Samsung Electronics Co., Ltd. and Apple Inc.
v.
RJ Technology, LLC

Patent Owner Demonstratives
IPR2023-01183
U.S. Patent No. 7,749,641
October 22, 2024

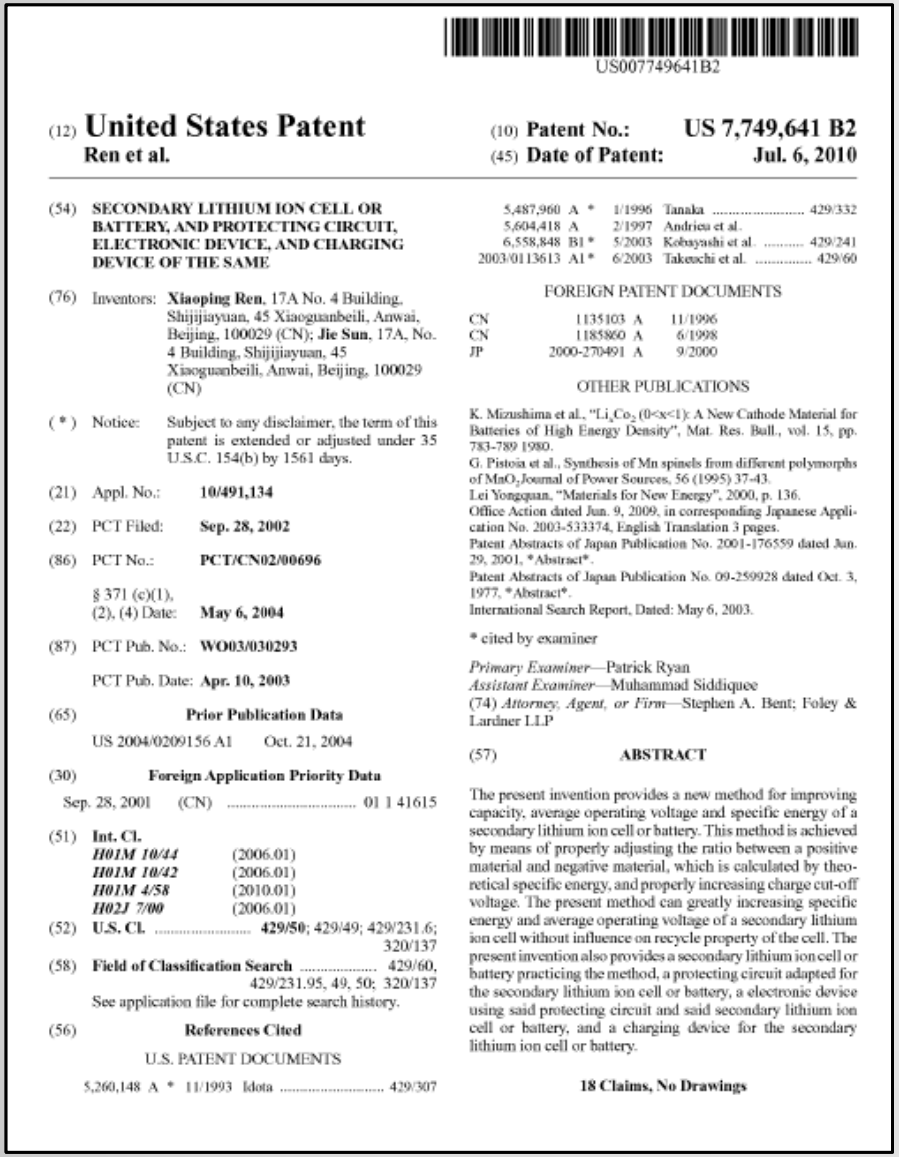
Minghui Yang
James Carmichael
Carmichael IP, PLLC

Michael Ng
Daniel Zaheer
George Stamatopoulos
Robert Zhou
Kobre & Kim LLP

The ’641 Patent

1. The ’641 Patent
2. Claim Construction
3. The Challenged Claims Are Patentable

The ’641 Patent



US007749641B2

(12) **United States Patent**
Ren et al.

(10) **Patent No.: US 7,749,641 B2**
(45) **Date of Patent: Jul. 6, 2010**

(54) **SECONDARY LITHIUM ION CELL OR BATTERY, AND PROTECTING CIRCUIT, ELECTRONIC DEVICE, AND CHARGING DEVICE OF THE SAME**

(76) Inventors: **Xiaoping Ren**, 17A No. 4 Building, Shijijiayuan, 45 Xiaoguanbeili, Anwai, Beijing, 100029 (CN); **Jie Sun**, 17A, No. 4 Building, Shijijiayuan, 45 Xiaoguanbeili, Anwai, Beijing, 100029 (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1561 days.

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(2), (4) Date: **May 6, 2004**

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H02J 7/00 (2006.01)

(52) **U.S. Cl.** **429/50**; 429/49; 429/231.6; 320/137

(58) **Field of Classification Search** 429/60, 429/231.95, 49, 50; 320/137
See application file for complete search history.

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Primary Examiner—Patrick Ryan
Assistant Examiner—Muhammad Siddiquee
(74) *Attorney, Agent, or Firm*—Stephen A. Bent; Foley & Lardner LLP

(57) **ABSTRACT**

The present invention provides a new method for improving capacity, average operating voltage and specific energy of a secondary lithium ion cell or battery. This method is achieved by means of properly adjusting the ratio between a positive material and negative material, which is calculated by theoretical specific energy, and properly increasing charge cut-off voltage. The present method can greatly increasing specific energy and average operating voltage of a secondary lithium ion cell without influence on recycle property of the cell. The present invention also provides a secondary lithium ion cell or battery practicing the method, a protecting circuit adapted for the secondary lithium ion cell or battery, a electronic device using said protecting circuit and said secondary lithium ion cell or battery, and a charging device for the secondary lithium ion cell or battery.

18 Claims, No Drawings

(10) **Patent No.: US 7,749,641 B2**
(45) **Date of Patent: Jul. 6, 2010**

(57) **ABSTRACT**

The present invention provides a new method for improving capacity, average operating voltage and specific energy of a secondary lithium ion cell or battery. This method is achieved by means of properly adjusting the ratio between a positive material and negative material, which is calculated by theoretical specific energy, and properly increasing charge cut-off voltage. The present method can greatly increasing specific energy and average operating voltage of a secondary lithium ion cell without influence on recycle property of the cell. The present invention also provides a secondary lithium ion cell or battery practicing the method, a protecting circuit adapted for the secondary lithium ion cell or battery, a electronic device using said protecting circuit and said secondary lithium ion cell or battery, and a charging device for the secondary lithium ion cell or battery.

18 Claims, No Drawings

The ’641 Patent

5. A secondary lithium ion cell or battery, characterized in that the secondary lithium ion cell or battery has a charge cut-off voltage of greater than 4.2 V but less than 5.8 V, and a ratio of positive electrode material to negative electrode material of the secondary lithium ion cell or battery is from 1:1.0 to 1:2.5, as calculated by a theoretic capacity with a charge cut-off voltage set at 4.2 V.

Ex. 1001, Cl. 5

The ’641 Patent

11. A secondary lithium ion cell or battery according to claim **5**, wherein the secondary lithium ion cell or battery maintains at least 7500 of capacity after 400 cycles.

12. A secondary lithium ion cell or battery according to claim **5**, wherein the secondary lithium ion cell or battery maintains at least 75.83% of capacity after 400 cycles.

13. A secondary lithium ion cell or battery according to claim **5**, wherein the secondary lithium ion cell or battery maintains at least 80% of capacity after 400 cycles.

14. A secondary lithium ion cell or battery according to claim **5**, wherein the secondary lithium ion cell or battery maintains at least 80.72% of capacity after 400 cycles.

Ex. 1001, Cl. 11-14

Claim Construction – “Charge cut-off voltage”

Term	Construction
“charge cut-off voltage”	The maximum voltage to which the battery is configured to be charged.

POR at 18

Claim Construction – "Charge cut-off voltage"

C. Claim Construction

Without agreeing to the correctness of—or taking ownership of—the following constructions, Petitioner bases its challenges on claim constructions advanced by Patent Owner in co-pending district court litigation and constructions that are implicit from Patent Owner's infringement contentions. *See W. Digital Corp. v. SPEX Techs., Inc.*, IPR2018-00084, Paper No. 14, p.11 (PTAB Apr. 25, 2018) ("37 C.F.R. § 42.104(b)(3) does not require Petitioner to express its subjective agreement regarding correctness of its proffered claim constructions or take ownership of those constructions.").

Pet. at 8

Claim Construction – "Charge cut-off voltage"

IV. CONCLUSION

For the foregoing reasons, the Court construes the disputed claim terms as follows:

No.	Term	Court's Construction
1.	"charge cut-off voltage"	"the maximum voltage to which the battery is configured to be charged."

