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13 **UNITED STATES DISTRICT COURT**
14 **CENTRAL DISTRICT OF CALIFORNIA**
15 **SOUTHERN DIVISION**

16 RJ TECHNOLOGY LLC

17 Plaintiff,

18 vs.

19 APPLE INC.,

20 Defendant.
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27
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Case No. 8:22-CV-1874-JVS-JDE

**PLAINTIFF RJ TECHNOLOGY
LLC'S OPENING CLAIM
CONSTRUCTION BRIEF**

RJ TECHNOLOGY'S OPENING CLAIM CONSTRUCTION BRIEF

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I. INTRODUCTION

U.S. Patent No. 7,749,641 (“’641 Patent”) addresses a problem that had long plagued the battery industry: how to increase the battery’s capacity without losing performance or increasing its size. At the time of the ’641 Patent’s filing, it was universally understood that a manufacturer could not charge a battery over 4.2V without substantially degrading it and harming performance. But by adopting the 4.2V ceiling, manufacturers limited the performance of the battery, including its capacity, energy density, and operating voltage. After years of experimentation, the inventors developed the solution claimed in the ’641 Patent. Among other things, the patent teaches a novel battery design in which the battery is configured to have a charge cutoff voltage above 4.2V while the capacity of the anode relative to the cathode is increased. The patent describes that by using this novel and unique combination, capacity, energy density, and operating voltage are increased and are also maintained over hundreds of charges—contravening the conventional wisdom at the time of the ’641 Patent’s filing.

Apple has profited from this groundbreaking invention. All of the batteries in the accused products are configured to charge over 4.2V, have the claimed ratio of anode to cathode material, and maintain substantial capacity over hundreds of cycles. Apple vigorously touts the very benefits that use of the invention enables in its products, understanding that the patent’s key innovations drive those results.

The patent describes fundamental design characteristics of the batteries in the accused devices. Both at the time of the invention and presently, battery engineers would have readily understood the terms used in the patent—which carry a plain and ordinary meaning in the art. Reflecting this, the parties dispute just five terms, and even in those cases the proposed constructions are similar, meaning the ultimate disputes are narrow. The disputed terms are as follows:

- 1 a. “Charge Cut-off Voltage”
- 2 b. “Ratio of Positive Electrode Material to Negative Electrode Material as
- 3 Calculated by a Theoretic Capacity with a Charge Cut-off Voltage Set at
- 4 4.2V”
- 5 c. “A Secondary Lithium Ion Cell or Battery”
- 6 d. “Overcharge Protection Voltage”/“Overcharging Protection Release
- 7 Voltage”/“Overcharge Protection Release Voltage”
- 8 e. “Maintains at Least ... Capacity after 400 Cycles”

9 Fundamentally, the parties’ dispute can be boiled down to the following: RJ
 10 Technology believes the patent and the terms used in its claims are clear on their
 11 face. Apple incorrectly claims the terms are indefinite or otherwise seeks to
 12 improperly narrow them, often reading limitations from the file history into the
 13 claims. Apple’s positions are wrong. “[A]bsent a clear disavowal or alternative
 14 lexicography by a patentee, he or she ‘is free to choose a broad term and expect to
 15 obtain the full scope of its plain and ordinary meaning.’” *Wasica Fin. GmbH v.*
Cont’l Auto. Sys., Inc., 853 F.3d 1272, 1282 (Fed. Cir. 2017).

16 As the concurrently filed declaration of RJ Technology’s expert, University
 17 of Houston engineering professor Dr. Yan Yao, makes clear, the terms are
 18 commonly used in the industry and would be well known to a person of skill in the
 19 art. RJ Technology’s constructions merely adopt those plain meanings, and are
 20 therefore presumptively correct. Far from reflecting any disclaimer, the intrinsic
 21 evidence (the patent and the prosecution history) confirm that the customary
 22 meanings of the terms proposed by RJ Technology are correct, and the extrinsic
 23 evidence (publications regarding lithium-ion batteries) are also in accord. For those
 24 reasons, and the additional ones provided below, RJ Technology’s proposed

1 constructions should be adopted, and Apple’s indefiniteness arguments should be
2 rejected.¹

3 **II. TECHNICAL BACKGROUND**

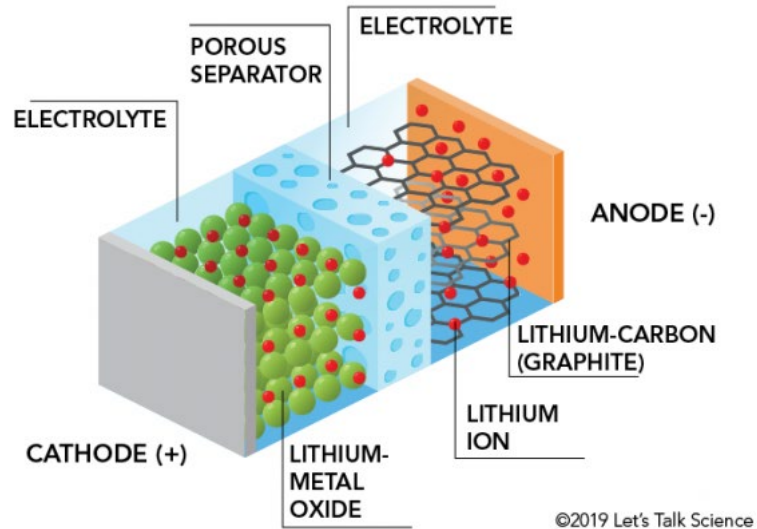
4 Lithium-ion batteries have become ubiquitous. From consumer electronics
5 to electric vehicles to residential homes, lithium-ion batteries support all manner of
6 products and applications. Declaration of Dr. Yan Yao (“Yao Decl.”), ¶ 7. The
7 batteries are attractive because they safely and usefully combine rechargeability
8 with high energy density. *Id.*, ¶ 10. Products using these batteries can therefore
9 store high quantities of energy in relatively little space, and largely maintain that
10 storage capability over a lifetime of recharging.

11 Lithium-ion batteries in use today are rechargeable (secondary batteries). *Id.*,
12 ¶ 8. Charging is done by applying electricity to the battery. Discharging refers to
13 the release of electricity, which is used to power a device. *Id.*, ¶ 9.

14 Lithium-ion batteries consist of a positive electrode (cathode) and a negative
15 electrode (anode), among other components, as shown in the following diagram.
16 Yao Decl., ¶¶ 11, 12.

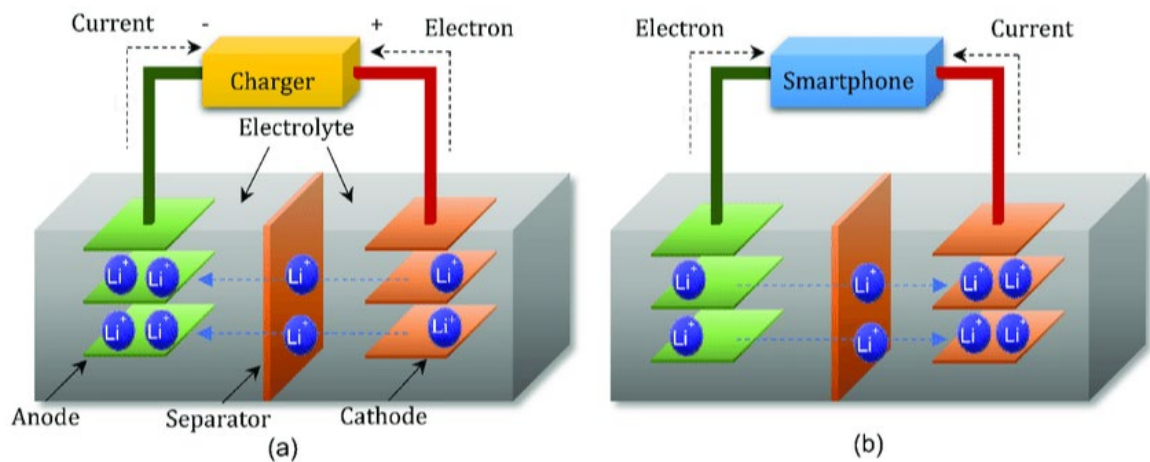
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27 ¹ Documents cited as “Ex. [x]” herein are attached as exhibits to the Declaration of
28 Zach Ruby in Support of RJ Technology’s Opening Claim Construction Brief.
The ’641 Patent is attached as Ex. 1.

PARTS OF A LITHIUM-ION BATTERY



The cathode is typically made of a compound of lithium, another element, and oxygen (such as lithium cobalt oxide, or LiCoO_2). *Id.*, ¶ 11. The anode is commonly made of a carbon material, such as graphite. *Id.* Other components include the electrolyte (a chemical medium that helps with the movement of ions), the separator (which physically separates the cathode and the anode from each other), the current collectors (which collect electrical current from the reactions taking place in the anode and cathode), and the exterior case. *Id.*, ¶ 12. The battery typically also consists of circuitry that regulates charge and discharge of the battery—sometimes called the battery management system. *Id.*

When a battery is charged, electricity is applied to it. Charging is illustrated in the image on the left below (fig. a). *Id.*, ¶¶ 9, 14.



As shown in fig. (a), when the battery is being charged, the cathode undergoes a process where both electrons and lithium ions are released. *Id.*, ¶ 14. The lithium ions travel through the separator from the cathode to the anode, where they nest neatly into the anode. *Id.*

When the battery is discharged (meaning electricity is released to power a device), the process reverses. Electrons from the anode are drawn through the device (powering it) and then to the cathode. *See* fig. b, above; Yao Decl., ¶ 15. At the same time, the lithium ions leave the anode, travel back across the separator, and move back to the cathode. *Id.*

Electricity can be measured in terms of current, voltage, and capacity. Current is measured in amperes (A), which describes the flow of electricity. Yao Decl., ¶¶ 9, 16, 17. Voltage is measured in volts (V) and describes the strength of the electric potential difference within a system. *Id.*, ¶ 16. The capacity of the battery—*i.e.*, how much electricity it can store—is measured in ampere-hours (Ahs) or milliamper hours (mAh), which reflect the amount of electrical current the battery can deliver in one hour. *Id.*, ¶ 17. One useful analogy for these concepts is the flow of water. *Id.*, ¶ 16. In this analogy, electrical current is the flow of water and voltage is water pressure. *Id.* Capacity is the size of the water reservoir. *Id.*, ¶ 17.

Each electrode has a different capacity, determined by the materials used and the size. The total capacity of the battery is limited by the lower capacity of the two electrodes. Yao Decl., ¶ 21. The excess capacity of the other electrode is unused, *i.e.*, wasted. *Id.* To minimize such waste and optimize capacity and size, battery manufacturers work to strike the right balance between the amount of negative electrode material and positive electrode material. *Id.*, ¶ 22. To perform such balancing, the manufacturer will carefully design and measure the mass, area, volume, and/or capacity of the active material of each electrode. *Id.*

While lithium-ion batteries are very efficient at storing energy, the chemistry supporting their use is inherently unstable. Unless meticulously controlled, the reactions that power these batteries can overload, leading to battery degradation, fires, or even explosions. Yao Decl., ¶¶ 10, 18-20. To prevent this, charging can be done via several different methods (called “algorithms”). Typically, these algorithms are controlled by the battery management system, which is circuitry within the battery. *Id.*, ¶ 31. They can also be controlled through the power supply (*e.g.*, the charger), general circuitry within the device, software, and firmware. *Id.*

The algorithms regulate the amount of voltage and current that are fed to the battery, usually to maximize the amount of electricity the battery can store, while minimizing damage to the battery. Some commonly used charging algorithms are:

- **Constant Voltage (CV):** The battery is charged at a constant voltage until fully charged.
- **Constant Current (CC):** The battery is charged at constant current until it reaches the charge cut-off voltage.
- **Constant Current/Constant Voltage (CC/CV):** The battery is first charged at constant current up to a specific voltage (typically in the prior art 4.2V) and then charged at constant voltage until the battery is fully charged.

- **Pulse Charging:** The battery is charged by intermittent pulses of charging current rather than a continuous stream.

In each case, there is a maximum voltage to which the battery is configured to be charged. This is called the charge cutoff voltage. Yao Decl., ¶ 33. It can also be referred to as the cutoff voltage, the potential limit, the upper voltage limit or the upper charge limit, but in each case, it refers to the designed maximum charging limit of the battery. *Id.*, ¶ 26.

When a battery is charged beyond the charge cutoff voltage, it is overcharged. Yao Decl., ¶¶ 18-20, 27, 66. Overcharge can lead to serious problems in the battery including fires and explosions. *Id.* Overcharge can also damage the battery by degrading core components. *Id.* For example, overcharging the battery risks clogging the anode—a process called lithium plating. *Id.*, ¶ 20. When this occurs, the lithium ions do not nest neatly into the anode but are forcibly wedged into the structure, causing the formation of tree-like structures on the surface of the anode that may lead to short circuit and ultimately result in battery failure. *Id.*

Even in the absence of overcharging, batteries will lose capacity after normal use. Yao Decl., ¶ 23. As the battery is used (*i.e.*, charged and discharged), even at or below the charge cutoff voltage, the battery degrades, meaning the capacity of the anode and cathode to store electricity may be reduced. *Id.* The difference is that the batteries degrade much more slowly if they are charged at or below the charge cutoff voltage. *Id.* Because of this natural degradation, battery manufacturers also design for and track the capacity loss of the battery over successive charge and discharge cycles. *Id.* In other words, battery manufacturers would seek to ensure batteries maintain a reasonable capacity over their useful life. *Id.*

III. DISCUSSION

Claim construction begins with the words of the claims. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc). “[T]he words of a claim

‘are generally given their ordinary and customary meaning’” which is read “in the context of the written description and the prosecution history”—*i.e.*, intrinsic evidence. *Id.* at 1312–13. The court may also consult extrinsic evidence, though “it is less significant than the intrinsic record[.]” *Id.* at 1317.

a. Charge Cutoff Voltage

RJ Technology’s Construction	Apple’s Construction
Plain and ordinary meaning. The maximum voltage to which the battery is configured to be charged.	The voltage at which the charging changes from constant current charging to constant voltage charging.

The parties’ constructions of “charge cutoff voltage” are similar. RJ Technology proposes a construction covering the full scope of the plain and ordinary meaning of the term, which is the maximum voltage to which the battery is configured to be charged. Apple’s proposed construction, “[t]he voltage at which the charging changes from constant current charging to constant voltage charging,” describes a means of implementing the charge cutoff voltage in a common charging algorithm: CC/CV. In that algorithm, the battery is initially charged at a constant current (allowing voltage to increase), but when the battery reaches the maximum voltage to which the battery is configured to be charged, the voltage is held constant until the battery is fully charged. Yao Decl., ¶ 32. The question for the Court is whether the patent limits the definition of charge cutoff voltage to this one specific algorithm through which it is implemented (Apple’s construction, CC/CV), or whether it incorporates the full plain and ordinary meaning of the term (RJ Technology’s construction).

The answer is clear—the patent does not mention CC/CV charging at all, and neither does the prosecution history. Absent any such express limitation, the term should be construed in accordance with its plain and ordinary meaning. *See Wasica*, 853 F.3d at 1281–82. As the patent explains, one of the central design characteristics of a lithium-ion battery is its “charge cutoff voltage.” *See generally*

1 '641 Patent. This is a basic feature of the battery, and the term the patentees used
 2 is one that a battery engineer would understand to have a plain meaning—*i.e.*, the
 3 maximum voltage to which the battery is configured to be charged.

4 RJ Technology's construction is supported by intrinsic evidence. The term
 5 is used throughout the specification, and in each case, it refers to the charging
 6 voltage maximum:

- 7 • "At present, the charge cut-off voltage of single secondary lithium ion cell
 8 is limited to *no more than* 4.2V, and this is well accepted as a technical
 9 requirement in the industry. . . ." '641 Patent, 1:46-48 (emphasis added).
- 10 • "As to the common opinion in the art that *increasing* the charge cut-off
 11 voltage *above* 4.2V" *Id.*, 3:3-4 (emphasis added).
- 12 • "Further, when the charge cut-off voltage is *greater than* 5.8V, the cell
 13 has inferior properties and is unsuitable for use." *Id.*, 7:48-50 (emphasis
 14 added).

15 In these quotations and elsewhere, the patent explains that the charge cutoff voltage
 16 is a maximum voltage for use in normal operation, and if exceeded, deleterious
 17 effects will be inflicted on the battery, effects which are mitigated through the
 18 invention of the patent. *Id.*, 1:55-63, 2:38-60.

19 It does not mean that during normal use of the battery, the charging voltage
 20 can never exceed the charge cut-off voltage. Indeed, as discussed below, a
 21 malfunction can cause the battery to be charged over the charge cutoff voltage, *i.e.*,
 22 overcharged. However, a battery is not configured (*i.e.*, designed and
 23 manufactured) to be charged above its charge cutoff voltage, as the patent explains.
 24 *Id.* RJ Technology's construction thus captures the meaning used in the
 25 specification and therefore carries a "heavy presumption" of correctness. *See*
 26 *Aventis Pharms. Inc. v. Amino Chemicals Ltd.*, 715 F.3d 1363, 1373 (Fed. Cir.
 27 2013); *see also Phillips*, 415 F.3d at 1321. This meaning applies "absent a clear
 28 disavowal or alternative lexicography by [the] patentee[s]" as they are "free to

1 choose a broad term and expect to obtain the full scope of its plain and ordinary
2 meaning.” *Wasica*, 853 F.3d at 1281-82.

3 The intrinsic record carries no evidence of such a disavowal. The patentees
4 did not narrow the term from its full scope in the claims or in prosecution. To the
5 contrary, the intrinsic evidence shows that the patentees used the term “charge
6 cutoff voltage” consistently to refer to the maximum voltage to which the battery is
7 configured to be charged. For example, during prosecution, the inventors
8 distinguished a prior art reference by arguing that the reference “shows that the
9 cycle property of a cell drastically decreases when the *charging voltage increases*
10 beyond 4.2V.” Ex. 2, ’641 Patent File History (“File History”) at Nov. 13, 2009,
11 Applicant’s Remarks, at 8 (emphasis added); *see also id.*, 12 (“[A] battery of the
12 claimed invention can sustain normal operation under a charge cut-off voltage
13 greater than 4.2V”) (emphasis in original).

14 The Examiner understood the term the same way, using charge cutoff without
15 reference to a particular charging algorithm and, in many cases, synonymously with
16 charging voltage. For example, the Examiner distinguished one prior art reference
17 on the basis that it “teaches that [the] life cycle property of a cell drastically
18 decreases when the *charging voltage increases* beyond 4.2V. Accordingly, one of
19 ordinary skill at the time of [the] invention would not have predicted that the
20 resulting cell would have high capacity.” *E.g.*, Ex. 2 (File History) at Notice of
21 Allowability, at 2-3 (emphasis added).

22 Still further, the patent specification repeatedly refers to 4.2V as the then-
23 universal industry standard for charge cutoff voltage, *e.g.*, ’641 Patent at 2:38-41
24 (“In 1990, Sony Corporation issued the lithium ion cell using coke as negative
25 electrode, which has a charge cut-off voltage of not more than 4.20V, and it is
26 accepted as a common technical requirement of lithium ion cells thereafter.”), and
27 the extrinsic sources confirm that the 4.2V limit was a maximum charging voltage
28 and not a particular algorithm for implementing that voltage. *E.g.*, Ex. 3 (Amatucci

1 et al., *Cobalt dissolution in LiCoO₂-based nonaqueous rechargeable batteries*, 83
 2 Solid State Ionics, 167 (1996)) (noting that the “traditional limit” for reversibly
 3 charging lithium ion batteries was 4.2V); Ex. 4 (B. Johnson et al., *Characterization*
 4 *of commercially available lithium ion batteries*, 70 J. Power Sources 48-54 (1998))
 5 (“All manufacturers had suggested potential limits of 4.1 to 4.2 V . . .”). In short,
 6 the intrinsic and extrinsic evidence all aligns with RJ Technology’s proposed
 7 construction. As such, RJ Technology’s proposal should be adopted. *See Aventis*,
 8 715 F.3d at 1373; *Wasica*, 853 F.3d at 1281–82 (Holding that the “full scope” of
 9 plain and ordinary meaning applies absent disavowal).

