SPECIFICATION OF PRODUCT

for Lithium-ion Rechargeable Cell

Model: ICR18650-22P

June, 2010

Samsung SDI Co., Ltd.

Battery Business Division
1. **Scope**

This product specification has been prepared to specify the rechargeable lithium-ion cell ('cell') to be supplied to the customer by Samsung SDI Co., Ltd.

2. **Description and Model**

   2.1 Description       Cell (lithium-ion rechargeable cell)
   2.2 Model            ICR18650-22P

3. **Nominal Specifications**

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Typical Capacity</td>
<td>2150mAh (0.2C, 2.75V discharge)</td>
</tr>
<tr>
<td>3.2 Minimum Capacity</td>
<td>2050mAh (0.2C, 2.75V discharge)</td>
</tr>
<tr>
<td>3.3 Charging Voltage</td>
<td>4.2V±0.05 V</td>
</tr>
<tr>
<td>3.4 Nominal Voltage</td>
<td>3.62V (1C discharge)</td>
</tr>
<tr>
<td>3.5 Charging Method</td>
<td>CC-CV (constant voltage with limited current)</td>
</tr>
</tbody>
</table>
| 3.6 Charging Current          | Standard charge: 1075mA
                                | Rapid charge: 2150mA                                 |
| 3.7 Charging Time             | Standard charge: 3hours
                                | Rapid charge: 2.5hours                                |
| 3.8 Max. Charge Current       | 2150mA                                                |
| 3.9 Max. Discharge Current    | 10A (Continuous discharge)                            |
| 3.10 Discharge Cut-off Voltage| 2.75V                                                 |
| 3.11 Cell Weight              | 44.5g max                                             |
| 3.12 Cell Dimension           | Diameter(max.): Φ 18.40 mm
                                | Height: 65mm max                                      |
| 3.13 Operating Temperature    | Charge: 0 to 45℃                                    |
                                | Discharge: -20 to 60℃                                |
| (Cell Surface temperature)    | 1 year: -20~25℃ (1*)
                                | 3 months: -20~45℃ (1*)
                                | 1 month: -20~60℃ (1*)                                 |

Note (1): If the cell is kept as ex-factory status (50% of charge), the capacity recovery rate is more than 80%.
4. Outline Dimensions
   See the attachment(Fig. 1)

5. Appearance
   There shall be no such defects as scratch, rust, discoloration, leakage which may adversely affect commercial value of the cell.

6. Standard Test Conditions
   6.1 Environmental Conditions
      Unless otherwise specified, all tests stated in this specification are conducted at temperature 25±5℃ and humidity 65±20%.

   6.2 Measuring Equipment
      (1) Ammeter and Voltmeter
         The ammeter and voltmeter should have an accuracy of the grade 0.5 or higher.
      (2) Slide caliper
         The slide caliper should have 0.05 mm scale.
      (3) Impedance meter
         The impedance meter with AC 1kHz should be used.

7. Characteristics
   7.1 Standard Charge
      This "Standard Charge" means charging the cell with charge current 1075mA and constant voltage 4.2V at 25℃, 0.02C cutoff.

   7.2 Standard Discharge Capacity
      The standard discharge capacity is the initial discharge capacity of the cell, which is measured with discharge current of 430mA with 2.75V cut-off at 25℃ within 1 hour after the Standard charge.
      Standard Discharge Capacity ≥ 2050mAh

   7.3 Rated Discharge Capacity
      The rated discharge capacity is the initial discharge capacity of the cell, which is measured with discharge current of 2150mA with 2.75V cut-off at 25℃ within 1 hour after the Standard charge.
      Rated Discharge Capacity ≥ 2000mAh

   7.4 Initial internal impedance
      Initial internal impedance measured at AC 1kHz after Standard charge.
      Initial internal impedance ≤ 35mΩ

   7.5 Temperature Dependence of Discharge Capacity
      Discharge capacity comparison at each temperature, measured with discharge
constant current 2150mA and 2.75V cut-off with follow temperature after the standard charging at 25℃.

<table>
<thead>
<tr>
<th>Charge Temperature</th>
<th>Discharge temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>25℃</td>
<td>-10℃ 0℃ 25℃ 45℃</td>
</tr>
<tr>
<td>Relative Capacity</td>
<td>60% 80% 100% 100%</td>
</tr>
</tbody>
</table>

Note: If charge temperature and discharge temperature is not the same, the interval for temperature change is 3 hours. Percentage as an index of the Rated discharge capacity(=2000mAh) is 100%.

