

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Clive P. Bosnyak, et al.
U.S. Patent No.: 10,153,483 Attorney Docket No. 18768-0210IP6
Issue Date: Dec. 11, 2018
Appl. Serial No.: 13/529,797
Filing Date: June 21, 2012
Title: LITHIUM ION BATTERIES USING DISCRETE CARBON
NANOTUBES, METHODS FOR PRODUCTION THEREOF AND
PRODUCTS OBTAINED THEREFROM

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**PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT
NO. 10,153,483 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42**

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EXHIBITS

LGES-1001	U.S. Patent No. 10,153,483 (“the ’483 Patent”)
LGES-1002	Excerpts from Prosecution History of the ’483 Patent (“the Prosecution History”)
LGES-1003	Declaration of Dr. Yu Zhu
LGES-1004	U.S. Patent Pub. No. 2004/0160156 (“Ohata”)
LGES-1005	“Multi-walled carbon nanotubes functionalized by carboxylic groups: Activation of TiO ₂ (anatase) and phosphate olivines (LiMnPO ₄ ; LiFePO ₄) for electrochemical Li-storage.” Ladislav Kavan et al. Journal of Power Sources 195 (2010) 5360-5369 (“Kavan”)
LGES-1006	Chinese Patent Pub. No. CN 101364643A
LGES-1007	Certified English Translation of CN 101364643 (LGES-1006) and Translator’s Declaration (“Gong”)
LGES-1008	Chinese Patent Pub. No. CN 102456881A
LGES-1009	Certified English Translation of CN 102456881A (LGES-1008) and Translator’s Declaration (“Liu”)
LGES-1010	Chinese Patent Pub. No. CN 101714627A
LGES-1011	Certified English Translation of CN 101714627A (LGES-1010) and Translator’s Declaration (“Cheng”)
LGES-1012	Int’l Patent Pub. No. WO 2011056290 (“Peng”)
LGES-1013	U.S. Patent No. 10,608,282 (“the ’282 Patent”)

- LGES-1014 “Surface modified multi-walled carbon nanotubes in CNT/epoxy-composites,” Florian H. Gojny, Jacek Nastalczyk, Zbigniew Roslaniec, Karl Schulte. Chemical Physics Letters 370 (2003) 820–824 (“Gojny”)
- LGES-1015 “Sonochemical Oxidation of Multiwalled Carbon Nanotubes,” Yangchuan Xing, Liang Li, Charles C. Chusuei, and Robert V. Hull. Langmuir 2005, 21, 4185-4190 (“Xing”)
- LGES-1016 U.S. Patent Pub. No. 2010/0124713 (“Farrugia”)
- LGES-1017 “Chemical oxidation of multiwalled carbon nanotubes,” V. Datsyuk et al. Carbon 46 (2008) 833-840 (“Datsyuk”)
- LGES-1018 U.S. Provisional Application No. 61/500,560 (“560 Application”)
- LGES-1019 to LGES-1023 RESERVED***
- LGES-1024 U.S. Patent Pub No. 2009/0035469 (“Sue”)
- LGES-1025 U.S. Patent No. 8,241,794 (“Sheem”)
- LGES-1026 U.S. Patent Pub. No. 2011/0159366A1 (“Nakura”)
- LGES-1027 “A Lithium-Ion Cell Based on a Sodium Insertion Material.” J. Barker et al., Electrochemical and Solid-State Letters, 9 (4) A190-A192 (2006) (“Barker”)
- LGES-1028 “A multifunctional 3.5 V iron-based phosphate cathode for rechargeable batteries,” Nature Materials 6 (2007), 749-753 (“Nazar 2007”)
- LGES-1029 “Crystal Structure and Electrochemical Properties of A_2MPO_4F Fluorophosphates (A = Na, Li; M = Fe, Mn, Co, Ni),” Brian L. Ellis

- et al., Chem. Mater, 2010, 22, 1059-1070 (“Nazar 2010”)
- LGES-1030 “Attachment of Metal Oxide Nanoparticles on Carbon Nanotubes with Different Oxidation Levels,” C.T. Hsieh et al. Advanced Materials Research, Vols. 55-57, pp. 545-548 (“Hsieh”)
- LGES-1031 “Incorporation of MWCNTs into leaf-like CuO nanoplates for superior reversible Li-ion storage,” J.Y. Xiang et al., Electrochemistry Communications 12 (2010) 1103-1107 (“Xiang”)
- LGES-1032 “Surface and structural characterization of multi-walled carbon nanotubes following different oxidative treatments,” Kevin A. Wepasnick et al., Carbon 49 (2011) 24-36 (“Wepasnick”)
- LGES-1033 Wikipedia: The Free Encyclopedia, “Chemical bond” at https://en.wikipedia.org/wiki/Chemical_bond, last accessed 6/7/2024
- LGES-1034 U.S. Patent Pub. No. 2006/0269842 (“Ichinose”)
- LGES-1035 “Functionalization of Single-Walled Carbon Nanotubes,” A. Hirsch, *Angew. Chem. Int. Ed.* 2002, 41, No. 11, 1853-1859 (“Hirsch”)

LGES-1036 to LGES-1040 RESERVED

- LGES-1041 “Hydrothermal synthesis of lithium iron phosphate,” J. Chen, M. Whittingham. Electrochemistry Communications 8 (2006) 855-858 (“Chen”)
- LGES-1042 “The preparation and electrochemical performances of LiFePO₄-multiwalled nanotubes composite cathode materials for lithium ion batteries,” Y. Feng. Materials Chemistry and Physics 121 (2010)

302-307 (“Feng”)

LGES-1043 to LGES-1049 RESERVED

LGES-1050 *Molecular Rebar Design, LLC, and Black Diamond Structures, LLC v. LG Energy Solution, Ltd.*, Plaintiffs’ Disclosure of Asserted Claims and Infringement, 2:24-cv-00107-JRG

LGES-1051 Declaration of June Ann Munford (Kavan)

LGES-1052 RESERVED

LGES-1053 *Molecular Rebar Design, LLC, et al. v. LG Energy Solution, Ltd.*, Sample Docket Control Order, 2:24-cv-00107-JRG

CLAIM LISTING

Limitation	Claim Language
[1pre]	A composition useful for lithium ion batteries comprising:
[1a]	discrete, non-agglomerated, and exfoliated carbon nanotubes having a surface, and
[1b]	mixtures of ion active materials comprising migratable ions said materials comprising crystals or layers of lithium ion active material,
[1c]	wherein a ratio of lithium ion to other total ions in the ion active materials is at least 2:1 to 25:1, and
[1d]	wherein the discrete carbon nanotubes have crystals or layers of lithium ion active material ionically attached to their surface and
[1e]	wherein the discrete carbon nanotubes comprise oxidized species selected from the group consisting of carboxylic, ketone, or hydroxyl functionalities, and
[1f]	wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and
[1g]	oxidation levels from 1% to 15% by weight of the carbon nanotube.
[2]	The composition of claim 1, wherein the crystals or layers of lithium ion active material comprise a lithium metal salt and an element selected from the group consisting of: iron, manganese, cobalt, copper, nickel, vanadium, titanium, and mixtures thereof.
[3]	The composition of claim 2, wherein the lithium metal salt has an olivine crystal structure and wherein the lithium metal salt is LiFePO_4 or LiMnPO_4 .
[4]	The composition of claim 1, wherein the crystals or layers of lithium ion active material comprise tin, silicon, copper, antimony, aluminum, germanium, titanium, or mixtures thereof.
[7pre]	A composition useful for lithium ion batteries, comprising
[7a]	discrete, non-agglomerated, and exfoliated carbon nanotubes having a surface, and

Limitation	Claim Language
[7b]	mixtures of ion active materials comprising migratable ions said materials comprising crystals or layers of lithium ion active material,
[7c]	wherein a ratio of lithium ion to other total ions in the ion active materials is at least 2:1 to 25:1,
[7d]	wherein the discrete carbon nanotubes have crystals or layers of lithium ion active materials ionically attached to their surface, and
[7e]	wherein the carbon nanotubes are in a weight ratio of carbon nanotubes to lithium salts of 0.1% to 10% and
[7f]	wherein the discrete carbon nanotubes comprise oxidized species selected from the group consisting of carboxylic, ketone, or hydroxyl functionalities, and
[7g]	wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and
[7h]	oxidation levels from 1% to 15% by weight of the carbon nanotube.
[8pre]	A composition useful for lithium ion batteries, comprising
[8a]	oxidized discrete, non-agglomerated, and exfoliated carbon nanotubes having a surface, and
[8b]	mixtures of ion active materials comprising migratable ions said materials comprising crystals or layers of lithium ion active material,
[8c]	wherein a ratio of lithium ion to other total ions in the ion active materials is at least 2:1 to 25:1,
[8d]	wherein the discrete carbon nanotubes have crystals or layers of lithium ion active materials attached to their surface, and
[8e]	wherein the carbon nanotubes are uniformly dispersed without clustering on a dimension scale of less than about 1 micrometer and
[8f]	wherein the discrete carbon nanotubes comprise oxidized species selected from the group consisting of carboxylic, ketone, or hydroxyl functionalities, and

Limitation	Claim Language
[8g]	wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and
[8h]	oxidation levels from 1% to 15% by weight of the carbon nanotube.
[9pre]	A composition useful for lithium ion batteries, comprising
[9a]	uniformly dispersible oxidized, non-agglomerated carbon nanotubes having a surface, and
[9b]	mixtures of ion active materials comprising migratable ions said materials comprising crystals or layers of lithium ion active material,
[9c]	wherein a ratio of lithium ion to other total ions in the ion active materials is at least 2:1 to 25:1, and
[9d]	wherein the discrete carbon nanotubes have crystals or layers of lithium ion active materials ionically attached to their surface and
[9e]	wherein the discrete carbon nanotubes comprise oxidized species selected from the group consisting of carboxylic, ketone, or hydroxyl functionalities, and
[9f]	wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and
[9g]	oxidation levels from 1% to 15% by weight of the carbon nanotube.
[10]	The composition of claim 9, wherein the crystals or layers of lithium ion active materials are chemically attached to the surface of the dispersible oxidized carbon nanotubes.
[11]	The composition of claim 1 where the ratio of lithium ion to other total ions in the ion active materials is from 3:1 to 25:1.
[12]	The composition of claim 1 where the ratio of lithium ion to other total ions in the ion active materials is from 10:1 to 25:1.
[13]	The composition of claim 7 where the ratio of lithium ion to other total ions in the ion active materials is from 3:1 to 25:1.
[14]	The composition of claim 7 where the ratio of lithium ion to other total ions in the ion active materials is from 10:1 to 25:1.

Limitation	Claim Language
[15]	The composition of claim 8 where the ratio of lithium ion to other total ions in the ion active materials is from 3:1 to 25:1.
[16]	The composition of claim 8 where the ratio of lithium ion to other total ions in the ion active materials is from 10:1 to 25:1.
[17]	The composition of claim 9 where the ratio of lithium ion to other total ions in the ion active materials is from 3:1 to 25:1.
[18]	The composition of claim 9 where the ratio of lithium ion to other total ions in the ion active materials is from 10:1 to 25:1.

