



Samsung Recall Support Note7 Investigation

Root Cause Analysis

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Background and Project Scope

- After reports of failures in the field, Exponent was retained as an independent third-party to investigate the root cause for thermal failures of Note7 lithium-ion battery cells
- A suite of destructive and non-destructive techniques was used to evaluate the field failure and exemplar cells from both manufacturers that provided cells to Samsung
- In addition to analysis of the cells, an analysis of the design of the battery, device and electronics was conducted



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MADE IN CHINA / FABRIQUÉ EN CHINE

ENSAMBLADO EN CHINA / MONTADO NA CHINA

제조사 : Ningde Amperex Technology Limited

Secondary Li-ion Battery / 리튬이온2차전지 / 제2물명 : 저지리

Nominal Voltage / 공칭전압 / 定格 : 3.85 V = ...

Charge Voltage / 충전전압 / 充電電圧・4.4V =

A/S 무이 저하|버튼 · 1588-3366 3500 mAh 13.48 Wh

11CP6/39/08



YU10427-16003



SAMSUNG

JAPAN Co., Ltd. Li-ion 00



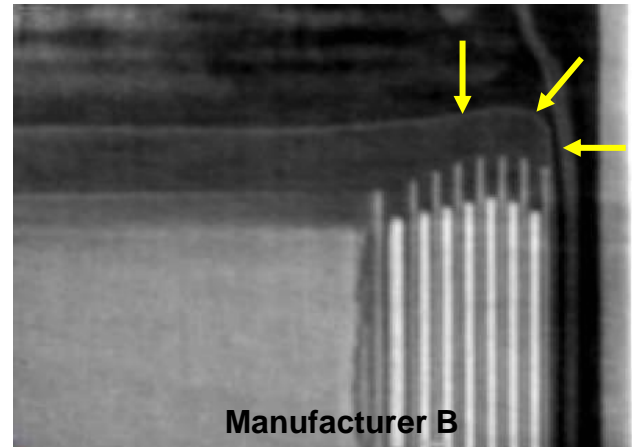
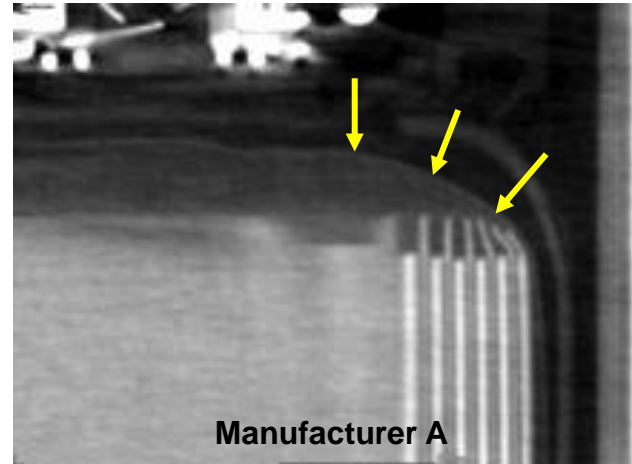
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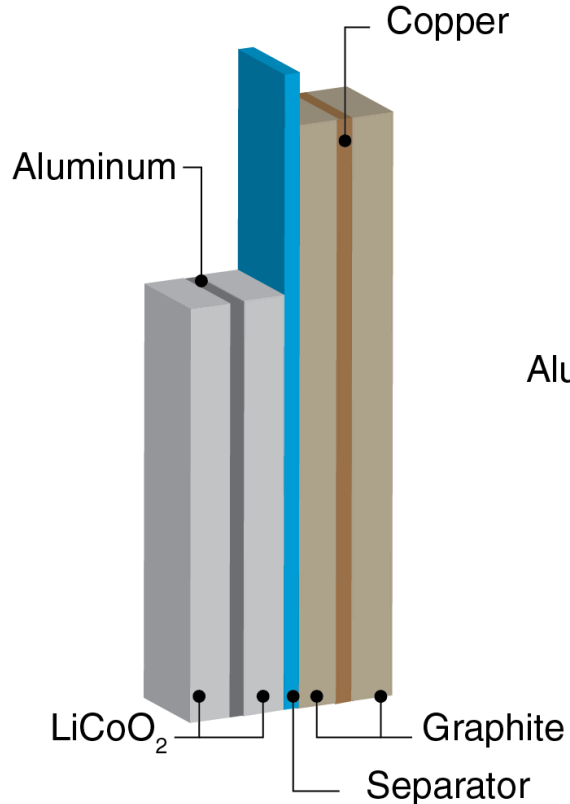
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Root Cause: Manufacturer A