7.6 Temperature Dependence of Charge Capacity
Capacity comparison at each temperature, measured with discharge constant current 2150mA and 2.75V cut-off at 25℃ after the Standard charge is as follow temperature.

<table>
<thead>
<tr>
<th>Charge temperature</th>
<th>Discharge temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>0℃ 25℃ 45℃ 25℃</td>
<td>80% 100% 100%</td>
</tr>
</tbody>
</table>

Note: If charge temperature and discharge temperature is not the same, the interval for temperature change is 3 hours. Percentage as an index of the Rated discharge capacity(=2000mAh) is 100%.

7.7 Charge Rate Capabilities
Discharge capacity is measured with constant current 2150mA and 2.75V cut-off after the cell is charged with 4.2V as follows.

<table>
<thead>
<tr>
<th>Charge Condition</th>
<th>Current</th>
<th>0.5C (1075mA)</th>
<th>1.0C (2150mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut-off</td>
<td>3h or 0.02C</td>
<td>2.5h or 0.02C</td>
<td></td>
</tr>
<tr>
<td>Relative Capacity</td>
<td>100%</td>
<td>97%</td>
<td></td>
</tr>
</tbody>
</table>

Note: Percentage as an index of the Rated discharge capacity(=2000mAh) is 100%.

7.8 Discharge Rate Capabilities
Discharge capacity is measured with the various currents in under table and 2.75V cut-off after the standard charge.
## 7.9 Cycle Life (1)
Each cycle is an interval between the charge (charge current 1075mA) with 0.05C cutoff and the discharge (discharge current 2150mA) with 2.75V cut-off. Capacity after 700 cycles.

\[
\text{Capacity} \geq 1400\text{mAh (70\% of Rated Capacity)}
\]

## 7.10 Cycle Life (2)
Each cycle is an interval between the charge (charge current 2150mA) with 0.05C cutoff and the discharge (discharge current 6450mA) with 2.75V cut-off. Capacity after 300 cycles

\[
\text{Capacity} \geq 1600\text{mAh (80\% of Rated Capacity)}
\]

## 7.11 Storage Characteristics
Capacity after storage for 30 days at 60 °C after the Standard charged, measured with discharge current 2150mA with 2.75V cut-off at 25 °C.

\[
\text{Capacity recovery(after the storage)} \geq 1800\text{mAh (90\% of Rated Capacity)}
\]

## 7.12 Status of the cell as of ex-factory
The cell should be shipped in 3.65V ~ 3.85V Charging voltage range.

## 8. Mechanical Characteristics

### 8.1 Drop Test
Test method: Cell(as of shipment or full charged) drop onto the oak-board (thickness: \( \geq 30\text{mm} \)) from 1.5m height at a random direction 6 times.

Criteria: No leakage

### 8.2 Vibration Test
Sample condition: Fully charged state 5 samples
Test Method: 20±5 °C / 1.6mm max. excursion / 1 hertz/minute between 10 hertz to 55 hertz to 10 Hertz / for mutually perpendicular directions

Criteria: No ventilation and leakage

(Test shall be performed with the following criteria IEC 62133, UL1642)
9. Safety

9.1 Overcharge Test
Test method: To charge the standard charged cell with 12V and 2150mA at 25°C for 2.5 hours.
Criteria: No fire, and no explosion.

9.2 External Short-circuit Test
Test method: To short-circuit the standard charged cell by connecting positive and negative terminal by less than 100mΩ wire for 3 hours.
Criteria: No fire, and no explosion.

9.3 Reverse Charge Test
Test method: To charge reversely the standard charged cell with charge current 2150mA for 2.5 hours.
Criteria: No fire, and no explosion.

9.4 Heating Test
Test method: To heat the standard charged cell at heating rate of 5°C per minute up to 130°C and keep the cell in oven for 60 minutes.
Criteria: No fire, and no explosion.

9.5 Nail Penetrating Test
Test method: Cell shall be fully charged. Penetrate completely center of cell with 2.5mm diameter nail at the velocity of 150 mm/sec.
Criteria: No fire, and no explosion.

10. Warranty
Samsung SDI will be responsible for replacing the cell against defects or poor workmanship for 1 year from the date of shipping. Any other problems caused by malfunction of the equipment or unsuitable use of the cell are not under this warranty. The warranty set forth in proper use, handling conditions described above, and excludes in the case of a defect which is not related to manufacturing of the cell.

11. Others

11.1 Storage for a long time
If the cell is kept for a long time (3 months or more), it is strongly recommended that the cell is preserved at dry and low-temperature.