Ex. 2010 at 31; POR at 18

Petitioner Agrees with the Construction of "Charge cut-off voltage"

EXHIBIT A: AGREED CONSTRUCTIONS

Claims	Term	Agreed Construction	Court's Construction
Claims 5–14	"charge cut-off voltage"	the maximum voltage to which the battery is configured to be charged	the maximum voltage to which the battery is configured to be charged
Claims 6, 7	"within a range from"	the range is inclusive	the range is inclusive
Claims 9, 10	"overcharging protection voltage"	the voltage level at which the battery's protection mechanism(s) engage(s) to prevent the battery from being charged to a higher voltage	the voltage level at which the battery's protection mechanism(s) engage(s) to prevent the battery from being charged to a higher voltage
Claims 9,10	"overcharg[ing/e] protection release voltage"	the voltage level at which the battery's protection mechanism(s) disengage(s) or reset(s)	the voltage level at which the battery's protection mechanism(s) disengage(s) or reset(s)
Claim 11	"7500"	75%	75%

Ex.2011 at 6; POR at 18

Petitioner's Expert Agrees with the Construction of "Charge cut-off voltage"

Q. It also says that if this term needs construction, it should be afforded its plain and ordinary meaning, which is the maximum voltage to which the battery is configured to be charged, right?

A. Right. That's the plain and ordinary meaning that I agree with.

Ex. 2008, 217:6-11; POR at n.3

The “Charge cut-off voltage” is a Battery Property

5. A secondary lithium ion cell or battery, characterized in that the secondary lithium ion cell or battery has a charge cut-off voltage of greater than 4.2 V but less than 5.8 V, and a ratio of positive electrode material to negative electrode material of the secondary lithium ion cell or battery is from 1:1.0 to 1:2.5, as calculated by a theoretic capacity with a charge cut-off voltage set at 4.2 V.

6. A secondary lithium ion cell or battery according to claim **5**, characterized in that the secondary lithium ion cell or battery has a charge cut-off voltage within a range from 4.3 V to 5.2 V.

7. A secondary lithium ion cell or battery according to claim **5**, characterized in that the secondary lithium ion cell or battery has a charge cut-off voltage within a range from 4.3 V to 4.8. V.

Ex. 1001, Cl. 5-7; Sur-Reply at 2

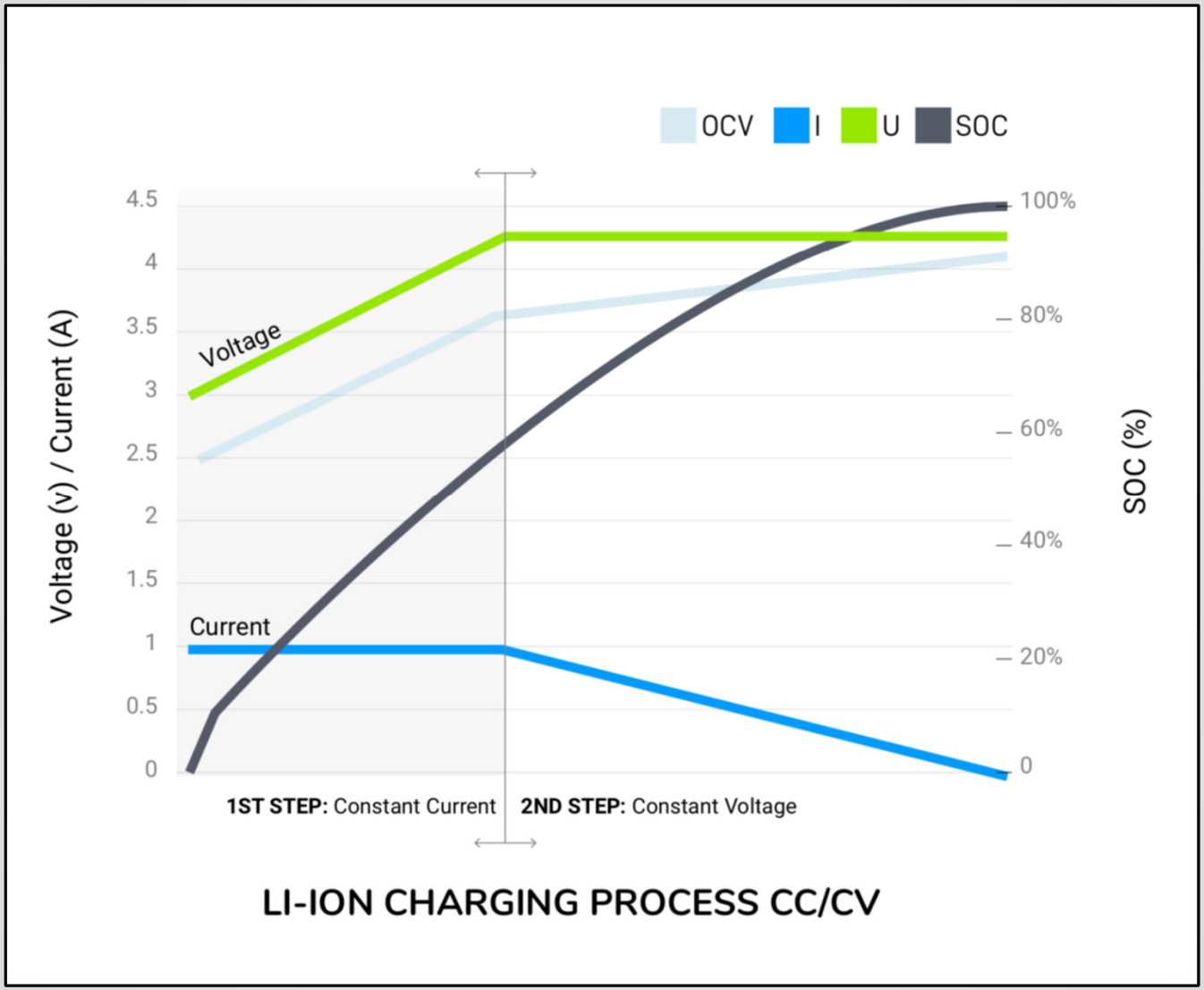
The "Charge cut-off voltage" is a Battery Property

It is one object of the present invention to provide a new method for improving capacity, average operating voltage and energy density of a secondary lithium ion cell or battery, wherein the charge cut-off voltage of the singe cell is greater than 4.2 V, and less than 5.8 V, and the ratio of positive electrode material to negative electrode material of the single cell is from 1:1.0 to 1:2.5, preferably from 1:1.16 to 1:2.5, as calculated by the specific capacity with the charge voltage limited to 4.2 V.

Another object of the present invention is to provide a secondary lithium ion cell or battery, wherein the single secondary lithium ion cell has an charge cut-off voltage of greater than 4.2 V but less than 5.8 V, and the ratio of positive electrode material to negative electrode material of the single cell is from 1:1.0 to 1:2.5, preferably from 1:1.15 to 1:2.5, as calculated by the specific capacity with the charge voltage limited to 4.2 V.

Ex. 2001, 3:20-21; 3:26-29; PO Sur-Reply at 2

The Applied Voltage is Different from the Charge Cutoff Voltage



Ex. 2013 at 3; Ex. 2006, ¶¶86-91; POR at 30-31

The Applied Voltage is Different from the Charge Cutoff Voltage

> 88. The applied voltage, which is different than the battery voltage, is always greater than the battery voltage during charging. That is because to drive the charging process to force lithium ions to move from the cathode to the anode, an *external* voltage higher than the battery voltage is required. Accordingly, the applied voltage is a measure of external voltage applied to the battery during charging (e.g., by a charging device).

Ex. 2006, ¶88; POR at 19.

The Applied Voltage is Different from the Charge Cutoff Voltage

> Q. So in order to move ions from the cathode to the anode, one would have to apply a voltage external to the battery that is greater than the open circuit voltage. Correct?
> A. Yes.

Ex. 2008, 57:1-5; POR at 19.

Examples 14 and 15

In the present method, the elevating of the charge cut-off voltage is advantageously carried out during the formation and examination of the cell. The use of charge cut-off voltage of 4.20 V or high could increase the specific energy of cell, the capacity of positive electrode active material and the average operating voltage, and activate the cell so that the cell reaches its optimal working state with simultaneously achieving the effect of the formation, substantial improvement of the specific energy of commercial lithium ion cells, and imparting the competitiveness of lithium ion cells without altering the original process.

Ex. 1001, 4:43-53; Sur-Reply at 3

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Moreover, Plaintiff's added limitation that the maximum voltage must be "designed and manufactured" (Pl.'s Br. 9) improperly introduces a requirement as to the ***subjective intent*** of a designer or manufacturer regarding the cut-off voltage. In other words, Plaintiff's proposed construction introduces the new requirement that a battery be "***configured***" ("*i.e.*, ***designed and manufactured***") (*id.*) to be charged at a charge cut-off voltage of 4.2 V, not just that it have the physical property of a charge cut-off voltage set at 4.2 V, as claim 5 requires. *See* Horn Decl., ¶12. Plaintiff's

Sur-Reply at 4

The *Apple* Litigation

The batteries at issue, as well as lithium ion batteries generally, have physical characteristics, some of which are determined by the design and manufacture of the battery, some of which are set by, for example, the first charge to which the battery is charged. And then, obviously, in the process of charging, the charging circuitry actually does charge the battery up to a maximum, which is the limit that we have addressed in our proposed construction.