10 Apple must demonstrate that the inventors disavowed other charging
 11 methods besides constant current/constant voltage in order for its construction to be
 12 adopted. *See id.* But there is no evidence of such a disavowal. The patent nowhere
 13 mentions CC/CV charging, nor does the prosecution history. Apple therefore relies
 14 on extrinsic evidence, Dkt. 67-1 at Ex. A, 1-2, but these sources do not contradict
 15 the plain meaning of the term or the intrinsic evidence. Many of Apple’s sources
 16 do not even reference the term or use it in the appropriate context. For example, the
 17 dictionary cited by Apple does not use the term “charge cutoff voltage” but instead
 18 uses the term “cutoff voltage” and uses it to refer to the voltage at which the battery
 19 stops discharging (*i.e.*, when it is depleted). Ex. 5, (Graf, R., MODERN DICTIONARY
 20 OF ELECTRONICS (7th ed. 1999)). The same is true with the handbook. Ex. 6
 21 (Linden D, HANDBOOK OF BATTERIES (2001)) (defining “cut-off voltage” as the “the
 22 end of discharge.”) at 3.2.1. They are therefore referring to a different term, related
 23 to different subject matter (discharge), with a different meaning that is not a
 24 maximum. Although the Linden handbook reaffirms that the then-industry standard
 25 4.2V limit was typically implemented via CC-CV charging at that level (*see, e.g.*,
 26 *id.* at Fig. 22.9, showing “Charging characteristics of a typical ... lithium-ion
 27 battery”), it does not refer to this as the “charge cutoff voltage” or otherwise suggest
 28 that that term is exclusively used to describe CC-CV charging. Indeed, elsewhere

1 in the handbook, the authors describe that “Li-ion cells are typically charged using
2 either a constant current (CC) or constant current, constant voltage with a taper
3 charge (CCCV) regime” (*id.* at 35.67) – thereby reflecting that there were multiple
4 algorithms used at the time and neither was exclusively synonymous with “charge
5 cutoff voltage.”²

6 Apple has not shown a disavowal, thus full scope of the ordinary meaning of
7 the term—*i.e.*, RJ Technology’s construction—applies.

22
23 ² Apple did not comply with its obligations to provide internal technical documents
24 reflecting on infringement in April, when that production was due. *See* N.D. Cal.
25 Patent L.R. 3-4(a). That production should have included documents reflecting the
26 charge cutoff voltages and the charging algorithms used in the accused products.
27 The rules provide for such a production prior to claim construction so that the
28 accused infringer does not have the advantage of knowing how a particular claim
construction impacts infringement while that same information is unknown to the
patentee. Accordingly, RJ Technology reserves its rights to amend its briefing once
Apple complies with its obligations.

b. Ratio of Positive Electrode Material to Negative Electrode Material as Calculated by a Theoretic Capacity with a Charge Cut-off Voltage set at 4.2V

RJ Technology's Construction	Apple's Construction
<p>Plain and ordinary meaning. The ratio calculated as 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 cutoff voltage is 4.2V.</p>	<p>Indefinite.</p> <p>In the alternative, the ratio calculated as the product of the theoretic 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 cell charge cutoff voltage is set at 4.2V,</p> <p><u>wherein “theoretic capacity” means “theoretical, rather than actual, capacity that assumes all of the active substances participate in the reaction of the battery.”</u></p>

The patent discloses that the battery of the invention should have increased capacity in the anode relative to the cathode. This claim term describes how to measure the relative capacities of the two electrodes.

The parties' constructions are, once again, similar. Both parties' constructions propose the same formula to calculate the ratio, which can be shown as follows:

$$\text{Ratio} = \frac{C_p \times m_p}{C_n \times m_n}$$

where C_p is the capacity per mass unit of the cathode active material (typically measured in milliamperes per gram, or “mAh/g”), m_p is the weight of the cathode active material (here measured in grams), C_n is the capacity per mass unit of the

1 anode active material, and m_n is the weight of the anode active material. Yao Decl.,
 2 ¶ 38. In other words, each part of the ratio is a simple multiplication in which
 3 capacity per mass unit (mAh/g) is multiplied by weight (g) such that the grams
 4 mathematically cancel each other out, leaving a capacity ratio. *Id.*, ¶ 39. The final
 5 ratio is therefore stated as a ratio of cathode capacity (in mAh) to anode capacity (in
 6 mAh). *Id.*

7 The constructions differ in that Apple asserts that the “theoretic capacity”
 8 should assume “all of the active substances participate in the reaction of the
 9 battery,” whereas RJ Technology recognizes that the term is modified by the clause
 10 “with a charge cut-off voltage set at 4.2V,” which acts as a reference point from
 11 which a POSA would determine the theoretical capacity.³

12 RJ Technology’s construction is correct. By specifying that the ratio is
 13 calculated “with a charge cut-off voltage set at 4.2V” the patent requires that a
 14 portion of the maximum theoretical capacity be used in the formula. The charge
 15 cutoff voltage acts as a reference point in this way because it determines the amount
 16 of lithium ions that participate in the reactions generating and storing electricity.
 17 Yao Decl., ¶ 45. For example, for LiCoO_2 when the charge cutoff voltage is 4.2V,
 18 half of its lithium ions participate in the reaction, and its capacity is approximately
 19 137 mAh/g. *Id.*, ¶¶ 45, 46; ’641 Patent 1:40-49, 1:64-2:1. This was well known at
 20 the time and described throughout the art and in the patent. *Id.* For most cathode
 21 materials (such as LiCoO_2), 4.2V points to an adjustment to something less than
 22 100% of the maximum theoretical capacity. Yao Decl. ¶ 40. But with other
 23 materials, a charge cutoff voltage of 4.2V would cause all of the lithium to be
 24 extracted and the theoretical capacity at that voltage would be equal to the maximum
 25

26
 27 ³ The parties agree that there is no difference in meaning between “theoretic” and
 28 “theoretical,” and that this grammatical variation has no impact on the construction
 of the claim.

1 theoretical capacity. *Id.* The key point is that by specifying that the theoretic
 2 capacity be calculated at a charge cutoff voltage of 4.2V, the patent directs a POSA
 3 to use that reference point to determine the relevant capacity figure for the
 4 calculation.

5 RJ Technology's construction follows the claim's own language and intrinsic
 6 evidence while Apple's construction cannot be squared with the claim language
 7 itself or with the intrinsic and extrinsic evidence. The ratio limitation does not use
 8 the term "theoretic capacity" in isolation but instead instructs that the calculation
 9 must be done using the "theoretic capacity *with a charge cut-off voltage set at 4.2V.*"
 10 '641 Patent at Claim 5 (emphasis added). When faced with a reference number like
 11 this, a POSA would recognize that this 4.2V reference point directly and necessarily
 12 requires that the cathode capacity variable in the calculation cannot refer to the
 13 theoretical maximum capacity but instead must refer to the theoretical capacity at
 14 that voltage because it means some of the lithium may not participate in the
 15 reactions. *Id.*, ¶¶ 42-51. This was a common way in which skilled artisans referred
 16 to theoretical capacity at the time. *Id.* The meaning is also dictated by the patent's
 17 express teaching that capacity increases as charge cutoff voltage increases. '641
 18 Patent 8:21-22 ("[C]apacity of [the] cell is greatly elevated when the charge cut-off
 19 voltage is above 4.20V[.]"); 2:21-23 ("[T]he capacity of lithium cobalt oxides
 20 reaches 159 mAh/g when the charge cut-off voltage is 4.35V..."). And, lest there
 21 be any doubt, the patent specification expressly defines theoretical capacity to mean
 22 the capacity at 4.2V:

23 'theoretical capacities of the positive and negative electrode' means
 24 the capacities of the positive electrode and the negative electrode
 25 calculated with a charge cut-off voltage set at 4.2 V.

26 '641 patent at 4:5-9. This rules out Apple's construction and is dispositive. *See*
 27 *Jack Guttman, Inc. v. Kopykake Enterprises, Inc.*, 302 F.3d 1352, 1360–61 (Fed.
 28 Cir. 2002) ("Where, as here, the patentee has clearly defined a claim term, that

1 definition usually is dispositive; it is the single best guide to the meaning of a
2 disputed term”) (internal quotation omitted).

3 Apple’s construction, which requires that “all of the active substances
4 participate in the reaction of the battery,” implicates a distinct concept: the
5 theoretical maximum capacity. This concept assumes that all of the lithium ions are
6 extracted from the cathode, Yao Decl., ¶¶ 43-51, and therefore reads out the “set at
7 4.2V” portion of the claim language. For example, the theoretical maximum
8 capacity of LiCoO_2 (*i.e.*, irrespective of charge cutoff voltage) is 274 mAh/g. *Id.*, ¶
9 40. By specifically including the clause “*with a charge cut-off voltage set at 4.2V*,”
10 the patentees instructed a skilled artisan reading the claims to calculate the ratio of
11 materials based upon the corresponding cathode capacity to the specified voltage of
12 4.2V. In the case of LiCoO_2 , the capacity would be 50% of the maximum (137
13 mAh/g). *Id.*, ¶¶ 40, 42.

14 The patentees chose a well-known reference point for calculating capacity—
15 4.2V was the industry standard charge cutoff voltage at the time of the invention,
16 so researchers could easily identify the theoretical capacity of materials charged at
17 this voltage. In fact, the voltage was used so ubiquitously, sometimes references
18 would use the term “theoretical capacity” to refer to the 4.2V capacity, even though
19 the capacity would be different when the battery was charged differently. *See* Yao
20 Decl., ¶ 46; Ex. 6, 1.10-1.11 & Table 1.1 (listing .137 Ah/g—*i.e.*, 137 mAh/g—as
21 the “theoretical capacity” of LiCoO_2); *see also* ’641 patent at 4:5-9; Ex. 7 (K.
22 Brandt, *Historical development of secondary lithium batteries*, 69 Solid State Ionics
23 (1994) 173-183 Table 3) (describing 137 mAh/g as the “theoretical value” for the
24 specific capacity of LiCoO_2). Linden further describes why this number is
25 “theoretical” even though it is not the theoretical maximum—because the variable
26 to determine the percentage of lithium extracted (called “x”) is assumed to be .5 or
27 50%, even though “higher values may be obtained in practice.” Yao Decl., ¶ 46;
28 Ex. 6, Table 1.1, note 3. This further bolsters RJ Technology’s construction, since

1 the specification in the claim of the 4.2V charge cutoff voltage points directly to the
2 use of an “x” of .5 for lithium cobalt oxide.

3 To be sure, both the extrinsic evidence (*e.g.*, Exs. 6, 7) and the intrinsic
4 evidence (*e.g.*, ’641 Patent 1:40-49, 1:64-2:1) use the words “theoretical capacity”
5 sometimes to refer to the theoretical maximum and sometimes to refer to the
6 theoretical value modified by an “x” factor. But when a particular charge cutoff
7 voltage is identified in combination with the words “theoretical capacity” there is
8 no ambiguity. Theoretical capacity in that context *must* refer to a value modified
9 by the applicable x factor. Because Apple’s proposed construction reads out of the
10 claim language the phrase “with a charge cutoff voltage set at 4.2V,” it cannot be
11 correct. “It is highly disfavored to construe terms in a way that renders them void,
12 meaningless, or superfluous.” *Wasica*, 853 F.3d at 1288 n.10; *see also Bicon, Inc.*
13 *v. Straumann Co.*, 441 F.3d 945, 950 (Fed. Cir. 2006) (“[C]laims are interpreted
14 with an eye toward giving effect to all terms in the claim.”).

15 i. The ratio term is not indefinite

16 Properly construed, the ratio limitation does not render the asserted claims
17 invalid as indefinite, as Apple contends. A claim is indefinite only if defendant
18 proves by clear and convincing evidence that “when read in light of the specification
19 and prosecution history, [the claim] fails to inform those skilled in the art about the
20 scope of the invention with reasonable certainty.” *Exmark Mfg. Co. Inc. v. Briggs*
21 *& Stratton Power Prod. Grp., LLC*, 879 F.3d 1332, 1344–45 (Fed. Cir. 2018).
22 Where measurement is concerned, “potential for inconsistent results . . . surely does
23 not render a claim indefinite” so long as the variances are not proven to be
24 significant. *Takeda Pharm. Co. v. Zydus Pharms. USA, Inc.*, 743 F.3d 1359, 1367
25 & n.3 (Fed. Cir. 2014).

26 There is no ambiguity here. Rather, Apple’s incorrect construction
27 manufactures an indefiniteness problem where there is none. Apple defines
28 “theoretic capacity” in a way that ignores that the claim expressly provides that the

capacity is measured “at 4.2V.” Then Apple claims the ratio term is indefinite because it includes the very “at 4.2V” language that Apple ignored.

Apple has it backwards—a construction that reads out claim language to make the claim nonsensical does not prove indefiniteness; it proves that the construction is wrong. By simultaneously specifying that the theoretical capacity should be interpreted as the theoretical maximum capacity while also providing that the measurement should be conducted using the capacity “with a charge cutoff voltage set at 4.2V,” Apple’s construction creates inconsistent reference points from which the capacity should be measured. It is Apple’s construction that is nonsensical, not the term itself. “A claim construction that renders asserted claims facially nonsensical cannot be correct.” *See Neville v. Found. Constructors, Inc.*, 972 F.3d 1350, 1357 (Fed. Cir. 2020); *see also Ruckus Wireless, Inc. v. Innovative Wireless Sols., LLC*, 824 F.3d 999, 1004 (Fed. Cir. 2016) (“If, after applying all other available tools of claim construction, a claim is ambiguous, it should be construed to preserve its validity.”). Of course, if the claim language is read as a whole (as it must be, *see Exmark*, 879 F.3d at 1344–45), it is plainly definite, intelligible, and reasonably certain.

c. A Secondary Lithium Ion Cell or Battery

RJ Technology’s Construction	Apple’s Construction
No construction is needed.	A lithium ion battery, wherein the battery electrode materials must not be substantially changed from what was available in the art and made without substantially decomposing the electrolyte, which can be recharged to its original capacity, without any decreased capacity or cycle life at a charge cut-off voltage above 4.2V.

The term “a secondary lithium ion cell or battery” has a well-understood meaning in the art and requires no construction. The Court has already recognized the clear meaning of the term. Dkt. 47 at 1; *accord* Yao Decl., ¶ 57; Ex. 6. at 22.3

1 (“Secondary or rechargeable batteries are widely used in many applications.”).
 2 Construing the term “secondary” as “rechargeable” merely replaces the claim term
 3 with a synonym. It adds nothing, and therefore no construction is necessary. *See*
 4 *Wasica*, 853 F.3d at 1282.

5 Apple’s construction is not what a skilled artisan would have understood the
 6 term to mean and is inconsistent with the intrinsic evidence.⁴ Yao Decl., ¶ 62.
 7 Apple’s contention that a secondary battery must be rechargeable “without any
 8 decreased capacity or cycle life at a charge cut-off voltage above 4.2V” has no
 9 support in the specification or prosecution history and is contrary to basic science.
 10 The intrinsic evidence consistently explains that the claimed secondary battery will
 11 experience capacity loss over discharge/recharge cycles—though a loss low enough
 12 to be viewed as desirable. *See, e.g.*, ’641 Patent at 4:37-42, 7:1-8, 7:29-33. In the
 13 specification, prosecution history, and in the patent claims themselves, the patentees
 14 explain that the claimed secondary battery experiences *low* capacity loss over
 15 hundreds of charges—not *no* capacity loss, as Apple’s construction would have it—
 16 *e.g.*, “above 75% after 400 cycles.” *See* Ex. 2. (File History) at Nov. 13, 2009
 17 Applicant Remarks, at 12; ’641 Patent at Claims 11-18, Examples 1-28.

18 Aside from being irreconcilable with the words of the patent, Apple’s
 19 construction must be rejected for two other reasons. First, its construction is
 20 scientifically impossible. Secondary batteries inevitably lose capacity over
 21 successive charge and discharge cycles, regardless of the charging method. Yao
 22 Decl., ¶¶ 59, 60, 62. Because Apple ignores this scientific fact, its construction
 23 must be rejected. *See AlterWAN, Inc. v. Amazon.com, Inc.*, 63 F.4th 18, 23 (Fed.
 24 Cir. 2023) (finding the district court’s construction, which required a physical
 25

26
 27 ⁴ Apple’s construction also appears to have inadvertently read “cell” out of the term
 28 being construed. RJ Technology understands that this omission was unintentional
 and that the dispute here concerns the meaning of “secondary.”

1 impossibility, *i.e.*, providing bandwidth when the internet was not operating, is not
 2 reasonable in light of the specification, “since it requires the impossible”); *Wasica*,
 3 853 F.3d at 1282. Second, Apple’s construction also improperly renders the
 4 independent claims narrower than the dependent claims. The dependent claims
 5 allow for decreased capacity (*see* claims 11-14), but Apple’s construction does not.
 6 It is improper to “interpret an independent claim in a way that is inconsistent with a
 7 claim which depends from it.” *See Wright Medical Technology, Inc. v. Osteonics*
 8 *Corp.*, 122 F.3d 1440, 1445 (Fed. Cir. 1997).

9 Apple appears to base its flawed construction on a purported disclaimer in
 10 the file history, in which the inventors explained that a combination of prior art
 11 references would not be expected to succeed because “the expected result would
 12 have been a lithium ion battery with very poor cyclability, *e.g.*, a capacity of 50%
 13 after the cell is depleted and recharged” and that this would not be a “secondary”
 14 battery because a secondary battery “denotes a battery that can be recharged to
 15 capacities relatively close to the original capacity.” Ex. 2. (File History) at Nov. 13,
 16 2009, Applicant Remarks, at 11. This does not in any way support Apple’s
 17 proposed construction, which permits zero decreased capacity. The applicants said
 18 the opposite, explaining that “secondary” denotes a battery that “can be recharged
 19 to capacities *relatively close* to the original capacity.” *Id.* (emphasis added).
 20 Apple’s proposed construction is irreconcilable with the intrinsic evidence.

21 In any event, there was no disclaimer. The prosecution history merely
 22 reflects the plain and ordinary meaning of the term. It distinguishes between
 23 secondary batteries, which can be “recharged to capacities relatively close to the
 24 original capacity” from primary batteries which have “very poor cyclability” such
 25 that they lose 50% of capacity or more in a single discharge/charge cycle. *Id.*; Yao
 26 Decl., ¶¶ 63-65. This is not a disclaimer. *See Wasica*, 853 F.3d at 1282.

27 Apple adds another strange limitation to its construction, but this too is
 28 contrary to law. Specifically, Apple claims that the term must include a limitation

1 requiring that the “battery electrode materials must not be substantially changed
 2 from what was available in the art.” But this position directly contradicts Federal
 3 Circuit precedent, which expressly “allows for after-arising technology to be
 4 captured within the literal scope of valid claims that are drafted broadly enough.”
 5 *Innogenetics, N.V. v. Abbott Lab’ys*, 512 F.3d 1363, 1371–72 (Fed. Cir. 2008).
 6 Here, the term at issue is broad and was not narrowed, and the specification
 7 specifically contemplates after arising technology. *See* ’641 Patent at 7:11-15
 8 (noting that the invention can be applicable to “electrode materials having higher
 9 specific energy developed in the future.”). The Court should adopt RJ Technology’s
 10 construction and interpret the term in accordance with its plain and ordinary
 11 meaning.

12 d. Overcharging Protection Voltage / Overcharging Protection Release
 13 Voltage/ Overcharge Protection Release Voltage

RJ Technology’s Construction	Apple’s Construction
<p>14 Plain and Ordinary Meaning.</p> <p>15 • “overcharging protection</p> <p>16 voltage” refers to the voltage</p> <p>17 level at which the battery’s</p> <p>18 protection mechanism(s)</p> <p>19 engages to prevent the battery</p> <p>20 from being charged to a higher</p> <p>21 voltage.</p> <p>22 • “overcharge/overcharging</p> <p>23 protection release voltage”</p> <p>24 refers to the voltage level at</p> <p>which a battery’s protection</p> <p>mechanism(s) disengages or</p> <p>resets.</p>	<p>Overcharging protection voltage /</p> <p>release voltage, implemented in the</p> <p>secondary lithium ion cell or battery,</p> <p>and not in a protection circuit.</p>

25 The parties agree that this term covers the implementation and release of the
 26 overcharge protection mechanisms. The only dispute is whether, as Apple
 27 contends, these mechanisms must be implemented “in the secondary lithium ion cell
 28

1 or battery, and not in a protection circuit.” Apple’s construction conflicts with the
2 intrinsic evidence and therefore must be rejected.

3 Overcharge protection was well known at the time of the invention as
4 measures to protect the battery if charged above the charge cutoff voltage, *i.e.*,
5 overcharged, due to a malfunction for example. Yao Decl., ¶¶ 66, 67. Overcharge
6 protection can be implemented in the battery itself, such as in the battery
7 management system or related circuitry, but it may also be implemented in software
8 or firmware that operates on the battery. *Id.*, ¶ 67. It may also be implemented in a
9 protection circuit (*id.*; Ex. 6 at 35.37, 35.69), as the patent expressly describes:
10 “necessary modification is made to the protecting circuit or relevant devices and
11 equipment[] comprising said circuit” and “[t]he type and structure of the protecting
12 circuit . . . *shall not be specifically restricted* . . . provided that the first overcharging
13 protection voltage is greater than 4.35V” ’641 Patent at 9:24-36 (emphasis
14 added). It should therefore be interpreted without restriction from its ordinary,
15 broad meaning. The Federal Circuit “normally do[es] not interpret claim terms in
16 a way that excludes embodiments disclosed in the specification,” *Oatey Co. v. IPS*
17 *Corp.*, 514 F.3d 1271, 1276 (Fed. Cir. 2008).

18 Apple appears to rely on the inventors’ compliance with a restriction
19 requirement⁵ issued during prosecution to limit the claims in this way. *See* Dkt. No.
20 67-1 at Ex. A, 10 (citing May 23, 2008 Office Action). “But a restriction
21 requirement election does not necessarily imply a disclaimer of claim scope.”
22 *Dynamic Digital Depth Rsch. PTY LTD v. LG Elecs., Inc.*, 2016 WL 7444569, at *7
23 n.3 (C.D. Cal. Nov. 7, 2016). Such is not entitled to “much weight” here because
24 the examiner did not construe or limit the term. *E.g., Honeywell Int’l, Inc. v. ITT*

25
26
27 ⁵ When a patent application includes more than one “independent and distinct”
28 invention, the USPTO may impose a “restriction requirement” requiring the filing
of separate applications for each invention. MPEP § 802.