I. INTRODUCTION

LG Energy Solution, Ltd. (“Petitioner”) petitions for IPR of claims 1-4 and 7-18 (“Challenged Claims”) of U.S. Patent No. 10,153,483 (“the ’483 Patent”).

II. REQUIREMENTS FOR IPR

A. Grounds for Standing

Petitioner certifies that the ’483 Patent is available for IPR. Petitioner is not barred or estopped from requesting this review.

B. Challenge and Relief Requested

Petitioner requests IPR of the Challenged Claims on the below grounds. Dr. Yu Zhu provides supporting explanations in his Declaration (LGES-1003) cited throughout this petition. LGES-1003, ¶¶1-161.

Ground	Claims	Basis for Rejection
1A/1B	1-4, 7-18	§103: Ohata and Kavan in view of Gong (1A) or Liu (1B)
2	1, 2, 7-18	§103: Ohata, Kavan, and Ichinose

The ’483 Patent was filed on 6/21/2012 as a U.S. application of U.S. Application No. 13/529,797 (“’797 Application”), which claimed the benefit of U.S. Provisional Application No. 61/500,560 (“’560 Application”), filed on 6/23/2011. But, as explained in §II.C, *infra*, the ’483 patent is not entitled to the benefit of its priority claim to the ’560 Application (with June 23, 2011 filing date), because the ’560 Application does not provide sufficient written description

of various claimed features.

Accordingly, the Petitioner takes the position that the '483 patent is not entitled to the benefit of its priority claim to the '560 Application. As explained below, the earliest possible priority date for all the challenged claims of the '483 Patent is June 21, 2012 ("Critical Date").

As seen below, each reference applied in this Petition predates the Critical Date and qualify as prior art.¹ *See generally* LGES-1004, LGES-1005, LGES-1007, LGES-1009, LGES-1034, LGES-1051.

Reference	Date	Section
Ohata	8/19/2004 (published)	102(b)
Kavan	3/12/2010 (published)	102(b)
Gong	2/11/2009 (published)	102(b)
Liu	5/16/2012 (published)	102(a)
Ichinose	5/31/2011 (published)	102(b)

¹ In the May 15, 2024 infringement contentions in the co-pending district court case, Patent Owner alleges 32 alternative priority dates that the '483 Patent may be entitled to. LGES-1050, 11-13. While such allegations do not appear to be justified—among other things because of failure to demonstrate possession of the lithium ratio, aspect ratio, and oxidation level features as claimed—Petitioner reserves the right to respond to any such similar allegations made in this IPR proceeding.

C. The Challenged Claims Are Not Entitled to the Benefit of Priority to the '560 Application

1. Legal Standard for Priority

The challenged claims include new subject matter that were not disclosed or taught by the '560 Application, filed on June 23, 2011, to which the '483 Patent claims priority. Patent Owner first introduced the subject matter in the '797 Application, filed on June 21, 2012. LGES-1002, 551.

To benefit from the filing date of an earlier application, 35 U.S.C. § 120 requires that the earlier application include a disclosure that complies with the written description requirement of 35 U.S.C. § 112. *Lockwood v. Am. Airlines, Inc.*, 107 F.3d 1565, 1571-72 (Fed. Cir. 1997). The written description requirement is separate and distinct from the enablement requirement. *See Vas-Cath Inc. v. Mahurkar*, 935 F.2d 1555, 1563-64 (Fed. Cir. 1991). “The purpose of the ‘written description requirement’ is broader than to merely explain how to ‘make and use’; the applicant must also convey with reasonable clarity to those skilled in the art that, as of the filing date sought, he or she was in possession of the invention.” *Id.*

To comply with the written description requirement, the specification “must describe the invention sufficiently to convey to a person of skill in the art that the patentee had possession of the claimed invention at the time of the application, i.e.,

that the patentee invented what is claimed.” *Lizardtech, Inc. v. Earth Res.*

Mapping, Inc., 424 F.3d 1336, 1345 (Fed. Cir. 2005). “The question is not whether a claimed invention is an obvious variant of that which is disclosed in the specification. Rather, [the] application itself must describe an invention, and do so in sufficient detail that one skilled in the art can clearly conclude that the inventor invented the claimed invention as of the filing date.” *Lockwood*, 107 F.3d at 1572.

2. Because the ’560 Application Does Not Provide Support for (i) “aspect ratio of 10 to 500” and (ii) “ratio of lithium ion ... at least 2:1 to 25:1,” the Challenged Claims Are Not Entitled to the Benefit of Priority to the ’560 Application

First, independent claims 1 and 7-9 of the ’483 Patent recites “wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500.” LGES-1001, Claims 1 and 7-9. However, the ’560 Application, to which the ’483 Patent claims priority, lacks written description support for the limitations that are directed toward the claimed aspect ratio range of “10 to 500.”

Indeed, contrary to the claimed aspect ratio range of “10 to 500” of the independent claims 1 and 7-9 of the ’483 Patent, the specification of the ’560 Application merely discloses an aspect ratio of “60” and aspect ratio range of “25-500,” with no mention of the claimed aspect ratio range of “10 to 500.” For instance, the only places in the ’560 Application specification that disclose the aspect ratio are found in Examples 1-3 and claim 5, where the disclosure is limited

to numerical values. Examples 1-3 disclose utilizing carbon nanotubes with “aspect ratio of about 60” and claim 5 merely discloses the aspect ratio range of 25-500. LGES-1018, 6-7. Moreover, the ’560 Application provides no discussion of aspect ratio of 60 or 25-500 other than merely making the use of the carbon nanotubes having aspect ratio of 60, let alone any evidence, of unexpected results or criticality associated with nanotubes having the aspect ratios in the range of 25-500. *See, generally, id.*

Second, claims 1 and 7-9 of the ’483 Patent further recites “wherein a ratio of lithium ion to other total ions in the ion active materials is at least 2:1 to 25:1.” LGES-1001, Claims 1 and 7-9. However, the ’560 Application, to which the ’483 Patent claims priority, lacks written description support for this ratio limitation. In fact, there is nothing in the ’560 Application that mentions or provides guidance for any such ratio of lithium to other total ions, much less the specifically claimed range of “at least 2:1 to 25:1.”

Because the ’560 Application lacks written description support for at least these two limitations, the earliest possible priority date for each of the independent claims (claims 1 and 7-9) and all claims dependent therefrom in the ’483 Patent is June 21, 2012, the date when the Patent Owner first introduced these two (and many other descriptions) in the then-pending claims of the ’797 Application.

III. SUMMARY OF THE '483 PATENT

A. Brief Description

The '483 Patent describes its purported “invention” as relating to compositions that are “useful for lithium ion batteries comprising discrete oxidized carbon nanotubes having attached to their surface lithium ion active materials in the form of nanometer sized crystals or layers.” LGES-1001, Abstract.

B. Prosecution History

The underlying '797 Application to the '483 Patent went through various rejections that eventually led to an Appeal, which ultimately led to allowance. LGES-1002, 30. However, none of the art relied upon in this Petition were cited during prosecution.

In reversing the Examiner, the Appeal Board explained that “Li fails to teach ‘discrete, non-agglomerated, and exfoliated carbon nanotubes’ as claimed.” *Id.*, 32. Specifically, the Board agreed with Appellants’ explanation that Li failed to teach “discrete, non-agglomerated, and exfoliated carbon nanotubes” because “one cannot even ascertain two ends of even a single nanotube due to the agglomeration and entanglement of the nanotubes.” *Id.*, 34. The Board further remarked that the Examiner’s bare statements “without more” fails to overcome “Li’s express teaching that suggests bundling or agglomeration of carbon nanotubes.” *Id.*, 34-35. A Notice of Allowance subsequently issued on August 27, 2018. *Id.*, 8.

However, and as further detailed below, the Examiner and the Board did not consider either the prior art and rationale presented in this Petition, including the teachings of Ohata and the explanations of Dr. Zhu, which provide a clear disclosure of this and other features and, in combination with other references, render the Challenged Claims obvious

C. Level of Ordinary Skill in the Art

A person of ordinary skill in the art relating to the subject matter of the '483 Patent as of the Critical Date (a "POSITA") would have had at least a Master's degree in materials science, chemistry, chemical engineering, a field relevant to polymer science and engineering, or the equivalent, and at least three years of experience in nanomaterials, electrochemistry, batteries, or polymer related activities. Additional work experience can compensate for less formal education, and vice versa. LGES-1003, ¶¶11-12.

D. Claim Construction

All claim terms should be construed according to the *Phillips* standard. *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005); 37 C.F.R. §42.100. Petitioner submits that the claim element listed below should be construed for purposes of this proceeding, and that the remaining claim terms do not require a formal construction for purposes of demonstrating that the claims are obvious based on Grounds 1A/1B/2 in this Petition. *Wellman, Inc. v. Eastman Chem. Co.*,

642 F.3d 1355, 1361 (Fed. Cir. 2011); LGES-1003, ¶18.

Petitioner further reserves the right to respond to any constructions offered by Patent Owner or adopted by the Board. Petitioner is not conceding that each challenged claim satisfies all statutory requirements, nor is Petitioner waiving any arguments concerning indefiniteness or claim scope that can only be raised in district court or otherwise outside the context of an IPR. Moreover, the Board has regularly compared indefinite claims to the prior art for purposes of considering unpatentability. *See, e.g., Chicago Mercantile Exchange, Inc. v. 5th Market, Inc.*, CBM2013-00027, Paper 33, 3 (PTAB 2014); *SAP America, Inc. v. Lakshmi Arunachalam*, CBM2013-00013, Paper 61, 29 (PTAB 2014). For this Petition, Petitioner applies prior art in a manner consistent with disclosure of the claimed features in the '483 Patent itself.

“ratio of lithium ion to other total ions in the ion active materials” (claims 1, 7-9, 11-18)

The claim term “a ratio of lithium ion to other total ions in the ion active materials” should be interpreted as *a ratio of lithium ions to other migratable ions in the ion active materials*. LGES-1003, ¶¶19-21.

First, this scope is reflected by the claim language itself, where the first time the term “ions” appears in the claim, it appears as “migratable ions.” LGES-1001, 7:8 (Claim 1). No other types of ions are subsequently mentioned in the claims, except for “lithium ion” and “total ions.” *Id.*, 7:10. And the specification makes it

clear that a “lithium ion” is a type of “migratable ion.” *Id.*, 4:23-31. It follows that “total ions” are also referring to a type of migratable ions.

Petitioner’s proposed construction is further supported by the specification, where the **only** place that the claimed ratio numbers of 2:1, 3:1, 10:1, and 25:1—as found in Claims 1, 7-9, 11-18—appears is with regard to a disclosure where more than one migratable ions are being used. LGES-1001, 4:57-59; LGES-1003, ¶20. In the preceding sentence in the specification, it is noted that when such “migratable ion mixture” having multiple migratable ions is used, the lithium ion may be the “minority ionic component,” although that is not preferred. LGES-1001, 4:53-57. Thus, a POSITA would understand that the exemplary ratio numbers provided are referring to the ratio of lithium ions to other migratable ions. LGES-1003, ¶20.