I think it actually -- again, taking this somewhat on the fly because this is a new argument, introduces new types of uncertainty, to adopt a claim construction that says how it is charged. The physical characteristics of the battery are what counts here. There are physical properties of the battery that set the maximum to which it is charged. And then obviously in the devices themselves, they are charged up to a particular level. That is not the subjective intent of the designer. It is not the subjective intent of the user. It is the physical characteristic of the battery.

"The physical characteristics of the battery are what counts here."

Sur-Reply at 4; Ex. 1041, 7:24-8:18

The Charge Cutoff Voltage is the Full-cell Voltage

5. A secondary lithium ion cell or battery, characterized in that the secondary lithium ion cell or battery has a charge cut-off voltage of greater than 4.2 V but less than 5.8 V, and a ratio of positive electrode material to negative electrode material of the secondary lithium ion cell or battery is from 1:1.0 to 1:2.5, as calculated by a theoretic capacity with a charge cut-off voltage set at 4.2 V.

Term	Construction
"charge cut-off voltage"	The maximum voltage to which ***the battery*** is configured to be charged.

Ex. 1001, Cl. 5.; Sur-Reply at 5.

The Charge Cutoff Voltage is the Full-cell Voltage

For instance, as to lithium cobalt oxides that is used as positive electrode material in the most commercial lithium ion batteries, the charge cut-off voltage is limited to below 4.2 V and the actual capacity is 120-140 mAh/g, i.e., about 50% of the theoretical capacity, although many documents indicate that the charge cut-off voltage can be over 4.2 V for a test cell using metallic lithium as counter electrode. In fact, according to MIZUSHIMAK et al., "A new cathode material for batteries of high energy density", Mater. Res. Bull., 1980, 15:783, the quantity of dedoped lithium ion increases with the increase of charge voltage, and the electrochemical capacity of lithium cobalt oxides increases accordingly. However, the study deems that the reversible charge-discharge voltage is about 4.3 V when metallic lithium is used as counter electrode, and when said voltage is higher than 4.3 V, the structure of lithium cobalt oxides changes and the lattice parameter C decreases from 4.4 nm to 4.0 nm, and thus the recycle life of cell is affected.

Ex. 1001, 1:64-2:14; POR at 22-23; Sur-Reply at 5.

“Capacity Ratio Range”

Term	Construction
“a ratio of positive electrode material to negative electrode material of the secondary lithium ion cell or battery is from 1: 1.0 to 1 :2.5, as calculated by a theoretic capacity with a charge cut-off voltage set at 4.2 V.”	The product of the capacity of the cathode active material per mass unit and the amount of the cathode active material in the same mass unit divided by the product of the capacity of the anode active material per mass unit and the amount of the anode active material in the same mass unit, when the charge cut-off voltage is 4.2V

POR at 23.

"Capacity Ratio" is Calculated with Theoretical Capacity at 4.2V

5. A secondary lithium ion cell or battery, characterized in that the secondary lithium ion cell or battery has a charge cut-off voltage of greater than 4.2 V but less than 5.8 V, and a ratio of positive electrode material to negative electrode material of the secondary lithium ion cell or battery is from 1:1.0 to 1:2.5, as calculated by a theoretic capacity with a charge cut-off voltage set at 4.2 V.

POR at 25; Sur-Reply at 6-7; Ex1001, Cl. 5.

"Capacity Ratio" is Calculated with Theoretical Capacity at 4.2V

litigation against Apple. EX1016, p.4. Patent Owner identifies passages including the statement in the '641 patent that "'theoretical capacities of positive electrode and negative electrode' means the capacities of the positive electrode and negative electrode calculated with a charge cut-off voltage set at 4.2 V." EX1001, 4:4-9; EX1016, p.4. Patent Owner has further contended that the recitation of the voltage being "set at 4.2 V" "theoretical capacity" does not refer to "theoretical maximum capacity," but instead "theoretical capacity at" 4.2 V. EX1031, p.15. Patent Owner identifies certain examples, including examples 14-18, which provide the mass of active materials (*e.g.*, lithium manganese oxide and MCMB). EX1001, 12:60-66; EX1016, p.4. Patent Owner's litigation construction is applied herein.

Pet. at 10; POR at 24.

The *Apple* District Court Agrees with PO

As an initial matter, the '641 Patent defines "theoretical capacities" of the anode and cathode as "the capacities of the positive electrode and the negative electrode calculated with a[] charge cut-off voltage set at 4.2 V." ('641 Patent at 4:5–9.) "Where, as here, the patentee has clearly defined a claim term, that definition usually is dispositive; it is the single best guide to the meaning of a disputed term." Jack Guttman, Inc. v. Kopykake Enterprises, Inc., 302 F.3d 1352, 1360-61 (Fed. Cir. 2002). This definition is also reflected in the claim term itself. (See id. at 17:10–11.) Disputed Clain Term 2 states that the ratio of positive to negative electrode material is calculated by the "theoretic capacity" at a charge cut-off voltage of 4.2 V, precisely how the specification defines "theoretic capacities." Indeed, within the claim, "theoretic capacity" is not an isolated term. Rather, it is part of the direction for how to calculate the appropriate ratio of positive to electrode material: by applying "a theoretic capacity with a charge cut-off voltage set at 4.2 V." ('641 Patent, 17:10–11.)

POR at 24; Ex. 2010 at 14

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itself or with the intrinsic and extrinsic evidence. The ratio limitation does not use the term "theoretic capacity" in isolation but instead instructs that the calculation must be done using the "theoretic capacity *with a charge cut-off voltage set at 4.2V*." '641 Patent at Claim 5 (emphasis added). When faced with a reference number like this, a POSA would recognize that this 4.2V reference point directly and necessarily requires that the cathode capacity variable in the calculation cannot refer to the theoretical maximum capacity but instead must refer to the theoretical capacity at that voltage because it means some of the lithium may not participate in the reactions. *Id.*, ¶¶ 42-51. This was a common way in which skilled artisans referred

Sur-Reply at 6-7; Ex. 1032 at 15.

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materials in the cell." Dkt. 69-10 at 447. What Apple neglects to point to is that in the very same section, the Linden handbook lists 137 mAh/g as the theoretical capacity for $LiCoO_2$–which undisputedly is not the theoretical maximum of that material—274 mAh/g is—but instead the capacity after an "x" factor of .5 is applied. *See id.* at 447-448; *see also* RJ Tech. Br. at 16. If there is any ambiguity about whether theoretical capacity refers to the theoretical maximum capacity, or the capacity at 4.2V, the claim clears that ambiguity by specifying that it is the theoretical capacity at 4.2V.

Sur-Reply at 6-7; Ex. 2012 at 12.

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> I think that there is another sort of mistake at the core of Apple's argument, and that is that "theoretical capacity" has some unique meaning that is distinguished from "specific capacity." And this comes up in a number of different ways, but that is also incorrect. They define "specific capacity" as what they call "actual capacity," which I believe what they mean by that is that you actually have to measure the particular material in front of you to determine the capacity. You don't as with theoretical capacity in the way that we use it determine it by using a particular coefficient, a particular mathematical reference adjustment, to determine how much is pulled out at a particular voltage.

Sur-Reply at 6-7; Ex. 1041 at 21:11-19.

Grounds 1-2

Ground	Claims	Basis
1	1-8	Anticipated under §102(e) by Uemura
2	1-8	Obvious under §103(a) over Uemura

Pet. at 7.

Uemura Discloses an Applied Voltage

[0081] The charge-discharge was repeatedly performed at a constant current of 0.5 mA/cm^2 and a voltage ranging from 4.3 V to 2.0 V at an atmospheric temperature of 60° C. by the use of the made sealed type non-aqueous solvent battery cell. The number of cycles taken to a point where the discharge capacity becomes less than 90% of the initial discharge capacity was obtained. Thus, the resistance was evaluated. A result thereof is shown in Table 1 together with the other values.

Ex. 1009, ¶81; POR at 28; Sur-Reply at 8.

Petitioner's Expert Agrees That Uemura Discloses an Applied Voltage

Q. And according to Uemura's description, the charging would stop once the externally applied voltage would reach 4.3 volts. Correct?

A. The way it's written in paragraph 81, yes.

Q. Is there any other way to understand what's written in paragraph 81?

ATTORNEY SOMMER: Object to form.

A. No, unless they left out the constant voltage component, if they left that out. But when you charge and discharge a cell, if you charge it at a slow enough rate, you don't need that constant voltage component if you charge at a slow enough rate.

Ex. 2008, 113:5-12; Sur-Reply at 8-9

Uemura's Applied Voltage is Higher Than the Battery Voltage

Q. So in order to move ions from the cathode to the anode, one would have to apply a voltage external to the battery that is greater than the open circuit voltage. Correct?

A. Yes.

Ex. 2008, 57:1-5; POR at 28.