11.2 Other
Any matters that specifications does not have, should be conferred with between the both parties.
12. Packaging

See Fig. 2, Package Drawing

Fig. 1 Outline Dimensions of ICR18650-22P
Fig 2. Package Drawing
Pack Quality Requirement for safety and quality epidemic issue.

1-1 The battery pack’s consumption current.
   - Sleep Mode : Under 250uA.
   - Shut Down Mode : Under 10uA / Under 3.0V.
     Under 1uA / Under 2.5V.
1-2 SOC 0%
   - Cell voltage in SOC 0% of Pack should be Min. 3.0V.
     (Discharging Cut-off Voltage)
1-3 Operating Charging Voltage of a cell.
   - Normal operating voltage of a cell is 4.20V
   - Max operating voltage of a cell is 4.25V.
1-4. No continuous charge
   - Charge cut-off condition : Cut-off Current over than 1/20C
     (Charging method: CC-CV)
   - Initial recharging condition : Remaining Capacity under than 90%
     or voltage under than 4.10V
1-5. Pre-charging function
   - Pre-charge function should be implemented to prevent abnormal high rate
     charging after deep discharge.
   - Pre-charging condition Operation : Under 3.0V
     Charging current : Under 150mA/Cell.(Continuous)
     Pre-charge stop (Normal Charge Start) : All cells reach 3.0V
1-6 Pre-charging function.
   - Pre-charge function should be implemented to prevent abnormal high rate
     charging after deep discharge.
   - Pre-charging condition
     Operation : Under 3.0V
     Charging current : <150mAh/Cell.
1-7 Mechanical Guides.
   - PCBA and Cell stack should have heat insulation material between
     them.(Such as plastic barrier which is giving air isolation or non-thermal
     conductive material.)
   - B+ and B- wire connection should not be crossed each other. Do not make
     wire which had the voltage difference more than 4.0V get together.
   - The material such as double sided tape and rubber which are used in battery
     pack should be verified for its flammability

If Pack cannot meet above requirement,
we cannot take responsibility for quality issue.
Proper Use and Handling of Lithium Ion Cells
See before using lithium-ion cell
Supplied by
Samsung SDI Co., Ltd.

1. General
This document has been prepared to describe the appropriate cautions and prohibitions, which the customer should take or employ when the customer uses and handles the lithium ion cell to be manufactured and supplied by Samsung SDI Co., Ltd., in order to obtain optimum performance and safety.

2. Charging

2.1 Charging current
Charging current should be less than maximum charge current specified in the product specification.

2.2 Charging voltage
Charging should be done by voltage less than that specified in the product specification.

2.3 Charging time
Continuous charging under appropriate voltage does not cause any loss of characteristics. However, the charge timer is recommended to be installed from a safety consideration, which shuts off further charging at time specified in the product specification.

2.4 Charging temperature
The cell should be charged within a range of specified temperatures in the product specification.

2.5 Reverse charging
The cell should be connected, confirming that its poles are correctly aligned. Inverse charging should be strictly prohibited. If the cell is connected improperly, it may be damaged.

3. Discharging

3.1 Discharging
3.1.1 The cell should be discharged at less than maximum discharge current specified in the product specification.

3.2 Discharging temperature
3.2.1 The cell should be discharged within a range of temperatures specified in the product specification.
3.2.2 Otherwise, it may cause loss of characteristics.

3.3 Over-discharging
3.3.1 The system should be equipped with a device to prevent further discharging exceeding discharging cut-off voltage specified in the product specification. (over-discharging)

3.3.2 Over-discharging may cause loss of performance, characteristics, of battery function.

3.3.3 Over-discharging may occur by self-discharge if the battery is left for a very long time without any use.

3.3.4 The charger should be equipped with a device to detect cell voltage and to determine recharging procedures.

4. Storage

4.1 Storage conditions
   4.1.1 The cell should be stored within a range of temperatures specified in the product specification.
   4.1.2 Otherwise, it may cause loss of characteristics, leakage and/or rust.

4.2 Long-term storage
   4.2.1 The cell should be used within a short period after charging because long-term storage may cause loss of capacity by self-discharging.
   4.2.2 If long-term storage is necessary, the cell should be stored at lower voltage within a range specified in the product specification, because storage at higher voltage may cause loss of characteristics.

5. Cycle life

5.1 Cycle life performance
   5.1.1 The cell can be charged/discharged repeatedly up to times specified in the produce specification with a certain level of capacity also specified in the product specification.
   5.1.2 Cycle life may be determined by conditions of charging, discharging, operating temperature and/or storage.