Moreover, besides other non-lithium migratable ions in the ion active material, there is simply no other “ion” that can be reasonably considered to be part of the “other total ions.” For instance, to the extent that Fe, Mn, and/or PO₄ in the exemplary ion active material of LiFePO₄ or LiMnPO₄ can be considered to be “other total ions,” then it becomes impossible to obtain ratios of 2:1, 3:1, 10:1, and as high as 25:1 because Fe, Mn, and/or PO₄ within a lithium ion active material will always be present at a higher mole ratio compared to Li, not vice versa as required by the claims. *Id.*, 1:31-35, Claim 3; LGES-1003, ¶21.

IV. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. [GROUND 1A/1B] – CLAIMS 1-4 AND 7-18 ARE OBVIOUS OVER OHATA AND KAVAN IN VIEW OF GONG OR LIU

The sections below provide an introduction to Ohata, Kavan, Gong, Liu and their combination.² LGES-1003, ¶22.

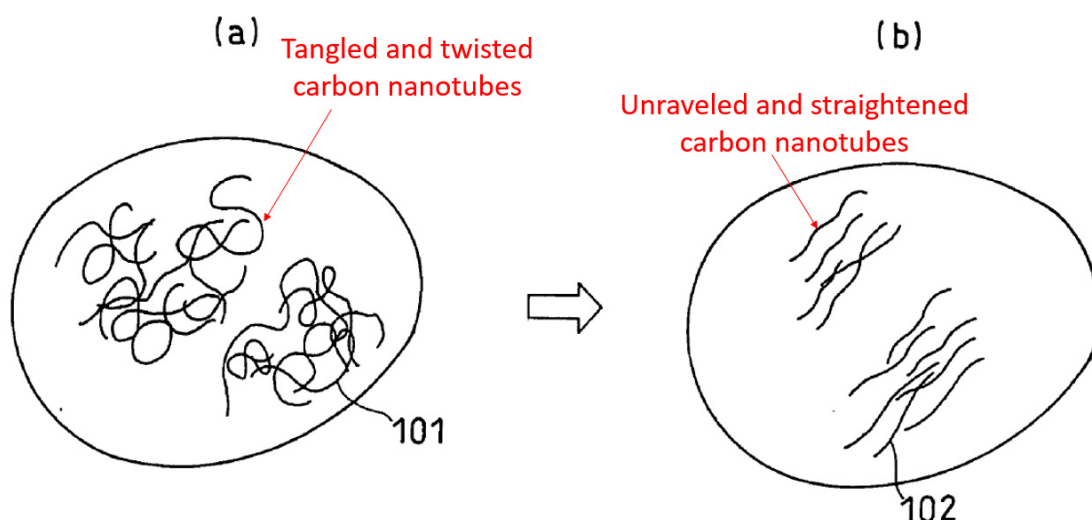
1. Ohata describes a nanotube-containing paste for lithium ion batteries

Ohata describes composites of carbon nanotubes and either positive or negative electrode active materials for use as electrodes in lithium ion batteries. These composites form “an electrode superior in conductivity with a small amount of conductive material, yet with high capacity.” LGES-1004, [0004]; LGES-1003, ¶23.

Ohata prepares its composites by first “producing a masterbatch by blending at least carbon nanotubes with a resin,” such as a fluorocarbon resin, *e.g.*, PVDF. LGES-1004, [0015], [0022]. In this process, carbon nanotubes that are initially “tangled and twisted with one another” (FIG. 1(a), *infra*) are “unraveled and straightened by blending them with a resin” such that they are “dispersed” in the resin (FIG. 1(b)). *Id.*, [0016]-[0017]. This morphology “form[s] an excellent conductive path in an electrode” and “serves to increase the mechanical strength of an electrode plate.” *Id.*; LGES-1003, ¶24.

² Petitioner incorporates this discussion into Ground 1A/1B.

FIG. 1



LGES-1004, FIG. 1 (annotated)

Subsequently an “electrode material mixture paste” is formed by mixing “the masterbatch and an electrode active material with a dispersion medium.” LGES-1004, [0023]. The electrode active material can be a positive electrode active material (*e.g.*, lithium metal oxides) or negative electrode active material (*e.g.*, graphite or other carbonaceous material, or an alloy such as a Si—Ni alloy). *Id.*, [0026]-[0027]. The electrode material mixture paste is applied “onto an electrode substrate” to form an “electrode plate” for use in a battery, such as a lithium secondary battery. *Id.*, [0025]; LGES-1003, ¶25.

Ohata indicates that the size of the nanotubes impacts the conductivity of the electrode, and provides suitable size ranges for the diameter and length of the nanotubes. *See* LGES-1004, [0018]-[0020]; LGES-1003, ¶26. Specifically, Ohata

states that “[t]he carbon nanotubes preferably have an aspect ratio ... of not less than 100” and “not greater than 1000,” explaining that “[w]hen the aspect ratio is too small, excellent conductive paths may not be formed in some electrodes,” while “when the aspect ratio is too large, the carbon nanotubes are unlikely to be straightened sufficiently even after a resin is blended thereto.” LGES-1004, [0020]. The ratio of nanotubes to electrode active material is also relevant for electrode performance: “[t]he amount of the carbon nanotubes contained in the electrode material mixture is, for example, 0.2 to 3 parts by weight per 100 parts by weight of the electrode active material,” and “is preferably not greater than 0.8 parts by weight” “[i]n order to obtain a high-capacity electrode.” *Id.*, [0024]; LGES-1003, ¶26.

2. Kavan describes composite materials containing oxidized nanotubes for use in lithium ion batteries

Kavan describes multi-walled carbon nanotubes (MWNTs) functionalized by oxygen-containing groups (*e.g.*, carboxylic groups) used in composites with either positive electrode active materials or negative electrode active materials, for use as electrodes in lithium ion batteries. *See* LGES-1005, 1. Kavan sets out its “central motivation” as a desire to gain an “understanding ... of the MWNT functionalization (by surface oxidation forming carboxyls) for optimum attachment of MWNT towards titania or olivine surfaces.” *Id.*, 2; LGES-1003, ¶27.

Kavan describes performing “oxidative functionalization” on the MWNTs to produce “MWNT-ox” (“material functionalized by oxidation with HNO₃”).

LGES-1005, 2. Titration analysis of the oxidized nanotubes indicates that “[t]he amount of acid groups in the nanotubes was found to be 2.54×10^{-4} mol g⁻¹ in MWNT-ox, and close to 0 in MWNT-bl.”³ *Id.* Moreover, “[t]he amount of atomic oxygen present on the MWNT-ox surface was also analyzed by X-ray photoelectron spectroscopy” and “gave a value of 7%.” *Id.*, 4; LGES-1003, ¶28.

Oxidized nanotubes were mixed with “a powder material (TiO₂, LiMnPO₄ or LiFePO₄),” as were non-functionalized nanotubes as a control, “in a proportion of 1-10wt% of nanotubes in the mixture,” and pastes were prepared using the resulting material. LGES-1005, 2. The structure, composition, and electrochemical behavior of the resulting composites were characterized. LGES-1003, ¶29.

Incidentally, when TiO₂ is used as a negative electrode active material, Kavan’s results indicate that “the interaction of [oxidized] nanotubes with titania is excellent” and that “[a]ll nanotubes are covered with individual nanocrystals of P90 [titania] in a homogeneous nanocomposite.” LGES-1005, 3; *see* Fig. 2. These

³ “MWNT-bl” refers to a control sample of “non-functionalized blank material.”

LGES-1005, 2.

data “support the idea that oxidative functionalization through HNO₃ is crucial for proper anchoring of nanotubes towards TiO₂.” *Id.*, 4. Cyclic voltammetry data (*see* Fig. 5) demonstrates “[t]he beneficial effect of nanotube networking” in the composites of TiO₂ and oxidized nanotubes; specifically, “the rate of electrochemical charge transfer is higher due to nanotube networking.” *Id.*, 5, 9. The cyclic voltammetry results also reveal new “pseudocapacitive features in the TiO₂/MWNT-ox composite” that are enabled by “the interactions between the oxidized (carboxylated) surface of the carbon nanotubes and TiO₂.” *Id.*; LGES-1003, ¶30.

For the case of phosphate olivines as a positive electrode active material, Kavan describes that structurally “naked nanotubes are easily recognized between the individual crystals” of LiMnPO₄ or LiFePO₄. LGES-1005, 4; *see* Fig. 3. Functionally, cyclic voltammetry demonstrates that “the oxidative treatment of nanotubes improves the reversibility of LiMnPO₄ charge/discharge,” and that “the improvement” in electrochemical activation of LiFePO₄ “caused by surface oxidation of nanotubes is dramatic.” *Id.*, 7; *see* Figs. 7-8; LGES-1003, ¶¶31-33. Overall, Kavan concludes that “the functionalization of nanotubes is ... crucial for enhancing the electrochemical activity of the composite materials with LiFePO₄.” *Id.*, 8; LGES-1003, ¶31.

3. Gong and Liu each describes lithium position doping in olivine crystal structures for improved performance

Overview of Gong

Gong describes a lithium iron phosphate/carbon composite for use in a lithium-ion battery, where a lithium site of the olivine structure (*i.e.*, lithium iron phosphate) is doped with a metal ion. *See* LGES-1007, pp. 8, 26, 27, Claim 1.⁴ For example, Gong discloses a boron-containing lithium iron phosphate/carbon composite having a chemical formula of $\text{Li}_{1-x}\text{M}_x\text{Fe}_{1-y}\text{N}_y\text{P}_{1-z}\text{Si}_z\text{O}_4 \cdot \xi\text{BO}_2/\text{C}$, where a metal element M can be doped at the lithium site, and where M is at least one of Mg, Ca, Zn, Al, Cr, V, Ti, Zr and Nb, and $0 \leq x \leq 0.1$. *Id.*, p. 8. In other words, Gong describes a lithium iron phosphate crystal structure where doping is used to replace a portion of the lithium ions with another metal ion. LGES-1003, ¶34.

Additionally, for lithium iron phosphate doped at lithium sites (*e.g.*, $\text{Li}_{0.98}\text{Zr}_{0.005}\text{FePO}_4$), Gong recognizes that the “changing trends of tapped density and average particle size are similar to those without doping” and further that, compared to undoped lithium iron phosphate, lithium iron phosphate doped at

⁴ CN 101364643 to Gong (LGES-1006) was published in Chinese. Thus, all citations to Gong are to its English translation (LGES-1007).

lithium sites has discharge capacity that is “generally higher.” LGES-1007, pp. 26-27.

Gong further recognizes that “the composite material of the present invention [with lithium iron phosphate doped at lithium sites] has advantages such as low preparation temperature, small average particle size, high tapped density, and good rate charge and discharge characteristics.” *Id.*, p. 27. Regarding the carbon source for the composite material, Gong discloses that “a carbon nanotube, acetylene black, or a carbon black conductive additive” can be used. *Id.*, Claim 7, p. 11; LGES-1003, ¶35.

