ProLogium Lithium Ceramic Battery Profile

Thin battery with Bending flexibility
ProLogium Technology (Pro-Prolong-Logic-ium)

Establishment Time: Oct 3rd, 2006

Location: Taipei, Taiwan

Capital: ≈ 10.18 Million USD (2013/E)

Employees: 163 members (2015/1)

Type: Battery Cell Maker

Product: LCB (Lithium Ceramic Battery)

Technologies: 100% ProLogium owned
Next Generation Battery: LCB

- Flexible
- High Energy Density
- Ultra-Thin
- Ultra-Safe

LCB (Lithium Ceramic Battery)
- Safe
- No Leakage
Unfair Advantages: Intrinsic Safety
(Solid-State Ceramic Electrolyte System)

【 LCB cross section 】

<table>
<thead>
<tr>
<th>Al Foil (Current Collector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathode</td>
</tr>
<tr>
<td>(Solid-State) Ceramic Electrolyte</td>
</tr>
<tr>
<td>Anode</td>
</tr>
<tr>
<td>Cu Foil (Current Collector)</td>
</tr>
</tbody>
</table>

【 LPB cross section 】

<table>
<thead>
<tr>
<th>Al Foil (Current Collector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathode</td>
</tr>
<tr>
<td>(Liquid/Jelly) Polymer Separator</td>
</tr>
<tr>
<td>Anode</td>
</tr>
<tr>
<td>Cu Foil (Current Collector)</td>
</tr>
</tbody>
</table>

- No Thermal Runaway
- No Leakage
- Incombustible
- Incompressible
- No Swelling
  - never Melt
  - Good Thermal Stability (200~260°C / 3~10 sec)
  - No Salting Out at low temp.

- Thermal Runaway
- Leakage
- Flammable
- Compressible
- Swelling
  - Melt around 120~150°C
  - Poor Thermal Stability
  - Salting Out at low temp.
The biggest difficulty of solid-state Li Battery: (1) Poor C-rate. (2) High inner resistance.

LCB conquer the difficulties & keep improving better product.

**Evolution of Chemical System**

- **First Chemical system (AH) (2013 MP)**
  - C-rate: 50% - 60%

- **New AP-01 (2014/10 MP)**
  - C-rate: 80% - 90%

- **New AP-02 (2014 RD ready, 2015/4 MP)**
  - C-rate: 92% - 95%

**Cell electrical performance: 1C Discharge Profile**

0.2C CC/CV charge to 4.35V, Cut off 1/20C→ 1.0C discharge to 2.75V

<table>
<thead>
<tr>
<th>System</th>
<th>LPB</th>
<th>AH-01</th>
<th>AP-01</th>
<th>AP-02</th>
</tr>
</thead>
<tbody>
<tr>
<td>1C Discharge Rate</td>
<td>97.8%</td>
<td>65.1%</td>
<td>92.8%</td>
<td>95.9%</td>
</tr>
</tbody>
</table>

*Fig. 1*
### 3 main products of LCB: FLCB, PLCB, ELCB (Logithium)

<table>
<thead>
<tr>
<th>Li-ion</th>
<th>Li-Metal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLCB (FPC Type- LCB)</strong></td>
<td><strong>ELCB (Logithium)</strong></td>
</tr>
<tr>
<td>✤ Excellent Flexibility, good for Dynamic Bending application</td>
<td>✤ High Energy Density</td>
</tr>
<tr>
<td>✤ Thickness: 0.38mm</td>
<td>✤ Li-Metal anode.</td>
</tr>
<tr>
<td>✤ “Injection Molding” is adaptable</td>
<td>✤ Ultra-high Energy density</td>
</tr>
<tr>
<td>✤ Dynamic Bending</td>
<td>✤ 700-800Wh/L: 240-280Wh/Kg</td>
</tr>
<tr>
<td><strong>PLCB (Pouch Type- LCB)</strong></td>
<td></td>
</tr>
<tr>
<td>✤ Next version of FLCB.</td>
<td></td>
</tr>
<tr>
<td>✤ Thickness: 1~2 mm</td>
<td></td>
</tr>
<tr>
<td>✤ Low Swelling: ≤2%</td>
<td></td>
</tr>
<tr>
<td>✤ “Curved Battery”</td>
<td></td>
</tr>
<tr>
<td>✤ Good for consumer &amp; large current loading application (xEV..)</td>
<td></td>
</tr>
<tr>
<td>✤ “Injection Molding” is adaptable</td>
<td></td>
</tr>
</tbody>
</table>
## Difference between Li-ion & Li-Metal (Chemical system)