1 *Indus., Inc.*, 452 F.3d 1312, 1319 (Fed. Cir. 2006). This is not enough to overcome
 2 the strong presumption created by the specification's express preservation of scope
 3 in the embodiments. *See Oatey*, 514 F.3d at 1276.

4 e. Maintains at Least ... Capacity after 400 Cycles

RJ Technology's Construction	Apple's Construction
Plain and ordinary meaning. "maintains at least [a percentage] of capacity after 400 complete charge and discharge cycles of the battery"	Indefinite

9 The '641 Patent repeatedly describes that the benefit of the claimed invention
 10 is the preservation of capacity even after numerous charging cycles. In doing so,
 11 the patent employs a simple measurement of this benefit: the percentage of capacity
 12 preserved. This form of benefit is straightforward, long known (Yao Decl., ¶¶ 72,
 13 73), and has a plain meaning, which should be adopted.

14 The term is articulated in plain English and merely requires calculation of
 15 what percentage of capacity remains compared to what was the initial capacity.
 16 This is elementary school math:

$$\frac{\text{Remaining Capacity}}{\text{Initial Capacity}}$$

17 *Id.*, ¶ 74.

20 The patent describes several instances of capacity loss, from which the
 21 calculation can be easily derived. For example, the patent describes the results of
 22 experiments where "the capacity of lithium cobalt oxide[] reaches 159 mAh/g when
 23 the charge cut-off voltage is 4.35V, but it drops to 135 mAh/g after several cycles."
 24 *E.g.*, '641 Patent 2:20-24. The remaining capacity is 84.9%. Yao Decl., ¶ 78.

25 All experiments disclosed in the patent describe an initial capacity as well as
 26 the capacity remaining after 400 cycles. '641 Patent at Examples 1-28. For
 27 example, experiment 1 describes an initial capacity of 1113 mAh, and discloses that
 28 the battery retains 85.72% of capacity after 400 cycles. '641 Patent at 10:29-37. A

1 person of skill would understand that the capacity of the battery would be 954 mAh
 2 after 400 cycles (85.72% of 1113 mAh). Yao Decl., ¶ 79.

3 The extrinsic evidence echoes this understanding. For example, Ex. 6
 4 (HANDBOOK OF BATTERIES), refers to “Capacity Fade,” which it describes as a well-
 5 known and extensively studied battery property, illustrated in the charts below.

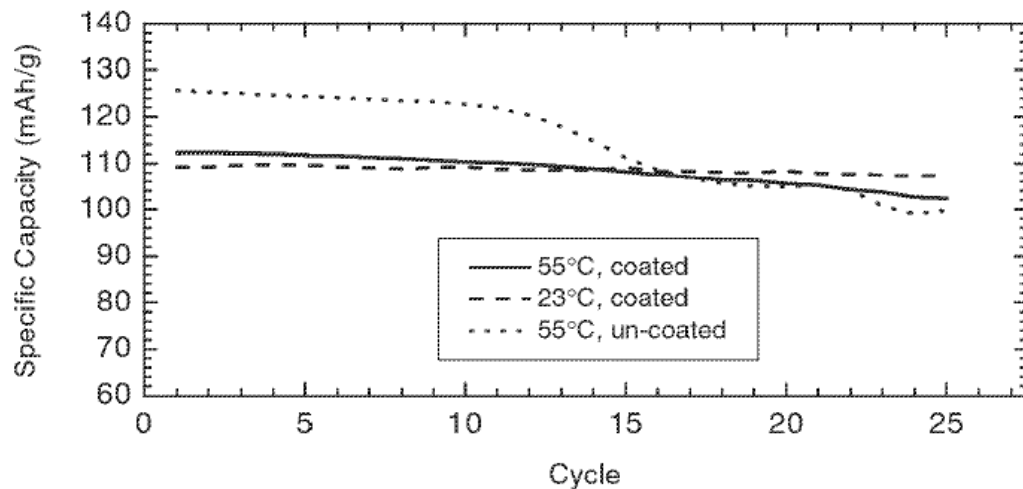


FIGURE 35.15 Specific capacity of LiCoO₂ coated and un-coated spinels cycled at the C/2 rate between 4.2 and 3.5 V at 23°C or 55°C. (Courtesy of Carus Chemical.)

Ex. 6 at, A.4, 35.13-16, 35.42.

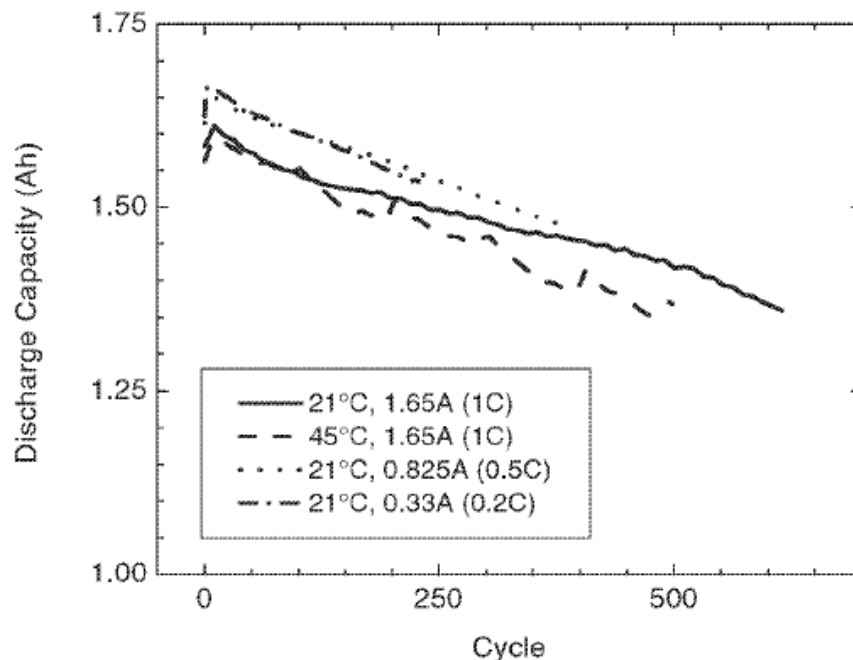


FIGURE 35.45 Capacity of 18650-type C/LiCoO₂ batteries when cycled at either 21°C or 45°C at rates from 0.2C (0.33 A) to 1.0C (1.65 A) between 4.2 V and 2.5 V. (Courtesy of NEC Moli Energy.)

1 *Id.* at 35.42.

2 The patent's claiming of a widely studied and described battery property,
 3 using elementary math, reflects a readily understandable concept which is far from
 4 indefinite. Yao Decl., ¶ 80. Apple provides no support for its indefiniteness
 5 contention, and even if the claim language was ambiguous about how to measure
 6 capacity loss (it is not), that would not support invalidation of the patent. *Takeda*
 7 *Pharm.*, 743 F.3d at 1367 & n.3. Indeed, Apple's public advertisements use the
 8 same measurement:

9 iPhone Owners

10 Your battery is designed to retain up to 80% of its original capacity at 500 complete
 11 charge cycles. The one-year warranty includes service coverage for a defective
 12 battery. If it is out of warranty, Apple offers a [battery service](#). Prices and terms may
 13 vary.

14
 15 Ex. 8 (*Battery Service and Recycling*, APPLE,
 16 <https://www.apple.com/batteries/service-and-recycling/>). If the term is
 17 understandable to a lay consumer, it plainly is not indefinite.

18 IV. CONCLUSION

19 For all the foregoing reasons, RJ Technology respectfully requests the Court
 20 adopt its constructions and find that the claims are not indefinite.

1 Dated: June 23, 2023

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Certification Per Local Rule 11-6.2

The undersigned counsel of record for Plaintiff RJ Technology LLC certifies that this brief contains 6,990 words, as calculated by the limitations in L.R. 11-6.1.

By: /s/ Daniel Zaheer
Daniel Zaheer

**UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA
SOUTHERN DIVISION**

RJ TECHNOLOGY LLC

Plaintiff,

vs.

APPLE INC.,

Defendant.

Case No. 8:22-CV-1874-JVS-JDE

**DECLARATION OF DR. YAN YAO
IN SUPPORT OF PLAINTIFF RJ
TECHNOLOGY LLC'S OPENING
CLAIM CONSTRUCTION BRIEF**

**DECLARATION OF DR. YAO IN SUPPORT OF PLAINTIFF RJ
TECHNOLOGY'S OPENING CLAIM CONSTRUCTION BRIEF**

1 I, Dr. Yan Yao declare and state as follows:

2 1. I am a professor in the Cullen College of Engineering at the University
3 of Houston. I am also a Fellow of the Royal Society of Chemistry, a senior member
4 of the National Academy of Inventors, and a senior member of the Institute for
5 Electrical and Electronics Engineers. I received Bachelor of Science and Master of
6 Science degrees from Fudan University in China, where I studied materials science.
7 I received my Ph.D. from the University of California, Los Angeles, where I studied
8 Materials Science and Engineering. I was also appointed to be a Postdoctoral
9 Scholar at Stanford University, where I spent two years conducting battery research.
10 The focus of my research is batteries, particularly lithium ion batteries and
11 rechargeable batteries using non-lithium ions, and I have published over 100 papers
12 on the topic. A copy of my CV is attached here as **Exhibit A**.

13 **I. Scope of Work**

14 2. I have been retained by Plaintiff RJ Technology LLC (“RJ
15 Technology”), and their counsel, Kobre & Kim LLP, as an expert in the lawsuit
16 captioned above. I understand that RJ Technology has asserted U.S. Patent No.
17 7,749,641 (“’641 Patent”) against Apple, accusing Apple smartphones, watches,
18 tablets, and airpod cases of infringement. My hourly rate is \$500 per hour.

19 3. I have reviewed the ’641 Patent, the file history, and all of the intrinsic
20 and extrinsic evidence identified by the parties in their joint claim construction
21 statement (Dkt. 67). A complete list of the materials I have considered in
22 preparation for this declaration can be found in **Exhibit B**.

23 4. I understand that the parties are currently engaged in a process called
24 claim construction, whereby the Court must determine the meaning of certain
25 disputed terms of the ’641 Patent. I understand that the parties dispute the following
26 terms and have asked the Court to provide their meaning:

27 a. Charge Cutoff Voltage
28

- b. Ratio of Positive Electrode Material to Negative Electrode Material as Calculated by a Theoretic Capacity with a Charge Cut-off Voltage Set at 4.2V
- c. A Secondary Lithium Ion Cell or Battery
- d. Overcharge Protection Voltage/Overcharging Protection Release Voltage/Overcharge Protection Release Voltage
- e. Maintains at Least ... Capacity after 400 Cycles

Each term or phrase is commonly used in the field, and each has a well-known meaning.

5. I understand that the Court must determine the meaning of these terms by assessing how a person of ordinary skill in the art (the “POSA”) would have understood them at the time of the invention. I have been informed that the claim construction inquiry begins with the claim language itself. A claim term must be read in light of the specification and other intrinsic evidence of the patent, such as the prosecution history. Extrinsic evidence, such as dictionaries and articles in the field, can help further explain the meaning of a claim term. If, however, a person of ordinary skill cannot ascertain the scope of the claimed invention with reasonable certainty, when read in view of the specification and prosecution history of a patent, I understand that the Court would consider the term “indefinite.”

6. I further understand that Apple argues that the following terms are indefinite:

- a. Ratio of Positive Electrode Material to Negative Electrode Material as Calculated by a Theoretic Capacity with a Charge Cut-off Voltage Set at 4.2V
- b. Maintains at Least ... Capacity after 400 Cycles

As further explained below, Apple is incorrect. Each of these phrases and their constituent terms is well known and commonly used in the industry, and a POSA would readily and easily ascertain the scope of the relevant claims with reasonable certainty—especially when read in the context of the specification and prosecution history. These terms are not indefinite.

**DECLARATION OF DR. YAO IN SUPPORT OF PLAINTIFF RJ
TECHNOLOGY’S OPENING CLAIM CONSTRUCTION BRIEF**

II. Technical Background

7. Lithium ion batteries have become ubiquitous. They are now used not only to power personal electronic devices, such as the phones, tablets, watches, and airpods cases accused in this case, but also to power electric vehicles and even to store power for residential homes and for municipal and private electric utilities.

8. Lithium ion batteries in use today are rechargeable. Rechargeable batteries are also called secondary batteries, and non-rechargeable batteries are called primary batteries. The terms “primary” and “secondary” are used to distinguish these two types of batteries based on their rechargeability, rather than their quality or performance.

9. Charging refers to the process of replenishing the energy stored in a battery. During charging, an external power source is connected to the battery. Discharging is the process of releasing the stored energy from the battery to power another device.

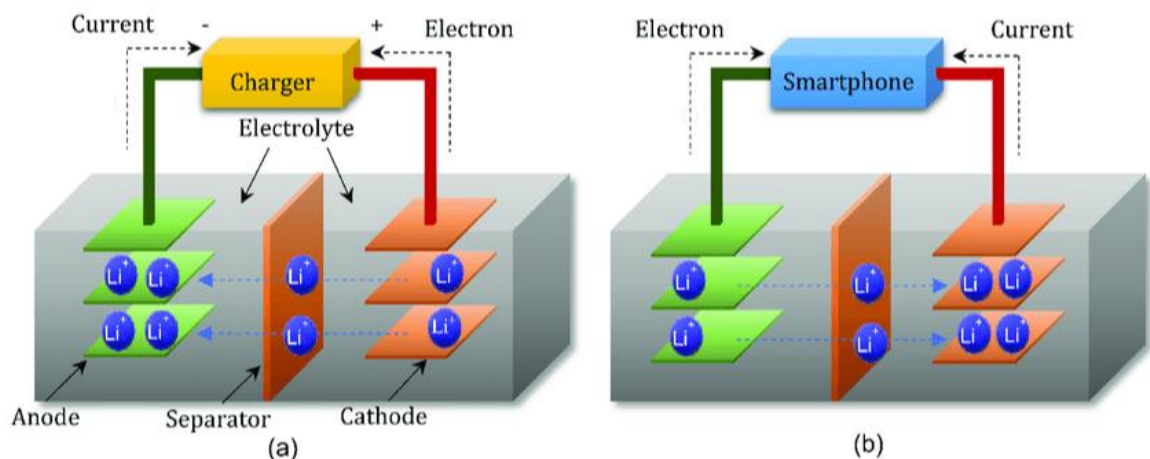
10. One reason lithium ion batteries have become so widely used is because they have a high energy density, meaning that they efficiently store a lot of power in a relatively small volume. However, that density comes at a cost. Lithium ion batteries can be dangerous. The chemical reactions that power these batteries are inherently unstable and need to be conscientiously controlled and monitored. Otherwise, the batteries may overcharge, overheat, and degrade, or worse. In extreme cases, the batteries may reach a state called thermal runaway, which may lead to fires and explosions.

11. Let’s first discuss the basic anatomy of a secondary lithium-ion battery. Most relevant to these proceedings are the two electrodes: the anode (negative electrode) and the cathode (positive electrode). The cathode is typically made of a compound of lithium, another element, and oxygen. At the time of the invention, a common cathode material was lithium cobalt oxide (LiCoO_2). A common anode material is graphite, which is made of sheets of carbon (C_6).

**DECLARATION OF DR. YAO IN SUPPORT OF PLAINTIFF RJ
TECHNOLOGY’S OPENING CLAIM CONSTRUCTION BRIEF**

12. Other lithium ion battery components include the electrolyte, which allows the flow of lithium ions between the electrodes while preventing the direct flow of electrons, the separator, which acts as a barrier to prevent direct contact of the electrodes, the current collector, which collects current from each electrode as the electrochemical reactions occur, and the case, which houses the battery. The battery typically also contains circuitry that regulates charge and discharge of the battery—sometimes called the battery management system.

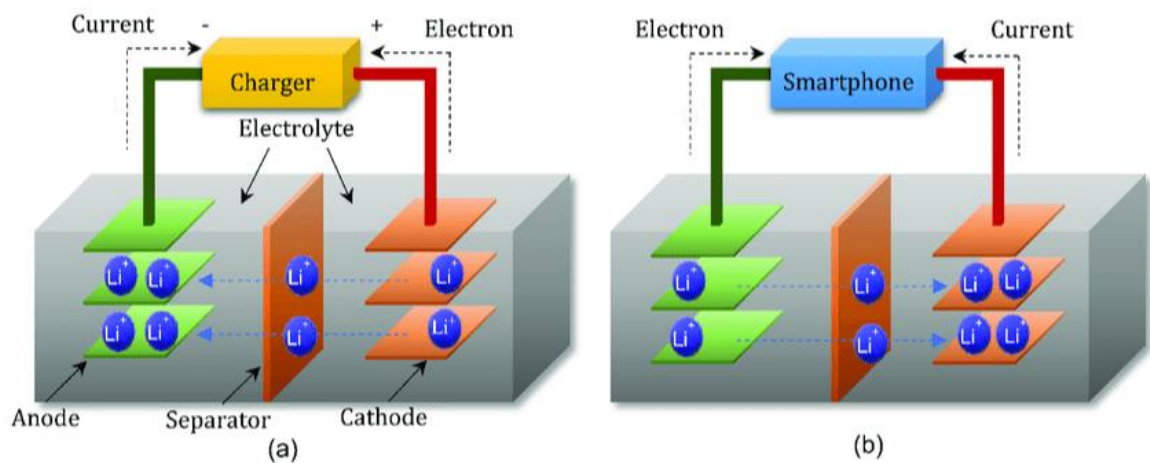
13. Next, I will describe the chemical reactions that occur during the charging and discharging of the battery. Lithium ion batteries use what is known as a “rocking chair” mechanism to charge and discharge the battery. The rocking chair mechanism derives its name from the analogy of the back-and-forth motion of lithium ions, resembling the motion of a rocking chair. This is illustrated in the images below:



14. Diagram “(a)” on the left above illustrates charging of the battery. As shown in that image, when electrical current is applied to charge the battery, the cathode undergoes a process where both electrons and lithium ions are released. The lithium ions traverse the electrolyte to reach the anode, while the electrons flow through the external circuit and also reach the anode. Once the lithium ions reach the anode, they intercalate into the anode. One key function the anode plays is to

1 store the lithium ions which have been pulled from the cathode through this
2 charging process in a way that can be easily removed.

3 15. Let's now discuss discharge, which is shown in diagram "(b)" on the
4 right (reproduced again below for ease of reference). Discharge refers to the use of
5 the battery to power a device, such as a smartphone. As the battery discharges, the
6 anode releases electrons into the external circuit, where they then flow into the
7 device as electricity, giving it power. At the same time, the lithium ions leave the
8 anode and travel back through the electrolyte to intercalate back into the cathode.
9 As the battery continues to discharge, more lithium ions traverse the electrolyte and
10 intercalate into the cathode until the battery is fully discharged.



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19 16. I will now describe some of the basic measurements for key attributes
20 of the battery which are of relevance to this case. But first, a useful analogy.
21 Electricity can be viewed as behaving like water in that it has both flow (current)
22 and pressure (voltage). Current describes the flow of electricity, and is measured in
23 amperes (A). Voltage describes the amount of "pressure," e.g., the strength at which
24 the electrons flow, and is measured in volts (V). Voltage can be thought as the
25 driving force behind the flow of current. The greater the voltage, the stronger the
26 force, and the higher the current will be. Taken together, higher voltage and current
27 mean more energy in the system.

28
**DECLARATION OF DR. YAO IN SUPPORT OF PLAINTIFF RJ
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1 17. The capacity of the battery measures the amount of electrical charge
2 the battery can store. Returning to the water analogy, it would be the size of the
3 reservoir. Capacity is often measured in Ampere-hours (Amp-hours) or milliamp-
4 hours (mAh), which indicates how many amperes or milliamperes of current the
5 battery can deliver over a period of one hour. For example, per its label, the Apple
6 Watch Series 7 has a capacity of 309 mAh. Dkt. 51 at 11. That means the Apple
7 Watch Series 7 should be able to deliver a current of 309 milliamperes for one hour
8 before it is completely discharged.

9 18. As the '641 Patent describes, increasing the charging voltage applied
10 to a battery can increase its capacity—at least in the short term—by pulling more
11 lithium from the cathode and pulling it to the anode. But increasing the charging
12 voltage can damage the battery, ultimately leading to capacity loss, rendering the
13 battery inoperable, and/or making the battery unsafe. For example, when the
14 voltage is higher, the lithium ions traverse the electrolyte and intercalate into the
15 anode with greater force, increasing the risk both components will be damaged.
16 Similarly, the energy can be dissipated into the system as heat, which can denature
17 the electrolyte and other components.