6. Design of System

6.1 Connection between the cell and the battery
   6.1.1 The cell should not be soldered directly with leads. Namely, the cell should be welded with leads on its terminal and then be soldered with wire or leads to soldered lead.
   6.1.2 Otherwise, it may cause damage of component, such as separator and insulator, by heat generation.

6.2 Positioning the battery in the System
   6.2.1 The battery should be positioned as possible as far from heat sources and high temperature components.
   6.2.2 Otherwise, it may cause loss of characteristics.
6.3 Mechanical shock protection of the battery
   6.3.1 The battery should be equipped with appropriate shock absorbers in order to
   minimize shock.
   6.3.2 Otherwise, it may cause shape distortion, leakage, heat generation
   and/or rupture.

6.4 Short-circuit protection of the cell
   6.4.1 The cell is equipped with an insulating sleeve to protect short-circuit which
   may occur during transportation, battery assembly and/or system
   operation.
   6.4.2 If the cell sleeve is damaged by some causes such as outside impact,
   it may cause short-circuit with some wiring inside the battery.

6.5 Connection between the battery and charger/system
   6.5.1 The battery should be designed to be connected only to the specified
   charger and system.
   6.5.2 A reverse connection of the battery, even in the specified system,
   should be avoided by employing special battery design such as
   a special terminals.

7. Battery Pack Assembly

7.1 Prohibition of usage of damaged cell
   7.1.1 The cell should be inspected visually before battery assembly.
   7.1.2 The cell should not be used if sleeve-damage, can-distortion and/or
   electrolyte-smell is detected.

7.2 Transportation
   7.2.1 If the cell is necessary to transport to order place, such as the
   battery manufacturer, careful precautions should be taken to avoid
   damage of cell.

8. Others

8.1 Disassembly
   8.1.1 The cell should not be dismantled from the battery pack.
   8.1.2 Internal short-circuit caused by disassembly may lead to heat generation
   and/or venting.
   8.1.3 When the electrolyte is coming in contact with the skin or eyes,
   wash immediately with fresh water and seek medical advice.

8.2 Short-circuiting
   8.2.1 Short-circuit results in very high current which leads to heat generation.
   8.2.2 An appropriate circuitry should be employed to protect accidental
   short-circuiting.
8.3 Incineration
   8.3.1 Incinerating and disposing of the cell in fire are strictly prohibited,
       because it may cause rupture.

8.4 Immersion
   8.4.1 Soaking the cell in water is strictly prohibited, because it may cause
       melt of components to damaged to functions.

8.5 Mixing use
   8.5.1 Different types of cell, or same types but different manufacturer’s cell
       may lead to cell rupture or damage to system due to the different
       characteristics of cell.

8.6 Battery disposal
   8.6.1 Although the cell contains no environmentally hazardous component,
       such as lead or cadmium. the battery should be disposed according to
       the local regulations when it is disposed.
   8.6.2 The cell should be disposed with a discharged state to avoid heat generation
       by an inadvertent short-circuit.

8.7 Caution - The Battery used in this device may present a risk of fire or chemical burn if
    mistreated. Do not disassemble, heat above 100℃ or incinerate. Replace
    battery with Samsung SDI battery only. Use of another battery may present a risk
    of fire or explosion. Dispose of used battery promptly. Keep away from children.
    Do not disassemble and do not dispose of in fire.

8.8 Warning – Attached
Handling Precaution and Prohibitions of Lithium Ion & Lithium Ion Polymer Rechargeable Cells and Batteries

Inaccurate handling of lithium ion and lithium ion polymer rechargeable battery may cause leakage, heat, smoke, an explosion, or fire. This could cause deterioration of performance or failure. Please be sure to follow instructions carefully.

1.1 Storage
Store the battery at low temperature (below 20 ℃ is recommended), low humidity, no dust and no corrosive gas atmosphere.

1.2 Safety precaution and prohibitions
To assure product safety, describe the following precautions in the instruction manual of the application.

[ Danger! ]

■ Electrical misusage
Use dedicated charger.
Use or charge the battery only in the dedicated application.
Don't charge the battery by an electric outlet directly or a cigarette lighter charger.
Don't charge the battery reversely.

■ Environmental misusage
Don't leave the battery near the fire or a heated source.
Don't throw the battery into the fire.
Don't leave, charge or use the battery in a car or similar place where inside of temperature may be over 60 ℃.
Don't immerse, throw, wet the battery in water / seawater.