Overview of Liu

Similar to Gong, Liu is generally directed to “a positive electrode material for a secondary lithium battery ... and specifically relates to an olivine phosphate positive electrode material.” LGES-1009, [0001], Abstract.⁵ With regard to “[t]ransition metal lithium phosphates (LiMPO_4 , $M = \text{Fe, Co, Mn, or Ni}$) having an olivine structure,” Liu recognizes common disadvantages such as “low electron conductivity and low ion conductivity.” *Id.*, [0002]. Liu goes on to disclose that “doping Li sites ... with aliovalent ions [can] improve the electron conductivity and

⁵ CN 102456881 to Liu (LGES-1008) was published in Chinese. Thus, all citations to Liu are to its English translation (LGES-1009).

ion conductivity of the material.” *Id.*, [0003]. In this way, similar to Gong, Liu recognizes that lithium iron phosphate doped at lithium sites can lead to various performance improvements for lithium-ion battery systems. LGES-1003, ¶36.

In one example, Liu discloses an olivine phosphate positive electrode material mixed with carbon nanotubes, where the positive electrode materials are particles having an olivine crystal structure and having the following chemical composition : $\text{Li}_x\text{A}_a\text{M}_m\text{B}_b\text{PO}_z\text{N}_n$, where “doping element A is selected from at least one of Na, Mg, Ti, V, Cr, Cu, Mn, Co, Ni, Zn, Ga, In, Ge, W, Hg, Au, Ag, Nb, and Zr.” LGES-1009, [0010]-[0013], Claim 1; LGES-1003, ¶37. That is, similar to Gong, Liu discloses lithium iron phosphate olivine crystal particles that are doped at lithium sites with various types of metals. LGES-1003, ¶37. Regarding its carbon nanotubes, Liu discloses that they can be “single-walled or multi-walled” and “hav[e] a diameter of 0.5 to 200 nm and an aspect ratio of 20 to 10000.” LGES-1009, [0025], Claim 6.

4. Combinations of Ohata, Kavan, Gong, and Liu

In the sections that follow, the base Ohata-Kavan combination as well as the subsequent Ohata-Kavan-Gong (Ground 1A) and the Ohata-Kavan-Liu (Ground 1B) combinations are described.

Ohata-Kavan Combination

The Ohata-Kavan combination composition uses the teachings of Ohata as a starting point. LGES-1003, ¶38. For instance, “an electrode material mixture containing the masterbatch and an electrode active material” is blended with “a dispersion medium” to form “[a]n electrode material mixture paste.” LGES-1004, [0023]. The masterbatch contains carbon nanotubes dispersed in a resin, where the aspect ratio of the nanotubes is between 100 and 1000, as taught by Ohata. *See id.*, [0015], [0020]. The ratio of carbon nanotubes to electrode active material is also consistent with Ohata’s teachings, *e.g.*, “[t]he amount of the carbon nanotubes contained in the electrode material mixture is, for example, 0.2 to 3 parts by weight per 100 parts by weight of the electrode active material,” and “is preferably not greater than 0.8 parts by weight,” which Ohata indicates is sufficient “to obtain a high-capacity electrode.” *Id.*, [0024]; LGES-1003, ¶38.

Based on the teachings of Kavan, the carbon nanotubes used in the masterbatch of the combination are oxidized, as discussed in the next paragraph. *See* LGES-1005, Abstract, 2, 4; LGES-1003, ¶39. Also based on the teachings of Kavan, the electrode material is a phosphate olivine such as LiMnPO_4 or LiFePO_4 (for a positive electrode composition). *See* LGES-1005, Abstract; LGES-1003, ¶39.

In the Ohata-Kavan combination, the carbon nanotubes used in preparation of the masterbatch (*see* LGES-1004, [0015]) are functionalized, *e.g.*, “by

carboxylic groups,” as taught by Kavan. LGES-1005, Abstract; LGES-1003, ¶40.

For instance, the nanotubes are exposed to the “oxidative functionalization” process described by Kavan, in which the nanotubes are “functionalized by oxidation with HNO₃” such that “[t]he amount of atomic oxygen present” on the nanotube surface is “7%.” *Id.*, 2, 4. These oxidized nanotubes are then “unraveled and straightened by blending them with a resin” to form a masterbatch, consistent with the process described by Ohata. LGES-1004, [0016]. For instance, “the carbon nanotubes contained in the masterbatch” are present in an amount of “5 to 20 parts by weight per 100 parts by weight of the resin.” *Id.*, [0021]; LGES-1003, ¶41.

As taught by Ohata, “an electrode material mixture containing the masterbatch and an electrode active material” is blended with “a dispersion medium” to form “[a]n electrode material mixture paste.” LGES-1004, [0023]; LGES-1003, ¶42. Ohata indicates that “[t]he positive electrode active material” or “[t]he negative electrode active material to be used” in the electrode material mixture “varies depending on the battery type.” LGES-1004, [0026]-[0027]. Consistent with this flexibility, in the Ohata-Kavan combination, a positive electrode material mixture paste is formed using a phosphate olivine, *e.g.*, LiFePO₄ or LiMnPO₄, as taught by Kavan. *Id.*, 2. The resulting “electrode material mixture paste” can be used to form “[a]n electrode plate,” *e.g.*, for a lithium ion battery.

LGES-1004, [0025]; LGES-1003, ¶43. For instance, when TiO_2 is used as the electrode active material, the resulting electrode is a negative electrode for a lithium ion battery. As an alternative, when a phosphate olivine is used as the electrode active material, the resulting electrode is a positive electrode for a lithium ion battery. LGES-1003, ¶43.

Ohata-Kavan-Gong and Ohata-Kavan-Liu Combinations

The Ohata-Kavan-Gong and Ohata-Kavan-Liu combinations each build on the Ohata-Kavan combination. LGES-1003, ¶44. Specifically, in the Ohata-Kavan combination as noted above, a POSITA would have found it obvious to form a positive electrode material mixture paste using a phosphate olivine, *e.g.*, LiFePO_4 or LiMnPO_4 . LGES-1005, 2. The resulting “electrode material mixture paste” can be used to form “[a]n electrode plate,” *e.g.*, for a lithium ion battery. LGES-1004, [0025]; LGES-1003, ¶44. For instance, when a phosphate olivine is used as the electrode active material, the resulting electrode is a positive electrode for a lithium ion battery. LGES-1003, ¶44. Similarly, when TiO_2 is used as the electrode active material, the resulting electrode is a negative electrode for a lithium ion battery. *Id.*

As described *supra*, Gong discloses that the performance of such phosphate olivine electrode materials, as in Ohata-Kavan, can be improved through doping by replacing a portion of the lithium ions in the phosphate olivine electrode active

material with another, non-lithium metal ion. LGES-1007, 8, 26-27; LGES-1003,

¶45. Liu similarly discloses that the phosphate olivine electrode materials as in Ohata-Kavan can be improved by doping at lithium sites with various types of metals. LGES-1009, [0002]-[0003], [0010]-[0013], Claim 1; LGES-1003, ¶45.

Thus, for reasons further detailed below, a POSITA would have been motivated to apply doping to the positive electrode material of Ohata-Kavan (*i.e.*, a phosphate olivine such as LiFePO_4 or LiMnPO_4) as taught by either of Gong or Liu to obtain battery electrodes with improved performance. LGES-1003, ¶46.

5. Reasons for the combination

Reasons for incorporation of oxidized nanotubes

A POSITA would have been motivated to use oxidized nanotubes in the Ohata-Kavan electrode material mixture paste for at least the following reasons. LGES-1003, ¶¶47-55.

First, when the electrode material mixture paste is a positive electrode material mixture paste having a phosphate olivine as the active material (*see* LGES-1005, 2), electrochemical performance of an electrode is improved by the presence of oxidized nanotubes. LGES-1003, ¶48. For instance, Kavan reports that “the LiFePO_4 olivine exhibits excellent performance in a composite with MWNT-ox,” with “impressive values” for the capacity of the LiFePO_4 /MWNT-ox composite LGES-1005, 7; *see id.* (describing that in the LiFePO_4 /MWNT-ox

composite “[t]he improvement caused by surface oxidation of nanotubes is dramatic”), 8, Figs. 8 and 10. A POSITA would have been motivated to incorporate oxidized nanotubes into the combination positive electrode material mixture paste to achieve the dramatic performance advantages taught in Kavan. LGES-1003, ¶48.

Second, a POSITA would have been motivated to use oxidized nanotubes in furtherance of Ohata’s goal to have well-dispersed nanotubes in the composite. LGES-1003, ¶49. Ohata’s masterbatch process is designed to generate an electrode material paste with dispersed nanotubes, *e.g.*, because of the electrical and mechanical advantages they provide: “The unraveled and straightened carbon nanotubes 102 are expected to form an excellent conductive path in an electrode even if the amount thereof is small. The resin with the unraveled and straightened carbon nanotubes dispersed therein also serves to increase the mechanical strength of an electrode plate.” LGES-1004, [0016]-[0017]; LGES-1003, ¶49. Oxidized nanotubes, as in Ohata, are generally consistent with this objective: they are more readily dispersible than unfunctionalized nanotubes, *e.g.*, because the functional groups provide both chemical and physical hindrance against agglomeration. LGES-1003, ¶¶50-51 (citing LGES-1035, 1854; LGES-1014, 821-822; LGES-1015, 4186-4187; LGES-1016, [0027]). A POSITA would have been motivated to use oxidized nanotubes in the masterbatch process because doing so is consistent

with, and can enhance, Ohata's goal of a masterbatch with nanotubes dispersed therein. LGES-1003, ¶52.

Third, a POSITA would have been motivated to use oxidized nanotubes in the combination electrode material mixture paste because oxidative treatments can "remove amorphous carbon and metallic impurities from as-produced CNTs [carbon nanotubes]," thus leading to a higher-purity starting material. LGES-1010, 2; LGES-1003, ¶53.

Fourth, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (oxidized nanotubes in an electrode composition) to a known structure (Ohata's electrode material paste, which already includes nanotubes) to yield predictable results (a electrode material paste including oxidized nanotubes). LGES-1003, ¶54; *see KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007) (a supposed invention that "simply arranges old elements with each performing the same function it had been known to perform" is obvious).

A POSITA would have expected success in incorporating oxidized nanotubes into the Ohata-Kavan electrode material mixture paste for at least the following reasons. LGES-1003, ¶56.

First, use of oxidized nanotubes in compositions for lithium ion battery electrodes was conventional. *See* LGES-1005, Abstract, 9; LGES-1025, 3:28-52; LGES-1003, ¶57.

Second, the composition of Kavan's slurry is generally similar to the composition of Ohata's electrode material paste. LGES-1003, ¶58. For instance, both use a fluorocarbon resin such as polyvinylidene fluoride (PVDF) and a dispersant/solvent such as N-methyl-2-pyrrolidone, and both mix the nanotubes with a powder of the electrode active material. *See* LGES-1004, [0022], [0032]; LGES-1005, 2. This similarity would have provided the POSITA with a reasonable expectation that oxidized nanotubes, as taught in the context of Kavan's slurry, would be compatible with Ohata's electrode material paste. LGES-1003, ¶58.

Reasons for use of a phosphate olivine as the electrode active material

A POSITA would have been motivated to use a phosphate olivine as the positive electrode active material in the Ohata-Kavan electrode material mixture paste for at least the following reasons. LGES-1003, ¶59.

