles between 2.7V to 0V (low-rate current: degrades significantly at high rates) or short-term storage for several months. Fig.24 shows the test result of charge-discharge cycle test where CT04120 was excessively discharged to 0V.

For example, if a device is left unattended for a long period of time, or if it is stored in inventory before shipment, the battery may be discharged to 0V due to the power consumed by the IC. Even if this happens several times, the operation of devices using the CT series will not be significantly affected.

In general lithium ion secondary batteries, graphite is used for the anode, so aluminum foil cannot be used for the current collector foil, but copper foil is used. This is because the reaction potential of graphite and lithium ions is close to the potential at which aluminum and lithium are alloyed. The copper foil used for anode may melt and precipitate when the battery voltage reaches 0V, which may cause a short circuit in the battery.

On the other hand, in the CT series, it is possible to use aluminum foil for the current collector foil by using lithium titanate, which has a high reaction potential, for the anode. Aluminum foil does not melt or precipitate even when the battery voltage drops to 0V, so there is no risk of the battery shorting.

<Note>
The graphs of the characteristics shown in “Chapter.3 Features and Applications”, “Chapter.4 Usage and Characteristics”, and “Chapter.5 Comparison with Other Energy Storage Devices” are references only, and do not guarantee the characteristics.
6 Safety

6.1 Safety of CT series

CT series are safety designed lithium ion secondary battery used high safety activate material as a negative electrode. CT series pass the safety test such as external short circuit test and abnormal charge test.

6.2 Correspondence standard

UL1642 : MH12566(UL certificated number)

7 Caution on handling

7.1 Limited use

Contact us before using our products for the applications listed below which require especially high reliability for the prevention of defects which might directly or property.

① Aircraft equipment
② Aerospace equipment
③ Undersea equipment
④ Power plant control equipment
⑤ Medical equipment
⑥ Transportation equipment (vehicles, trains, ships, etc.)
⑦ Traffic signal equipment
⑧ Disaster prevention/ Crime prevention equipment
⑨ Data-processing equipment
⑩ Application of similar complexity and/or reliability requirements to the applications listed in the above

Also please refrain from using our products for the following purpose

① Military equipment

7.2 Storage condition

Keep it in the sealed condition or our packing condition under the following conditions.

Temperature : 10～30℃
Humidity : 60%RH or less
※Please note that battery aging will be accelerated if the battery is placed in a high temperature environment.

7.3 Cautions in designing

(1) This product must be used within the range from the upper limit charging voltage to the lower limit discharging voltage. If used beyond this voltage range, this product may be deformed or liquid leakage may occur.

(2) This product has polarity. Before use, please refer to Fig. 5 and check the polarity as it may cause damage to the electrolyte and electrodes.

(3) Do not do short circuit between terminals especially high charge rate of battery in situation. Product may be deformed or electrolyte leakage may be caused.
(4) Do not use this product in an acidic or alkaline environment. 

(5) When considering using in a low pressure environment, the expected performance may not be obtained. Contact our sales or technical staff. 

(6) In a low-temperature environment, the discharge characteristics of the battery deteriorate, and when it is stored in a high-temperature environment, the usable time is shortened. Please contact us when using in low temperature environment or high temperature environment.

### 7.4 Cautions for mounting

(1) This product is not designed for flow soldering or reflow soldering. Mount the product so that the temperature does not exceed the guaranteed temperature range, such as when soldering or mounting connectors. Do not apply excessive mechanical shock, vibration or pressure to the product when mounting, as it may cause deterioration of the electrode terminals and electrical characteristics. 

(2) In case of 6 month passed after the delivery, please check the solder conditions. 

(3) Soldering Iron Mounting 

In case of mounting with soldering irons, we recommend mounting under the following conditions 

Solder Type: Resin flux cored solder wire (φ1.2mm) 
Solder: Lead-free solder: Sn·3Ag·0.5Cu 
Soldering iron temperature at 350 °C±10 °C 
Solder Iron wattage: 70W max. 
Soldering time: 3~4 sec per one terminal 
Allowable soldering frequencies: 2 times maximum per one terminal. 
Allowable cumulative soldering time per device: 20 sec max total. 
To prevent damage to the product, do not allow the iron tip to touch the body of the product during mounting. If bending is performed after soldering, stress will be applied to the base of the terminal, leading to product failure. Before soldering, bend the terminal without applying any force to the base of the terminal. 

(4) Do not wash after mounted. 

(5) The contact surface should be insulated to prevent electrical connection between this product and the parts that come into contact with it. 

(Example) As per shown Fig.25, resist protection is required on substrate surface. 

### 7.5 About resin coating

In case of this product is coated with resin, there are risks that metal corrosion may occur depending on the type of coating resin, and deformation of terminals and product packages may occur due to shrinkage stress during resin curing. Please evaluate the reliability of the resin with the product mounted and then select the resin.
7.6 Disassembly
Do not disassemble this product as it may cause leakage and defective.

7.7 Disposal
Dispose according to local laws and regulations.
Since this contain volatile electrolyte, do not throw it into fire.

7.8 Transport regulation
Although this product is applicable to UN38.3, it conforms to the Special Provision 188, therefore it can be shipped as an exemption from Class 9 dangerous goods. However, in air transportation, it is necessary to be transported as Class 9 dangerous goods in accordance with IATA DGR (Dangerous Goods Regulation) and Packing Instruction 965-Section IB. In addition, when the number of package is not more than one as per single consignment, it can be shipped in accordance with Packing Instruction 965-Section II. The above regulation is effective only for the packing condition at the time of shipment from the Murata factory. If any problem happens under the packing condition other than Murata specification, Murata would not have any responsibility for the compensation. For the details of transportation regulation, please refer to the latest edition of IATA DGR (Dangerous Goods Regulation), IMO IMDG Code.

7.9 About returning the damage/defective batteries
Air transport of damaged / defective lithium-ion secondary batteries is prohibited under the IATA DGR (Air Dangerous Goods Regulations). If you are considering returning it, please contact us in advance.