18 19. The failure modality most relevant to the '641 Patent is called
19 overcharging. When a battery is overcharged, it is charged at a voltage higher than
20 its chemistry can accommodate. As discussed above, a battery's voltage can be
21 thought of as the pressure by which the components of the battery, including the
22 lithium ions, are pushed or pulled. Overcharging pushes the lithium ions too hard
23 and will break the battery if done for long enough or at a high enough voltage. In
24 the most extreme case, charging the battery at too high a voltage will cause the
25 cathode to collapse and cause the electrolyte to oxidize, releasing flammable gasses,
26 which ultimately causes the battery to catch fire or explode.

27 20. In the less extreme case, applying too much voltage can cause the
28 lithium ions to irreversibly wedge themselves in the anode in the incorrect sites.

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1 This limits the amount of lithium ions that can traverse the electrolyte between the
2 anode and cathode as some lithium ions can become metallic lithium. This
3 phenomenon, known as lithium plating, can cause the formation of potentially tree-
4 like structures on the surface of the anode that penetrate the separator, potentially
5 leading to short circuit and ultimately resulting in battery failure.

6 21. Each electrode has a different capacity, determined by the material
7 used and its size. The total capacity of the battery is limited by the lower capacity
8 of the two electrodes. The excess capacity of the other electrode is not used and
9 therefore is wasted. If, for example, the anode has far more capacity than the
10 cathode, the excess capacity is not used and is instead dead weight, making the
11 battery larger, heavier, and more expensive.

12 22. Therefore, it is important for battery manufacturers to know the
13 capacity of each electrode to ensure that the battery is properly balanced. To
14 perform such balancing, the battery manufacturer will carefully design and measure
15 the mass, area, volume, and/or capacity of the active material of each electrode.

16 23. As the battery is charged and discharged over successive cycles, it
17 loses capacity, regardless of the charging voltage (though this process is slower
18 when the battery is charged at or below the charge cutoff voltage). Capacity can be
19 lost at any charging voltage because of issues like the occurrence of side reactions,
20 degradation of the cathode chemistry, denaturation of the electrolyte, and lithium
21 plating. Therefore, practitioners not only track the capacity of the battery when it
22 is being manufactured, they track it over time, referring to the diminished capacity
23 as a percentage of the original capacity of the battery.

24 **III. Person of Ordinary Skill in the Art**

25 24. In my opinion, the '641 patent is directed to a person of ordinary skill
26 in the art who at that time would have had at least a master's degree in electrical
27 engineering, material science, or a related field and would have been working in the
28

field of battery design for at least three years, with some direct experience with lithium-ion batteries.

IV. Disputed Claim Terms

a. Charge Cut-off Voltage

RJ Technology's Construction	Apple's Construction
Plain and ordinary meaning , which is the maximum voltage to which the battery is configured to be charged.	The voltage at which the charging changes from constant current charging to constant voltage charging

25. I understand the parties dispute the definition of the term “charge cutoff voltage,” and I further understand that the disputed positions are included in the table above.

26. A POSA would readily understand that the charge cutoff voltage of a battery, as that term is used in the '641 Patent, is the maximum voltage to which the battery is configured to be charged. The charge cutoff voltage is a fundamental design feature of a lithium ion battery. Each lithium ion battery is configured with this design feature in mind, and the charge cutoff voltage is determined through extensive research, testing and consideration of the specific chemistry inside the battery. Depending on the context, the term “charge cut-off voltage” is used synonymously with several other terms in the industry, which all refer to the maximum voltage to which the battery is configured to be charged. These include the upper charge limit, the upper voltage limit, the cutoff voltage, or the potential limit.

27. The '641 Patent's use of “charge cutoff voltage” confirms that the term is being used to describe the maximum voltage to which the battery is configured to be charged. For example, the patent explains that, at the time of the invention, “the charge cut-off voltage . . . is limited to no more than 4.2V, and this is well accepted as a technical requirement in the industry of manufacture of secondary lithium ion battery.” '641 Patent at 1:46-49. The '641 Patent further explains that

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1 charging the battery above this voltage (*i.e.*, overcharging) can lead to a number of
2 undesirable side effects: “the positive electrode materials and the negative electrode
3 materials will undergo structure change, the electrolyte may decompose, and the
4 recycle property of the cell will be adversely affected.” ’641 Patent at 1:55-63. In
5 all these instances, the ’641 Patent refers to the “charge cut-off voltage” as the
6 charging maximum.

7 28. A POSA would understand that during normal use of a battery, the
8 charging voltage should not exceed this charge cutoff voltage. However, a battery
9 may experience charging voltage that exceeds the charge cutoff voltage in certain
10 scenarios. For example, a failure in the charging system may lead to unintentionally
11 charging the battery to a voltage higher than the charge cut-off voltage. The battery
12 has protection mechanisms to address these scenarios, which are discussed further
13 below. However, the battery is not configured, *i.e.*, designed and manufactured, to
14 be charged higher than the charge cutoff voltage.

15 29. I have reviewed the file history of the patent as well, which further
16 supports my opinion regarding the meaning of charge cutoff voltage. Neither the
17 patentee, nor the patent examiner appears to have used the term to refer to a specific
18 charging algorithm like constant current/constant voltage charging (as provided in
19 Apple’s construction). *E.g.*, Ex. 2, (’641 Patent File History (“File History”)) at
20 Nov. 13, 2009, Applicant’s Remarks at 8; Ex. 2 (File History) at Notice of
21 Allowability at 2-3.

22 30. Apple’s proposed claim construction defines charge cutoff voltage to
23 be limited to one particular and common charging algorithm: the constant
24 current/constant voltage algorithm (“CC/CV”). But a POSA would understand that
25 other charging algorithms could be used and that “charge cutoff voltage” does not
26 refer exclusively to any single algorithm.

27 31. As discussed above, it is important to carefully control the mechanism
28 through which a battery is charged, to ensure its safety, longevity, and performance.

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1 Researchers in the field thus have developed various charging algorithms to charge
2 the battery. Typically, a charging algorithm is controlled through the battery
3 management system, which is a circuit included within the battery. However, the
4 algorithms may also be controlled through other components such as the power
5 supply (the charger), or through software, such as the operating system.

6 32. Apple's construction refers to a specific type of charging algorithm—
7 CC/CV. Pursuant to that algorithm, the battery is charged using a constant current
8 until it reaches a maximum configured voltage, at which point it is charged at that
9 voltage until charging is complete. The constant current stage allows the battery to
10 be charged quickly and efficiently. During the constant voltage stage, the battery is
11 slowly charged to its full capacity, and this constant voltage stage prevents the
12 battery from being overcharged, *i.e.*, charging to a level higher than the charge
13 cutoff voltage.

14 33. At the time of the invention, and still today, CC/CV charging was a
15 common way of charging a lithium-ion battery, and regarded as a sound means to
16 strike a balance between fast charging and safe charging. But CC/CV charging is
17 not the only way to charge a battery. A charge cutoff voltage can be implemented
18 by other charging algorithms. For example, in many laboratory settings, batteries
19 are charged at a constant current without a constant voltage stage. Once the battery
20 reaches a predetermined voltage (*i.e.*, the charge cut-off voltage), the charging
21 stops. Sometimes the battery is charged at a constant voltage, without first being
22 charged at a constant current. Sometimes pulse charging is used, which involves
23 delivering charging current in pulses rather than a continuous stream. In each of
24 these cases, there is a charge cut-off voltage, which is the maximum voltage to
25 which the battery is configured to be charged.

26 34. I have reviewed the sources that Apple relies upon for its construction.
27 Apple cites a technical dictionary, which defines the term "cutoff voltage" as
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1 1. The electrode voltage that reduces the dependent variable of an
2 electron-tube characteristic to a specified value. *See also* critical
3 voltage. 2. The voltage at which the discharge is considered complete.
This need not be a very low voltage.

4 Ex. 5. (Graf, R., Modern Dictionary of Electronics (7th ed. 1999)) at 167. The first
5 definition of “cutoff voltage” is not relevant to a lithium-ion battery, as it concerns
6 electron-tubes. The second definition of “cutoff voltage” is the voltage at which the
7 battery stops discharging (*i.e.*, powering the device). In other words, it is the
8 *discharge* cutoff voltage, instead of *charge* cutoff voltage. Neither of these
9 definitions is relevant here. Apple also cites the handbook by David Linden and
10 Thomas B. Reddy. Similarly, there the “cut-off voltage” is “designated as the end
11 of the discharge. Usually, it is the voltage above which most of the capacity of the
12 cell or battery has been delivered.” Ex. 6. (LINDEN D, HANDBOOK OF BATTERIES,
13 (2001)) at 3.2.1. This too is not relevant, because the phrase “cut-off voltage” is
14 used to refer to a totally different concept from “charge cutoff voltage” as used in
15 the ’641 patent.

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b. Ratio of Positive Electrode Material to Negative Electrode Material as Calculated by a Theoretic Capacity with a Charge Cut-off Voltage set at 4.2V

RJ Technology's Construction	Apple's Construction
<p>Plain and ordinary meaning. The ratio calculated as 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 cutoff voltage is 4.2 V.</p>	<p>Indefinite.</p> <p>In the alternative, the ratio calculated as the product of the theoretic 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 cell charge cutoff voltage is set at 4.2 V,</p> <p>wherein “theoretic capacity” means “theoretical, rather than actual, capacity that assumes all of the active substances participate in the reaction of the battery”</p>

35. As discussed above, the capacity of the battery is determined by the capacity of the electrode material. More specifically, the battery's capacity is limited by the capacity of the electrode which has the least capacity. To the extent the other electrode has more capacity, that capacity is wasted. Because of this, it is important to determine the right ratio of positive to negative electrode materials to optimize overall capacity and minimize waste. This process is sometimes called “balancing” and refers to achieving the right balance between electrode materials.

36. The claim language at issue here concerns that balancing process. At a broad level, the patent instructs practitioners to compare the capacity of the anode material (negative electrode material) to that of the cathode material (positive

1 electrode material) in the form of a ratio. This is a common way in the industry of
2 describing the electrode capacity ratio and of measuring it.

3 37. The claim language provides that the ratio be calculated as the product
4 of the capacity of the cathode active material per mass unit and the amount of the
5 cathode active material in the same mass unit divided by the product of the capacity
6 of the anode active material per mass unit and the amount of the anode active
7 material in the same mass unit, when the charge cutoff voltage is 4.2 V.

8 38. This can be reflected in the following equation:

$$\text{Ratio} = \frac{C_p \times m_p}{C_n \times m_n}$$

9
10
11 where C_p is the specific capacity of the cathode active material (typically measured
12 in milliamperes per gram, or “mAh/g”), m_p is the mass of the cathode active material
13 (here measured in grams), C_n is the specific capacity of the anode active material
14 (in mAh/g), and m_n is the mass of the anode active material (in grams). The final
15 ratio is stated as a ratio of cathode capacity (in mAh) to anode capacity (in mAh).

16 39. The ratio refers to a ratio based on specific capacity. Specific capacity
17 is simply the capacity of the material divided by a specific unit measure, most
18 commonly mass. Here, the specific capacity of the material is multiplied by the
19 amount of material to get to the capacity. For example, graphite (a common anode
20 material), has a specific capacity of 372 mAh/g, which means for 1 gram of graphite,
21 it will have a capacity of 372 mAh. Under the claim language in the patent, the
22 capacity of the anode is determined by multiplying this figure by the mass of the
23 active material in the anode.

24 40. The capacity of the cathode would be determined in the same manner.
25 For example, LiCoO_2 has a specific capacity of 137 mAh/g when charged at 4.2V,
26 which is half of its maximum specific capacity (274 mAh/g). The reason for this,
27 as discussed further below, is that at 4.2V, only 50% of the lithium ions are removed
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1 from LiCoO₂. Other materials may have different amounts of lithium extracted at
2 that voltage, up to and including 100%, and therefore different capacities.

3 41. Apple's construction follows the general calculation approach above,
4 except that Apple defines "theoretic capacity" to mean "theoretical, rather than
5 actual, capacity that assumes all of the active substances participate in the reaction
6 of the battery." While I agree that the term "theoretic" means "theoretical" and
7 therefore refers to the battery's theoretical capacity, in my opinion the remainder of
8 Apple's construction is incorrect.

9 42. In providing that "all of the active substances participate in the reaction
10 of the battery" Apple's construction appears to require that to calculate the ratio, a
11 POSA should assume that all of the lithium is extracted from the cathode and
12 therefore "participate[s] in the reaction of the battery." But that construction is
13 contrary to the plain language of the claim term, which requires that the capacity be
14 calculated using "a charge cutoff voltage set at 4.2V." As discussed above, the
15 specification of a charge cutoff voltage means that *not* all of the lithium is extracted
16 from the cathode. Instead, the voltage provides for a lesser number—for example,
17 50% for LiCoO₂, which is 137 mAh/g.

18 43. Apple's construction conflicts with the claim language in another
19 respect. The claim language uses "theoretic capacity" whereas Apple's construction
20 implicates another concept: the theoretical maximum capacity.

21 44. The difference between the theoretical capacity and the theoretical
22 maximum capacity is the amount of lithium that participates in the reaction. The
23 capacity of each electrode is determined by the reactions within that electrode. If
24 more of the amount of lithium within the electrode participates in the reaction, the
25 capacity is increased.

26 45. Importantly, the voltage applied to the cathode determines the amount
27 of lithium in the cathode active material that participates in the reaction (*i.e.*, is
28 extracted from the cathode). The inventors specifically included the phrase "a

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1 charge cut-off voltage set at 4.2V” as a reference point to show how much of the
2 lithium is extracted. A POSA would use this reference number to identify the
3 theoretical capacity using well-known equations or would simply look the figure up
4 in a table. For example, at a charge cutoff voltage of 4.2V, 50% of the lithium ions
5 are extracted from a cathode made of LiCoO₂. This means its capacity is half of its
6 theoretical maximum at this voltage. A POSA would understand this as the
7 theoretical capacity of the material at the stated voltage.

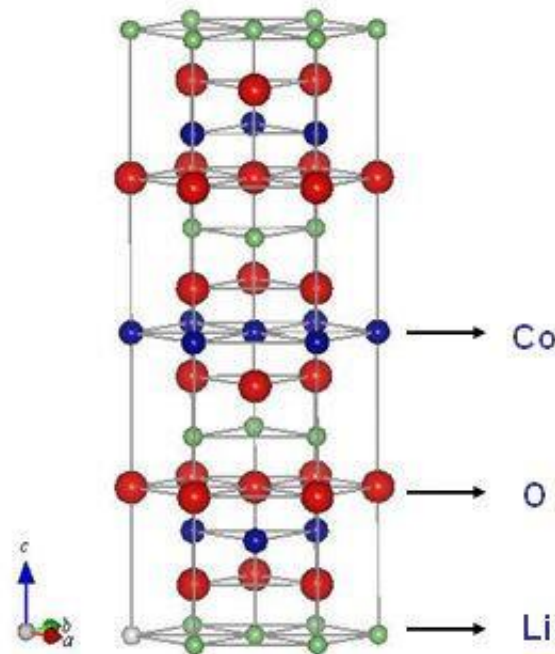
8 46. This was well-known at the time of the invention. Indeed, some
9 references contemporaneous with the '641 Patent simply use the term “theoretical
10 capacity” to mean the specific capacity at 4.2 V. For example, the HANDBOOK OF
11 BATTERIES, which was frequently used as a textbook for college students, describes
12 the “theoretical capacity” of LiCoO₂ to be 137 mAh/g. *See* Ex. 6. (LINDEN D,
13 HANDBOOK OF BATTERIES, (2001)) at 1.10-1.11 & Table 1.1 (.137 Ah/g is 137
14 mAh/g). The HANDBOOK OF BATTERIES also explains that the 137 number is based
15 on “x=0.5,” which is the percentage of lithium extracted from the cathode active
16 material, even though “higher values may be obtained in practice.” *Id.* at 1.11. In
17 another article that describes the history of development of secondary lithium ion
18 batteries, the author describes 137 mAh/g as the “theoretical value” of the specific
19 capacity of lithium cobalt oxide. *See* Ex. 7. (K. Brandt, *Historical development of*
20 *secondary lithium batteries*, Solid State Ionics 69 (1994)) at 173-183 Table 3.

21 47. This understanding is consistent with the specification of the '641
22 Patent. The '641 Patent defines “theoretic capacity” of the positive electrode to
23 mean “the capacities of the positive electrode ... calculated with a charge cut-off
24 voltage set at 4.2 V.” '641 Patent at 4:5-9. The specification here does not say it is
25 the theoretical maximum, but the capacity at 4.2 V.

26 48. Using the 4.2 V theoretical capacity also makes practical sense. A
27 POSA would readily appreciate that the theoretical maximum capacity is not
28 achievable in real life. Lithium ions are a core component of the active material of

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the cathode. The cathode typically has a crystal structure, and the lithium ions are nested within this structure. An exemplary image can be found below:



H. Xia, et al., *Electrochemical behavior and Li Diffusion study of LiCoO₂ thin film electrodes prepared by PLD*, Advanced Materials for Micro- and Nano-Systems at Fig. 1 (2007) available at <https://dspace.mit.edu/handle/1721.1/35827>. As can be seen in this structure, the lithium ions support the structure. Therefore, if all of the lithium ions are removed during charging, the compound would collapse, breaking the cathode and the battery.

49. This was a well-known issue at the time of the invention, and the '641 Patent discusses it at several points in the specification. For example, in column 6, the specification discusses a situation in which "lithium ions are completely dedoped," (*i.e.*, removed) from the cathode, leading to several negative consequences including the release of oxygen gas. '641 Patent at 6:14-34.

50. In contrast, 4.2 V was the industry standard for charge cutoff voltage at that time. The specific capacity of the cathode active material at a charge cutoff voltage of 4.2 V was easily identifiable by a POSA at the time of the invention. Such specific capacity is also closer to the actually usable capacity, so it acts as a

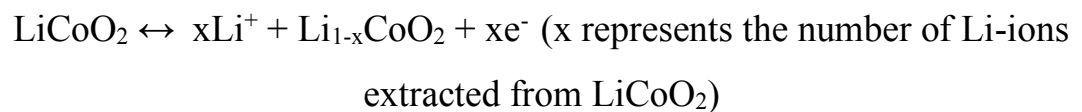
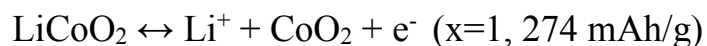
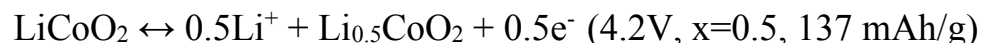
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1 good reference point to determine how to balance the capacities of cathode and
2 anode in a battery.

3 51. Therefore, to the extent Apple intends the phrase “all of the active
4 substances participate in the reaction of the battery” to imply that all of the lithium
5 is extracted, this is inconsistent with the plain language of the claim itself, the
6 written description in the patent and with the way the term was generally used.

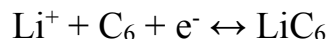
7 52. Apple’s construction is also flawed because it is ambiguous in that it
8 is unclear what Apple means by “the reaction of the battery.” In reality, there is no
9 “reaction of the battery” but instead multiple, independent reactions which
10 contribute to the energy stored within the battery as well as detrimental “side
11 reactions” which also occur.

12 53. Electrodes can be broken down into sub-components, which include
13 both the active material, *i.e.*, where the reaction occurs, as well as inert components
14 that perform necessary, non-reaction functions. There is generally one set of active
15 material in each electrode. In the cathode, it is generally the lithium metal oxide,
16 such as LiCoO_2 , discussed above. In the anode, it is generally graphite. It is
17 common to refer to them separately as they each participate in independent half
18 reactions. That is to say, the LiCoO_2 does not react directly with the graphite and
19 the graphite does not react directly with the LiCoO_2 , as separator in the battery
20 ensures that the cathode and the anode will not directly interact with each other, as
21 discussed above. Instead, both active materials independently react with lithium
22 ions. Using a battery with lithium cobalt oxide as the cathode active material and
23 graphite as the anode active material, at the cathode side, the half reaction during
24 charge can be written as below:



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1 At the anode side, the half reaction during charge can be written as below:



2
3 These two half-reactions collectively represent the overall electrochemical reactions
4 taking place during the discharge and charge processes in a lithium ion battery.

5 54. In addition to the two half reactions described above, batteries can also
6 experience detrimental “side reactions.” These are reactions that are unintended
7 and do not contribute to the energy storage of the battery. It is unclear if the
8 “reaction of the battery” in Apple’s proposed construction allows for these side
9 reactions, therefore rendering it vague, imprecise, and ambiguous. A POSA would
10 not interpret the language to create such problems.

11 55. I also understand that Apple argues that this term is indefinite. I have
12 been informed that a patent claim is indefinite if, when read in light of the
13 specification and prosecution history, the claim fails to inform those skilled in the
14 art about the scope of the invention with reasonable certainty.

15 56. The ratio term is not indefinite. For the same reasons I discuss above,
16 the term is clear on its face, and would be understood with reasonable certainty by
17 a POSA. Because the term explicitly specifies the charge cutoff voltage of the
18 cathode that will be used to determine the theoretical capacity, a POSA would
19 understand that the theoretical capacity at 4.2 V should be used for the calculation,
20 instead of the theoretical maximum capacity.

c. A Secondary Lithium Ion Cell or Battery

RJ Technology's Construction	Apple's Construction
No construction is needed.	A lithium ion battery, wherein the battery electrode materials must not be substantially changed from what was available in the art and made without substantially decomposing the electrolyte, which can be recharged to its original capacity, without any decreased capacity or cycle life at a charge cut-off voltage above 4.2V.

