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台灣 新竹市

新竹科學園區力行路6號

昇陽國際半導體股份有限公司

JOYCE CHEN



JOYCE CHEN  
 PHOENIX SILICON INTERNATIONAL CORP  
 NO.6 LI-HSIN RD  
 SCIENCE PARK  
 HSINCHU  
 300 TAIWAN

Date: 2017/04/06  
 Subscriber: 234044001  
 PartySite: 602517  
 File No: MH45837  
 Project No: 4787871730  
 PD No: 17015423  
 Type: R  
 PO Number:

Subject: **Procedure And/Or Report Material**

The following material resulting from the investigation under the above numbers is enclosed.

**Issue**

<u>Date</u>	<u>Vol</u>	<u>Sec</u>	<u>Pages</u>	<u>Revised Date</u>
2007/05/29	1	1	Revised Description Page(s) 5,6,7	2017/03/30
2007/05/29	1	1	New Test Record 5	2017/03/30
		2	Index Page(s)	
		2	Appendix	
2009/09/28	2	1	Revised Description Page(s) 1,3	2017/03/30

Please file revised pages and illustrations in place of material of like identity. New material should be filed in its proper numerical order.

NOTE: Follow-Up Service Procedure revisions DO NOT include Cover Pages, Test Records and Conclusion Pages. Report revisions DO NOT include Authorization Pages, Indices, Section General Pages and Appendixes.

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TPI File

## MARKINGS/INSTRUCTIONS:

Recognized Company, Model designation, and date of manufacturer on the cell.

The cell or smallest package containing the cell shall be marked with the UL Recognition Mark.

The date of manufacturer may be in code provided that the code does not repeat in less than 20 years and does not require reference to the production records of the manufacturer to determine the date the product was manufactured.

The date code consists of the following:

\*

**Example:**  $\frac{4KFT}{1}$   $\frac{D}{2}$   $\frac{5}{3}$   $\frac{10---}{4}$   $\frac{0183}{5}$

**1 : Product number**

**2 : Year**

**3 : Month**

**4 : Production serial number**

**5 : Cell serial number**

**Year code:**

2007: K	2008: M	2009: O	2010: Q	2011: S
2012: U	2013: W	2014: Y	2015: B	2016: D
2018: F	2019: H	2020: J	2021: L	2022: N
2023: P	2024: R	2025: T	2026: V	2027: X
2028: Z	2029: A	2030: C	...	

\*

The following statements, or equivalent, shall be included on the smallest package containing cells:

"WARNING: Risk of Fire, Explosion, and Burns. Do Not Disassemble, Crush, Heat Above manufacturer's recommended charge/discharge temperature/100°C (212°F), or Incinerate." (++)

(++) - This warning statement may contain additional precautions such as a warning about short-circuiting the cells.

## Lithium-ion Cylindrical Cells

General - See Ills. 1, 2 for additional details of construction.

1. Cell Case - Consists of material, overall dimensions, and thickness of plating as noted below.

Model	Case Material	Case Dimensions, mm		Case Thickness, mm	Plating Thickness, mm
		Length	OD		
PC26065F1, 2BF1	Al (Al3003)	65.0	26.0	0.3	1
PC26070F1, 2AF1	Al (Al3003)	70.0	26.0	0.3	1
PC40138F1, 4BF1	Al (Al3003)	138.0	40.6	0.5	2
PC40155F1, 4AF1	Al (Al3003)	155.0	40.6	0.5	2
PC40138-LFP	Al (Al3003)	138.0	40.6	0.5	1
PC40138-LFP-K	Al (Al3003)	138.0	40.6	0.5	1

2. Electrode Assemblies - Consists of positive and negative electrodes rolled in a "jelly roll" assembly within the case and constructed as noted below.

Model No.	Positive Electrode		Negative Electrode		Negative Electrode/ Positive Electrode Capacity ratio (Ah <sub>NE</sub> /Ah <sub>PE</sub> )
	Drawing No.	Dimensions, mm	Drawing No.	Dimensions, mm	
PC26065F1, 2BF1	--	55 x 1390	--	58 x 1470	1.115
PC26070F1, 2AF1	--	58 x 1390	--	61 x 1470	1.112
PC40138F1, 4BF1	--	116 x 3665	--	122 x 3745	1.097
PC40155F1, 4AF1	--	125 x 3665	--	133 x 3745	1.087
PC40138-LFP	--	119 x 3450 ± 1%	--	123 x 3550 ± 1%	1.1 ± 0.1
PC40138-LFP-K	--	124×3800±2%	--	126×3880±2%	<b>1.06±0.1</b>

3. Separator - Battery separator Located between the electrodes and constructed as noted below. The separator is sized to extend beyond the electrodes as noted below for reliable insulation.