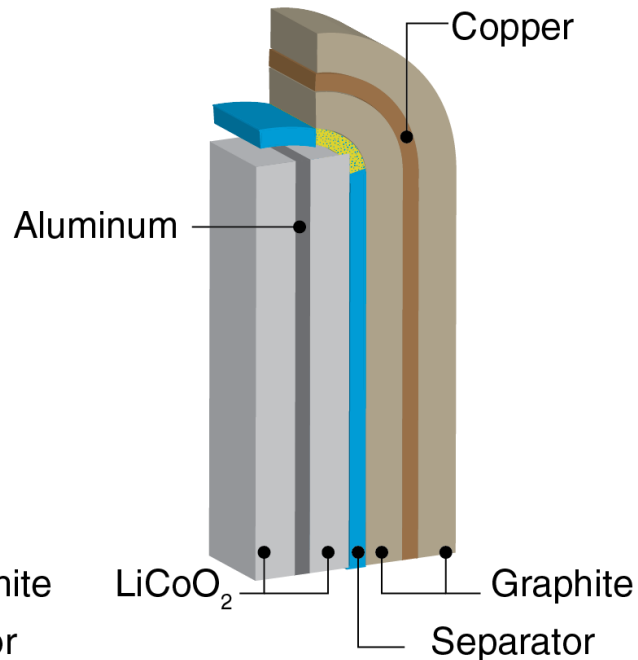
- Based on the results of analysis and testing, the most likely root cause for the thermal failure of certain Manufacturer A cells was determined to be unintended damage to the negative electrode windings consistently in the corner of the cell closest to the negative tab
 - The unintended damage was present in all of the cells examined by Samsung and Exponent
 - The damage was caused by a cell pouch design that provided inadequate volume to accommodate the electrode assembly
 - The observed damage provides multiple potential routes to internal cell faulting and thermal failure with normal cycling, including compromise of the separator and lithium plating
- Exponent's initial analysis of cells from Manufacturer B showed no deficiencies in the pouch, design or manufacturing
 - Manufacturer B cells manufactured after our initial investigation was complete were shown to contain a distinctly different defect that was not present in the initial cells we investigated



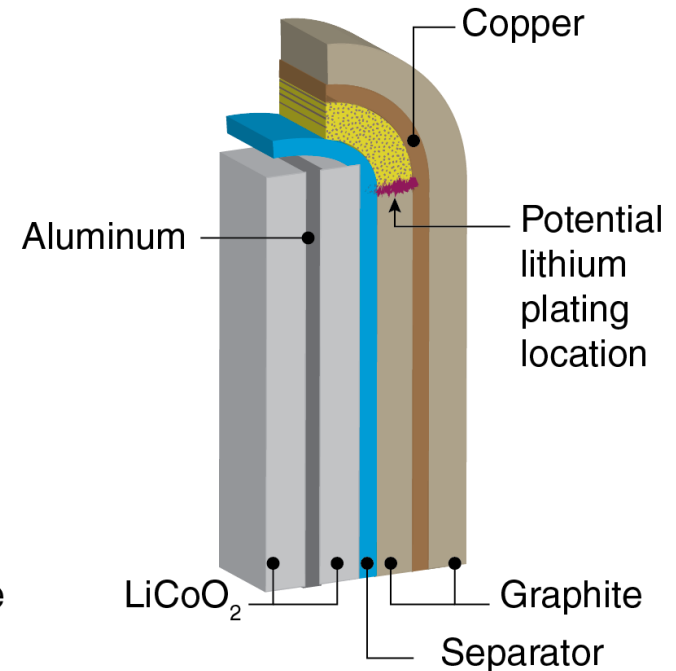
Proper Electrode Geometry



Damaged Separator: Short Circuit



Damaged Negative Coating: Lithium Plating and Short Circuit



Root Cause: Manufacturer B

- Based on the results of analysis and testing, the most likely root cause for the thermal failure of Manufacturer B cells was determined to be internal cell faulting between positive electrode tab welding defects and the copper foil of the negative electrode directly opposite the defective welds
 - Welding defects in some incident cells were found to be tall enough to bridge the distance to the negative electrode foil
 - Some cells examined were assembled without protective tape over the positive electrode tab, increasing the likelihood of an internal cell fault