Uemura Does Not Disclose a Battery Voltage Above 4.2V

121. However, based on published data for batteries with similar cathode materials as those used in Uemura, it is reasonably certain that the charge cutoff voltage of the batteries in Uemura were lower than 4.2V when the applied voltage reached 4.3V. For example, as shown below, for a typical rechargeable lithium-ion battery with $LiCoO_2$ as the cathode, when the applied voltage reached 4.2V for the first time under the constant current charging phase, its capacity was only 60%, when the current was 1A.[65] When the constant current was 0.5A, the state of charge when the applied voltage reached 4.2V was around 80%.

Ex. 2006, ¶121; POR at 28-34.

Uemura Charges Its Battery Using Only Constant Current

[0081] The charge-discharge was repeatedly performed at a constant current of 0.5 mA/cm^2 and a voltage ranging from 4.3 V to 2.0 V at an atmospheric temperature of 60° C. by the use of the made sealed type non-aqueous solvent battery cell. The number of cycles taken to a point where the discharge capacity becomes less than 90% of the initial discharge capacity was obtained. Thus, the resistance was evaluated. A result thereof is shown in Table 1 together with the other values.

Ex. 1009, ¶81; POR at 29; Sur-Reply at 9-10.

Uemura's Constant Current Charging Does Not Charge Its Battery to >4.2V

23 A. When you charge at a constant current, you
24 don't -- you can't move all the lithium from the cathode
25 that you want to move into the anode. You have some

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1 diffusion limits so you have to diffuse lithium through
2 the SEI layer into the active anode material, and that
3 takes time. And you have to allow it that time.
4 So you want to hold the battery at a voltage
5 so that you have that electromotive force so you hold it
6 at that upper charge cutoff and then the current slowly
7 drops and -- as you start -- as you continue to
8 intercalate lithium into the graphite.
9 So it's a very common method. If you only did
10 a constant current charge, you might only get, let's
11 say, 80 percent charge if you don't do the full charge.
12 If you charge at a very high rate, like a 2C rate, you
13 might only get 60 percent capacity in the cell if you
14 only do the constant current portion.

Uemura's Constant Current Charging Does Not Charge Its Battery to >4.2V

mA. According to the capacity data reported in Uemura, the charging for each of the examples in Fig. 3 lasted between 3-4 hours. A POSITA would understand that generally this is a relatively medium charging current, but certainly not the kind of slow charging that could charge a battery to its full capacity using only constant current charging.

Ex. 2006, n.64; POR at n.5

Uemura's Constant Current Charging Does Not Charge Its Battery to >4.2V

Q. Is that a fast discharge rate or a slow discharge rate?

ATTORNEY SOMMER: Object to form.

A. That would be kind of in the middle of your typical 10 hours and one hour rates. But the actual -- you have to look at the electrodes themselves and look at the porosity of the electrodes, the surface area of the electrodes, the connectivity of the electrodes to determine for that particular material, is that a low or high rate for that particular material.

Ex. 2008, 117:16-25; POR at n.5.

Uemura's Constant Current Charging Does Not Charge Its Battery to >4.2V

strike a balance between fast charging and safe charging. But CC/CV charging is not the only way to charge a battery. A charge cutoff voltage can be implemented by other charging algorithms. For example, in many laboratory settings, batteries are charged at a constant current without a constant voltage stage. Once the battery reaches a predetermined voltage (*i.e.*, the charge cut-off voltage), the charging stops. Sometimes the battery is charged at a constant voltage, without first being

understand that. In your opinion you're telling the board that constant current charging sometimes will reach the charge cut-off voltage and sometimes will not reach the charge cut-off voltage, depending on conditions?

MR. STAMATOPOULOS: Object to form.

A. I'm telling the board under current condition sometimes it reach equilibrium if you charge at pretty slow rate. Some -- you know, if you charge at the higher rate or medium rate, it will not reach the equilibrium at the end of the charge.

Ex. 2022, ¶33; Ex. 1043, 25:1-13; PO Sur-Reply at 9-10.

IPR2023-01183 Exhibit 2040

Uemura Does Not Disclose a Battery Voltage >4.2V

So in a typical lithium-ion battery, a 10-hour rate would be slow, but that would be a very high, very dense electrode. And so, you know, for this one, it's hard -- they don't specifically say -- yeah, it's -- it's difficult for the amount of information they give you whether or not that's a low or a high rate.

Ex. 2008, 118:6-11; POR at n.5

Uemura Does Not Disclose a Battery Voltage >4.2V

Q. So just to sum things up a little bit, there's a number of things that you would need to look at in order to determine whether the charge -- the discharge rate you just calculated for Uemura's example is slow or fast. Correct?

A. Yes.

Q. And that information that would be necessary for you to consider in order to make that determination is not available in Uemura. Correct?

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A. That's correct.

Ex. 2008, 118:17-119:1; POR at n.5.

Uemura Does Not Disclose a Battery Voltage >4.2V

> 46. A person of skill would conclude from these results that the resulting battery cells (i.e., those described in Uemura's Example 2 but with the cathode prepared using the ion exchange method), to the extent at all rechargeable, are not configured to be charged to a maximum voltage above 4V because of their performance degradation after a single charge cycle at or around that voltage.

Ex. 2031, ¶46; POR at 32.

Uemura Does Not Disclose a Battery Voltage >4.2V

123. As discussed below, Dr. Yanliang Liang tried to reproduce the alleged experimental results in Uemura. Even with the successful synthesis of Co-doped layered $LiMnO_2$, when a cell with $Li_{0.8}Mn_{0.5}Co_{0.5}O_2$ as the cathode active material (similar to the cathode active material in Example 2 of Uemura) and hard carbon as the anode active material was charged with a current density of 0.14 mA/cm^2 (an even lower current than what was allegedly used in Uemura), before the applied voltage even reached 4V, the cell had already started to degrade.[67] The results suggest that the disclosed battery in Uemura cannot be safely charged to 4.2V without causing severe damages to the battery. Accordingly, Uemura does not disclose a charge cutoff voltage higher than 4.2V and does not anticipate any claim of the '641 Patent, or render them obvious.

Ex. 2006, ¶123; POR at 32.

Uemura's "Capacity Balance" Was Not Calculated Using the Theoretical Capacity of the Cathode

FIG.3

	Positive electrode material						Negative electrode material					
	Used transition metal material	Composition of positive electrode material	X	Y	Weight (mg)	Total capacity : Pc (mAh)	Weight (mg)	Total capacity : Nc (mAh)	Total irreversible capacity : Ic	Capacity balance Pc:Nc	Ic/Pc ×100(%)	Number of cycles
Comparative example		$LiMn0_{2-\delta}$	0	0	15	2.7	10	–	–	(1:1.3)	–	10

133. For the comparative example, Uemura reports that it has a "total capacity" of 2.7 mAh when its weight is 15 mg.[81] The specific capacity of the comparative example thus is 180 mAh/g:

$$\frac{2.7\ \text{mAh}}{0.015\ \text{g}} = 180\ \text{mAh/g}$$

Ex. 2006, ¶133; Ex. 1009, FIG. 3; POR at 35-37.

Uemura's "Capacity Balance" Was Not Calculated Using the Theoretical Capacity of the Cathode

134. However, this is not the value representing the theoretical capacity of layered $LiMnO_2$ at 4.2V. One common way of identifying the theoretical capacity of an electrode material is through slow charging.[82] As Armstrong 1996 shows, when the charging rate is as low as 10 $\mu A/cm^2$, the specific capacity of layered

Ex. 2006, ¶134; POR at 36; Sur-Reply at 10-11.

Uemura's "Capacity Balance" Was Not Calculated Using the Theoretical Capacity of the Cathode

Synthesis of layered $LiMnO_2$ as an electrode for rechargeable lithium batteries

A. Robert Armstrong & Peter G. Bruce

School of Chemistry, University of St Andrews, North Haugh, St Andrews, Fife KY16 9ST, UK

RECHARGEABLE lithium batteries can store more than twice as much energy per unit weight and volume as other rechargeable batteries[1-4]. They contain lithium ions in an electrolyte, which shuttle back and forth between, and are intercalated by, the electrode materials. The first commercially successful rechargeable lithium battery[5], introduced by the Sony Corporation in 1990, consists of a carbon-based negative electrode, layered $LiCoO_2$ as the positive electrode, and a non-aqueous liquid electrolyte. The high cost and toxicity of cobalt compounds, however, has prompted a search for alternative materials that intercalate lithium ions. One such is $LiMn_2O_4$, which has been much studied as a positive electrode material[6-9]; the cost of manganese is less than 1% of that of cobalt, and it is less toxic. Here we report the synthesis and electrochemical performance of a new material, layered $LiMnO_2$, which is structurally analogous to $LiCoO_2$. The charge capacity of $LiMnO_2$ (~270 mA h g^{-1}) compares well with that of both $LiCoO_2$ and $LiMn_2O_4$, and preliminary results indicate good stability over repeated charge–discharge cycles.