57. Lithium ion batteries may be rechargeable, or they may not be. Rechargeable batteries are called “secondary” batteries. Conversely, non-rechargeable batteries are called “primary” batteries. *See, e.g.*, Ex. 6 (LINDEN D, HANDBOOK OF BATTERIES, (2001)) at, A.10, A.11

58. However, even though they are not designed to operate in this way, some primary batteries can be recharged and re-used. The issue is that the recharged capacity is severely limited. Therefore, even though they can store some charge after being recharged, primary batteries are simply not meant to operate this way.

59. Conversely, even though secondary batteries may be recharged, they do not always recharge to 100% of their original capacity. In fact, after enough use, no battery can recharge to this ideal figure, and in many cases, there is irreversible capacity loss after the very first charge.

60. Even though these secondary batteries are not capable of charging to 100% of their original capacities after significant use, that does not change their character. They are still rechargeable (*i.e.*, secondary) batteries as the term is commonly understood.

61. I understand that the parties dispute the meaning of the term “Secondary Lithium Ion Cell or Battery.” As discussed previously, this term is commonly used and refers to a rechargeable lithium ion battery.

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62. Apple proposes a construction that is inconsistent with the way the term is used in the industry and again does not make sense. Apple claims that a secondary battery must be capable of “recharging to its original capacity, without any decreased capacity or cycle life at a charge cut-off voltage above 4.2V.” However, this is not how the term is used in the industry and is in conflict with scientific fact. As discussed above, *all secondary batteries* lose capacity after use. In other words, no battery exists that meets Apple’s definition. It is both inconsistent with the way the term is used in practice and inconsistent with the ways batteries operate.

63. I understand that Apple bases its construction on statements made during the prosecution history of the ’641 Patent. Specifically, Apple relies on the statement below:

Even if it is assumed, *arguendo*, that the references somehow are properly combinable under Section 103, the fact would remain that modifying the battery of Idota to include a charge cut-off voltage above 4.2V would result in a battery with decreased capacity and/or cycle life, in contrast to applicant’s claimed invention. Such a battery also would not be a ‘secondary’ lithium ion battery, as the present claims require. Put another way, even if the skilled artisan had ignored conventional wisdom and combined Idota with Tanaka or Kobayashi, the expected result would have been a lithium ion battery with very poor cyclability, *e.g.*, a capacity of 50% after the cell is depleted and recharged. Those in the battery field would not categorize such a battery as a ‘secondary’ type cell, since that appellation denotes a battery that can be recharged to capacities relatively close to the original capacity. The battery obtained by combining Idota with Tanaka or Kobayashi would meet neither these capacity requirements upon recharge nor the requirement prescribed by the present claims.

Ex. 2. (File History) at Nov. 13, 2009, Applicant Remarks at 11-12.

64. I have reviewed the prosecution history of the ’641 Patent, and I understand the patentees to have used the term “secondary battery” consistently with its plain and ordinary meaning in the prosecution history, including in the quotation above. As the patentees suggest, a secondary battery is one that is capable

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of recharging to capacities “relatively close” to its original capacity. The patentees further state that a battery that can only recharge to 50% after a single depletion and charging cycle is not secondary/rechargeable. I agree. A POSA would not consider a battery with those characteristics to be secondary because it is not practically rechargeable.

65. Therefore, Apple’s construction is inconsistent with basic science and how the term would be understood by a POSA at the time of the invention.

d. Overcharging Protection Voltage / Overcharging Protection Release Voltage / Overcharge Protection Release Voltage

RJ Technology’s Construction	Apple’s Construction
<p>Plain and Ordinary Meaning.</p> <ul style="list-style-type: none"> “overcharging protection voltage” refers to the voltage level at which the battery’s protection mechanism(s) engages to prevent the battery from being charged to a higher voltage. “overcharge/overcharging protection release voltage” refers to the voltage level at which a battery’s protection mechanism(s) disengages or resets. 	<p>Overcharging protection voltage / release voltage, implemented in the secondary lithium ion cell or battery, and not in a protection circuit.</p>

66. As discussed above, lithium ion batteries have naturally unstable chemistries. If they are charged beyond what is recommended, battery manufacturers and users risk serious consequences such as thermal runaway, leading to fires and explosions. This is called overcharge and can happen unintentionally, such as through a short circuit.

67. Well aware of these risks, battery and device manufacturers include various mechanisms to prevent overcharge. These mechanisms operate a feedback loop that will reduce the current or even shut it off altogether if certain thresholds

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1 are exceeded. They can be implemented in the device (e.g., in circuitry or software)
2 or in the battery itself (e.g., in the battery management system). The patent
3 describes overcharge protection in terms of voltage, but it can also be implemented
4 by measuring the battery's temperature and other metrics.

5 68. The phrases in question here have a plain and ordinary meaning: the
6 voltage level at which the battery's protection mechanism or mechanisms engage to
7 prevent the battery from being charged to a higher voltage, and the voltage level at
8 which a battery's protection mechanism or mechanisms disengages or resets.

9 69. Apple's construction provides that the overcharge protection voltage
10 cannot be implemented in a protection circuit. I disagree. That interpretation is not
11 consistent with the plain meaning of overcharge protection (as it would be
12 understood by a POSA) or with how the term is used in the patent.

13 70. While it is not clear what Apple means by a protection circuit, to the
14 extent Apple is referring to the battery management system, Apple again uses the
15 term inconsistently with how it is commonly used in the industry. The battery
16 management system is a circuit that is part of the battery. *See* Ex.6. (LINDEN D,
17 HANDBOOK OF BATTERIES, (2001)) at 35.37, 35.69. During charging, current from
18 the power supply is filtered through this circuit before it reaches the battery cells.
19 As such, the circuit includes overcharge protection mechanisms. To an industry
20 professional, the term overcharge protection would be understood to include the
21 battery management system circuitry.

22 71. To the extent Apple is attempting to exclude other circuitry besides the
23 battery management system, that is inconsistent with the plain and ordinary
24 meaning of the term. Overcharge protection generally refers to all protection
25 mechanisms available to the battery, including those in the device or in software.

e. Maintains at Least ... Capacity after 400 Cycles

RJ Technology's Construction	Apple's Construction
Plain and ordinary meaning. “maintains at least [a percentage] of capacity after 400 complete charge and discharge cycles of the battery”	Indefinite

72. As discussed above, batteries degrade after use, regardless of the configuration and charging algorithm. Battery manufacturers are well aware of this process and regularly conduct testing to determine how much of the battery's original capacity is retained after successive charge and discharge cycles, and this was done long before lithium ion batteries were invented.

73. Often, a battery's specification will demand a certain cycle life, meaning that the battery has to maintain certain capacity thresholds after a certain number of successive charge and discharge cycles. These requirements are common in the industry and would be well understood by practitioners.

74. A battery manufacturer determines how much of the battery's initial capacity is retained after successive charging cycles using basic math, as can be seen in the ratio below:

$$\frac{\text{Remaining Capacity}}{\text{Initial Capacity}}$$

75. A POSA would have understood the claim language to be referring to this calculation.

76. This concept is present in several contemporaneous publications I have reviewed. For example, in the HANDBOOK OF BATTERIES, the authors discuss “capacity fade” to refer to loss of capacity over successive charging cycles. Ex. 6. (LINDEN D, HANDBOOK OF BATTERIES (2001)) at A.4, 35.13-16, 35.42. The handbook has multiple examples of this concept, such as the figures below:

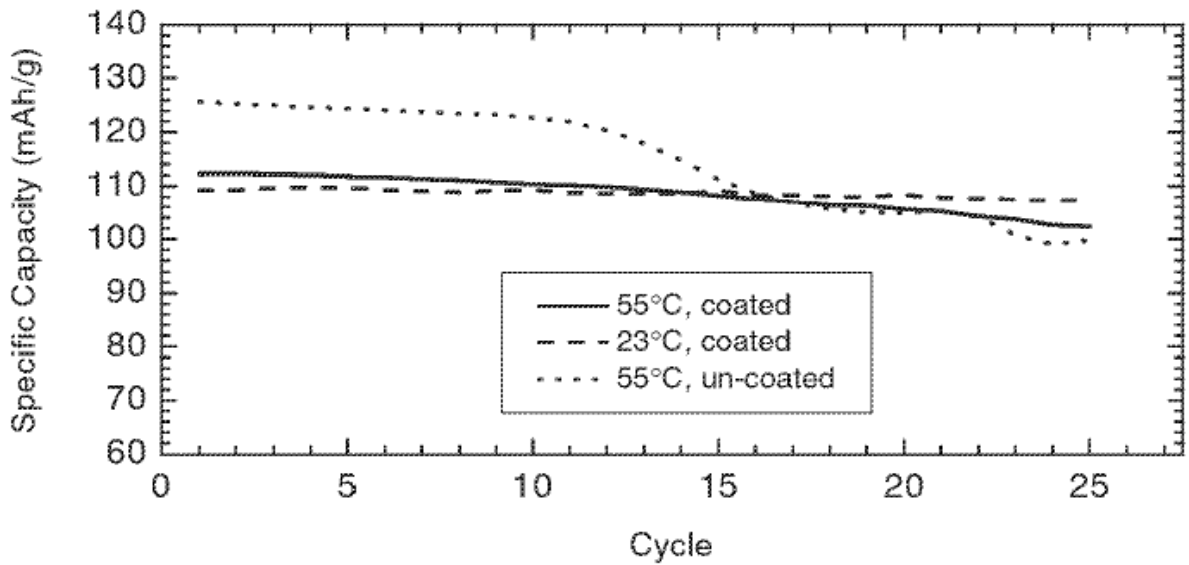


FIGURE 35.15 Specific capacity of LiCoO₂ coated and un-coated spinels cycled at the C/2 rate between 4.2 and 3.5 V at 23°C or 55°C. (Courtesy of Carus Chemical.)

Id. at 35.16.

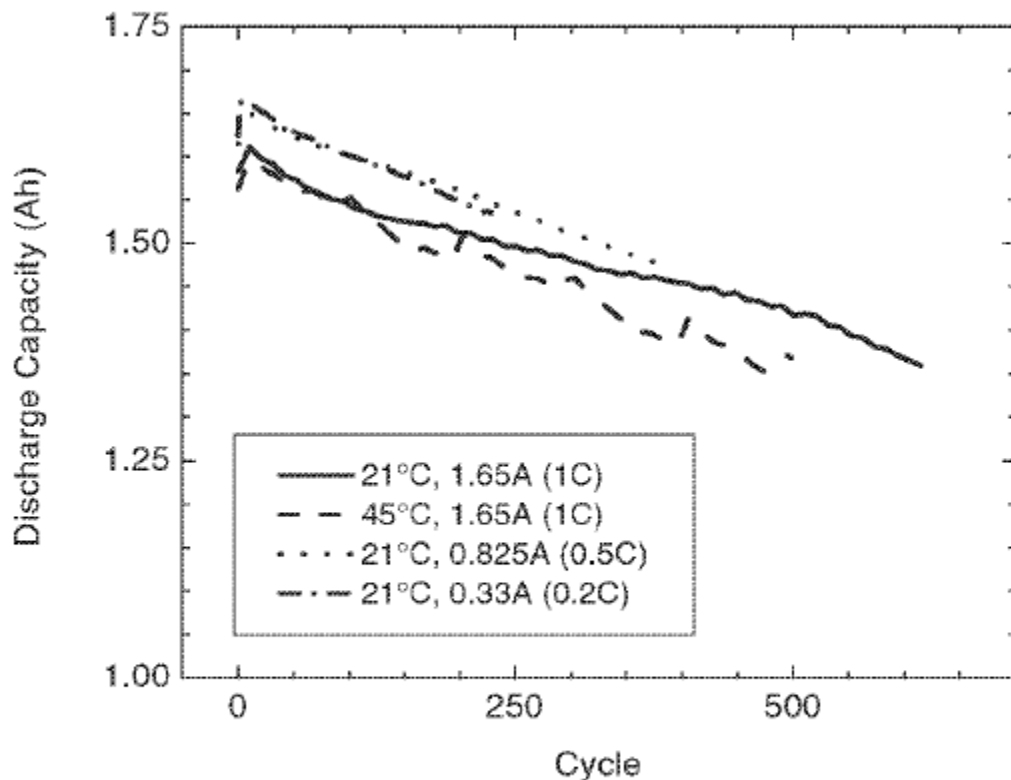


FIGURE 35.45 Capacity of 18650-type C/LiCoO₂ batteries when cycled at either 21°C or 45°C at rates from 0.2C (0.33 A) to 1.0C (1.65 A) between 4.2 V and 2.5 V. (Courtesy of NEC Moli Energy.)

Id. at 35.42.

DECLARATION OF DR. YAO IN SUPPORT OF PLAINTIFF RJ TECHNOLOGY'S OPENING CLAIM CONSTRUCTION BRIEF

1 77. I understand that the patent claims similar requirements. Claims 11
2 through 18 list out battery lifespan thresholds, similar to what would be found in a
3 specification provided by a device manufacturer to a battery manufacturer. These
4 would be well understood in the industry. The same is true for Examples 1-28 in
5 the '641 Patent.

6 78. The patent also references capacity measurements, which a person of
7 skill would readily understand. For example, the patent describes the results of
8 experiments where "the capacity of lithium cobalt oxide[] reaches 159 mAh/g when
9 the charge cut-off voltage is 4.35V, but it drops to 135 mAh/g after several
10 cycles" '641 Patent at 2:20-24. In this calculation, the percentage of remaining
11 capacity would be 84.9%.

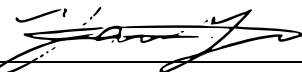
12 79. Similarly, in experiment 1, the patent describes a battery with an initial
13 capacity of 1113 mAh, that retains only 85.72% of capacity after 400 cycles. '641
14 Patent at 10:29-37. A person of skill would understand that the capacity of the
15 battery would be 954 mAh after 400 cycles (85.72% of 1113 mAh).

16 80. I understand that Apple believes these claims are indefinite. I do not
17 understand how Apple has reached this conclusion. As discussed above, this is a
18 simple calculation, and it is well known and commonly used throughout the
19 industry. In my opinion, the words used in the patent are not uncertain or
20 ambiguous.

21 **V. Conclusion**

22 81. I declare under penalty of perjury under the laws of the United States
23 of America that the foregoing is true and correct.

24
25 Executed on June 23, 2023

/s/ 

26 Dr. Yan Yao
27
28

**DECLARATION OF DR. YAO IN SUPPORT OF PLAINTIFF RJ
TECHNOLOGY'S OPENING CLAIM CONSTRUCTION BRIEF**

EXHIBIT A

Yan Yao

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EDUCATION

Postdoctoral Scholar in Materials Science and Engineering <i>Stanford University</i> , Stanford, CA	2010–2012
Ph.D. in Materials Science and Engineering <i>University of California Los Angeles</i> , Los Angeles, CA	2008
M.S. in Materials Science <i>Fudan University</i> , Shanghai, China	2003
B.S. in Materials Science <i>Fudan University</i> , Shanghai, China	2000

PROFESSIONAL EXPERIENCE

University of Houston, Houston, TX (2012–Present)

Electrical and Computer Engineering & Chemical and Biomolecular Engineering (Affiliated) & Materials Science and Engineering Program (Affiliated)

Hugh Roy and Lillie Crazz Cullen Distinguished Professor (2022–Present), Professor (2020–2022), Associate Professor (2017–2020), Assistant Professor (2012–2017)

Principal Investigator, Texas Center for Superconductivity (TcSUH) (2012–Present)

(a) PI/co-PI for over \$15 million research funding from ARPA-E, DOE, NSF, ONR, NASA and industries, *etc*; (b) Discovered ultrafast proton coupled electron transfer in quinone solids, leading to long cycle-life aqueous batteries in a broad range of pH (*Nature Mater.* 16, 841, 2017); (c) Pioneered a high-power Mg battery based on heterogeneous enolization chemistry and weakly coordinating electrolytes (*Nature Energy* 5, 1043, 2020); (d) Reported first all-solid-state batteries using organic cathode and sulfide-based electrolytes and proposed a pathway to reach specific energy of 500 Wh kg⁻¹; (e) Invented an operando multimodal diagnostic system for monitoring solid-state batteries; (f) Co-founded LiBeyond and Solid Design Instruments LLC.

Stanford University, Stanford, CA (2010–2012) Postdoctoral Scholar

(a) Invented interconnected hollow nanosphere-based silicon lithium-ion anodes with high specific capacity and record cycle life in 2011. The paper has been cited 1,300 times; (b) Designed and demonstrated a broadband light trapping structure using low-Q whispering gallery resonant modes in spherical silicon nanoshells; (c) Demonstrated the effect of conducting polymer coating in improving stability of silicon nanowire anodes. (d) Contributed to developing double-walled Si nanotube anodes and “York-shell” silicon nanostructures for stabilizing electrolyte-silicon interfaces.

Polyera Corporation, Skokie, IL (2008–2010) Senior Scientist

(a) Led the development of high-performance semiconducting polymers for organic solar cells and set the

world record efficiency of 8.3%; **(b)** Investigated all-polymer solar cells using non-fullerene polymeric acceptors that led to 5.2% efficiency; **(c)** Inventor of 5 US and 7 international patents licensed to Rayenergy Tek Inc.

UCLA, Los Angeles, CA (2003–2008) Graduate Researcher

(a) Pioneered the “solvent-annealing” method in polymer solar cell processing that led to the world record efficiency certified by NREL. Two papers have been cited 6,400 and 1,355 times, respectively; **(b)** Invented near-infrared photodetectors using a low bandgap (1.3 eV) polymer; **(c)** Elucidated the role of solvent additive in mixture solvent processing of nanoscale phase separation in the P3HT:PCBM system.

RESEARCH EXPERIENCE & INTERESTS

Dr. Yao’s research experience and interests span from fundamental understanding, materials development, to operando characterizations and roll-to-roll manufacturing for batteries, supercapacitors, solar cells, light-emitting devices, etc. His current research interests include:

- Solid-state metal batteries
- Multivalent-ion batteries (aqueous and non-aqueous)
- Organic and perovskite materials for energy devices
- Operando characterization for air sensitive materials
- Roll-to-roll manufacturing and non-destructive characterizations
- Novel materials processing methods for lithium-ion batteries including dry process and 3D printing
- Electrode engineering and architectures
- Process-property-performance relationship
- Electrocatalysts for CO₂ reduction and CO₂ removal from sea water

Research Contributions

Professor Yao is a globally recognized scientist in advanced battery technologies, an area of intense interest worldwide as the world transitions away from fossil fuels and towards electrical energy storage systems. There is a compelling need for batteries that offer safety, electrical performance, and the ability to be made from earth-abundant materials. In this rapidly advancing field, Dr. Yao is widely respected as a pioneer and leader in the area of next-generation batteries beyond lithium ions. His research will lead to a promising game-changing way to fix the lithium, nickel, and cobalt-dependent problems with Li-ion batteries, which is one of the keys to reaching the goal of net zero greenhouse gas emissions by the middle of this century. His achievements are summarized below:

- Dr. Yao invented a lithium-free and transition-metal-free fast-charging battery based on magnesium and organic cathode materials (*Nature Energy* 5, 1043, 2020). He founded LiBeyond to commercialize this technology. His review paper titled "Current status and future directions of multivalent metal-ion batteries" (*Nature Energy* 5, 646, 2020) has received 400 citations.
- Dr. Yao investigated the fundamental science and molecular design for long-cycle-life aqueous batteries (*Nature Materials* 16, 841, 2017), which has been cited over 500 times. His review paper (*Nature Review Materials*, 2022, <https://doi.org/10.1038/s41578-022-00511-3>) provided a holistic and critical overview of modern aqueous battery design.
- Dr. Yao pioneered high-energy all-solid-state batteries using organic electrode materials with ceramic electrolytes (*Angew. Chem.* 6, 201, 2018; *ACS Energy Lett.* 6, 201, 2021; *Joule* 5, 1845, 2021; *ACS Energy Lett.* 6, 3287, 2021). They demonstrated a roadmap of solid-state organic batteries toward 500 Wh kg⁻¹, twice that of today’s state-of-art lithium-ion batteries.
- Dr. Yao developed an integrated operando characterization platform across multiple length scales and techniques to understand the battery failure mechanisms. This project was ranked top 3 among 73

projects in the annual merit review of the DOE Vehicle Technology Office in 2021. He co-founded Solid Design Instruments LLC to commercialize this tool.