First, a POSITA would have recognized phosphate olivines—*e.g.*, specifically LiFePO_4 —as desirable positive electrode active materials specifically in the Ohata-Kavan electrode material mixture paste because of their good electrochemical performance when combined with oxidized nanotubes, as

described by Kavan. LGES-1003, ¶60. Kavan notes that “the LiFePO_4 olivine exhibits excellent [electrochemical] performance in a composite with MWNT-ox,” and specifically, that it “exhibits a capacity of 149 mAhg^{-1} ... and nearly perfect charge/discharge reversibility of 99-100%.” LGES-1005, 7; *see* Abstract (“excellent [electrochemical] performance was found for LiFePO_4 (olivine) in composite materials containing only 2wt% of functionalized nanotubes”); LGES-1003, ¶60 (citing LGES-1042, Abstract).

Second, phosphate olivines are desirable electrode active materials because of their robust safety profile. *See* LGES-1005, 1 (“the phosphate olivines...are promising cathode materials for Li-ion batteries due to high safety”), LGES-1026, [0004] (“olivine-type lithium phosphates are less likely to promote heat generation....”); LGES-1003, ¶61.

Third, phosphate olivines are economically desirable electrode active materials. *See* LGES-1005, 1 (“the phosphate olivines...are promising cathode materials for Li-ion batteries due to...low cost”); LGES-1026, [0004] (“Olivine-type lithium phosphates can be stably supplied relatively easily at low costs”); LGES-1041, 1; LGES-1042, 1; LGES-1003, ¶62.

Fourth, phosphate olivines are desirable positive electrode active materials because they are environmentally friendly and generally non-toxic: “the phosphate olivines ... are promising cathode materials for Li-ion batteries due to ...

environmental tolerability.” LGES-1005, 1; *see also* LGES-1041, 1; LGES-1042, 1; LGES-1003, ¶63.

Fifth, phosphate olivines such as LiFePO_4 have good electrochemical performance, such as high capacity, long cycle life, and stability. *See* LGES-1041, 1; LGES-1042, 1; LGES-1003, ¶64.

Sixth, a POSITA would have been prompted to pursue this implementation because doing so is merely the application of known techniques (a phosphate olivine as an electrode active material in lithium ion battery electrode composition) to a known structure (Ohata’s positive electrode material paste) to yield predictable results (a positive electrode material paste including phosphate olivine as the electrode active material). LGES-1003, ¶65; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in incorporating a phosphate olivine into the Ohata-Kavan electrode material mixture paste for at least the following reasons. LGES-1003, ¶66.

First, use of phosphate olivines in compositions for lithium ion battery positive electrodes was conventional, and phosphate olivines were well-characterized as positive electrode active materials. LGES-1026, [0004]; LGES-1041, Abstract; LGES-1003, ¶67.

Second, Ohata indicates that various positive electrode active material compositions can be used with its positive electrode material mixture paste: “The

positive electrode active material to be used varies depending on the battery type.”

LGES-1004, [0026]. Given this flexibility, and the conventional nature of phosphate olivines as positive electrode active materials as noted *supra*, a POSITA would have expected these materials to be compatible with Ohata’s positive electrode material mixture paste. LGES-1003, ¶68.

Third, the composition of Kavan’s slurry is generally similar to the composition of Ohata’s positive electrode material paste, as previously discussed. *See* LGES-1004, [0022], [0032]; LGES-1005, 2; LGES-1003, ¶69. Such similarity would have provided the POSITA with a reasonable expectation that phosphate olivines, as taught in the context of Kavan’s slurry, could be used with Ohata’s positive electrode material paste. LGES-1003, ¶69.

Reasons for doping the phosphate olivine in the electrode active material to replace lithium with another ion

A POSITA would have been motivated to dope the phosphate olivine in the electrode active material of Ohata-Kavan, as per the teachings of Gong and/or Liu, to replace lithium with another ion. LGES-1003, ¶¶70-74.

First, a POSITA would have recognized that phosphate olivines—*e.g.*, LiFePO_4 —used as an electrode material in Ohata-Kavan can be doped as per the teachings of Gong and/or Liu to obtain improved performance characteristics. LGES-1003, ¶71. Indeed, Ohata notes that its object is “to provide an electrode

superior in conductivity with a small amount of conductive material, yet with high capacity” and further provide one that is “excellent in cycle characteristics.”

LGES-1004, [0004], [0017]. Kavan similarly touts the importance of such improved performance characteristics. LGES-1005, 7, Abstract; LGES-1003, ¶71. Thus, a POSITA would have been motivated to apply lithium site doping to Ohata-Kavan’s phosphate olivine electrode material to attain the performance benefits of such doping as per Gong and/or Liu. LGES-1003, ¶71. Indeed, as noted above, Gong notes that lithium iron phosphate doped at lithium sites can have higher discharge capacity as well as other advantages such as “low preparation temperature, small average particle size, high tapped density, and good rate charge and discharge characteristics.” LGES-1007, pp. 26-27. Similarly, Liu notes that such doping can lead to improved “electron conductivity and ion conductivity.” LGES-1009, [0002]-[0003]. A POSITA would have been motivated to provide one or more of these additional benefits to Ohata-Kavan. LGES-1003, ¶71.

Second, a POSITA would have been prompted to pursue this lithium position doping implementation because doing so is merely the application of known techniques (lithium position doping a phosphate olivine of an electrode active material in lithium ion battery electrode composition) to a known structure (Ohata/Kavan’s positive electrode material) to yield predictable results (a positive

electrode material with improved performance characteristics, such as improved conductivity and cyclability). LGES-1003, ¶72; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in incorporating lithium position doping into the Ohata-Kavan's phosphate olivine electrode material mixture paste for at least the following reasons. LGES-1003, ¶73.

First, use of lithium position doping when synthesizing phosphate olivines in compositions for lithium ion battery positive electrodes was conventional, and such doped phosphate olivines were well-characterized as positive electrode active materials. LGES-1011, [0050]-[0051] (Describing a “carbon nanotube doped-lithium iron phosphate composite cathode material [that] was synthesized by using a technique of doping in Li sites ... during synthesis of a lithium iron phosphate cathode material.”; *see also* LGES-1012, Claims 1, 81 82 110, 111, 132; LGES-1003, ¶74. It was further well known to use such doped phosphate olivines in conjunction with carbon nanotubes. LGES-1011, [0050]-[0051]; LGES-1012, Claims 127, 132, 133, 145, 153; LGES-1007, p. 11, Claim 7; LGES-1009, [0025], Claim 6; LGES-1011; LGES-1003, ¶74.

Second, composition of the Li-ion battery electrode material in both Gong and Liu is similar to that of Ohata-Kavan as previously discussed, for instance both being a lithium iron phosphate/carbon nanotube composite as in Ohata-Kavan. *See* LGES-1007, pp. 8, 26, 27, Claim 1; LGES-1009, [0025], Claim 6; LGES-1003,

¶75. Such similarities in terms of both composition and application would have provided the POSITA with a reasonable expectation that doped phosphate olivines, as taught in the context of Gong and/or Liu, could be used with Ohata-Kavan's positive electrode material. LGES-1003, ¶75.

6. Analysis

(i) Claim 1

[1pre] A composition useful for lithium ion batteries comprising:

To the extent the preamble is deemed limiting, the combination of Ohata and Kavan in view of Gong or Liu ("Ohata-Kavan-Gong/Liu") renders it obvious. LGES-1003, ¶76.

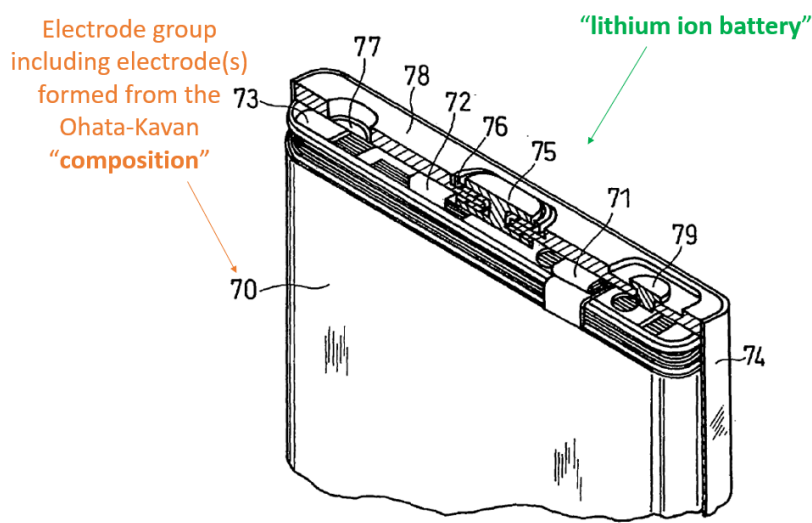
First, the Ohata-Kavan-Gong/Liu combinations render obvious a **composition** based on Ohata's "electrode material mixture paste." LGES-1004, Abstract; *see* [0005]; LGES-1003, ¶77. The combination **composition** includes "a masterbatch comprising at least carbon nanotubes and a resin" and "an electrode active material," as taught by Ohata. LGES-1004, [0005]; *see also id.*, [0022], Abstract, [0016], [0021]-[0022], [0030]-[0032], [0040]-[0042], [0046], claim 1. Consistent with the teachings of Ohata, the electrode active material of the combination composition can be "a positive electrode active material." *Id.*, [0007]; *see* [0026], claim 4. Specifically, in the combination **composition**, the positive electrode active material is implemented as a phosphate olivine, based on the

active material compositions described by Kavan. *See* LGES-1005, Abstract, 2; *see* [1b], *infra*; LGES-1003, ¶77.

Additionally, based on Ohata's teachings, the combination electrode material mixture paste (a **composition**) is used to produce "[a]n electrode for a battery superior in conductivity," *e.g.*, the composition is **useful for batteries**. LGES-1004, Abstract; *see* [0017] (describing that using Ohata's electrode material mixture, "it is possible to produce a secondary battery excellent in cycle characteristics"), [0005], [0015], claim 1; LGES-1003, ¶78. An example of a **lithium ion battery** is illustrated in Ohata's FIG. 2, *infra*, which shows a "prismatic non-aqueous electrolyte secondary battery." LGES-1004, [0036]; LGES-1003, ¶78. This secondary battery includes a positive electrode formed from the combination electrode material mixture (*see* LGES-1004, [0037] ("The positive and negative electrodes produced above"), [0032]) and a "non-aqueous electrolyte" including "LiPF₆ in a solvent mixture comprising ethylene carbonate (EC) and ethylmethyl carbonate (EMC)." *Id.*, [0039]; *see* [0026] ("As ***the positive electrode active material for a lithium secondary battery***, there can be used, for example, a transition metal oxide").⁶

⁶ Emphasis added throughout unless otherwise noted.