Cell Model	Separator Mfg.	Type Designation	Report Reference (UnListed Component)		Dimensions, mm		Minimum Extension beyond electrodes, mm
			File Number	Report Date	Length	Width	
PC26065F1, 2BF1	Celgard	2325 (thickness 25±2.5µm)	MH45837	2009-09-28	1550	61	Each side 1.5
PC26070F1, 2AF1	Celgard	2325 (thickness 25±2.5µm)	MH45837	2009-09-28	1550	64	Each side 1.5
PC40138F1, 4BF1	Celgard	2325 (thickness 25±2.5µm)	MH45837	2009-09-28	3900	125	Each side 4.5
PC40155F1, 4AF1	Celgard	2325 (thickness 25±2.5µm)	MH45837	2009-09-28	3900	142	Each side 4.5
PC40138-LFP	Celgard	2325 (thickness 25±2.5µm)	MH45837	2009-09-28	4000 ± 1	127.5	Each side 4.5
PC40138-LFP-K	Celgard	M825 (thickness 16±2.0µm)	MH45837	2009-09-28	4180±2%	128.5	Each side 4.5
<b>PC40138-LFP-K</b>	<b>Celgard</b>	<b>H1612 (thickness 16±1.6µm)</b>	<b>MH45837</b>	<b>2009-09-28</b>	<b>4030±2%</b>	<b>130</b>	<b>Each side 4.5</b>

TEST RECORD NO. 5

## SAMPLES:

The manufacturer furnished representative samples of the cell Model noted below for the investigation. These samples were subjected to the test program described on the following pages.

Model	Cell Chemistry	Cell Shape	Energy Density, mAh/mm <sup>3</sup>	End Point Voltage, V dc	Nominal Voltage Rating, V dc	Capacity, Ah	Maximum Charging Current, mA	Maximum Charging Voltage, V dc
PC40138-LFP-K	LiFePO4	cylindrical	0.10075	2.1	3.3	18±2	18000	3.65

## GENERAL:

Test results relate only to the items tested.

The tests were conducted at UL.

Only limited tests were performed on Model PC40138-LFP-K employing the alternate separator source, type H1612 by Celgard, correction of Electrode Assemblies information, and revise date code consists, due to testing previously performed on the subject unit.

Tests were considered covered as follows:

Test	File Reference	Report Date	Test Record No.
Short Circuit Test at room	MH48419	2011-12-14	1
Shock Test	MH48419	2011-12-14	1
Vibration Test	MH48419	2011-12-14	1
Temperature Cycling Test	MH48419	2011-12-14	1
Low Pressure Test (Altitude Simulation Test)	MH48419	2011-12-14	1
Short Circuit Test at 55°C	MH48837	2007-05-29	4
Abnormal Charging Test	MH48837	2007-05-29	4
Projectile Test	MH48837	2007-05-29	4

The following tests were conducted.

Model	Test	UL 1642, Section	Complied, Y, N Or N/A	Comments
PC40138-LFP-K	Crush Test	13	Y	Compliance
PC40138-LFP-K	Impact Test	14	Y	Compliance
PC40138-LFP-K	Heating Test	17	Y	Compliance

The test methods and results of the above tests have been reviewed and found in accordance with the requirements in the Standard for Lithium Batteries, UL 1642, Fifth Edition, Dated March 13, 2012, and contains revisions through Dated July 30, 2013.

Test Record Summary:

The results of this investigation, including construction review and testing, indicate that the products evaluated comply with the applicable requirements in the UL Standard for Safety for Lithium Batteries, UL 1642, Fifth Edition, Dated March 13, 2012, and contains revisions through Dated July 30, 2013, therefore, such products are judged eligible to bear UL's Mark as described on the Conclusion Page of this Report. Any information and documentation involving UL Mark services are provided on behalf of UL LLC (UL) or any authorized licensee of UL.