HONORS AND AWARDS

- **Hugh Roy and Lillie Cranz Cullen Distinguished Professor** – University of Houston (2022)
- **TAMEST Protégés** – TAMEST (2022)
- **Senior Faculty Research Excellence Award** – University of Houston Cullen College of Engineering (2022)
- **Excellent Paper of the Year** – International Mg Science and Technology Award (2021)
- **Fellow of Royal Chemical Society** (2020)
- **Senior Member of National Academy of Inventors** (2020)
- **Cullen College of Engineering Professorship** – College of Engineering (2020)
- **50-in-5 Scholars** University of Houston (2021, 2020, 2019, 2018)
- **Emerging Investigators in Electrochemical Energy Conversion and Storage** – Journal of Electrochemical Energy Conversion and Storage (2020)
- **Senior Member of IEEE** (2019)
- **Top 1% Highly Cited Researchers List** – Clarivate Analytics (2018)
- **Award for Excellence in Research, Scholarship, or Creative Activity** – University of Houston (2018)
- **Scialog Collaborative Innovation Award** – Research Corporation for Science Advancement (2018)
- **Scialog Fellow on Advanced Energy Storage** – Research Corporation (2017)
- **Junior Faculty Research Excellence Award** – University of Houston Cullen College of Engineering (2016)
- **Teaching Excellence Award** – University of Houston Cullen College of Engineering (2016)
- **Office of Naval Research Young Investigator Award** – U.S. Office of Naval Research (2013)
- **Principal Investigator** – Advanced Research Projects Agency-Energy (2013, 2015)
- **Ralph E. Powe Junior Faculty Enhancement Award** – Oak Ridge Associated Universities (2013)
- **TcSUH Welch Foundation Professorship Award** – The Welch Foundation (2012)
- **Excellence in Graduate Polymer Science Research** – American Chemical Society (2008)
- **Chinese Government Award for Outstanding Students Abroad** – Chinese Scholarship Council (2007)
- **ICI Student Award Finalist in Applied Polymer Science** - American Chemical Society (2007)
- **Dissertation Year Fellowship** – UCLA (2007)
- **Chun-Tsung Scholar** – Chun-Tsung Endowment (2000)
- **Outstanding Undergraduate Student Award** – Shanghai Educational Council (2000)

SYNERGISTIC ACTIVITIES

Peer Review Panel

Reviewer for DOE Vehicle Technology Office Annual Review (2023)
Reviewer for DOE Joint Center for Energy Storage Research (2021)
Reviewer for DOE Office of Electricity Energy Storage Program (2021)

Proposal Reviewer

Reviewer for DOE “Bipartisan Infrastructure Law (BIL) Battery Materials Processing and Battery Manufacturing” (2022)
Reviewer for DOE BES Funding “Chemical and Materials Sciences to Advance Clean Energy Technologies and Low-Carbon Manufacturing” (2022)

Reviewer for university proposals (NTU, CCNY, HKPolyU) (2021)
Reviewer for DOE BES Materials Chemistry Program (2022, 2019)
Reviewer for DOE Energy Frontier Research Center (2018)
Reviewer for DOE SBIR/STTR (2019, 2020)
Reviewer for NSF (2013, 2014, 2020)
Reviewer for Nazarbayev University Proposal (2019, 2020)
Reviewer for Qiu Shi Outstanding Young Scholar Award (2017, 2019)
Reviewer for ACS Petroleum Research Fund (2014, 2015, 2016, 2017, 2019, 2020)
Reviewer for NASA Graduate Student Fellowship (2018)
Reviewer for University of Maryland Industrial Partnership Program (2018)
Reviewer for DOE SLAC Beamline Proposal (2018)
Reviewer for German-Israel Electrochemistry Proposal (2017)
Reviewer for Kentucky Science and Technology Corp. (2017)
Reviewer for European Research Council (2015)
Reviewer for NASA EPSCoR Proposal (2015)
Reviewer for AAAS on an Indo-US Joint Center on Solar Cells (2015)

Editorial Board

Next Energy (2022–Present)
eScience (2020–Present)
Energy Storage and Saving (2021–Present)
Scientific Reports (2014–2018)

Editor

Academic editor for PLOS ONE (2018–Present)
Guest editor for Current Opinion in Electrochemistry (2021)
Guest editor for ChemSusChem (2020)

Journal Reviewer

ACS Energy Letters, ACS Nano, ACS Polymer Materials, Advanced Energy Materials, Advanced Materials, Angewandte Chemie, Chem, Chemistry of Materials, Chemical Review, Chemical Science, Chemical Society Review, Energy Environmental Science, Electrochimica Acta, Energy Storage Materials, JACS, Journal of Materials Chemistry A, Joule, Nano Energy, Nano Letters, Nano Research, Nature, Nature Communications, Nature Energy, Nature Materials, PNAS, Science, Science Advances, Scientific Reports, Small, Small methods.

Selected Projects

Principal investigator of DOE Batt500 Consortium Seedling Project \$0.9M (2023)
Principal Investigator of "Solid-state battery prototyping facility" \$5.5M funded by UH (2022)
Principal investigator of "Lithium and transition metal-free high-energy fast-charging batteries" \$3.4M funded by ARPA-E OPEN 2021 (2022)
Principal investigator of "Multidimensional diagnostics of the interface evolutions in solid-state lithium batteries" \$1.0M funded by DOE Vehicle Technology Office (2019)
Principal Investigator of "High-energy solid-state lithium batteries with organic cathode materials" \$1.2M funded by DOE Vehicle Technology Office as part of Battery 500 Consortium (2017)
Principal Investigator of two projects funded by Research Corporation (2018, 2020)
Principal Investigator of "High energy density Mg batteries" funded by Toyota Motor North America (2019)
Co-PI of "Developing and testing of new low-cost, safe, efficient, and renewable all-solid-state sodium batteries for grid-scale energy storage" \$3.2M funded by ARPA-E (2015)

Principal Investigator of "SusChEM: Design and Manufacture of Electrodes for High Energy Density Rechargeable Sodium Batteries" funded by NSF (2014)

Principal Investigator of "Developing multivalent ion intercalation batteries as high energy and safe marine distributed power sources" \$0.66M funded by Office of Naval Research (2013)

Principal Investigator of "Aqueous lithium-ion batteries with high-energy novel organic anodes for safe and robust energy storage" \$1.0M funded by ARPA-E (2013)

Conference/Symposium Organization Activities

Chairman of Organic Battery Days 2022 Workshop, Houston, TX, USA (10/13-14/2022)

Co-Chair, Organic Battery Days, Tianjin, China (2018)

Co-Chair, Nature Conference on Materials Electrochemistry: Fundamentals and Applications, Shenzhen, China (2018)

Co-Chair, Materials Research Society, "Organic Materials in Electrochemical Energy Storage", Phoenix, AZ (2019)

Co-Chair, European Materials Research Society, "Frontiers in Electrochemical Energy Storage", Strasbourg, France (2017)

Co-Chair, Electrochemical Society, "Electrochemistry and Batteries for Safe and Low-cost Energy Storage", 229th ECS meeting, San Diego, CA (2016)

Co-Chair, International Materials Research Congress, "Materials and Technologies for Stationary Electrochemical Energy Storage", Cancun, Mexico (2016)

Chair, Materials Research Society, "Materials and Architectures for Safe and Low-cost Electrochemical Energy Storage Technologies", Boston, MA (2015)

Co-Chair, Minerals, Metals and Materials Society, "Nanostructured Materials for Rechargeable Batteries and for Supercapacitors III", Orlando, FL (2015)

Co-Chair, American Chemical Society, "Batteries and Fuel Cell Technologies: Challenges and Solutions, San Francisco, CA (2014)

Professional Memberships and Service

Fellow of Royal Society of Chemistry (2019–Present)

Senior Member of Institute of Electrical and Electronics Engineers (IEEE) (2013–Present)

Senior Member of National Academy of Inventors (NAI) (2019–Present)

Member of Materials Research Society (MRS) (2012–Present)

Member of Electrochemical Society (ECS) (2012–Present)

Member of American Chemical Society (ACS) (2004–Present)

Materials Research Society Student Award Committee (2019)

Treasurer, IEEE Nanotechnology Council Houston Chapter (2015–Present)

University Service

Co-Director, Power electronics-Energy storage-Microgrids and Subsea Electrical Consortium (PEMSEC) at the University of Houston (2018–2022)

University of Houston Faculty Senate, Graduate & Professional Studies Committee (2019–2022)

University of Houston Faculty Senate, Intellectual Property Committee (2020–2023)

University of Houston Electrochemical Society Chapter, Faculty Advisor (2016–Present)

Cullen College of Engineering Promotion and Tenure Committee (2021-2023)

Cullen College of Engineering Best Dissertation Award Committee (2019)

ECE Chair of Faculty Search Committee (2022-2023)

ECE Post-tenure Review Committee (2020–2023)

ECE Faculty Governance Committee (2019–2022)

ECE Graduate Admission Committee (2014–Present)

Outreach

Research advisor for 4 high school students conducting 6-week summer research (2023)

Host undergraduate summer research for Energy Scholar (2023)

NASA High School Aerospace Scholars (HAS) lab tour with hands-on activity (2019)

Program for Mastery in Engineering Studies (PROMES) Engineering Summer Camp lab tour with hands-on activity (2019)

NSF REU lab tour (2019)

Lemelson-MIT InvenTeams lab tour (2017)

Science and Engineering Fair of Houston judge (2022, 2021, 2020, 2016, 2015, 2013)

International Sustainable World (Energy, Engineering & Environment) Project Olympiad (I-SWEEEP)

International Science Fair judge (2017, 2014)

SELECTED PUBLICATIONS AS CORRESPONDING AUTHOR

1. [Universal quinone electrodes for long cycle life aqueous rechargeable batteries](#). **Nature Mater.** 2017, 16, 841-848.
Featured in *Nature Energy* (2017, 2, 17149) and cited 521 times.
2. [Current status and future directions of multivalent-ion batteries](#), **Nature Energy** 2020, 5, 646-656.
Cited 424 times.
3. [Interlayer-expanded molybdenum disulfide nanocomposites for electrochemical magnesium storage](#). **Nano Letters** 2015, 15, 2194-2202. Cited 348 times.
4. [Fast kinetics of magnesium monochloride cations in interlayer-expanded titanium disulfide for magnesium rechargeable batteries](#). **Nature Comm.** 2017, 8, 339.
Featured in DOE Office of Science website and in 2017 Advanced Photon Source (APS) Science Report. Cited 277 times.
5. [Solvent engineering towards controlled grain growth in perovskite planar heterojunction solar cells](#). **Nanoscale** 2015, 7, 10595-10599. Cited 261 times.
6. [Positioning organic electrode materials in the battery landscape](#). **Joule** 2018, 2, 1690-1706. Cited 236 times.
7. [Poly\(anthraquinonyl sulfide\) cathode for potassium-ion batteries](#). **Electrochemistry Comm.** 2016, 71, 5-8. Cited 231 times
8. [Heavily n-dopable \$\pi\$ -conjugated redox polymers with ultrafast energy storage capability](#). **Journal of American Chemical Society** 2015, 137, 4956-4959.
Featured as Editors' Choice and JACS spotlight. Cited 227 times.
9. [High-power Mg batteries enabled by heterogeneous enolization redox chemistry and weakly coordinating electrolytes](#), **Nature Energy** 2020, 5, 1043-1050. Cited 107 times.
10. [Designing modern aqueous batteries](#), **Nature Rev. Mater.** 2022, <https://doi.org/10.1038/s41578-022-00511-3>.

PUBLICATIONS: JOURNALS

Dr. Yao has published 130+ peer-reviewed papers in prestigious scientific journals including *Nature Rev. Mater.* (x1), *Nature Energy* (x3), *Nature Mater.* (x2), *Nature Nano.* (x1), *Joule* (x4), *JACS* (x5), *Nature Comm.*

(x5), *Adv. Mater.* (x3), *ACS Energy Lett.* (x2), *Nano Lett.* (x3), *ACS Nano* (x5), *Nano Energy* (x9), *et al.* According to [Google Scholar](#), his work has received over 32,180 citations with an h-index of 64 as on 2/1/2023.

1. Hongzhi Zheng, Huan Li, Zisheng Zhang, Xiaojun Wang, Benjamin Emley, Ye Zhang, Hua Zhou, Yan Yao* and Yongye Liang*, Dispersed nickel phthalocyanine molecules on carbon nanotubes as cathode catalysts for Li-CO₂ batteries. *Small*, **2023**, DOI: 10.1002/sml.202302768.
2. Alae Eddine Lakraychi, Yan Yao*, [Designing organic pseudocapacitors through molecular hybridization](#). *Joule*, **2023**, 7, 858-860.
3. Chaoshan Wu*, Benjamin Emley*, Lihong Zhao, Yanliang Liang, Qing Ai, Zhaoyang Chen, Francisco C Robles Hernández, Fei Wang, Samprash Risal, Hua Guo, Jun Lou, Yan Yao*, Zheng Fan*, [Understanding the chemomechanical function of silver-carbon interlayer in sheet-type all-solid-state lithium-metal batteries](#). *Nano Lett.*, **2023**, 23, 4415-4422.
4. Jianing Meng, Alexandra Robles, Jacobo Jalife Said, Wen Ren, Ye Zhang, Lihong Zhao, Yanyang Liang*, Judy Wu*, Ognjen Miljanić*, Yan Yao*, [Cyclotetrazenil derivatives for electrochemical lithium-ion storage](#). *Angewandte Chemie*, **2023**, e202300892.
5. Samprash Risal, Chaoshan Wu, Fei Wang, Sandesh Risal, Francisco C Robles Hernandez, Yan Yao*, and Zheng Fan*, [Silver-carbon interlayers in anode-free solid-state lithium metal batteries: current development, interfacial issues and instability challenges](#). *Carbon*, 2023, <https://doi.org/10.1016/j.carbon.2023.118225>.
6. Sandesh Risal, Navdeep Singh*, Andrew Ian Duff, Yan Yao, Li Sun, Samprash Risal, Weihang Zhu*, [Development of RF-MEAM interatomic potential for Fe-C system to study temperature dependent elastic properties](#), *Materials*, 2023, 16, 3779
7. Guangxia Feng, Hao Jia, Yaping Shi, Xu Yang, Ye Zhang, Chaojie Yang, Kang Xu*, Yan Yao*, Wu Xu*, Xiaonan Shan*, [Imaging solid-electrolyte-interphase dynamics using in-operando reflection interference microscopy](#), *Nature Nanotechnology*, 2023, <https://doi.org/10.1038/s41565-023-01316-3>
8. Yanliang Liang, Yan Yao*, [Designing modern aqueous batteries](#), *Nature Rev. Mater.* 2022, 8, 109-122.
9. Qing Ai, Zhaoyang Chen, Boyu Zhang, Fan Wang, Tianshu Zhai, Yifeng Liu, Yifan Zhu, Tanguy Terlier, Qiyi Fang, Yanliang Liang, Lihong Zhao, Chaoshan Wu, Hua Guo*, Zheng Fan, Ming Tang, Yan Yao*, Jun Lou*, [High-spatial-resolution quantitative chemo-mechanical mapping of organic composite cathodes for sulfide-based solid-state batteries](#), *ACS Energy Letters*, 2023, 8, 1107-1113.
10. Kang Wang, Zih-Yu Lin, Zihan Zhang, Linrui Jin, Ke Ma, Aidan H. Coffey, Harindi R. Atapattu, Yao Gao, Jee Yung Park, Zitang Wei, Blake P. Finkenauer, Chenhui Zhu, Xiangeng Meng, Sarah N. Chowdhury, Zhaoyang Chen, Tanguy Terlier, Thi-Hoai Do, Yan Yao, Kenneth R. Graham, Alexandra Boltasseva, Tzung-Fang Guo, Libai Huang, Hanwei Gao, Brett M. Savoie, Letian Dou*, [Suppressing phase disproportionation in quasi-2D perovskite light-emitting diodes](#), *Nature Communications*, **2023**, 14, 397.
11. Qi Dong, Xin Zhang, Ji Qian, Shuaiming He, Yimin Mao, Alexandra H. Brozena, Ye Zhang, Travis P. Pollard, Oleg A. Borodin, Yanbin Wang, Bhargav Sai Chava, Siddhartha Das, Peter Zavalij, Carlo U. Segre, Dongyang Zhu, Lin Xu, Yanliang Liang, Yan Yao, Robert M. Briber, Tian Li*, Liangbing Hu*, [A cellulose-derived supramolecule for fast ion transport](#), *Science Advances*, 2022, 8, eadd2031.
12. Meiling Wu, Ye Zhang, Lin Xu, Chunpeng Yang, Min Hong, Mingjin Cui, Bryson C. Clifford, Shuaiming He, Shuangshuang Jing, Yan Yao*, and Liangbing Hu*, [A sustainable chitosan-zinc electrolyte for high-rate zinc metal batteries](#), *Matter*, 2022, 5, 3402-3416.

13. Xiaowei Chi, Ye Zhang, Fang Hao, Steven Kmieć, Hui Dong, Rong Xu, Kejie Zhao, Liang Wang, Lihong Zhao, Liqun Guo, Huolin Xin, Steve W. Martin*, **Yan Yao***, [An electrochemically stable defect-free glassy electrolyte formed at room temperature for all-solid-state sodium batteries](#), **Nature Comm.**, 2022, 13: 2854.
14. Zhaoyang Chen, **Yan Yao***, [Ultrahigh energy density Li-organic primary batteries](#), **Energy & Environmental Materials**, 2022, 5, 1010-1011.
15. Jang Wook Choi*, **Yan Yao***, [Editorial overview: Energy storage: rechargeable batteries and supercapacitors \(2022\) beyond organic electrolytes](#), **Current Opinion in Electrochemistry**, 2022, 36, 101157.
16. Peixun Xiong, Ye Zhang, Jingran Zhang, Sang Ha Baek, Lingxing Zeng, **Yan Yao**, Ho Seok Park*, [Recent progress of artificial interfacial layers in aqueous Zn metal batteries](#), **Energy Chem**, 2022, 4, 100076.
17. Xiaojun Wang, Hui Dong, Alae Eddine Lakraychi, Ye Zhang, Xu Yang, Hongzhi Zheng, Xinpeng Han, Xiaonan Shan, Chuanxin He*, **Yan Yao***, [Electrochemical swelling induced high material utilization of porous polymers in magnesium electrolytes](#), **Materials Today**, 2022, 55, 29-36.
18. Ye Zhang, Lihong Zhao, Yanliang Liang, Xiaojun Wang, **Yan Yao***, [Effect of electrolyte anions on the cycle life of a polymer electrode in aqueous batteries](#), **eScience**, 2022, 2, 110-115.
19. Maureen Kitheka, Morgan Redington, Jibo Zhang, **Yan Yao**, Puja Goyal*, [Density functional tight-binding method for redox, protonation and electronic properties of quinones](#), **Physical Chemistry Chemical Physics**, 2022, 24, 6742-6756.
20. Ye Zhang, Guang Yang, Michelle L. Lehmann, Chaoshan Wu, Lihong Zhao, Tomonori Saito, Yanliang Liang*, Jagjit Nanda*, **Yan Yao***, [Separator effect on zinc electrodeposition behavior and its implication for zinc battery lifetime](#), **Nano Lett.** 2021, 21, 10446-10452.
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141. Chaoxian Qi, David R. Jackson, **Yan Yao**, Jiefu Chen*, [*SIW Microstrip Cavity Resonators with a Sensing Aperture*](#), **IEEE Texas Symposium on Wireless and Microwave Circuits and Systems (WMCS)**, 2019, DOI: 10.1109/WMCaS.2019.8732530
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147. Hui Dong, **Yan Yao***, [Development of cathode materials for rechargeable magnesium batteries: from intercalation to enolization](#), *Encyclopedia of Nanomaterials*, 2022, doi:10.1016/B978-0-12-822425-0.00087-7.
148. Gang Li, Vishal Shrotriya, Jinsong Huang, **Yan Yao**, Tom Moriarty, Keith Emery, Yang Yang*, [High-efficiency solution processable polymer photovoltaic cells by self-organization of polymer blends](#), **Book Chapter in Materials for Sustainable Energy**, World Scientific, 2010, 80-84. Edited by Vincent Dusastre.
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PATENTS AND APPLICATIONS (12 granted, 4 pending)

1. **Yan Yao**, Yanliang Liang, High ionic conductivity rechargeable solid state batteries with an organic electrode, US Patent 11,621,420 granted on 4/4/2023.
2. **Yan Yao**, Yanliang Liang, Rechargeable alkaline battery using organic materials as negative electrodes, US Patent 10,749,180 granted on 8/18/2020.
3. **Yan Yao**, Yanliang Liang, Saman Gheytni, Yan Jing, Lead-acid batteries with fast charge acceptance, US Patent 10,522,875 granted on 12/31/2019.
4. **Yan Yao**, Yanliang Liang, Aqueous energy storage devices with organic electrode materials, US Patent 10,411,262 granted on 9/10/2019.
5. **Yan Yao**, Yanliang Liang, Rechargeable alkaline battery using organic materials as negative electrodes, US Patent 10,033,039 granted on 7/24/2018.
6. **Yan Yao**, Yanliang Liang, Non-lithium metal ion battery electrode materials architecture, US Patent 9,745,205 granted on 8/29/2017.
7. **Yan Yao**, Yanliang Liang, Non-lithium metal ion battery electrode materials architecture, US Patent 9,725,331 granted on 8/8/2017.
8. Zhengguo Zhu, Martin Drees, Hualong Pan, **Yan Yao**, He Yan, Shaofeng Lu, Antonio Facchetti, Conjugated polymers and their use in optoelectronic devices, US Patent 8,748,739 granted on 6/10/2014. Licensed by Raynergy Tek Inc.
9. Hualong Pan, He Yan, **Yan Yao**, Shaofeng Lu, Zhengguo Zhu, Antonio Facchetti, Conjugated polymers and their use in optoelectronic devices, US Patent 8,598,449 granted on 12/3/2013. Licensed by Raynergy Tek Inc.
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11. Hualong Pan, Martin Drees, Zhengguo Zhu, **Yan Yao**, Shaofeng Lu, Antonio Facchetti, Pyrrolo[3,2-b]pyrrole semiconducting compounds and devices incorporating same, US Patent 8,598,450 granted on 12/3/2013. Licensed by Raynergy Tek Inc.