FIG. 2



LGES-1004, FIG. 2 (annotated)

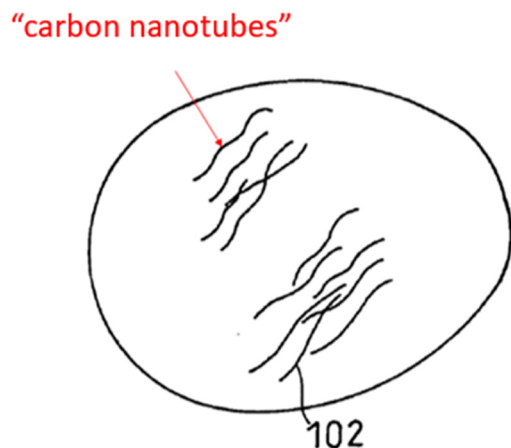
Importantly, even with the implementation of a phosphate olivine as the electrode active material, based on Kavan, the combination composition remains **useful for lithium ion batteries**. LGES-1003, ¶79. Phosphate olivines were conventional electrode active materials for lithium ion batteries, as explained by Dr. Zhu. LGES-1003, ¶79 (citing LGES-1005, 2; LGES-1026, [0004]).

[1a] discrete, non-agglomerated, and exfoliated carbon nanotubes having a surface, and

The combination composition includes carbon nanotubes

Ohata's "masterbatch" includes "***carbon nanotubes*** and a resin," as shown in Fig. 1(b), *infra*. LGES-1004, Abstract; *see* [0015] ("producing a masterbatch by blending at least ***carbon nanotubes*** with a resin"), [0016] ("The ***carbon nanotubes*** are unraveled and straightened by blending them with a resin"), [0017] ("The resin

with the unraveled and straightened **carbon nanotubes** dispersed therein”), [0005], [0006], [0009]-[0010], [0018]-[0022], [0030], claim 1, claim 3; LGES-1003, ¶80.



LGES-1004, Fig. 1(b) (annotated)

The combination composition (based on Ohata’s electrode material mixture paste; *see* [1pre]) is formed by “blending an electrode material mixture containing at least the masterbatch and an electrode active material with a dispersion medium to prepare an electrode material mixture paste.” LGES-1004, Abstract; *see* [0005], [0023], [0032], claim 1; LGES-1003, ¶81. As discussed in the preceding paragraph, the masterbatch includes **carbon nanotubes**. Thus, the **composition** of the Ohata-Kavan-Gong/Liu combinations (based on Ohata’s electrode material mixture paste), which includes the masterbatch, thus likewise include **carbon nanotubes**. *See* LGES-1004, [0024] (“The amount of the carbon nanotubes contained in the electrode material mixture”), [0007]-[0008], [0060]-[0061]; LGES-1003, ¶81.

Ohata describes specific examples of producing a positive electrode material mixture paste (**a composition**) from a masterbatch including **carbon nanotubes**: “Fifteen parts by weight of *carbon nanotubes* and 85 parts by weight of polyvinylidene fluoride as a resin component were blended in an extruder to produce a masterbatch,” and “[a] positive electrode material mixture paste was prepared by mixing 3.3 parts by weight of the resultant masterbatch, 100 parts by weight of lithium cobalt oxide (LiCoO₂) as an active material and 45 parts by weight of N-methyl-2-pyrrolidone.” LGES-1004, [0030], [0032]; *see* [0040]-[0042]; LGES-1003, ¶81.

The carbon nanotubes in the combination composition are discrete, non-agglomerated, and exfoliated

The **composition** of the Ohata-Kavan-Gong/Liu combinations (based on Ohata’s electrode material mixture paste) include a masterbatch, which contains **discrete/non-agglomerated/exfoliated**⁷ nanotubes, as taught by Ohata. LGES-1003, ¶82. Specifically, Ohata describes “producing a masterbatch by blending at least carbon nanotubes with a resin.” LGES-1004, [0015]. Prior to this blending,

⁷ In the ’282 Patent, which is another MRD patent from the inventors of the instant ’483 Patent, its “*discrete* carbon nanotubes” are noted as being “*alternatively termed exfoliated* carbon nanotubes.” LGES-1012, 6:50-57.

the nanotubes “are tangled and twisted with one another,” as illustrated in Ohata’s FIG. 1(a). *Id.*, [0016]. In the process of “blending them with a resin” to form the masterbatch, “[t]he carbon nanotubes are *unraveled and straightened*,” as shown in FIG. 1(b), *infra. Id.* The result is a “resin with the unraveled and straightened carbon nanotubes *dispersed therein*.” *Id.*, [0017]; *see* [0016] (“The unraveled and straightened carbon nanotubes 102 are expected to form an excellent conductive path in an electrode”), [0022] (“As the resin in which *the carbon nanotubes are dispersed*, a fluorocarbon resin can be used”), [0002] (“in order to reduce the amount of conductive material used, it is proposed to use a masterbatch process, whereby *a conductive material is uniformly predispersed in a binder*, in the production of a positive electrode”); LGES-1003, ¶82. For instance, to the extent **discrete** is interpreted as referring to nanotubes that are generally uniformly dispersed or individually distinct, a POSITA would have found it obvious that at least some these “unraveled and straightened carbon nanotubes” are **discrete** because they are generally uniformly “dispersed” as individual, distinct nanotubes (separated into individual tubes) in the resin, as described and illustrated by Ohata. LGES-1004, [0017]; LGES-1003, ¶82.

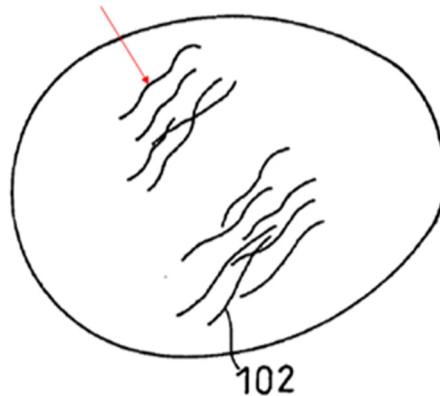
A POSITA would have recognized and/or otherwise found it obvious that—in view of Ohata’s description of its nanotubes as being “unraveled and straightened carbon nanotubes” and generally “dispersed” as individual nanotubes

in the resin, and further in view of its illustrative schematic (below)—Ohata’s nanotubes are discrete, non-agglomerated, and exfoliated. LGES-1003, ¶83.

Indeed, a POSITA would understand a carbon nanotube that is, as shown below, fully isolated from others to be discrete, non-agglomerated, and exfoliated. *Id.*

The carbon nanotubes in the combination have a surface because, among other things, Kavan discloses functionalizing the *surface* of its nanotubes. *See* LGES-1005, 2, 4; LGES-1003, ¶83.

“discrete, non-agglomerated, and exfoliated
carbon nanotubes”



LGES-1004, Fig. 1(b) (annotated)

Alternatively/additionally, a POSITA would have understood or found obvious that the nanotubes in the combination composition are **discrete/non-agglomerated/exfoliated** because, at least in some instances, oxidation of nanotubes can help promote non-agglomeration of the nanotubes. *See* [1e], *infra*; LGES-1003, ¶84. The sidewalls of oxidized nanotubes are functionalized by

species such as carboxylic acid or hydroxyl groups. *See* LGES-1010, Abstract; LGES-1014, 821-822; LGES-1015, 4186-4187; LGES-1016, [0027]-[0028]; LGES-1003, ¶84. As indicated by these references and as explained by Dr. Zhu, “the presence of these functionalities can contribute to physically and chemically inhibiting aggregation of nanotubes into clumps; instead, oxidized nanotubes are generally present as individually distinct nanotubes.” LGES-1003, ¶84. In light of this well-known behavior of oxidized nanotubes, a POSITA would have understood or found obvious that oxidized nanotubes of the combination composition can be present as generally individually distinct nanotubes, *e.g.*, that the nanotubes are **discrete, non-agglomerated, and exfoliated**. *Id.*

[1b] mixtures of ion active materials comprising migratable ions said materials comprising crystals or layers of lithium ion active material,

The combination composition (based on Ohata’s electrode material mixture paste; *see* [1pre]) is formed by “blending an electrode material mixture containing at least the masterbatch and *an electrode active material* with a dispersion medium to prepare an electrode material mixture paste.” LGES-1004, Abstract; *see* [0005], [0023], [0032], claim 1, claims 8-10. The electrode active material, *e.g.*, either a “positive electrode active material” or a “negative electrode active material,” including one that is a doped phosphate olivine crystal that as per the teachings of

Kavan/Gong/Liu as discussed *infra*, corresponds to the claimed mixture of lithium ion active materials. LGES-1004, [0026]-[0027]; LGES-1003, ¶85.

Consistent with the teachings of Kavan, these phosphate olivine electrode materials are present in the combination composition as **crystals**: “the naked nanotubes are easily recognized between the *individual crystals of LiMnPO₄* ... as well as between *LiFePO₄ crystals*.” LGES-1005, p.4; *see id.* (“the *olivine crystals* are typically hundreds of nm in size”), p.1 (“Carbon nanotubes form conductive composites with inorganic *nanocrystals*”); LGES-1003, ¶86. Moreover, olivine electrode materials contemplated in the combination, such as LiMnPO₄ and LiFePO₄, are mentioned in the ’483 Patent as being “[e]xamples of ion active materials.” LGES-1001, 4:35-38.

A POSITA would also recognize that the Li⁺ ions present within either LiMnPO₄ or LiFePO₄ are migratable ions. *See* LGES-1001, 4:27-38 (“The migrating ion is preferably lithium ion....”); LGES-1003, ¶87. A POSITA would further recognize that the ions used for lithium position doping, as per Gong and/or Liu, to take the place of the migratable lithium ions within the phosphate olivine material—including but not limited to Mg (magnesium), Na (sodium), Al (aluminum), Ni (nickel), Hg (mercury), Au (gold), and Ag (silver)—are examples of migratable ions because they are taking the place of migratable lithium ions (as opposed to other ions such as manganese and iron that are fixed within the olivine

crystal structure). LGES-1003, ¶87 (citing LGES-1027, 3; LGES-1028, 1-4; LGES-1029, 5-6). Moreover, the above-mentioned ions (*i.e.*, Mg, Na, Al, Ni, HG, Au, Ag) “and the like” are listed in the ’483 Patent as being examples of migratable ions in this context. LGES-1001, 4:32-34.

[1c] wherein a ratio of lithium ion to other total ions in the ion active materials is at least 2:1 to 25:1, and

As discussed above, a POSITA would have understood “a ratio of lithium ion to other total ions in the ion active materials” in the context of the ’483 Patent to refer to the ratio of lithium ions to other (*i.e.*, non-lithium) migratable ions.

LGES-1003, ¶88. Under such an interpretation, Ohata-Kavan-Gong/Liu renders obvious limitation [1c]. *Id.*

Specifically, the ion active material contemplated in the Ohata-Kavan combination includes a positive electrode material mixture paste formed using a phosphate olivine, *e.g.*, LiFePO_4 or LiMnPO_4 , as taught by Kavan. LGES-1005, 2; LGES-1003, ¶89.