<table>
<thead>
<tr>
<th>Li - Metal</th>
<th>Li - ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELCB</td>
<td>LCB (FLCB &amp; PLCB)</td>
</tr>
</tbody>
</table>

1. Thickness vs. Energy Density (cell size: 95X 105mm)

2. Voltage & Energy Density

### Diagrams
- **2015 AP-02**
- **2015 AP-02 (Vswell vs. Eswell)**

### Notes
- Al Foil (Current Collector)
- Cathode
- Ceramic Electrolyte
- **Lithium Metal with 3D Anode Electrode Structure**
- **Electrode Structure**
- Cu Foil (Current Collector)
50 Obtained Patents
10 Filed Patents

Core Tech: LCB (Lithium Ceramic Battery)

- Ultra-safe ceramic ELT
- NEW Anode (Li Alloy) Material
- Specific Equipment
- Application Cover Battery, Band Battery
- New Package Material & Mechanism
- BOF: Battery On FPC Substrate

Issued: 27
Published: 23
Filed: 10
Certification from 3rd Party

Over Charge test:
1. Level: Battery Pack
2. If Pass: 100Wh Pack is able to be shipped by air
   - LCB passed by CELL.
   - LCB cell (≤ 100Wh) is able to be shipped by air.
FLCB (FPC Lithium Ceramic Battery) Features

1. FPC Advantages
   - Flexible Printed Circuit
   - Roll to Roll production/
     Component integration & Post Processing Process.

2. Able to be Injection Molded (*p.45)
   - Durable at high temp. of 200~260°C & pressure of 3000atm

3. Able to be Bent to small Radius(*p.45)
   - Rolled as a Rod battery/ Pin-style battery

**FLCB** (FPC Type- LCB)

- Dynamic Bending
- Ultra-thin
- Flexible
- Small Roll
- Dynamic Bending
FLCB Features – 1. FPC (Flexible Printed Circuit) Advantages

- **Ultra-Thin**
  The thickness of FLCB is only 0.38mm.

- **Flexible/ Dynamic Bending**

- **Multiple Terminal Design**
  Includes terminal sets, position, size...
  /as Golden Finger
  Extend the FPC of FLCB directly.

- **Tin Soldering**
  Able to be Tin Soldered on terminals directly.

- **Antenna on Cell for Wireless Charging (*p.45)**
  Able to be integrated with antenna on battery cell directly for wireless charging (current ≤ 20-30mAh) ...

- **Roll to Roll Manufacturing**
  Manufacturing and assembling in Roll to Roll way, reduce the cost and higher the consistency.

- **Good for CCD alignment and automation**
  CCD on cell directly and reduce the post processing.
**Dynamic Bending**

FLCB is totally flexible. Its cycle life and electrical performance of curve shape is as same as that of flat status.

**Injection Molding increase FLCB durability**

After Injection Molding, Capability of Z axis Bending & X,Y axis Twisting will be increased. (*p.45)
**FLCB Features- 3. Able to be Bent to small Radius**

**Excellent Bending Ability**
FLCB is able to be “Bent” to a dramatically small radius.

The electrical performance of “Rod / Pin-style” FLCB is as same as originally flat ones.

**Extremely Small Diameter**
The smallest diameter that pass the test is “4-5mm”.

**Static Rod/ Pin-style Battery**
FLCB Target Market

FPC Advantages

Injection Molded

Bent to Small Radius

**IOT (Internet of Things)**
- Active RFID/ Smart Card/ Functional Card
- Logistic sensor/ Recorder
- Smart Home

**Wearable (on human body or pat)**
- Wearable Electronics: Smart watch/ wrist/ belt/ hat/ helmet/ shoe/ cloth....
- Attachable Devices: Heat sensor/ patch/ pat application

**Rod/Pin-style Application**
- Electrical Cigarettes
- Electrical Pens
- Smart Glasses
Smart Display Card

Rechargeable.
Card life: 2 years → 5~6 years.
NFC (of smartphone) / ATM charging.
Functional Display Card

Rechargeable.
Fulfill the high power consumption. High-drain capability, good for Pulse Discharge.