12. Zhengguo Zhu, Martin Dress, Hualong Pan, **Yan Yao**, He Yan, Shaofeng Lu, Antonio Facchetti, Conjugated polymers and their use in optoelectronic devices, US Patent 8,334,456 granted on 12/18/2012. Licensed by Raynergy Tek Inc.
13. **Yan Yao**, Xiaowei Chi, Solid electrolyte for sodium batteries, US Application 2021/0066748 A1.
14. **Yan Yao**, Hyun Deog Yoo, Method of activating two-dimensional materials for multivalent/polyatomic-ion intercalation battery electrodes, US Application 2018/0183038 A1.
15. **Yan Yao**, Hyun Deog Yoo, Method of activating two-dimensional materials for multivalent/polyatomic-ion intercalation battery electrodes, US Application 2021/0210742 A1.
16. Zheng Fan, **Yan Yao**, Air-free transfer vessel for multiple diagnostic tools, US Application, 6/2023.

INVITED PRESENTATIONS (170+ keynote and invited presentations)

Plenary/Keynote Presentations

1. (Plenary) “Organic Electrode Materials for Multivalent and Solid-state Batteries”, Organic Battery Days 2023, Donostia-San Sebastian, Spain, 6/8/2023.
2. (Plenary) “Redox active polymers for beyond Li-ion batteries”, International Conference on Functional Polymer Synthesis and Application, International Conference on Functional Polymer Synthesis and Application, Online, 12/9/2021.
3. (Keynote) “Organic electrode material design for beyond lithium ion batteries”, 8th International Conference on Nanoscience & Technology (ChinaNANO 2019), Topical Session on Energy Nanotechnology, Beijing, China, 8/17-19/2019.
4. (Keynote) “Universal quinone electrode for long cycle life energy storage”, Special Symposium in Honor of Michael Armand, ECS Fall Meeting, Cancun, Mexico, 10/2/2018.
5. (Keynote) “Versatile quinones for long cycle life aqueous batteries”, First International Conference on Energy Storage Materials, Shenzhen, China, 11/19-21/2017

Invited Presentations at U.S. and International Conferences

6. (Invited) “Understanding the role of mixed ionic-electronic conductor interlayer in all-solid-state lithium-metal batteries”, Materials Challenges in Alternatives & Renewable Energy 2023 Meeting (MCARE 2023), Seattle, WA, 8/22/2023.
7. (Invited) “Understanding the role of mixed ionic-electronic conductor interlayer in all-solid-state lithium-metal batteries”, 243rd ECS Meeting, Boston, MA, 5/28/2023.
8. (Invited) “Lithium- and transition metal-free fast-charging batteries”, ARPA-E EVs4All Kick-off Meeting, Alexandria, VA, 5/9/2023.
9. (Invited) “Multidimensional characterizations for all-solid-state batteries”, MRS Fall Meeting, Boston, MA, 11/28/2022.
10. (Invited) “Lithium- and transition metal-free fast-charging batteries”, MRS Fall Meeting, Boston, MA, 11/28/2022.
11. (Invited) “Redox-active polymers for energy storage”, ACS Fall 2022 Meeting, Chicago, IL, 8/23/2022.
12. (Invited) “Understanding solid electrolyte-lithium interfaces via operando characterizations”, ACS Fall 2022 Meeting, Chicago, IL, 8/22/2022.
13. (Invited) “Rational design of high-power Mg batteries: from intercalation to conversion chemistry”, ACS Fall 2022 Meeting, Chicago, IL, 8/21/2022.

14. (Invited) “Multidimensional characterizations for all-solid-state batteries”, 2022 Molecular Foundry User Meeting, Berkeley, CA, 8/19/2022.
15. (Invited) “Understanding Solid Electrolyte-lithium Interfaces via Multiscale Characterizations”, Pittcon 2022, Online, 6/9/2022.
16. (Invited) “Advanced Characterizations of Interfaces in Solid-State Batteries”, 241st ECS Meeting, Vancouver, BC, Canada, 5/29-6/2/2022.
17. (Invited) “Understanding solid electrolyte-lithium interfaces via operando multiscale characterizations”, 2022 MRS Spring Meeting, Honolulu, HI, 5/8-11/2022.
18. (Invited) “Next-generation batteries for electric transportation and stationary energy storage”, IEEE NMDC 2021, Online, 12/12-15/2021.
19. (Invited) “Multidimensional diagnostics of solid-state lithium batteries”, 2021 MRS Fall Meeting, Boston, MA, 12/2/2021.
20. (Invited) “Rational design of multivalent metal batteries: enolization cathode and nonporous separator”, 2021 MRS Fall Meeting, Boston, MA, 11/30/2021.
21. (Invited) “Cobalt-free all-solid-state lithium batteries and air-free vessels for operando diagnosis”, Organic Battery Days 2021, Online, 11/25-28/2021.
22. (Invited) “Impact of electrolytes on cathode reaction mechanism in Mg batteries: from intercalation to enolization chemistry”, Mg Batteries and Key Materials Workshop, Online, 10/29-30/2021.
23. (Invited) “Cobalt-free all-solid-state lithium batteries and air-free vessels for operando diagnosis”, Nano Korea 2021, Online, 7/7-9/2021.
24. (Invited) “Multidimensional diagnostics of the interface evolutions in solid-state lithium batteries”, VTO Annual Merit Review, Online, 6/24/2021.
25. (Invited) “High-energy solid-state lithium batteries with organic cathode materials”, VTO Annual Merit Review, Online, 6/24/2021.
26. (Invited) “Rational design of high-power Mg batteries: from intercalation to enolization Chemistry”, Beyond Lithium-ion XIII Conference, Online, 6/9-11/2021.
27. (Invited) “Quinone-based organic materials for all-solid-state lithium batteries”, IUPAC-MACRO Conference, Online, 5/19/2021.
28. (Invited) “High-energy all-solid-state organic-lithium batteries”, 2021 Virtual MRS Spring Meeting, Online, 4/22/2021.
29. (Invited) “Beyond Li-ion battery chemistries based on organic electrode materials”, International Battery Seminar, Online, 3/9/2021.
30. (Invited) “High-energy all-solid-state organic-lithium batteries”, 2020 Virtual MRS Spring/Fall Meeting, Online, 12/1/2020.
31. (Invited) “Charge storage mechanism of a quinone polymer electrode for aqueous zinc-ion batteries”, 2020 Virtual MRS Spring/Fall Meeting, Online, 12/1/2020.
32. (Invited) NSF CBET Energy Storage Workshop, Austin, TX, 8/13/2020
33. (Invited) “Potential alternatives of lithium-ion batteries for the motive application”, NATTBATT 2020, Pasadena, CA, 2/13/2020.
34. (Invited) “Electrolyte dictated organic electrode materials design for energy storage”, MRS Fall Meeting, Boston, MA, 12/4/2019.

35. (Invited) "Electrolyte dictated organic electrode materials design for beyond lithium ion batteries", ACS Meeting, San Diego, CA, 8/27/2019.
36. (Invited) "Developing all-solid-state batteries with organic electrode materials", 5th International Conference on Energy Conversion and Storage (5th ICECS), Beijing, China, 8/15-16/2019.
37. (Invited) "Electrolyte dictated organic electrode materials design for beyond lithium ion batteries", 10th International Conference on Materials for Advanced Technologies (ICMAT 2019), Singapore, 6/23-29/2019
38. (Invited) "Taming electrode-electrolyte interfaces using organic electrode materials in all -solid-state batteries", International Conference on Solid State Ionics (SSI-22), PyeongChang, Korea 6/16-21/2019.
39. (Invited) "Directing Mg-Storage Chemistry in Organic Polymers Toward High-Energy Mg Batteries", ECS Meeting, Dallas, TX, 5/26-31/2019.
40. (Invited) "Long Cycle Life All-Solid-State Batteries using Organic Electrode Materials", Nature Conference on Emergent Materials and Devices: Electronic Structures and Properties, Chengdu, China, 4/12-14/2019.
41. (Invited) "Electrolyte dictated organic electrode materials design for beyond lithium ion batteries", International Coalition for Energy Storage and Innovation and Pacific Power Source and Pacific Power Sources Symposium Joint Meeting, Hawaii, 1/5-10/2019.
42. (Invited) "Versatile redox-active organic molecules for long cycle life safe batteries", MRS Fall Meeting, Boston, MA, 11/28/2018.
43. (Invited) "Positioning organic electrode materials in the battery landscape", 2018 International Photonics and Optoelectronics Meetings, Wuhan, China, 11/3/2018.
44. (Invited) "Versatile redox-active organic molecules for long cycle life safe batteries", *Symposium on Electrochemical Storage Materials and Devices*, AIChE Annual Conference, Pittsburgh, PA, 10/28/2018.
45. (Invited) "Progress of safe lithium ion batteries for electric vehicles", 2018 CAPA Petroleum Technical Symposium, Houston, TX, 10/19/2018.
46. (Invited) "Redox-active organic electrode materials for safe energy storage", *Symposium L05 Electroactive and Redox Active Polymers 2*, ECS Meeting, Cancun, Mexico, 10/2/2018.
47. (Invited) "High-energy solid-state lithium batteries with organic cathode materials", DOE Battery500 Review Meeting, San Francisco, CA, 8/1/2018.
48. (Invited) "Electrolyte Dictated Organic Redox Materials Design for Beyond Li Ion Batteries", Chinese Chemical Society Meeting, Hangzhou, China, 5/7/2018.
49. (Invited) "Electrolyte dictated materials design in beyond lithium-ion batteries", *Symposium on Energy Harvesting and Storage: Materials, Devices, and Applications VIII*, SPIE Defense and Commercial Sensing Conference, Orlando, FL, 4/16/2018
50. (Invited) "Universal aqueous energy storage with organic electrodes", *Symposium EN14 Materials Science and Device Engineering for Safe and Long-Life Electrochemical Energy Storage*, MRS Spring Meeting, Phoenix, AZ, 4/2/2018.
51. (Invited) "Versatile quinones for long cycle life aqueous batteries", First Annual Meeting of the International Coalition for Energy Storage and Innovation (ICESI), Dalian, China, 1/17-19/2018.
52. (Invited) "Versatile quinones for long cycle life aqueous batteries", Nature Conference on Materials Electrochemistry: Fundamentals & Applications, Shenzhen, China, 1/13-15/2018.

53. (Invited) "Versatile quinones for long cycle life aqueous batteries", 5th Advanced Batteries for xEV/ESS Conference, Shantou, Guangdong, China, 11/23-25/2017
54. (Invited) "Development of two-dimensional materials and quinones for rechargeable magnesium batteries", Beyond Lithium Ion-X Symposium on Energy Storage, IBM, Almaden, CA 6/27-29/2017
55. (Invited) "Design quinone electrodes for proton and metal ion storage with long cycle life", 3rd International Symposium on Energy Conversion and Storage, Nanjing University, Nanjing, China 6/24-25/2017
56. (Invited) "Design quinone electrodes for proton and metal ion storage with long cycle life", Organic Battery Days, Uppsala, Sweden 6/8-10/2017
57. (Invited) "Transforming two-dimensional materials for high capacity rechargeable magnesium batteries", *Symposium H03 Properties and Applications of 2-Dimensional Layered Materials*, ECS Meeting, New Orleans, LA 5/2017
58. (Invited) "High Performance Magnesium Rechargeable Batteries", *Symposium ES3 Materials for Multivalent Electrochemical Energy Storage*, MRS Spring Meeting, Phoenix, AZ 4/17-21/2017
59. (Invited) "Organic Redox Materials for Stationary Energy Storage", *Symposium BM7 Functional Nanostructured Polymers for Emerging Energy Technologies*, MRS Fall Meeting, Boston, MA, 12/2016
60. (Invited) "A High Performance Magnesium Rechargeable Battery Enabled by a MgCl-ion Storage Mechanism", *Symposium ES1 Materials Science and Chemistry for Grid-Scale Energy Storage*, MRS Fall Meeting, Boston, 12/2016
61. (Invited) "Transforming two-dimensional materials for high capacity rechargeable magnesium batteries", *Organic Inorganic Hybrid Materials*, 2016 ACS Southwest Regional Meeting, Galveston, TX 11/2016
62. (Invited) "Redox-active organic materials for sustainable energy storage", *Colloidal & Surface Phenomena*, 2016 ACS Southwest Regional Meeting, Galveston, TX 11/2016
63. (Invited) "Research progress of rechargeable magnesium batteries", 11th International Forum on Li battery technology and industrial development, Hefei, Anhui, 10/2016
64. (Invited) "Designing Two-Dimensional Materials and Conjugated Redox Polymers for Safe and Low-Cost Energy Storage" Energy & Sustainable Materials Symposium at the University of Oregon, 9/2016
65. (Invited) "Critical kinetic control of non-stoichiometric intermediate phase transformation for efficient perovskite solar cells", *Symposium B7 Solar Fuels/Artificial Photosynthesis: Materials and Devices*, XXV International Materials Research Congress, Cancun, Mexico, 8/14-19/2016
66. (Invited) "Rational Nanostructured Cathode Design for Rechargeable Magnesium Batteries", *Symposium B3 Materials and Technologies for Energy Conversion, Saving and Storage (MATECSS)*, XXV International Materials Research Congress, Cancun, Mexico, 8/14-19/2016
67. (Invited) "Designing Two-Dimensional Materials and Conjugated Redox Polymers for Safe and Low-Cost Energy Storage", Chinese Chemical Society Annual Conference, Dalian, China, 7/1-4/2016.
68. (Invited) "Organic Redox Materials for Stationary Energy Storage", International Conference of Synthetic Metal 2016, Guangzhou, China, 6/26-30/2016
69. (Invited) "Organic Redox Materials for Stationary Energy Storage", 11th US-China Nano Forum, Nanjing, China, 6/18-20/2016
70. (Invited) "Transforming Two-dimensional Transition Metal Chalcogenides for High Capacity Rechargeable Magnesium Batteries", Nature Conference on Materials for Energy 2016, Wuhan, China, 6/11-14/2016

71. (Invited Panelist) 2016 US China Innovation and Investment Summit, Houston, TX, 5/17/2016.
72. (Invited) “Heavily n-Dopable π -Conjugated Redox Polymers for Ultrafast Energy Storage”, Symposium *ACS Award for Creative Invention: Symposium in honor of Antonio Facchetti*, ACS Meeting, San Diego, 3/14/2016
73. (Invited) “Rational Nanostructure Design for High Performance Mg Rechargeable Batteries”, *Interplay of Structure & Transport Properties in Materials for Energy Applications*, ACS Meeting, San Diego, 3/16/2016
74. (Invited) “Modification of Magnesium Ion Cathode and Electrolyte for Mg Rechargeable Batteries”, TMS Meeting, Orlando, FL, USA, 3/16/2015.
75. (Invited) “Advanced Aqueous Lithium Ion Batteries using Organic Materials”, ARPA-E Program Review Meeting, Tempe, AZ, 1/28/2015.
76. (Invited) “Atomic-Level Manipulation of Magnesium Ion Intercalation Materials for High-Density Energy Storage”, 2014 Electrochemical Conference on Energy & Environment, Shanghai, China, 3/13/2014.
77. (Invited) “Nanostructure Engineering of Layered Metal Chalcogenides for Magnesium Battery Cathode”, TMS Meeting, San Diego, CA, USA, 2/20/2014.
78. (Invited) “High Energy Density Silicon Anodes for Lithium-ion Batteries: Combining Hollow Nanospheres with Conductive Polymer Binder”, 245th ACS National Meeting, *Division of Energy and Fuels*, New Orleans, LA, 4/7-11/2013.
79. (Invited) “Nanostructure Design for Efficient Energy Devices”, Workshop on Materials Science and Materials Chemistry for Energy, Beijing, China, 9/16-18/2012.
80. (Invited) “Nanostructured Materials and Devices for Energy Harvesting and Storage”, Master Lecture in Printed Electronics, San Jose, CA, 12/2011.

University and Industry Seminars

81. (Invited) “Visualizing Lithium-Solid Electrolyte Interface Evolution via Operando Characterizations in All-solid-state Batteries”, Factorial Energy, Woburn, MA, 5/30/2023.
82. (Invited) “Visualizing Lithium-Solid Electrolyte Interface Evolution via Operando Characterizations in All-solid-state Batteries”, Lyten Corporation, San Jose, CA, 4/12/2023.
83. (Invited) “Visualizing Lithium-Solid Electrolyte Interface Evolution via Operando Characterizations in All-solid-state Batteries”, Prof. Yi Cui’s group, Stanford University, Stanford, CA, 4/11/2023.
84. (Invited) “Next-Generation Batteries for Electric Vehicles and Grid Energy Storage”, Department of Chemical Engineering, Imperial College London, London, UK, 1/27/2023.
85. (Invited) “The Key Challenges for Lithium-metal-based All-Solid-State Batteries”, AMOLF, Amsterdam, Netherland, 1/26/2023.
86. (Invited) “Multidimensional Characterizations for All-Solid-State Batteries”, Ford Motors, Virtual, 10/18/2022.
87. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Department of Industrial and Systems Engineering Seminar, Hong Kong Polytechnic University, Virtual, 9/15/2022.
88. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Materials Science and Engineering Department Seminar, UCLA, Los Angeles, CA, 4/15/2022.
89. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Chemistry and Biochemistry Department Biochemistry Divisional Seminar, Ohio State University, Columbus, OH

4/6/2022.

90. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Materials Science and Engineering/Applied Physics, KAUST, online, 3/31/2022.
91. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Mechanical Science and Engineering, University of Illinois Urbana-Champaign, Urbana, IL, 3/29/2022.
92. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Giner Inc., Online, 3/9/2022.
93. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Chemistry and Biochemistry Department Seminar, George Mason University, Online, 2/11/2022.
94. (Invited) “Multiscale characterizations for solid-state lithium batteries”, Solid-state battery colloquium, Argonne National Laboratory, Online, 1/26/2022.
95. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Materials Science and Engineering, University of Texas Arlington, Online, 10/21/2021.
96. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Materials Science and Engineering, Iowa State University, Online, 10/4/2021.
97. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Lindsay Seminar of Chemical Engineering, Texas A&M University, In person, 9/29/2021.
98. (Invited) “All-solid-state lithium batteries: materials, processing and diagnosis”, SLAC Photon Science Seminar, Online, 4/20/2021.
99. (Invited) “Cobalt-free solid-state lithium batteries”, Nissan North America Battery Group, Online, 3/25/2021.
100. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, ECS Webinar, Online, 2/24/2021.
101. (Invited) “Organic electrode materials design for emerging rechargeable batteries”, Yonsei University Department of Chemical Engineering, Online, 1/18/2021.
102. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, University of Freiburg, Germany, Online, 1/13/2021.
103. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, Mexican Energy Storage Network Webinar Series, Online, 12/11/2020.
104. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, UH Energy Webinar Series, Online, 12/8/2020.
105. (Invited) “Next-generation batteries for electric vehicles and stationary storage”, UH ECE Luncheon, Online, 10/14/2020.
106. (Invited) “Electrolyte dictated organic electrode materials design for beyond lithium ion batteries”, City University at New York Energy Institute, New York, NY, 11/25/2019.
107. (Invited) “Electrolyte dictated organic electrode materials design for beyond lithium ion batteries”, Shell Technology Center Houston, Houston, TX, 11/21/2019.
108. (Invited) “Electrolyte dictated organic electrode materials design for beyond lithium ion batteries”, Department of Chemistry, Binghamton University, Binghamton, NY, 11/1/2019.
109. (Invited) “Electrolyte dictated organic electrode materials design for beyond lithium ion batteries”, Department of Materials Science and NanoEngineering, Rice University, Houston, TX, 10/10/2019.