Referring first to the Ohata-Kavan-Gong combination (Ground 1A), as discussed above, Gong discloses replacing Li within the phosphate olivine structure of Ohata-Kavan with other migratable ions M (*i.e.*, $\text{Li}_{1-x}\text{M}_x$) such that ***x is between 0 and 0.1***. LGES-1007, Claim 1, p. 8; LGES-1003, ¶90. Applied to the phosphate olivine electrode material of Ohata-Kavan, the resulting composition of

the ion active material would then become, for example, $\text{Li}_{1-x}\text{M}_x\text{FePO}_4$ or $\text{Li}_{1-x}\text{M}_x\text{MnPO}_4$, where M_x corresponds to the doped, migratable ion that takes the place of some of the lithium ions. LGES-1003, ¶90. In one example, by setting the value of x to 0.1 (which is between 0 and 0.1), the ratio of lithium ions to other migratable ions in the resulting $\text{Li}_{0.9}\text{M}_{0.1}\text{FePO}_4$ or $\text{Li}_{0.9}\text{M}_{0.1}\text{MnPO}_4$ is **9:1**. *Id.* And by setting the value of x to 0.04 (which is between 0 and 0.1), the resulting ratio of lithium ions to other migratable ions in $\text{Li}_{0.96}\text{M}_{0.04}\text{FePO}_4$ or $\text{Li}_{0.96}\text{M}_{0.04}\text{MnPO}_4$ is **24:1**. *Id.* Accordingly, the range of the claimed ratio as disclosed by Ohata-Kavan-Gong falls within “at least 2:1 to 25:1” as claimed in [1c]. *Id.*

Referring now to the Ohata-Kavan-Liu combination (Ground 1B), as discussed above, Liu discloses replacing Li within the phosphate olivine structure of Ohata-Kavan with other migratable ions A (*i.e.*, Li_xA_a) such that **x is between 0.9 and 1.8 and a is between 0 and 0.1**. LGES-1009, [0010]-[0013], Claim 1; LGES-1003, ¶91. Applied to the phosphate olivine electrode material of Ohata-Kavan, the resulting composition of the ion active material would then become, for example, $\text{Li}_x\text{A}_a\text{FePO}_4$ or $\text{Li}_x\text{A}_a\text{MnPO}_4$, where A_a corresponds to the doped, migratable ion that takes the place of some of the lithium ions. LGES-1003, ¶91. In one example, assuming the metal A has the same positive charge as lithium, by setting the value of x to 0.909 (which is between 0.9 and 1.8) and the value of a to 0.091 (which is between 0 and 0.1), the ratio of lithium ions to other migratable

ions in the resulting $\text{Li}_{0.909}\text{A}_{0.091}\text{FePO}_4$ or $\text{Li}_{0.909}\text{A}_{0.091}\text{MnPO}_4$ is **10:1**. *Id.* And by setting the value of x to 0.9615 (which is between 0.9 and 1.8) and the value of a to 0.0385 (which is between 0 and 0.1), the ratio of lithium ions to other migratable ions in the resulting $\text{Li}_{0.9615}\text{A}_{0.0385}\text{FePO}_4$ or $\text{Li}_{0.9615}\text{A}_{0.0385}\text{MnPO}_4$ is **25:1**. *Id.* Accordingly, the range of the claimed ratio as disclosed by Ohata-Kavan-Liu falls within “at least 2:1 to 25:1” as claimed in [1c]. *Id.*

As Dr. Zhu explains, a POSITA would have known that a dopant that takes the place of Li can be considered to be a migratable ion, while a dopant that takes the place of transitional metals, such as Fe or Mn, would not be, as such a dopant is immobilized within the crystal structure of the active material. For instance, Na, which is mentioned as an example dopant material and migrating ion, is commonly known to be migratable and further intercalating, similar to Li ions. LGES-1003, ¶87 (citing LGES-1027, 3; LGES-1028, 1-4; LGES-1029, 5-6).

Notably, the '483 Patent provides no indication of criticality or unexpected results associated with the claimed range of ion ratios. LGES-1003, ¶92. Thus, the overlapping range of ratios of the Ohata-Kavan-Gong/Liu combinations present a *prima facie* case of obviousness of the claimed range. *See In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003) (“A *prima facie* case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art”); *In re Geisler*, 116 F.3d 1465, 1469–70 (Fed. Cir. 1997).

[1d] wherein the discrete carbon nanotubes have crystals or layers of lithium ion active material ionically attached to their surface and

Ohata-Kavan-Gong/Liu renders obvious [1d]. LGES-1003, ¶93. For example, the positive electrode active material (the **ion active material**) in the Ohata-Kavan electrode material is a phosphate olivine such as LiMnPO_4 or LiFePO_4 based on Kavan's teachings of forming a "paste" including "*nanotubes*" and "*LiMnPO₄ or LiFePO₄*." LGES-1005, 2; LGES-1003, ¶93; *see* LGES-1004, [0026] ("The positive electrode active material ... varies depending on the battery type"); LGES-1005, 2 (describing use of "carbon-free olivines, LiFePO_4 or LiMnPO_4 in fabricating samples), 4 ("Fig. 3 shows the morphological features of our olivine/MWNT-ox composites"), 6 ("Fig. 6 shows a series of cyclic voltammograms of $\text{LiMnPO}_4/\text{MWNT-ox}$ composite"), 7 ("Fig. 8 shows cyclic voltammograms" for "[t]he composite $\text{LiFePO}_4/\text{MWNT-ox}$ "), 7 ("Fig. 9 shows a series of cyclic voltammograms for a series of composite materials $\text{LiFePO}_4/\text{MWNT-ox}$ "), 8 ("Fig. 11 shows the initial discharge/charge of $\text{LiMnPO}_4/\text{MWNT-ox}$ at varying charge rates from C/10 to C. A similar plot for $\text{LiFePO}_4/\text{MWNT-ox}$ is shown in Fig. 12"), 9 ("composite materials in which multi-walled carbon nanotubes ... were interfaced to ... LiMnPO_4 and LiFePO_4 ").

Moreover, as per Kavan, the phosphate olivine crystals of the combination are attached to the nanotube surface due at least in part to the surface oxidation of the nanotubes (*see* [1e], *infra*): "The surface oxidation of carbon nanotubes ... was

sometimes mentioned to improve *the anchoring of ... LiMPO₄*.” LGES-1005, 2; *see id.* (“detailed understanding is desirable of the MWNT functionalization (by surface oxidation forming carboxyls) for *optimum attachment of MWNT towards ... olivine surfaces*”), 4 (“the interaction of -COOH with phosphate surface”); LGES-1003, ¶94. Indeed, in Ohata-Kavan-Gong/Liu, as described above in Section IV.A.4 and below for [1e], the carbon nanotubes used in preparation of the masterbatch (*see* LGES-1004, [0015]) are functionalized, *e.g.*, “by carboxylic groups,” as taught by Kavan, and thus capable of becoming attached to the lithium ion active material (*e.g.*, lithium position doped phosphate olivine crystal). LGES-1005, Abstract; LGES-1003, ¶94. Kavan is silent with regard to the type of bond that is formed between the carboxyl group and the olivine material (*i.e.*, lithium ion active material). LGES-1005, 2; LGES-1003, ¶94.

However, a POSITA would have recognized or otherwise found it obvious that the ion active materials of Kavan (*e.g.*, LiFePO₄) would be ionically attached to the surface of Ohata-Kavan’s nanotubes. LGES-1003, ¶95. For example, it was well-known that the oxidized nanotubes, as in Ohata-Kavan, “have a negative electrostatic charge on the outer surface of the nanotube wall” and, thus, a POSITA would have recognized that such “negative electrostatic charge on the outer surface of the nanotube wall” would be used to enhance attachment of positively charged metal ions in the ion active material (*e.g.*, LiFePO₄) to the nanotube surface via an

ionic/electrostatic interaction. LGES-1024, [0057]; *see* LGES-1030 (“These oxygen groups *show an affinity to couple with metal ions* ... via the *interaction of ionic exchange or surface polarity*.”); LGES-1003, ¶95 (citing LGES-1031, 2, FIG. 2g). Thus, a POSITA would have recognized or otherwise found obvious that the negatively charged carboxyl group on the surface of the carbon nanotubes in Ohata-Kavan-Gong/Liu would be electrostatically attracted to and become capable of ionically attaching to the positively charged metal ions (*e.g.*, Fe⁺⁺, Mn⁺⁺, or the like) in the phosphate olivines such as LiMnPO₄ or LiFePO₄. LGES-1003, ¶95.

[1e] wherein the discrete carbon nanotubes comprise oxidized species selected from the group consisting of carboxylic, ketone, or hydroxyl functionalities, and

The Ohata-Kavan-Gong/Liu combination renders obvious [1e]. For example, as described above in Section IV.A.4, the carbon nanotubes in the combination composition are **oxidized** based on the teachings of Kavan. LGES-1003, ¶96. For instance, the nanotubes are “*functionalized by oxidation* with HNO₃.” LGES-1005, 2; *see id.* (“For *oxidative functionalization*, 1 g of purified nanotubes was mixed with 50 mL of 65% HNO₃ and refluxed for 3 h at 120°C under stirring”). The result of this oxidation process is “nanotubes functionalized by carboxylic groups.” *Id.*, Abstract; *see* 2, 4, 9; LGES-1003, ¶96. These oxidized nanotubes are used in preparation of the masterbatch based on Ohata (*see* LGES-

1004, Abstract, [0015]-[0016],) and thus are present in the combination composition. LGES-1003, ¶96.

[1f] wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and

In the Ohata-Kavan-Gong/Liu combination, the nanotubes “have an aspect ratio determined by dividing the average length of the carbon nanotubes by the average diameter of the same of *not less than 100*” and “preferably *not greater than 1000*,” based on the teachings of Ohata. LGES-1004, [0020]; *see* [0006] (“The carbon nanotubes preferably have ... an aspect ratio of not less than 100”), [0009], [0010], claim 2, claims 9-10; LGES-1003, ¶97. For instance, the nanotubes of the combination can have an aspect ratio of **50** (LGES-1004, Table 2, *infra*), **100** (*id.*, [0030], Table 2), or **200** (*id.*, Table 2). LGES-1003, ¶97.

TABLE 2		
	Diameter of CNT (μm)	Aspect Ratio
Ex. 10	0.01	1000
Ex. 11	0.05	200
TABLE 2-continued		
	Diameter of CNT (μm)	Aspect Ratio
Ex. 12	0.05	50
Ex. 13	0.1	100
Ex. 14	0.1	50

CNT: Carbon nanotube

“aspect ratio of 10 to 500”

LGES-1004, Table 2

In the combination, the specific aspect ratios of **50**, **100**, and/or **200** (see LGES-1004, [0030], Table 2) for nanotubes of the Ohata-Kavan-Gong/Liu combination fall within the recited range of aspect ratios (**10 to 500**). LGES-1003, ¶¶98-100. In the combination, these specific aspect ratios disclosed by Ohata are thus a relevant disclosure for the recited range of aspect ratios. See *Ineos USA LLC v. Berry Plastics Corp.*, 783 F.3d 865, 869 (Fed. Cir. 2015) (“When a patent claims a range, as in this case, that range is anticipated by a prior art reference if the reference discloses a point within the range”); *Titanium Metals Corp. of Am. v. Banner*, 778 F.2d 775, 782 (Fed. Cir. 1985); *In re Petering*, 301 F.2d 676, 682, 49 C.C.P.A. 993, 1001, 133 USPQ 275, 280 (1962)). Thus, Ohata-Kavan-Gong/Liu renders obvious that the nanotubes in the combination composition have **an aspect ratio of 10 to 500**.⁸ LGES-1003, ¶98.