■ others
Don't fold the battery cased with laminated film such as pouch and Polymer.
Don't store the battery in a pocket or a bag together with metallic objects such as keys, necklaces, hairpins, coins, or screws.
Don't short circuit (+) and (-) terminals with metallic object intentionally.
Don't pierce the battery with a sharp object such as a needle, screw drivers.
Don't heat partial area of the battery with heated objects such as soldering iron.
Don't hit with heavy objects such as a hammer, weight.
Don't step on the battery and throw or drop the battery on the hard floor to avoid mechanical shock.
Don't disassemble the battery or modify the battery design including electric circuit.
Don't solder on the battery directly.
Don't use seriously scared or deformed battery.
Don't put the battery into a microwave oven, dryer, or high-pressure container.
Don't use or assemble the battery with other makers' batteries, different types and/or models of batteries such as dry batteries, nickel-metal hydride batteries, or nickel-cadmium batteries.
Don't use or assemble old and new batteries together.

[ Warning! ]
Stop charging the battery if charging isn't completed within the specified time.
Stop using the battery if the battery becomes abnormally hot, order, discoloration, deformation, or abnormal conditions is detected during use, charge, or storage.
Keep away from fire immediately when leakage or foul odors are detected. If liquid leaks onto your skin or cloths, wash well with fresh water immediately.
If liquid leaking from the battery gets into your eyes, don't rub your eyes and wash them with clean water and go to see a doctor immediately.
If the terminals of the battery become dirty, wipe with a dry cloth before using the battery.
The battery can be used within the following temperature ranges. Don't exceed these ranges.
  Charge temperature ranges       :  0℃ ~ 45℃
  Discharge Temperature ranges   :  -20℃ ~ 60℃
Store the battery at temperature below 60℃
Cover terminals with proper insulating tape before disposal.

[ Caution! ]
■ Electrical misusage
  Battery must be charge with constant current-constant voltage (CC/CV).
  Charge current must be controlled by specified value in Cell specification.
  Cut-off Voltage of charging must be 4.2V.
  Charger must stop charging battery by detecting either charging time or current specified in Cell's specification.
  Discharge current must be controlled by specified value in Cell's specification.
  Cut-off Voltage of discharging must be over 2.5V.

■ others
  Keep the battery away from babies and children to avoid any accidents such as swallow.
If younger children use the battery, their guardians should explain the proper handling method and precaution before using.

Before using the battery, be sure to read the user's manual and precaution of it's handling.

Before using charger, be sure to read the user's manual of the charger.

Before installing and removing the battery from application, be sure to read user's manual of the application.

Replace the battery when using time of battery becomes much shorter than usual.

Cover terminals with insulating tape before proper disposal.

If the battery is needed to be stored for an long period, battery should be removed from the application and stored in a place where humidity and temperature are low.

While the battery is charged, used and stored, keep it away from object materials with static electric chargers.

**Safety Handling Procedure for the Transporter**

- **Quarantine**: Packages that are crushed, punctured or torn open to reveal contents should not be transported. Such packages should be isolated until the shipper has been consulted, provided instructions and, if appropriate, arranged to have the product inspected and repacked.

- **Spilled Product**: In the event that damage to packaging results in the release of cells or batteries, the spilled products should be promptly collected and segregated and the shipper should be contacted for instructions.

**Design of positioning the battery pack in application and charger**

To prevent the deterioration of the battery performance caused by heat, battery shall be positioned away from the area where heat is generated in the application and the charger.

**Design of the Battery Pack**

Be sure adopting proper safe device such as PTC specified type or model in Cell Specification. If you intend to adopt different safety device which is not specified in Cell Specification, please contact Samsung SDI to investigate any potential safety problem.

Be sure designing 2nd protective devices such as PTC & PCM at the same time to protect Cell just in case one protective device is fault.

Please contact following offices when you need any help including safety concerns.
Samsung SDI Emergency Contact Information

■ Samsung SDI Headquater.
Samsung Life Insurance Bldg. 150 Taepyungro 2-ga, Jung-gu, Seoul, Korea
Tel: (+82)2-727-3686  Fax: (+82)2-727-3689

■ Samsung SDI Chonan factory.
508, Sungsung-Dong, Chonan City, Chungchongnam-Do, Korea
Tel: (+82)41-560-3669  Fax: (+82)41-560-3697

■ Samsung SDI America office.
18600 Broadwick Street Rancho Dominguez CA 90220
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■ Samsung SDI Taiwan office.
Rm. 3010, 30F., 333, Keelung Rd. Sec. 1, Taipei, Taiwan
Tel: (+886)2-2728-8469  Fax: (+886)2-2728-8480