Many attempts have been made to prepare layered $LiMnO_2$, mainly involving the use of aqueous solutions[4,10]. The resulting products, though interesting, have stoichiometries which differ from $LiMnO_2$, contain water or protons, are of poor crystallinity or do not maintain their structure during cycling. In contrast we have succeeded in preparing layered, anhydrous and stoichiometric $LiMnO_2$ which is analogous to $LiCoO_2$ and may be cycled in a rechargeable battery; it is obtained by ion exchange from $NaMnO_2$. The sodium compound was synthesized by solid-state reaction between stoichiometric quantities of Na_2CO_3 and manganese (III) oxide at 700–730 °C for 18–72 hours under flowing argon[11]. $LiMnO_2$ was obtained by refluxing $NaMnO_2$ with an excess of LiCl or LiBr in *n*-hexanol at 145–150 °C for 6–8 hours. After cooling to room temperature the product was filtered under suction and washed, first with *n*-hexanol and then with ethanol, and dried[12]. Phase purity was established by powder X-ray diffraction.

The layered structure of $LiMnO_2$ was confirmed by powder neutron diffraction carried out on the POLARIS diffractometer at the ISIS pulsed source (Rutherford Appleton Laboratory) (Fig. 1*a*). The structure was refined by the Rietveld method using the program TF12LS based on the Cambridge Crystallographic Subroutine Library[13]. Adoption of a layered model yielded a final agreement factor, $R_{weighted\ profile}$, of 2.06% compared with an $R_{expected}$ of 0.60%. A common structure obtained when attempts are made to prepare compounds with the $LiMnO_2$ composition is that of tetragonally distorted spinel $Li_2Mn_2O_4$ (ref. 4). This structure was tested in the refinement process; however, the fit obtained using the layered model was far superior to the fit assuming a tetragonal spinel structure for which $R_{wp} = 4.79\%$. The layered structure of $LiMnO_2$ is shown in Fig. 1*b*. The oxide ions are arranged in close-packed layers which are stacked in an ABC repeat sequence, that is, cubic close packing. Manganese ions are located in each octahedral site between the first and second oxide layers (Fig. 1*b*). Between the second and third layers the Li^+ ions reside also in octahedral sites. Refinement was carried out permitting the Li^+ and Mn^{3+} ions to occupy their

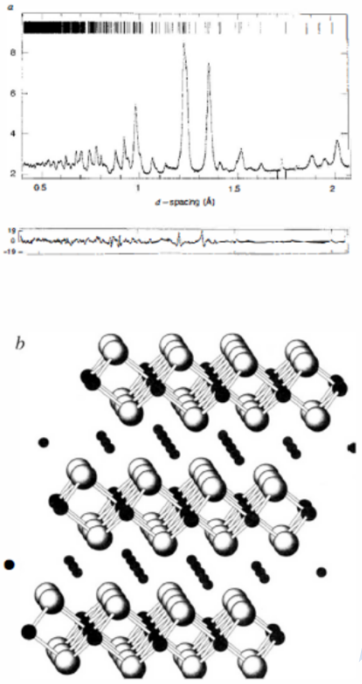


FIG. 1 *a*, Observed (dots) and calculated (solid line) neutron-diffraction profiles for monoclinic $LiMnO_2$. The lower plot shows the difference between observed and calculated standard deviation. *b*, Structure of $LiMnO_2$ emphasising the layered nature of the material. Mn, large dark circles; Li, smaller dark circles; O, pale circles.

TABLE 1 Crystallographic parameters of $LiMnO_2$

Atom	Wyckoff symbol	x	y	z	B_{eq}	Site occupancy
Li1/Mn1	2d	0	0.5	0.5	2.4(2)	0.91/0.09(4)
Li2/Mn2	2a	0	0	0	0.72(6)	0.10/0.90(3)
O1	4i	0.2723(3)	0	0.7706(2)	0.68(4)	1

Monoclinic, space group C2/m (no. 12). Unit-cell dimensions: $a = 5.4387(7)$ Å, $b = 2.80857(4)$ Å, $c = 5.3878(6)$ Å, $\beta = 116.006(3)°$, $\chi^2 = 11.83$. $R_{exp} = 0.60\%$, $R_p = 1.86\%$, $R_{wp} = 2.06\%$, $R = 3.98\%$.)

RJ Technology Exhibit 2009
Apple Inc. v. RJ Technology LLC
IPR2023-01183, Page 1 of 2

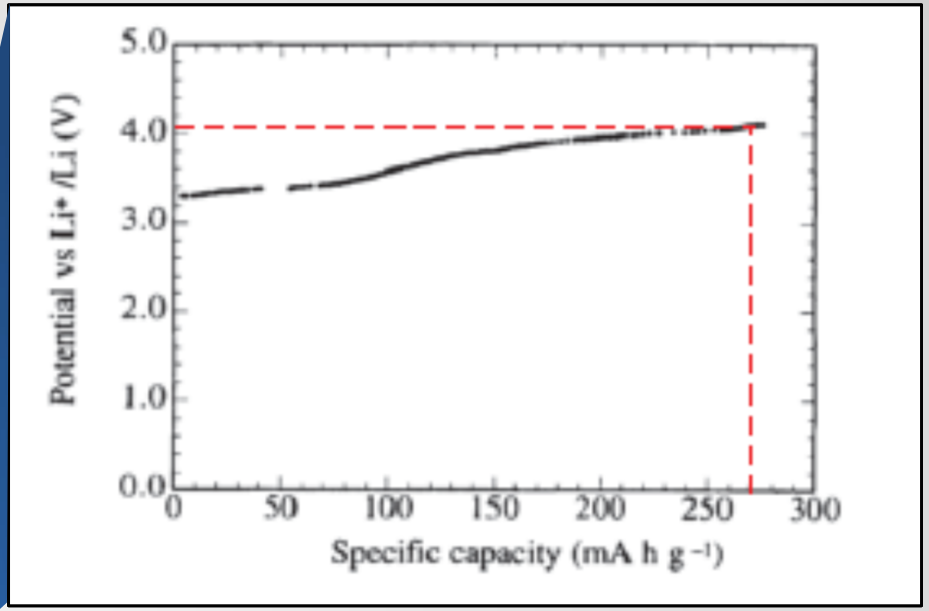


FIG. 2 Variation of electrode potential with capacity on charging $LiMnO_2$ at a current density of 10 μA cm^{-2}.

270 mAh/g is the theoretical capacity at 4.2V for $LiMnO_2$

Ex. 2006, ¶133, 134; Ex. 2009 at 500; POR at 36; Sur-Reply at 10-11.

Uemura's "Capacity Balance" Was Not Calculated Using the Theoretical Capacity of the Cathode

Q. (BY MR. COLIN) And so why did you pick 270 milliamp-hours per gram as the theoretic capacity at 4.2 volts of lithium manganese oxide as opposed to 200 milliamp-hour per gram that's obtained using a faster current?

MR. STAMATOPOULOS: Object to form.

A. Yeah. The reason I picked the specific capacity at a lower current density, 10 microamp per centimeter squared, it's more close equilibrium. And that's more close to the -- that's a number typical we use to consider as capacity, as a theoretic capacity value.

As I explained to you earlier, you know,

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that's how experimentally, you know, determine the theoretic capacity and know the X, you know, extraction ratio, typically at a very slow rate. 25 milliamp per centimeter is much higher rate. It's not considered close to equilibrium current capacity.

Sur-Reply at 11; Ex. 1043, 171:9-172:6

The "Capacity Balance" Reported in Uemura Includes Inactive Material Capacity that Should Be Excluded

capacity the anode material has.[87] In other words, according to Uemura, the sole purpose of the alleged non-carbon content was to create irreversible capacity, but the non-carbon content does not participate in the reversible intercalation and de-intercalation of lithium ions in subsequent charging and discharging cycles. A POSITA would thus understand that the non-carbon content of the anode is inactive material because it does not contribute to the battery's cyclable capacity or net output.

Ex. 2006, ¶140; POR at 38.

Petitioner's Expert Agrees that Only Active Material Is Involved in Charging and Discharging

Q. I guess my question is what's your understanding of active material?

A. Active material is -- active material is material that is involved in the intercalation and deintercalation of lithium-ions.

Ex. 2008, 86:7-11; Sur-Reply at 11-12.

Petitioner's Expert Agrees that Carbon Is the Active Material

Q. What is the active material?
A. The active material would be a carbon.
Q. So the anode contains a carbon. Fair?
A. Yes.
Q. And the active material of a lithium-ion battery is -- let me withdraw that question.
The active material of the anode of a lithium-ion battery would be a carbon within the anode. Correct?
A. Yes.

Ex. 2008, 20:14-19 , 20:20-23; POR at 38; Sur-Reply at 12.