FLCB Target Market 1: IOT
Active RFID tag/Card

- Rechargeable.
- Long battery life.
- Durable for low operation window.

Temperature tracking

Railroad car tracking

UHF Wristband on body
Smart Medical Care

SAFE.
Portable & Durable.

Smart HOME

SAFE.
Durable.
Non-sensible.
Smart Watch/ Wrist

Flexible.
Ultra thin, Fashion.
Non-sensible of battery.
Smart Clothes/ Shoes

SAFE.
Flexible.
Non-sensible of battery.
Smart Patch/ Sensor

Ultra thin.
Flexible & Safe.
Electrical Cigarettes/ Pens

SAFE.
φ 4.5~7.5mm
30/36/50/70mm/ customized
14 ~ 200mAh/ customized
PLCB Features

PLCB (Pouch Type- LCB)

1. Safe to be embedded in cover (protection-free)
2. Directly Paralleled with LPB
3. Big Capacity for 1.6mm Thin Cell
4. High Stability

- Higher C-Rate
- Curved Battery
- 1-2mm thickness
- Auto-current dividing
- Ultra Safe
- High energy density better than LPB (<=1.6mm)
- Low Temp. Storage
PLCB Features – 1. Safe to be embedded in cover

Invisible Power inside Cover
The total thickness of the flip with PLCB inside is only 3.85mm.

Ultra-Safe (Penetrate the battery & cover)
( **simulate Tesla EV fire accident) Even penetrate the battery, No smoke, No fire, No explosion.

Ultra-Safe (Punch the battery & cover)
Even hammer punch the battery, No smoke, No fire, No explosion.

Thinner assy. & device
Share Loading Share thickness

Power Jacket Without Boost
PLCB is able to be paralleled with LPB directly without any BMS’s protection.
PLCB Features – 2. Directly Paralleled with LPB

Make Device Thinner/ More Fashion
Share part or all of the main power to the accessory and make device thinner.

Extra Power
Add more power but no bulk. External battery concept.

No need Extra Charging
PowerJacket will be charged at the same time when user charge the smartphone.

Increase Power Efficiency & Battery Life
Sharing the loading of main battery, PLCB is able to increase the efficiency and extend the battery life of smartphone.

Protect Device PCM
Even if the PCM of main battery isn’t work, PLCB can protect it from dying when it’s under over-charging.

Ultra Thin
The total thickness of 5.5” smartphone flip with 1150mAh power inside is only 3.85mm.
PLCB Target Market

Safe in cover & Paralleled with LPB

Ultra-thin Battery (Thickness: 1-2mm)

High Stability

Consumer Accessory
- With Boost: Power Case for i6 & i6 plus, Power Jacket for i6 & i6 plus
- Without Boost: Power Flip Case
- Smart phone assy./ Tablet assy.

Consumer Device
- Slim e-Reader
- Slim e-Writter

Industrial Application
- Educational
- Metical
- Industrial
POWER Jacket/ Case

More than Enough JUICE for Single Day Use.
Extend More 50% Using Time of smartphone.
No Need Power Bank anymore.
PLCB Market 1: Consumer Accessory--- Power Jacket (without boost)

Lighter

POWER Jacket/ Case

More than Enough JUICE for Single Day Use.
Extend More 50% Using Time of smartphone.
No Need Power Bank anymore.

Times between charge for heavy user is 36hrs.
POWER
Cover/ KB Cover
Self contained power.
Extend the Using Time of tablet/ ebook.
Instead of paper filler in cover.
Zero Thickness Battery

Case Battery

e-book/ e-writer

Ultra thin.

Battery embedded inside the LCM module by Injection Molding process.