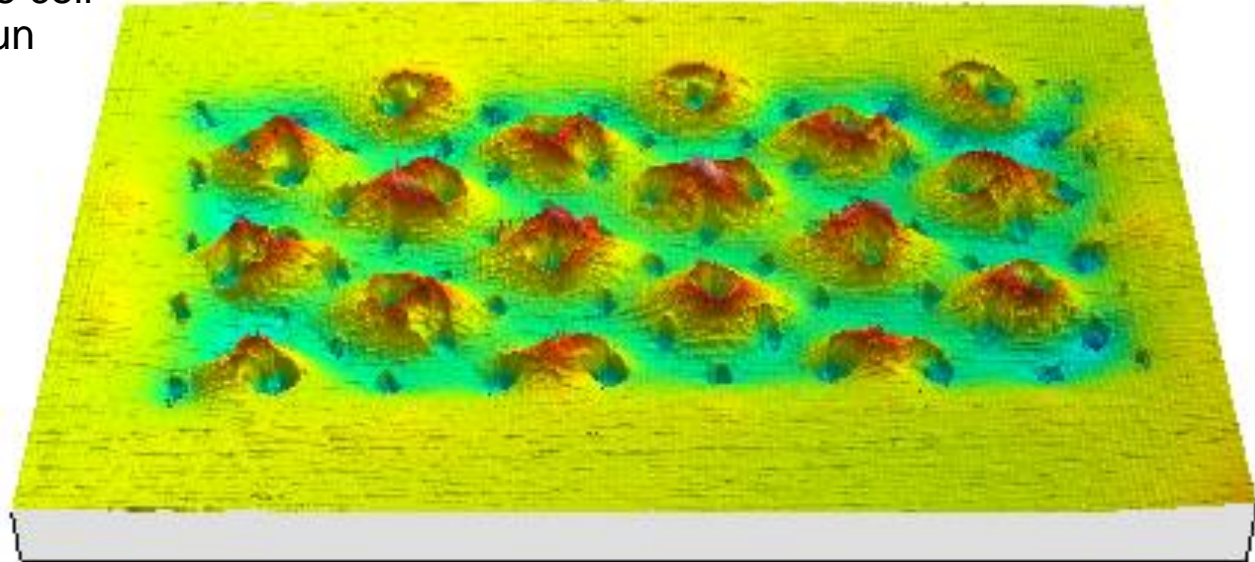
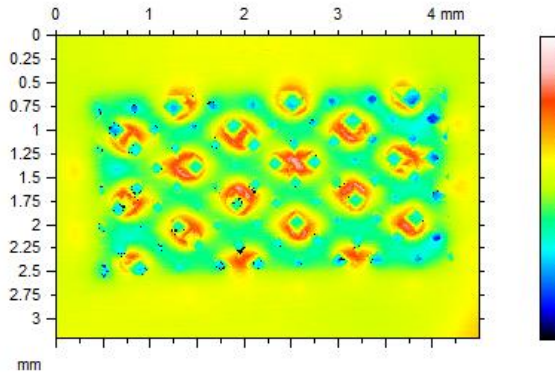
Positive Tab



Negative Electrode
Opposite Positive Tab



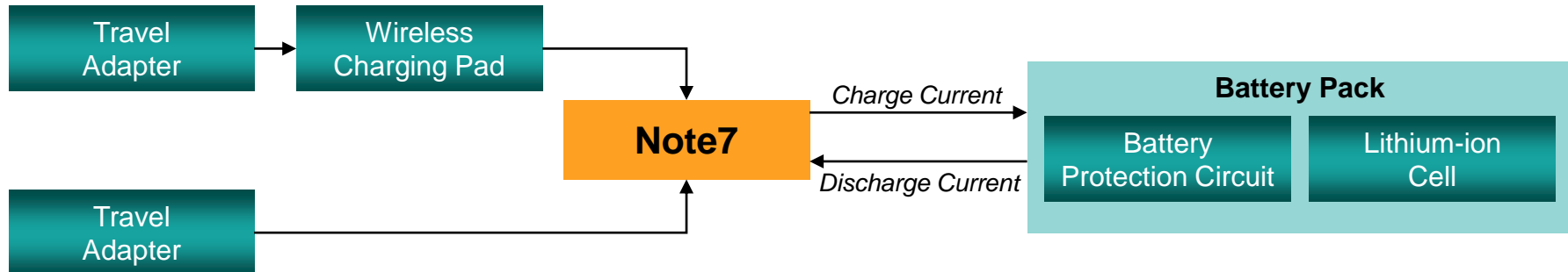
- Poorly controlled welding of the positive tab in Manufacturer B cells creates sharp, relatively tall welding defect features
- Normal swelling and contraction of the electrodes during charge and discharge forces the weld defect features into the opposing negative electrode
- Short circuit between the weld defect feature on the positive tab and the copper of the negative electrode results in heating of the cell
- At high states of charge, the cell heating results in thermal run away.



Battery System Analysis

- Analysis of the Note7 battery system design indicated that the system is designed with multiple levels of protection for the Li-ion cell
- The testing and analysis performed did not identify a fault in the Note7 battery system that could have triggered the observed battery failures in the field
- Testing performed with several third party wireless charging pads available for use with the Note7 device showed that the Note7 device is designed to prevent a failure of these charging pads from causing the Li-ion cell to operate outside its specifications

Note7 Battery System Architecture



Exponent[®]

Engineering & Scientific Consulting