The "Capacity Balance" Figures Reported in Uemura FIG. 3 Correspond to Uemura ¶33

	Total capacity : Pc (mAh)	ve electro- Total capacity : Nc (mAh)	Capacity balance Pc:Nc
Example 1	1.8	2.36	(1:1.3)
Example 2	2.24	3.41	(1:1.5)
Example 3	2.6	3.27	(1:1.3)
Example 4	2.6	2.6	(1:1)
Example 5	2	2.36	(1:1.3)
Example 6	2.24	2.36	(1:1.3)
Example 7	2.24	2.36	(1:1.3)
Example 8	2.24	2.36	(1:1.3)
Example 9	2.24	2.36	(1:1.3)
Example 10	2.24	2.36	(1:1.3)
Example 11	2.24	2.36	(1:1.3)
Example 12	2.24	2.36	(1:1.3)
Example 13	2.24	2.36	(1:1.3)
Example 14	2	2.36	(1:1.3)
Example 15	2.24	2.36	(1:1.3)
Example 16	2.24	2.36	(1:1.3)
Example 17	2.24	2.36	(1:1.3)
Comparative	2.7	–	(1:1.3)

[0033] Furthermore, a capacity balance ratio B/A of the total capacity B of the negative electrode material to the total capacity A of the positive electrode material is preferably fixed at a range of 1 to 1.5. If the capacity balance ratio B/A is below 1, lithium ion holding sites on the negative electrode material become insufficient. As the result, branch-

Ex. 1009; Sur-Reply at 12; POR at 34; Ex. 2006, ¶127.

Uemura Is not Enabling

"In the absence of such other supporting evidence to enable a skilled artisan to make the claimed invention, a standalone § 103 reference must enable the portions of its disclosure being relied upon."

Raytheon Techs. Cor. V. Gen. Elec. Co., 993 F.3d 1374, 1381 (Fed. Cir. 2021).



Uemura Is not Enabling

[0080] [Evaluation]

[0081] The charge-discharge was repeatedly performed at a constant current of 0.5 mA/cm^2 and a voltage ranging from 4.3 V to 2.0 V at an atmospheric temperature of 60° C. by the use of the made sealed type non-aqueous solvent battery cell. The number of cycles taken to a point where the discharge capacity becomes less than 90% of the initial discharge capacity was obtained. Thus, the resistance was evaluated. A result thereof is shown in Table 1 together with the other values.

Ex. 1009, ¶¶80-81; Sur-Reply at 13-14.

Following Uemura Does Not Lead to Layered Cathode Material

24. The samples do not have a layered structure because their peak patterns are more consistent with peak patterns of materials with a rock salt and/or spinel structure: if two compounds have similar XRD patterns, their crystal structures should be similar too. As shown below, the peak pattern of $Li_{0.67}Mn_{0.5}Co_{0.5}O_{2-\delta}$_Ar (i.e., the material I synthesized according to Uemura's Example 1) is consistent with the peak pattern for lithium cobalt oxides with rock salt and/or spinel structures. The peak pattern is also different from the XRD pattern of a doped layered $LiMnO_2$. I thus conclude that the three samples I synthesized by following Uemura's experimental procedures do not have a layered structure.

Ex. 2031, ¶24; POR at 43-44.

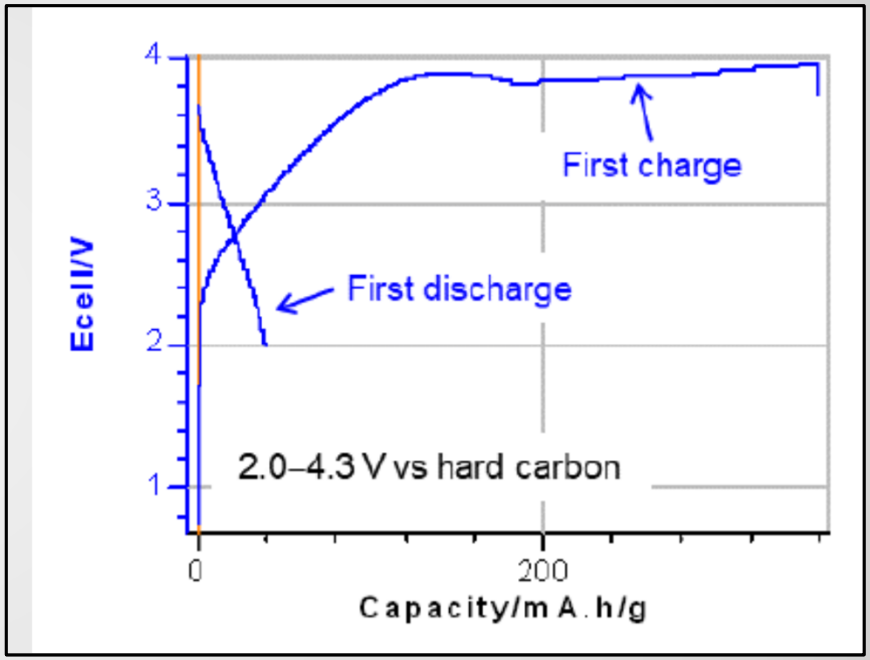
Following Uemura Does Not Lead to Layered Cathode Material

27. In particular, the first plotted graph on the left, which corresponds to the first battery cell, shows two curves in which capacity (on the *x* axis) is plotted against applied voltage (on the *y* axis). The curve trending upward corresponds to the first charge cycle; and the curve trending downward corresponds to the first discharge cycle. As can be seen in the upward trending curve, increasing the applied voltage up to 4.3V produced a charge capacity of the cathode of approximately 6 mAh/g, which a person of ordinary skill would recognize is insufficient for a working secondary lithium-ion battery. The other two plotted graphs have similar charge capacity characteristics (i.e., the charge capacities were below 10mAh/g and around 20mAh/g, respectively). This would lead a person of ordinary skill to understand that in all three examples, attaining an acceptable cathode capacity would likely require the battery to be charged at voltages well over 4.3V, or the material synthesized simply could not be used as a working cathode material.

Ex. 2031, ¶27; POR at 44.

Following Uemura Does Not Lead to Layered Cathode Material

45. Below is the charge and discharge curve when the synthesized cathode active material ($Li_{0.8}Mn_{0.5}Co_{0.5}O_2$) was assembled into a full cell with hard carbon as the anode material. As shown in the figure below, before the voltage reaches 4V, there is evidence of side reactions occurring and of the battery starting to degrade. Further, the downward trending curve (i.e., the first discharge cycle) shows a capacity of about 40 mAh/g, which is significantly lower than the first charge capacity (based on the upward trending curve, the first charge capacity was probably more than 100 mAh/g before the cell started to degrade).



Ex. 2031, ¶45; POR at 45.

Dr. Liang Implemented Robust Experimental Controls

18. I tried to synthesize $Li_xMn_{0.5}Co_{0.5}O_{2-\delta}$ with the method described in paragraph 71 of Uemura. In particular, $Co(NO_3)_2 \cdot 6H_2O$ (9.19 g) and $Mn(NO_3)_2$ (50 wt.% aqueous solution, 11.30 g) were dissolved with H_2O into a 1 M solution, which was added dropwise into a stirred 10 wt.% solution of LiOH·H2O (7.95 g) in H_2O over 30 min. The pH stayed higher than 9 throughout. The mixture was then filtered and washed with H_2O until the pH approximated 7. The resulting cake was vacuum-dried at 60 °C to yield the intermediate as deep gray powders.

19. The intermediate (1.5 g) was then finely ground with different amounts of $LiOH \cdot H_2O$ (0.464 g for $Li_{0.67}Mn_{0.5}Co_{0.5}O_{2-\delta}$; 0.574 g for $Li_{0.83}Mn_{0.5}Co_{0.5}O_{2-\delta}$, 0.669 g for $Li_{0.967}Mn_{0.5}Co_{0.5}O_{2-\delta}$) with mortar and pestle. The mixtures were annealed in argon at 500 °C for 5 h then 900 °C for 24 h before left to cool to room temperature.

Sur-Reply, 15-16, Ex. 2031, ¶ ¶ 18-19.