ABS concept.
PLCB Target Market 3: Industrial Application

Ultrasonic Scanner

Electronic clip board

Medical

Educational

Industrial

Smart Home

XEV

Car

Image of XEV car and electronic clip board

Image of medical equipment and ultrasonic scanner
ELCB (Logithium) Features

1. **High Energy Density (volume)**
   - 700-800Wh/L, 1.5 times of LPB

2. **Specific Energy Density (weight)**
   - 240~280Wh/Kg

3. **High Operation Voltage**
   - ≈ 100% of capacity is able to be used in Consumer products
<table>
<thead>
<tr>
<th>SPEC</th>
<th>FLCBxxxxxxA</th>
<th>033034</th>
<th>023060</th>
<th>018110</th>
<th>046050</th>
<th>025105</th>
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<tbody>
<tr>
<td>Dimension (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(With Terminal Area)</td>
<td>33.25*34.5</td>
<td>23*60</td>
<td>18*110</td>
<td>46*50</td>
<td>25*105</td>
<td></td>
</tr>
<tr>
<td>(Without Terminal Area)</td>
<td>33.25*27.3</td>
<td>23*54</td>
<td>18*100</td>
<td>46*46</td>
<td>25*99.8</td>
<td></td>
</tr>
<tr>
<td>Nominal Voltage (V)</td>
<td></td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
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<tr>
<td>Weight (g)</td>
<td></td>
<td>0.75</td>
<td>1.0</td>
<td>1.4</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Thickness (mm) (center)</td>
<td></td>
<td>0.39</td>
<td>0.39</td>
<td>0.39</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>Nominal Capacity (mAh) (4.35V~3.0V)</td>
<td>10.5</td>
<td>20</td>
<td>26</td>
<td>45</td>
<td>48</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>SPEC</th>
<th>FLCBxxxxxxA</th>
<th>050100</th>
<th>066113</th>
<th>073130</th>
<th>108170</th>
<th>160220</th>
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<tbody>
<tr>
<td>Dimension (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(With Terminal Area)</td>
<td>50*99.95</td>
<td>66*113</td>
<td>73*130</td>
<td>108*170</td>
<td>160*226</td>
<td></td>
</tr>
<tr>
<td>(Without Terminal Area)</td>
<td>50*92.75</td>
<td>66*107</td>
<td>73*121.6</td>
<td>108*161.5</td>
<td>160*220</td>
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<tr>
<td>Nominal Voltage (V)</td>
<td></td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
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<tr>
<td>Weight (g)</td>
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<td>4.0</td>
<td>6.0</td>
<td>7.7</td>
<td>15.5</td>
<td>31.5</td>
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<tr>
<td>Thickness (mm) (center)</td>
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<td>0.375</td>
<td>0.375</td>
<td>0.375</td>
<td>0.37</td>
<td>0.37</td>
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<tr>
<td>Nominal Capacity (mAh) (4.35V~3.0V)</td>
<td>105</td>
<td>175</td>
<td>235</td>
<td>495</td>
<td>1060</td>
<td></td>
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<tr>
<td>Model (PLCBxxxxxxxxA)</td>
<td>067115</td>
<td>060110</td>
<td>060110</td>
<td>070130</td>
<td>070130</td>
<td>140210</td>
</tr>
<tr>
<td>-----------------------</td>
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<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td><strong>Dimension (mm)</strong></td>
<td>67.5*115.5</td>
<td>60*110</td>
<td>60*110</td>
<td>70*130</td>
<td>70*130</td>
<td>140*210</td>
</tr>
<tr>
<td><strong>(Without Terminal Area)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Parallel Mode</strong></td>
<td>5P</td>
<td>7P</td>
<td>4P</td>
<td>7P</td>
<td>4P</td>
<td>7P</td>
</tr>
<tr>
<td><strong>Nominal Voltage (V)</strong></td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
<td>3.75</td>
</tr>
<tr>
<td><strong>Weight (g)</strong></td>
<td>31</td>
<td>38</td>
<td>23</td>
<td>52</td>
<td>31</td>
<td>145</td>
</tr>
<tr>
<td><strong>Thickness (mm) (center)</strong></td>
<td>1.9</td>
<td>2.6</td>
<td>1.6</td>
<td>2.6</td>
<td>1.6</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Nominal Capacity (mAh) (4.35V~3.0V)</strong></td>
<td>1050</td>
<td>1250</td>
<td>700</td>
<td>1800</td>
<td>1020</td>
<td>4970</td>
</tr>
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</table>