110. (Invited) “Electrolyte dictated organic electrode materials design for beyond lithium ion batteries”, Energy Storage and Membrane Materials Group, Oak Ridge National Laboratory, Oak Ridge, TN, 10/3/2019.
111. (Invited) “Electrolyte dictated organic electrode materials design for beyond lithium ion batteries”, Institute of Physics Chinese Academy of Sciences, Beijing, China, 8/21/2019.
112. (Invited) “Electrolyte dictated organic electrode materials design for beyond lithium ion batteries”, College of Materials and Engineering, University of Chinese Academy of Sciences, Beijing, China, 8/20/2019.
113. (Invited) “Developing all-solid-state batteries with organic electrode materials”, Hanyang University, Seoul, Korea, 6/17/2019.
114. (Invited) “Positioning organic electrode materials in the battery landscape”, Institut des Maerlaux Jean Rouxel, CNRS, Nantes, France, 11/7/2018
115. (Invited) “Positioning organic electrode materials in the battery landscape”, Texas Center for Superconductivity, Houston, TX, 10/18/2018
116. (Invited) “Versatile organic electrode materials for long life safe batteries”, College of Materials Science and Engineering, University of Science and Technology Beijing, Beijing, China 6/12/2018
117. (Invited) “Versatile organic electrode materials for long life safe batteries”, Energy Processes & Materials Division, Pacific Northwest National Lab, 6/7/2018
118. (Invited) “Versatile organic electrode materials for long life safe batteries”, SABIC, Sugar Land, Texas 6/5/2018
119. (Invited) “Electrolyte dictated materials design for beyond lithium ion batteries”, Shenzhen Institutes of Advanced Technology Chinese Academy of Sciences, Shenzhen, China, 5/11/2018
120. (Invited) “Electrolyte dictated materials design for beyond lithium ion batteries”, College of Materials Science and Engineering, Zhejiang University of Technology, Hangzhou, China 5/9/2018
121. (Invited) “Versatile organic electrode materials for long life safe batteries”, Ningbo Material Technology and Engineering Institute, Ningbo, China, 5/8/2018
122. (Invited) “Versatile organic electrode materials for long life safe batteries”, College of Chemical and Biomolecular Engineering, Zhejiang University, Hangzhou, China, 5/7/2018
123. (Invited) “Versatile organic electrode materials for long life safe batteries”, Department of Materials Science and Engineering, University of California Los Angeles, 4/13/2018
124. (Invited) “Electrolyte dictated materials design for beyond lithium-ion batteries”, Department of Nanoengineering, University of California San Diego, 4/11/2018
125. (Invited) “Electrolyte dictated materials design for beyond lithium-ion batteries”, Department of Materials Science and Engineering, Iowa State University, 2/22/2018
126. (Invited) “Electrolyte dictated materials design for beyond lithium-ion batteries”, Department of Applied Physics & Applied Mathematics, Columbia University, 12/1/2017
127. (Invited) “Electrolyte dictated materials design for beyond lithium-ion batteries”, Department of Materials Science and Engineering, Fudan University, 11/18/2017
128. (Invited) “Electrolyte dictated materials design for beyond lithium-ion batteries”, Center for Advanced Computing and Data Systems, University of Houston, 11/9/2017
129. (Invited) “Electrolyte dictated materials design for beyond lithium-ion batteries”, Department of Materials Science and Engineering, Texas A&M University, 10/23/2017

130. (Invited) “Materials design for beyond lithium-ion batteries”, Department of Mechanical and Aerospace Engineering, West Virginia University, 9/8/2017
131. (Invited) “Two-Dimensional Materials and Organic Redox Materials for Mg Rechargeable Batteries”, School of Materials Science and Engineering, Nanjing University of Posts and Telecomm, 6/26/2017
132. (Invited) “Two-Dimensional Materials and Organic Redox Materials for Mg Rechargeable Batteries”, School of Energy, Beijing University of Chemical Technology, 6/21/2017
133. (Invited) “Designing Two-Dimensional Materials and Conjugated Redox Polymers for Safe and Low-Cost Energy Storage”, School of Materials Science and Engineering, South University of Science and Technology, 1/6/2017
134. (Invited) “Designing Two-Dimensional Materials and Conjugated Redox Polymers for Safe and Low-Cost Energy Storage”, School of Chemical Engineering, Nantong University, 12/30/2016
135. (Invited) “Designing Two-Dimensional Materials and Conjugated Redox Polymers for Safe and Low-Cost Energy Storage”, Department of Chemical Engineering and Material Science, Michigan State University, 10/27/2016
136. (Invited) “Two-Dimensional Materials and Redox-Active Organic Materials for Sustainable Stationary Energy Storage”, School of Materials Science and Engineering, Tsinghua University, Beijing, China, 7/7/2016
137. (Invited) “Two-Dimensional Materials and Redox-Active Organic Materials for Sustainable Stationary Energy Storage”, Institute of Applied Chemistry and Engineering, Nankai University, Tianjing, China, 7/5/2016
138. (Invited) “Two-Dimensional Materials and Redox-Active Organic Materials for Sustainable Stationary Energy Storage”, Institute of Fundamental and Frontier Sciences, University of Electronic Science and Technology of China, Chengdu, China, 6/23/2016
139. (Invited) “Two-Dimensional Materials and Redox-Active Organic Materials for Sustainable Stationary Energy Storage”, School of Materials Science and Engineering, Nanjing University of Science and Technology, Nanjing, China, 6/20/2016
140. (Invited) “Designing Two-Dimensional Materials and Conjugated Redox Polymers for Safe and Low-Cost Energy Storage”, Department of Chemical and Biochemical Engineering, University of Houston, Houston, TX 4/29/2016
141. (Invited) “Designing Two-Dimensional Materials and Conjugated Redox Polymers for Safe and Low-Cost Energy Storage”, Department of Electrical and Computer Engineering, Texas Tech University, Lubbock, TX, 4/1/2016
142. (Invited) “Designing Two-Dimensional Materials and Conjugated Redox Polymers for Safe and Low-Cost Energy Storage”, Department of Materials and NanoEngineering, Rice University, Houston, TX, 3/24/2016
143. (Invited) “Low-Cost and Safe Magnesium Batteries”, Tianqi Lithium Industries Co., Sichuan, China 7/6/2015.
144. (Invited) “Interlayer-Expanded Molybdenum Disulfide Nanocomposites for Electrochemical Magnesium Storage”, Florida International University, Miami, FL 3/21/2015
145. (Invited) “Modification of Magnesium Ion Cathode and Electrolyte for Mg Rechargeable Batteries”, Department of Sustainable Energy Technologies, Brookhaven National Laboratory, Upton, NY 6/13/2014
146. (Invited) “Recent Development of Magnesium Rechargeable Batteries”, School of Materials Science

and Engineering, Wuhan Institute of Technology, Wuhan, China 3/10/2014

147. (Invited) “Advanced Aqueous Lithium Ion Batteries using Organic Materials”, ARPA-E RANGE Kick-off Meeting, Kennedy Space Center, Cape Canaveral, FL, 1/28/2014.
148. (Invited) “Rational Nanostructure Design for High Energy Density Batteries”, South University of Science and Technology of China, Shenzhen, China 12/13/2013.
149. (Invited) “Rational Nanostructure Design for High Energy Density Batteries”, Department of Electrical Engineering, Tsinghua University, Beijing, China 9/17/2013.
150. (Invited) “Rational Nanostructure Design for High Energy Density Batteries”, Department of Environmental Engineering, University of Shanghai for Science and Technology, Shanghai, China, 9/10/2013.
151. (Invited) “Nanostructure Design for Efficient Energy Devices”, Schlumberger Sugar Land Technology Center, Sugar Land, TX, 5/9/2013.
152. (Invited) “Nanostructure Design for Efficient Energy Devices”, Southwest Research Institute, San Antonio, TX, 3/13/2013.
153. (Invited) “Rational Nanostructure Design for High Energy Density Batteries”, Baylor College of Medicine, Houston, TX 3/4/2013.
154. (Invited) “Rational Nanostructure Design for High Energy Density Batteries”, Department of Mechanical Engineering, University of Houston, Houston, TX, 1/17/2013.
155. (Invited) “Rational Nanostructure Design for High Energy Density Batteries”, School of Materials Science and Engineering, Beijing University of Technology, Beijing, 9/19/2012.
156. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Mechanical Engineering, Yale University, New Haven, CT 5/2/2012.
157. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Materials Science and Engineering, University of Virginia, Charlottesville, VA 4/30/2012.
158. (Invited) “Nanostructure Design for Efficient Energy Devices”, College of Engineering, Dartmouth College, Hanover, NH 4/26/2012.
159. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Mechanical Engineering, University of Washington, Seattle, WA 4/16/2012.
160. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Materials Science and Engineering, University of Wisconsin Madison, Madison, WI 4/5/2012.
161. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Electrical and Computer Engineering, University of Houston, Houston, TX 4/2/2012.
162. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Mechanical and Automation Engineering, Chinese University of Hong Kong, Hong Kong, 3/27/2012.
163. (Invited) “Nanostructure Design for Efficient Energy Devices”, Suzhou Institute of Nanotechnology, Suzhou, China 3/23/2012.
164. (Invited) “Nanostructure Design for Efficient Energy Devices”, School of Engineering, Nanjing University, Nanjing, China 3/21/2012.
165. (Invited) “Nanostructure Design for Efficient Energy Devices”, Frontier Institute of Science and Technology, Xi’an Jiaotong University, Xi’an, China 3/19/2012.
166. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Mechanical Engineering,

EPFL, Lausanne, Switzerland 3/8/2012.

167. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Mechanical Engineering, Johns Hopkins University, Baltimore, MD 2/16/2012.
168. (Invited) “Nanostructure Design for Efficient Energy Devices”, Institute of Materials Research and Engineering, Singapore, 2/3/2012.
169. (Invited) “Nanostructure Design for Efficient Energy Devices”, Nanyang Technology University, Singapore, 2/1/2012.
170. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Mechanical Engineering, University of Texas San Antonio, San Antonio, TX 1/26/2012.
171. (Invited) “Nanostructure Design for Efficient Energy Devices”, Department of Materials Science and Engineering, Drexel University, Philadelphia, PA 12/13/2011.
172. (Invited) “Nanostructured Energy Devices: Polymer Solar Cells and Lithium Ion Batteries”, Institute of Chemistry of Chinese Academy of Sciences, China, 9/2011.
173. (Invited) “Nanostructured Energy Devices: Polymer Solar Cells and Lithium Ion Batteries”, Department of Materials Science, Fudan University, Shanghai, China, 9/2011.

MEIDA COVERAGE OF RESEARCH ACHIEVEMENTS

1. UH Team Develops Novel Microscope To Design Better High-Performance Batteries
POSTED ON FEBRUARY 9, 2023
2. ECE Researchers Charging the Future with Modern Aqueous Batteries
POSTED ON DECEMBER 12, 2022
3. Researchers Develop Sodium Glassy Electrolytes Capable Of Supporting Long-Duration Grid-Scale Energy Storage
POSTED ON JUNE 1, 2022
4. U.S. Department of Energy Announces \$175 Million for Novel Clean Energy Technology Projects
POSTED ON FEBRUARY 14, 2022
5. Altered Microstructure Improves Organic-Based, Solid State Lithium EV Battery
POSTED ON JUNE 17, 2021
6. Discoveries Highlight New Possibilities for Magnesium Batteries
POSTED ON NOVEMBER 30, 2020
7. A Roadmap to Better Multivalent Batteries
POSTED ON JULY 17, 2020
8. Four UH Faculty Members Elected to National Academy of Inventors
POSTED ON FEBRUARY 14, 2020
9. What Happens as Solid-State Batteries Begin to Fail?
POSTED ON OCTOBER 10, 2019
10. UH Engineer’s Battery Research Gets New Charge With Additional DOE Funding
POSTED ON MAY 22, 2019
11. Researchers Report High Performance Solid-State Sodium-Ion Battery
POSTED ON APRIL 19, 2019

12. Two UH Cullen College Engineers Among Most Cited Researchers in the World
POSTED ON JANUARY 2, 2019
13. Lean Electrolyte Design is a Game-Changer for Magnesium Batteries
POSTED ON DECEMBER 21, 2018
14. Cullen College Faculty Shine in UH Research Awards
POSTED ON APRIL 24, 2018
15. Battery Expert Powers Up With a Scialog Award
POSTED ON MARCH 13, 2018
16. From Exploding Hoverboards to Tomorrow's Batteries: UH engineering team lands on front cover of prestigious publication
POSTED ON MARCH 12, 2018
17. Tomorrow's Batteries Today: Yan Yao Charges Up Battery Research With DOE Award
POSTED ON DECEMBER 13, 2017
18. Researchers Report Breakthrough in Magnesium Batteries
POSTED ON AUGUST 24, 2017
19. Inexpensive Organic Material Gives Safe Batteries a Longer Life
POSTED ON JUNE 19, 2017
20. UH Electrochemical Society Student Chapter off to a Successful Start
POSTED ON MAY 8, 2017
21. Yan Yao Amps Up His Game: Becomes a Scialog Fellow
POSTED ON APRIL 26, 2017
22. Ph.D. Student Studies Solid-State Batteries With Prestigious NASA Fellowship
POSTED ON APRIL 20, 2017
23. Journal Features ECE Doctoral Student's Battery Research on Cover
POSTED ON DECEMBER 7, 2016
24. College Honors Faculty, Staff and Students with Outstanding Service Awards
POSTED ON MAY 4, 2016
25. ECE Energy Research Makes Cover of Research Journal
POSTED ON JANUARY 28, 2016
26. Naval Research Grant Will Speed UH Work on Materials, Energy
POSTED ON JANUARY 20, 2016
27. KHOU 11 News Interviews Professor About Exploding Hoverboards
POSTED ON DECEMBER 16, 2015
28. UH Engineer Joins Project to Transform Energy Storage
POSTED ON DECEMBER 15, 2015
29. Engineering Student Earns Silver Nano Research Poster Award
POSTED ON OCTOBER 23, 2015
30. UH Researchers Discover N-Type Polymer for Fast Organic Battery
POSTED ON APRIL 7, 2015
31. Magnesium-ion Batteries in the Fast Lane
POSTED ON MARCH 26, 2015

32. SURF Program Provides Undergrad Researchers 'Enlightening' Experience
POSTED ON SEPTEMBER 3, 2014
33. ECE Professor Developing Sodium-Ion Batteries With NSF Award
POSTED ON AUGUST 13, 2014
34. Business Students Win Big With Yao's Technology
POSTED ON APRIL 1, 2014
35. Professor Wins ARPA-E Funding to Build New Type of Electric Vehicle Battery
POSTED ON AUGUST 28, 2013
36. Professor Wins Naval Young Investigator Award for Battery Development
POSTED ON AUGUST 2, 2013
37. Experiential Learning: Undergrad Research in Energy Storage
POSTED ON JULY 30, 2013
38. Photos: Inside ECE Professor Yan Yao's Laboratory
POSTED ON JUNE 27, 2013
39. ECE Professor Wins Ralph E. Powe Junior Faculty Enhancement Award
POSTED ON MAY 22, 2013
40. New ECE Faculty Appointed Welch Professor
POSTED ON SEPTEMBER 5, 2012

TEACHING EXPERIENCE

University of Houston, Department of Electrical and Computer Engineering

- Spring 2023 Special Topics in Electrochemical Systems, ECE 6397, Instructor
- Fall 2022 MSE Seminar, MTLs 6111, Coordinator
- Spring 2022 Advanced Batteries, ECE 6308, Instructor
- Fall 2021 Senior Design II, ECE 4336, Facilitator
- Spring 2021 Senior Design I, ECE 4335, Facilitator
- Fall 2020 Advanced Batteries II, ECE 6397, Instructor
- Spring 2020 Advanced Batteries, ECE 6308, Instructor
- Fall 2019 Senior Design I, ECE 4335, Facilitator
- Spring 2019 Advanced Batteries, ECE 6308, Instructor
- Fall 2017 Introduction to Nanotechnology, ECE 5319/ECE 6306/MECE 5319/CHEE5319/CHEE 6319/MLTS 6319, Instructor
- Fall 2017 Nanotechnology Laboratory, ECE 5119, Instructor
- Spring 2017 Advanced Batteries: Principles, Materials, and Devices, ECE 6308, Instructor
- Fall 2016 Introduction to Nanotechnology, ECE 5319/ECE 6306/MECE 5319/CHEE5319/CHEE 6319/MLTS 6319, Instructor
- Fall 2016 Nanotechnology Laboratory, ECE 5119, Instructor
- Fall 2015 Introduction to Nanotechnology, ECE 5319/ECE 6306/MECE 5319/CHEE5319/CHEE 6319/MLTS 6319, Instructor
- Fall 2015 Nanotechnology Laboratory, ECE 5119, Instructor
- Spring 2015 Advanced Batteries: Principles, Materials, and Devices, ECE 6397, Instructor

Fall 2014 Introduction to Nanotechnology, ECE 5319/ECE 6306/MECE 5319/CHEE5319/CHEE 6319/MLTS 6319, Instructor
 Fall 2014 Nanotechnology Laboratory, ECE 5119, Instructor
 Spring 2014 Advanced Batteries: Principles, Materials, and Devices, ECE 6397, Instructor
 Fall 2013 Introduction to Nanotechnology, ECE 5319/ECE 6306/MECE 5319/CHEE5319/CHEE 6319/MLTS 6319, Instructor
 Fall 2013 Nanotechnology Laboratory, ECE 5119, Instructor
 Spring 2013 Advanced Batteries: Principles, Materials, and Devices, ECE 5397/6397, Instructor
Stanford University, Department of Materials Science and Engineering
 Fall 2011 Principles of Batteries, Short course, Contributor
UCLA, Department of Materials Science and Engineering
 Fall 2004 Science of Engineering Materials, MSE 104, Teaching Assistant
 Spring 2004 Science of Semiconductors, MSE 121, Teaching Assistant

GRADUATE AND UNDERGRADUATE STUDENT AWARDS AND HONORS

- 2023 UH Energy Scholars Program, Sadia Ashraf
- 2023 Third Prize, TcSUH 58th Student Research Symposium, Chaoshan Wu
- 2022 UH Postdoc Travel Award, Lihong Zhao
- 2022 TcSUH Travel Grant, Zhaoyang Chen
- 2020 Best Dissertation Award in Chemical Engineering, Karun Kumar Rao
- 2020 Houston Science Engineering Fair Second Place, Stephane Xie
- 2020 UH Provost's Undergraduate Research Scholarship, Robert Sipowicz
- 2019 Best Dissertation Award Second Place for Fall 2019, Fang Hao
- 2019 Best Poster Award of Battery500 Review Meeting, Dieu Nguyen
- 2019 5th Solid State Battery Symposium, Best Poster Award, Yang Chen
- 2019 235th ECS meeting Battery Division the Best Paper Award, Fang Hao
- 2019 Houston Endowment Fellowship, Dieu Nguyen
- 2019 NSF Graduate Research Fellowship, Audrey Wang
- 2019 UH Future Faculty Program Travel Award, Fang Hao
- 2019 Third Place, 56th TcSUH Student Symposium, Audrey Wang
- 2019 UH Summer Undergraduate Research Fellowship, Robert Sipowicz
- 2019 Cynthia Oliver Coleman Women in Engineering Rising Star Award, Audrey Wang
- 2019 Outstanding Senior in Electrical Engineering, Audrey Wang
- 2018 Audience Favorite Poster Award, UH Undergraduate Research Day, Audrey Wang
- 2018 Nature Conference of Electrochemistry Best Poster Award, Hui Dong
- 2017 NASA Space Technology Research Fellowship, Karun Kumar Rao
- 2017 TcSUH Travel Award, Fang Hao
- 2017 DOE Science Undergraduate Laboratory Internship, Stephanie Roohi
- 2017 Provost's Undergraduate Research Scholarship, Stephanie Roohi
- 2017 First Place, TcSUH 53rd Student Symposium, Saman Gheyhani

- 2016 Best Dissertation Award, Materials Science and Engineering, Yifei Li
- 2016 Third Prize, TcSUH 52nd Student Symposium, Fang Hao
- 2016 Best Poster Award, REEMS REU, Raymond McCoy
- 2016 TcSUH Travel Award, Hui Dong
- 2016 UH Future Faculty Program, Hui Dong
- 2016 Third Prize, TcSUH 51st Student Symposium, Hui Dong
- 2015 Nano Research Poster Award, Yanliang Liang
- 2015 UH Summer Undergraduate Research Fellowship, Kaysheva Champathi
- 2014 ECE Urvish Medh Award, Yifei Li
- 2014 UH Summer Undergraduate Research Scholarship, Matthew Patton
- 2014 Third Prize, TcSUH 47th Student Symposium, Yifei Li
- 2013 UH Summer Undergraduate Research Fellowship, David Pineda

EXHIBIT B

Exhibit B: Materials Considered

In addition to any documents, exhibits, or references cited or referred to in my report, I considered the following materials in forming my opinions:

- U.S. Patent No. 7,749,641
- Prosecution History of U.S. Patent 7,749,641
- Prosecution History of U.S. Patent Application No. 12/817,028
- Second Amended Complaint (April 13, 2023), Dkt. 51, 51-1, 51-2, 51-3
- U.S. Patent No. 5,260,148
- Motion to Dismiss Hearing Transcript, March 20, 2023
- Opposition to Motion to Dismiss (February 20, 2023), Dkt. 42
- U.S. Patent Pub. No. US 2003/0113613 A1
- RJ00001340_Apple
- RJ00001353_Apple
- RJ00001371_Apple
- RJ00001465_Apple
- RJ00001477_Apple
- RJ00001484_Apple
- RJ00001578_Apple
- RJ00001613_Apple
- RJ00001725_Apple
- RJ00001733_Apple
- RJ00001740_Apple
- RJ00001778_Apple
- RJ00003232_Apple
- RJ00003238_Apple
- RJ00003244_Apple
- APL-RJT_00001038
- APL-RJT_00001051
- APL-RJT_00001346
- APL-RJT_00001393
- APL-RJT_00001407
- APL-RJT_00001414
- APL-RJT_00001424
- APL-RJT_00785530