Dr. Liang Implemented Robust Experimental Controls

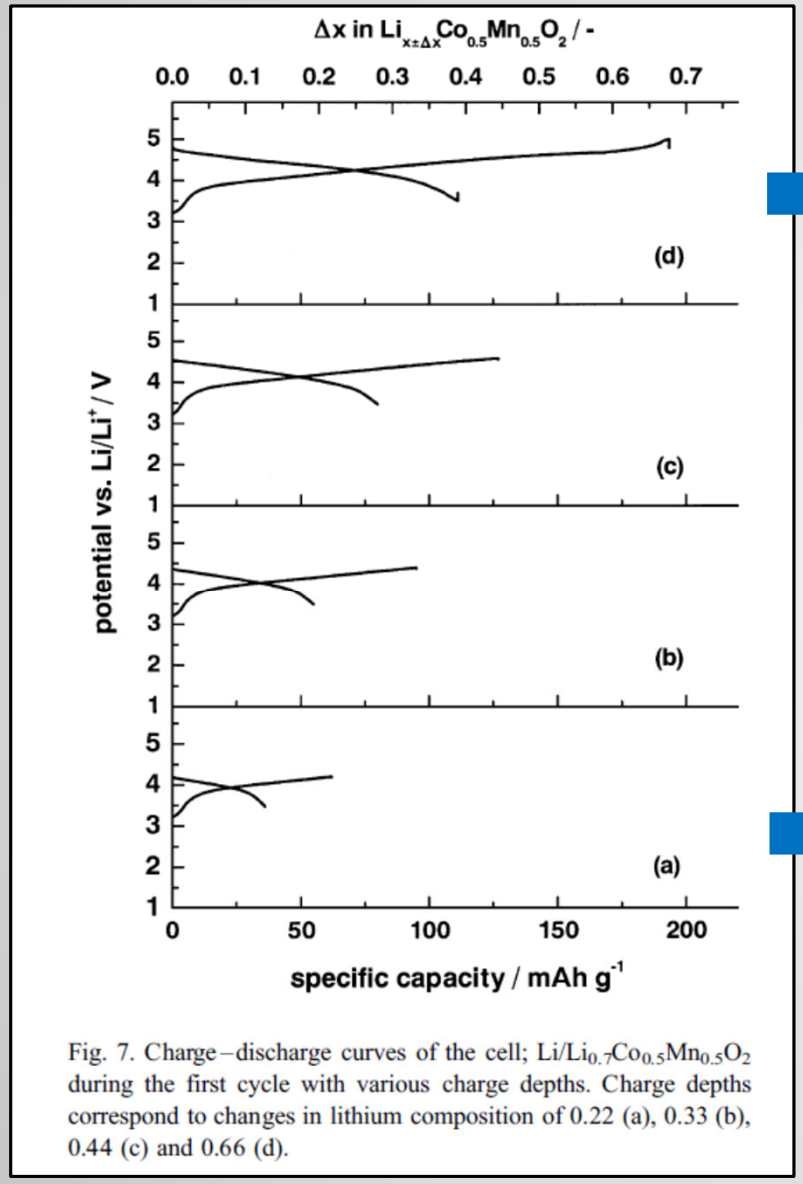
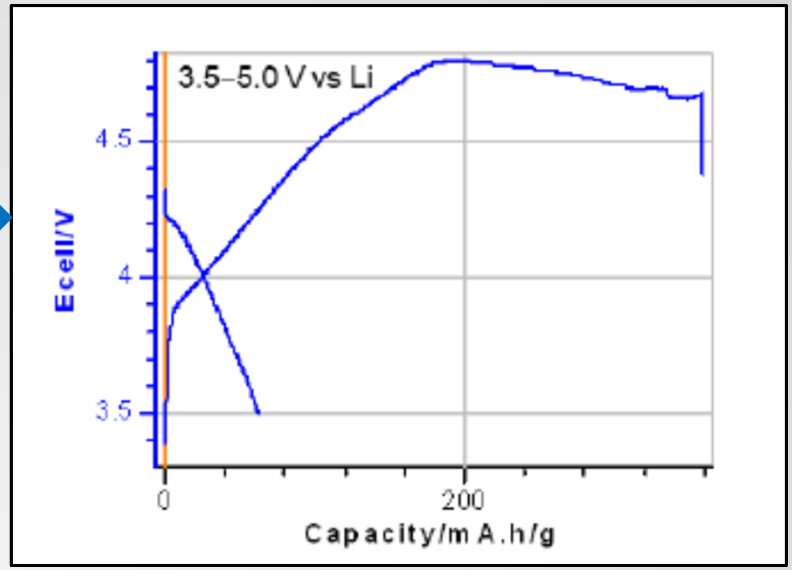
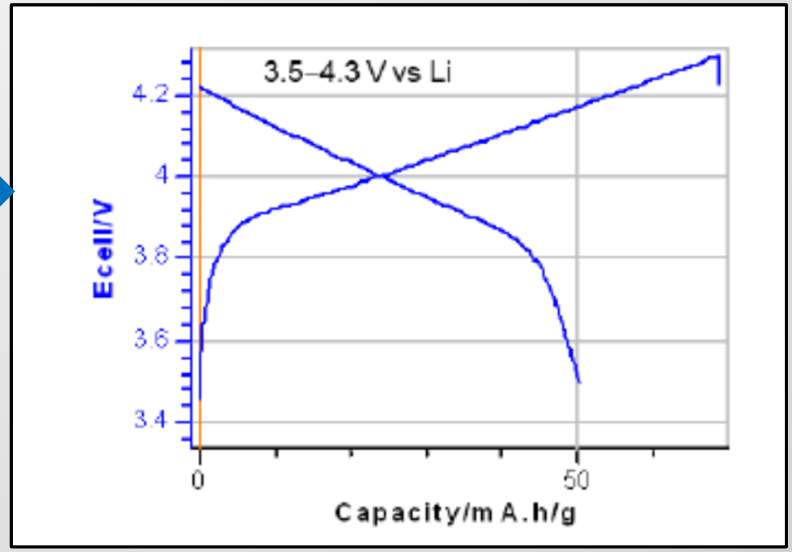


Fig. 7. Charge–discharge curves of the cell; $Li/Li_{0.7}Co_{0.5}Mn_{0.5}O_2$ during the first cycle with various charge depths. Charge depths correspond to changes in lithium composition of 0.22 (a), 0.33 (b), 0.44 (c) and 0.66 (d).





Uemura Claims Its Capacity Data Were Experimentally Determined

[0080] [Evaluation]

[0081] The charge-discharge was repeatedly performed at a constant current of 0.5 mA/cm^2 and a voltage ranging from 4.3 V to 2.0 V at an atmospheric temperature of 60° C. by the use of the made sealed type non-aqueous solvent battery cell. The number of cycles taken to a point where the discharge capacity becomes less than 90% of the initial discharge capacity was obtained. Thus, the resistance was evaluated. A result thereof is shown in Table 1 together with the other values.

Ex. 1009, ¶¶80-81; Sur-Reply at 21.

Uemura Claims Its Capacity Data Were Experimentally Determined

14 Q. And what conclusion did you arrive at based on
15 that similarity, if any?
16 A. Conclusion was that the total capacity values
17 that are shown in the table here are the values that
18 were measured experimentally, but there -- as with --
19 okay, the -- the theoretical capacity that I measured --
20 that I calculated multiplied by a ratio gave me these
21 total capacities here.

Ex. 2008, 173:16-18; Sur-Reply at 21.

Uemura Claims Its Capacity Data Were Experimentally Determined

Q. I agree with you there, Doctor. But my question is simply, you're making an assumption based on those paragraphs in Uemura that the capacity is experimentally measured; correct?

MR. STAMATOPOULOS: Object to form.

A. Yeah, that's my assumption, correct, because that's, you know, if -- what's the point of making battery and testing without monitoring the battery data? So that's my assumption; it's experimental.

Ex. 1043, 223:8-18; Sur-Reply at 21-22.

Uemura's Data Could Not Have Been Experimentally Determined

- Petitioner provides no rebuttal to Dr. Yao's opinions (Ex. 2008, ¶¶162-179) that the electrode capacity data in Uemura are erroneous.

Grounds 3-4, 8-9

Ground	Claims	Basis
3	11-18	Obvious under §103(a) over Uemura
4	11-18	Obvious under §103 over Uemura in view of Guyomard
8	9	Obvious under §103 over Uemura in view of Iwaizono
9	9-10	Obvious under §103 over Uemura in view of Iwaizono in view of Guyomard

Pet. 7.

Grounds 3-4, 8-9

[0009] As described above, $LiCoO_2$ is unstable though it has a large capacity. Meanwhile, $LiMn_2O_4$ of spinel structure cannot be said to be sufficient in cyclic resistance and the capacity thereof is small though it is stabler than $LiCoO_2$. Therefore, desired is development of a novel positive electrode material provided with both of the large capacity and the high cyclic resistance.

(57) Abstract

An electrolyte resistant to oxidation normally resulting from high voltage charging of a secondary battery comprising an $Li_{1+x}Mn_2O_4$ intercalation positive electrode comprises a 0.5 M to 2 M solution of $LiPF_6$ dissolved in a mixture of non-aqueous dimethylcarbonate (DMC) and ethylene carbonate (EC) solvents wherein said solvents are present in a weight percent ratio range from about 95 DMC : 5 EC to 20 DMC : 80 EC.

POR at 53; Ex. 1009, ¶9; Ex. 1008, Abstract.

Grounds 5-6

Ground	Claims	Basis
5	1-8	Anticipated under §102(b) by Abe
6	1-8	Obviousness under § 103(a) over Abe

Pet., 7.