Test Record by:  
JOY SHEN  
Associate Project Engineer

Reviewed by:  
JOHN WANG  
Associate Project Engineer

## INDEX

MODEL	SECTION
Battery Separator, Models Celgard 2325, Celgard M825, <b>Celgard H1612</b>	1



## COMPONENT - LITHIUM BATTERIES (BBCV2, BBCV3)

TABLE B - SAMPLE SELECTION GUIDE

Sample Group	#/Group	Model #	Report Date	Category	Type of Cells	Cell capacity (C) mAh	Thickness ( $\mu\text{m}$ )	Additional Info	Test Program Code
1	3	Celgard 2325	2009-09-28	Separator	-	-	25 +/- 2.5	# - To be determined after first FUS test	E, F
		Celgard H1612	2009-09-28	Separator	-	-	16 +/- 1.6	# - To be determined after first FUS test	E, F
		Celgard M825	2014-08-26	Separator	-	-	16 +/- 2	# - To be determined after first FUS test	E, F

COMPONENT - LITHIUM BATTERIES (BBCV2, BBCV3)

INDEX TO FOOTNOTES:

- \* - **This model has +/- 1000 mAh tolerance**
- + - **This model has +/- 10% mAh tolerance**

COMPONENT - LITHIUM BATTERIES (BBCV2, BBCV3)

TABLE C - TEST CRITERIA

Refer to Sp. App. B for Footnotes and TABLE B for Additional Information

Model #	Cell capacity (C) mAh	Open Circuit Voltage, Vdc	Top-off Charge voltage( $V_c$ ), Vdc	Top-off Charge current ( $I_c$ ), mA	End Point/ Cut Off Voltage, Vdc	External Protector Left in Circuit, Y/N?	IR Reference	TGA Reference	DSC Reference
Celgard 2325	-	-	-	-	-	-	#	#	#
Celgard H1612	-	-	-	-	-	-	#	#	#
Celgard M825	-	-	-	-	-	-	#	#	#





COMPONENT - LITHIUM BATTERIES (BBCV2, BBCV3)

TABLE 3  
PRODUCTION LEAKAGE TEST PARAMETERS

Cell Models	Section No.	No. of Production Samples Tested per Month, (≥ 5 Samples)
N/A		

TABLE 4  
PRODUCTION X-RAY CONSTRUCTION REVIEW PARAMETERS

Cell Models	Section No.	No. of Production Samples Tested per Month, (≥ 10 Samples)
N/A		

## DESCRIPTION

## PRODUCT COVERED:

Component - Battery separators:

Part Nos.
Celgard 2325
Celgard M825
<b>Celgard H1612</b>

## PARAMETERS SPECIFICATIONS:

See Table IA and IB for parameters specifications

## GENERAL MATERIAL COMPOSITION:

Part No.	Generic material(s) specification
Celgard 2325	PP/PE/PP
Celgard M825	PP/PE/PP
<b>Celgard H1612</b>	<b>PP/PE/PP</b>

## TECHNICAL CONSIDERATIONS (NOT FOR FIELD REPRESENTATIVE'S USE):

The products are lithium ion battery separators which are essentially a porous membrane of insulating material(s) intended to provide electrical insulation between the electrodes of a lithium ion battery while also allowing for ion transport between the electrodes. The separators have various parameter specifications related to the material and structural properties of the material and that are determined through testing.

Use - For use only in products where the acceptability of the combination is determined by Underwriters Laboratories Inc.

Conditions of Acceptability - The following are among the considerations to be made in judging the use of this material in an end-use product.

TABLE IA  
SEPARATOR PARAMETERS

Part No.	Permeability (secs/25/ml)	Thickness, $\mu\text{m}$	Tensile Strength $\text{kg-f/cm}^2$	
			Machine (MD)	Transverse (TD)
Celgard 2325	643s/100ml	$25 \pm 2.5$	1700kg/cm2	150kg/cm2
Celgard M825	585S/100ml	$16 \pm 2.0$	2000Kg/cm2	140Kg/cm2
<b>Celgard H1612</b>	<b>290S/100ml</b>	<b><math>16 \pm 1.6</math></b>	<b>1350Kg/cm2</b>	<b>100Kg/cm2</b>

TABLE IB  
SEPARATOR PARAMETERS

Part No.	Puncture Strength (g-f/mm)	Dimensional Stability* (g-f/mm)	Shutdown Temp, °C	Melt Temp, °C
Celgard 2325	380	--	132	164
Celgard M825	300	--	132	164
<b>Celgard H1612</b>	<b>300</b>	<b>--</b>	<b>132</b>	<b>165</b>

\* - During the dimensional stability test, the puncture strength test is repeated on samples subjected to conditioning for 1 hour at  $130 \pm 2^\circ\text{C}$ .