Abe Discloses the Voltage of a Lithium Metal Cell Not a Lithium-Ion Cell

than the design capacity of the cathode. The design capacity is determined, for example, from the initial charge capacity per unit weight of the active material in a predetermined charging voltage range and the amount of active material coated on the current collector. The charging capacity can be obtained, for example, by continuously recording a voltage that changes over time by applying a constant current using a three-electrode cell in which both the counter and the reference pole are made of metal lithium. The charge capacity is the amount of charge until a predetermined voltage is reached. In the triode cell, the starting voltage when using a vapor-phase-grown carbon fiber negative electrode as the working electrode is 3 V, and the charge (applying current from the working electrode to the counter electrode) proceeds and decreases toward 0 V. When a positive electrode is used for the working electrode, the voltage at the start is the potential difference between the metal lithium and the positive electrode material, and the voltage rises with charging (applying current from the counter electrode to the working electrode). The predetermined voltage is 0 V at the vapor-phase-grown carbon fiber negative electrode, and at the positive electrode, the voltage is set to a range in which no electrolyte decomposition occurs, and no irreversible structural breakdown of the positive electrode active material occurs. For example, $LiMn_2O_4$ is 4.2–4.3 V, preferably 4.2 V, and $LiCoO_2$ and $LiNiO_2$ are 4.1–4.2 V, preferably 4.1 V. The design capacity of the

POR at 53; Ex. 1005, ¶78.

Abe Discloses the Voltage of a Lithium Metal Cell Not a Lithium-Ion Cell

Page 28

A. "Secondary" is analogous to rechargeable.
"Lithium" is the material that's used in the battery.
When you say "lithium-ions," that will mean that you do not use lithium metal anodes.

POR at 54; Ex. 2008, 28:1-7.

Abe Does Not Disclose a Full-Cell Voltage Greater Than 4.2V

192. *Second*, as discussed in section VI.B., a POSITA would understand that the claimed charge cutoff voltage refers to the full-cell voltage, not to the half-cell voltage. Abe discloses using the half-cell configuration, e.g., a test cell with $LiMn_2O_4$ as the cathode and lithium metal as the anode, a POSITA would be able to determine the charge capacity of that cathode active material.[126] Abe thus discloses a half-cell voltage between 4.2V and 4.3V for $LiMn_2O_4$ as the cathode active material.

POR at 55-56; Ex. 2006, ¶192.

Abe Does Not Disclose a Full-Cell Voltage Greater Than 4.2V

In an effort to improve energy density of Li-ion cells, $LiNiO_2$ has been studied extensively as a cathode material by many investigators[1-12] because its specific capacity is higher than that of $LiCoO_2$, which is presently used in most commercially available Li-ion cells. $LiNiO_2$ shows a specific capacity up to 203 mAh/g (cf. 160 mAh/g for $LiCoO_2$) when cycled between 2.75 and 4.3 V *vs.* Li metal. This potential (4.3V *vs.* Li metal) corresponds approximately to a 4.2 V charging voltage for a practical Li-ion cell, because the potential of an incompletely charged carbon anode in the cell at the end of charge is approximately 0.1 V *vs.* Li. [1,2]

POR at 56-57; Ex. 2018, 15; Ex. 2006, ¶¶193-195.

Abe Does Not Disclose a Full-Cell Voltage Greater Than 4.2V

Commercially available Li-ion cells containing $LiCoO_2$ as the cathode material are typically charged to two different cutoff voltages, *i.e.*, 4.1 and 4.2 V, which corresponds to approximately 4.2 and 4.3 V *vs.* Li, respectively.[18,19] $LiCoO_2$ is structurally stable at both voltages.[20,21] However, the effect of cutoff voltage on cycling performance of $LiNi_{1-x}Co_xO_2$ is largely unknown, although these voltages

POR at 56-57; Ex. 2018, 15; Ex. 2006, ¶¶193-195.

Abe Does Not Disclose a Full-Cell Voltage Greater Than 4.2V

20 Q. And the full-cell potential between the anode
21 and the cathode will be equal to the difference between
22 the half-cell potentials of the anode and the cathode.
23 Correct?
24 A. Yes.

POR at 57; Ex. 2008, 79:8-18, 110:20-24.

Abe Does Not Disclose a Full-Cell Voltage Greater Than 4.2V

Q. And what is the reference voltage for graphite?

A. Graphite -- there's multiple plateaus as you discharge it, so those plateaus -- you know, you can charge graphite anode as high as, you know, 1.5 volts, and then you can discharge it down to zero volts. So the average plateaus are probably in the 0.1 to 0.2-volt range over the bulk of the discharge or, sorry, charge, I should say. It's -- it's -- yeah.

POR at 57; Ex. 2008, 79:8-18, 110:20-24.

Abe Does Not Disclose a Full-Cell Voltage Greater Than 4.2V

on the materials used. The battery or cell voltage is

$$V_{cell} = 4.2 = \phi_p - \phi_n$$

When graphite is used, the potential of the positive electrode relative to lithium is

$$\phi_p = 4.2 + \phi_{n,graphite} \approx 4.3\ \mathrm{V(Li/Li^+)}$$

POR at 58; Ex. 2018, ¶179.

Abe Teaches Away from Voltages >4.2V

[0080] Furthermore, in this non-aqueous electrolyte-based secondary battery, if the cut-off voltage at the time of charging is limited to 4.1 V, a longer-lived non-aqueous electrolyte-based secondary battery can also be obtained. The cut-off voltage at the time of charging is the upper limit value of the voltage at the time of charging.

POR at 58; Ex. 1005, ¶80.

Abe Teaches Away from Voltages >4.2V

[0097] (4) Charge/discharge test at different current values

Charge and discharge tests were carried out at current values of 800 mA, 1,600 mA, 2,400 mA, and 3,200 mA in the range of charge and discharge voltages of 2.5 to 4.1 V for each current value. The results are shown in Table 3 and Figure 1.

[0102] $LiMn_2O_4$ was used instead of $LiCoO_2$, and the positive electrode was made in the same manner as in Embodiment 1, except that the filling density was set to 2.9 g/cm^3.

[0103] A cylindrical non-aqueous electrolyte-based secondary battery was made in the same manner as in Embodiment 1 using a negative electrode, a cathode, and electrolyte solution similar to that in Embodiment 1. The (negative electrode design capacity/positive electrode design capacity) value of this non-aqueous electrolyte secondary battery was adjusted to 1.1, and the value is shown in Table 1.

[0104] A nail penetration test and a charge-discharge test were performed in the same manner as in Embodiment 1. The results are shown in Table 2, Table 3, and Figure 1.

POR at 58; Ex. 1005, ¶¶97, 104.

Abe Does Not Disclose the Claimed Ratio

Q. Fair to say that the capacity ratios of embodiment 1 correspond to a charge voltage no greater than 4.1 volts based on what's stated here in Abe?

ATTORNEY SOMMER: Object to form.

A. Yes.

POR at 60; Ex. 2008, 215:2-6; Sur-Reply, 25-26.

Grounds 7 and 10

Ground	Claims	Basis
7	2-4, 6-8, 11-18	Obvious under §103 over Abe in view of Guyomard
10	9-10	Obvious under §103 over Abe in view of Guyomard and Iwaizono

Pet. at 7.

$LiMn_2O_4$ Dissolves at Voltages >4.2V

> And there's different manganese materials. There's a manganese lithium, Mn204. But, you know, there's problems with that one. Particularly, it's got a lower capacity per gram and it's less stable at high temperatures. The manganese will come out of the material. The manganese will dissolve into the electrolyte and poison the anode.

POR at 63; Ex. 2008, 100:14-20.

$LiMn_2O_4$ Dissolves at Voltages >4.2V

Q. Are you aware of any reasons for which the use of lithium manganese oxide in the spinel form is limited to those two applications?

ATTORNEY SOMMER: Object to form.

A. The practical capacity of that material is lower than other materials, other cathode materials that are commonly used in the industry. It also has the issues that I talked about earlier where you -- you know, if you take it to high voltages at high temperatures you have manganese dissolution, poisoning of the anode, and reduction in cycle life.

BY ATTORNEY STAMATOPOULOS:

Q. And what do you mean by taking it to high voltages?

A. Above 4 point -- well, even 4.2 is a high enough voltage for that to occur. It's a really good compound in the way that it's -- the manganese spinel is

$LiMn_2O_4$ Dissolves at Voltages >4.2V

Q. So what's the recommended voltage for lithium manganese oxide in the spinel form?

ATTORNEY SOMMER: Object to form.

A. At the time I was working on it, it was 4.2 volts. But I don't know specifically what voltage

POR at 63; Ex. 2008, 124:21-25.

Abe Teaches Half-Cell Voltage of 4.2V Is Preferred

predetermined voltage is 0 V at the vapor-phase-grown carbon fiber negative electrode, and at the positive electrode, the voltage is set to a range in which no electrolyte decomposition occurs, and no irreversible structural breakdown of the positive electrode active material occurs. For example, $LiMn_2O_4$ is 4.2–4.3 V, preferably 4.2 V, and $LiCoO_2$ and $LiNiO_2$ are 4.1–4.2 V, preferably 4.1 V. The design capacity of the

POR at 63; Ex. 1005, ¶78.

Guyomard Does Not Address Cathode Dissolution Issue

> Q. And Guyomard is not focused on the phenomenon that you spoke about earlier concerning the cathode poisoning the electrolyte with manganese. Correct?
>
> ATTORNEY SOMMER: Object to form.
>
> A. He's not speaking about that, correct.

Sur-Reply at 26-27; Ex. 2008, 134:2-6.