Alternatively/additionally, the range of aspect ratios (“**not less than 100**” and “**not greater than 1000**”) for the nanotubes of the Ohata-Kavan-Gong/Liu combination partially overlaps with the recited range of aspect ratios (**10 to 500**). LGES-1003, ¶99. The ’483 Patent provides no indication of criticality or

⁸ Petitioner has applied art consistent with Patent Owner’s assertions in the Infringement Contentions, without necessarily agreeing with Patent Owner’s interpretation of the claim language. See generally LGES-1050.

unexpected results associated with the claimed range of aspect ratios. LGES-1003, ¶99. Thus, the partially overlapping range of ratios of the nanotubes of the Ohata-Kavan-Gong/Liu combination presents a *prima facie* case of obviousness of the claimed range. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

[1g] oxidation levels from 1% to 15% by weight of the carbon nanotube.

As discussed above for [1e], the carbon nanotubes in the Ohata-Kavan-Gong/Liu combination composition are oxidized based on the teachings of Kavan. *See* LGES-1005, 2, 4, Abstract, 9; LGES-1003, ¶101. As further noted, these oxidized nanotubes are used in preparation of the masterbatch based on Ohata (*see* LGES-1004, Abstract, [0015]-[0016],) and thus are present in the combination composition. LGES-1003, ¶101.

The oxidized nanotubes in the combination composition, functionalized as described by Kavan (*see* LGES-1005, 2), have 7% “atomic oxygen present” on their surface as “analyzed by X-ray photoelectron spectroscopy [XPS].” *Id.*, 4; *see* 2; LGES-1003, ¶102. As explained by Dr. Zhu, one method of determining the **oxidation level by weight of the nanotubes** is by calculating the weight of the oxygen atoms attached to the nanotubes divided by the total weight of the oxidized nanotubes. LGES-1003, 103. Based on this method, the specific case of Kavan’s 7 atomic percent oxygen corresponds to an **oxidation level of 9.1% by weight of**

the carbon nanotube, *e.g.*, 9.1% by weight of the oxidized carbon nanotubes is oxygen. LGES-1003, ¶¶103-104.⁹

This oxidation level value (9.1% by weight) (*see* LGES-1005, 4) for nanotubes of the Ohata-Kavan combination falls within the recited range of oxidation levels (**1% to 15% by weight**). LGES-1003, ¶105. In the combination, this specific oxidation level disclosed by Kavan, and applied to the nanotubes of the combination, is thus a relevant disclosure for the recited range of oxidation levels. *See Ineos*, 783 F.3d at 869; *Titanium Metals*, 778 F.2d at 782. Thus, Ohata-Kavan renders obvious a composition in which the nanotubes have **oxidation levels from 1% to 15% by weight of the carbon nanotube**. LGES-1003, ¶105.

Kavan's 9.1% by weight oxidation level is determined by calculating the weight of the oxygen atoms attached to the nanotubes divided by the total weight of the oxidized nanotubes. LGES-1003, ¶103. As Dr. Zhu explains, other approaches are also available to calculate oxidation levels by weight. LGES-1003,

⁹ The '483 Patent states that "[t]he term ... '% by weight' as used herein is calculated by dividing the weight of a reagent by the total weight of a mixture to which it is added subsequent to the addition of the reagent." LGES-1001, 3:65-4:1.

¶104. However, while the '483 Patent does not identify a specific approach for determining oxidation levels, a POSITA would have recognized or otherwise found obvious that the foregoing calculation is one reasonable and well-known way to determine oxidation levels for nanotubes such as those disclosed by Kavan (although there are other calculation methods that would also be reasonable). *Id.*

Moreover, while the oxidation levels of Kavan's nanotubes are measured using XPS (*see* LGES-1005, 4), other experimental techniques are available for measuring oxidation levels of carbon nanotubes. LGES-1003, ¶¶15-17. Again, while the '483 Patent does not identify a specific characterization technique to be used for determining oxidation levels, a POSITA would have recognized or otherwise found obvious that XPS characterization of oxidation levels is one reasonable and well-known way to determine oxidation levels for nanotubes such as those disclosed by Kavan (although there are other methods of characterization that may be appropriate in some circumstances). *See* LGES-1032, 6 ("XPS and EDX were both used to quantify the atomic oxygen concentration following different oxidative treatments"); LGES-1017, 4; LGES-1003, ¶¶15-17.

(ii) Claim 2

[2] The composition of claim 1, wherein the crystals or layers of lithium ion active material comprise a lithium metal salt and an element selected from the

group consisting of: iron, manganese, cobalt, copper, nickel, vanadium, titanium, and mixtures thereof.

In the above-described composition of the Ohata-Kavan-Gong/Liu combination, as described *supra* in [1d], the positive electrode active material (the ion active material) is a phosphate olivine such as LiMnPO_4 or LiFePO_4 based on Kavan's teachings of forming a "paste" including "nanotubes" and "***LiMnPO₄ or LiFePO₄***." LGES-1005, 2; *see also* LGES-1004, [0026]; LGES-1003, ¶106. Both LiMnPO_4 and LiFePO_4 are well-known lithium metal salts, as acknowledged by the '483 Patent. LGES-1001, Claim 3; LGES-1003, ¶106.

As further described above with respect to the combination involving Gong/Liu, the lithium position of such phosphate olivine crystals can further be doped to replace lithium with various types of metals including, but not limited to, ***titanium, copper, and nickel***. *See* LGES-1007, 8, Claim 1; LGES-1009, [0010]-[0013], Claim 1; LGES-1003, ¶107. Thus, the doped phosphate olivine crystals of Ohata-Kavan-Gong/Liu includes crystals of lithium ion active material comprising both a "lithium metal salt" and "an element selected from the group consisting of: iron, manganese, cobalt, copper, nickel, vanadium, titanium, and mixtures thereof," namely titanium, copper, or nickel. LGES-1003, ¶107.

Moreover, phosphate olivines such as LiMnPO_4 and LiFePO_4 each includes a lithium metal salt having an element selected from the group consisting of: ***iron, manganese***, cobalt, copper, nickel, vanadium, titanium, and mixtures thereof, thus

further satisfying the claim limitation even without the additional doping ions.

LGES-1003, ¶107.

(iii) Claim 3

[3] The composition of claim 2, wherein the lithium metal salt has an olivine crystal structure and wherein the lithium metal salt is LiFePO_4 or LiMnPO_4 .

In the above-described composition of the Ohata-Kavan-Gong/Liu combination, as described *supra* in [1d] and [2], the positive electrode active material (*e.g.*, lithium metal salt) is a phosphate olivine having an olivine crystal structure such as LiMnPO_4 or LiFePO_4 based on Kavan's teachings of forming an electrode from "nanotubes" and "***LiMnPO₄ or LiFePO₄***." LGES-1005, 2; *see also* LGES-1004, [0026]; LGES-1003, ¶108. Both LiMnPO_4 and LiFePO_4 are known to have a crystal structure. LGES-1005, 4 ("crystals of LiMnPO_4 " and " LiFePO_4 crystals"); LGES-1003, ¶108.

(iv) Claim 4

[4] The composition of claim 1, wherein the crystals or layers of lithium ion active material comprise tin, silicon, copper, antimony, aluminum, germanium, titanium, or mixtures thereof.

In the above-described composition of the Ohata-Kavan-Gong/Liu combination, as described *supra* in [1b]-[1d], the lithium position of the lithium ion active material (*e.g.*, phosphate olivine crystals) can be doped to replace lithium with various types of metals including, but not limited to, ***copper and***

titanium. See LGES-1007, 8, Claim 1; LGES-1009, [0010]-[0013], Claim 1;
LGES-1003, ¶109.

(v) Claims 7-9

The Ohata-Kavan-Gong/Liu combination renders these claims obvious in the same manner as explained above for the corresponding claims listed in the following table. LGES-1003, ¶¶110-144. Claim elements from Claims 7-9 that are not listed in the table—namely, [7e], [8e], and [9a]—are separately addressed below.

Claim Element from Claims 7-9	Corresponding Claim Element from Claim 1
[7pre]	[1pre]
[7a]	[1a]
[7b]	[1b]
[7c]	[1c]
[7d]	[1d]
[7f]	[1e]
[7g]	[1f]
[7h]	[1g]
[8pre]	[1pre]
[8a]	[1a], [1e]
[8b]	[1b]
[8c]	[1c]
[8d]	[1d]
[8f]	[1e]
[8g]	[1f]

Claim Element from Claims 7-9	Corresponding Claim Element from Claim 1
[8h]	[1g]
[9pre]	[1pre]
[9b]	[1b]
[9c]	[1c]
[9d]	[1d]
[9e]	[1e]
[9f]	[1f]
[9g]	[1g]

[7e] wherein the carbon nanotubes are in a weight ratio of carbon nanotubes to lithium salts of 0.1% to 10% and

In the Ohata-Kavan-Gong/Liu combination composition, the weight percentage of the carbon nanotubes is specified by Ohata, which teaches that “[t]he *amount of the carbon nanotubes* contained in the electrode material mixture is, for example, *0.2 to 3 parts by weight per 100 parts by weight of the electrode active material*. In order to obtain a high-capacity electrode, the amount thereof is preferably *not greater than 0.8 parts by weight*.” LGES-1004, [0024]. Notably, this range of “0.2 to 3 parts by weight” applies to both positive electrode active materials (*see id.*, [0008], [0010], claim 5) and negative electrode active materials (*see id.*, [0007], [0009], claim 4). LGES-1003, ¶115.

Ohata’s weight percentage range (0.2 to 3 parts by weight carbon nanotubes per 100 parts by weight electrode active material) corresponds to the carbon

nanotubes being present in a weight percentage of 0.2% (0.2 parts nanotubes per 100 parts ion active material) to 3.0% (3:100) by weight of the ion active material. LGES-1003, ¶116. Alternatively/additionally, to the extent the weight percentage is based on the total weight of both nanotubes and ion active material,¹⁰ Ohata's weight percentage range corresponds to the carbon nanotubes being present in a weight percentage of 0.2% (0.2 parts nanotubes per 100.2 parts total) to 2.9% (3:103) by weight. LGES-1003, ¶116. As noted above for Claim 2, the ion active material of the Ohata-Kavan-Gong/Liu combination can include lithium salts such as LiMnPO_4 and LiFePO_4 . *Id.*

This range of weight percentages disclosed by Ohata (**0.2% to 3.0%**) falls within the claimed **0.1% to 10% by weight** range recited in claim 4. As such, in the combination, this specific range of weight percentages disclosed by Ohata is a relevant disclosure for the recited weight percentage range, and Ohata-Kavan-Gong/Liu thus renders obvious the claimed range of weight percentages. *See Ineos*, 783 F.3d at 869; *Titanium Metals*, 778 F.2d at 782.

¹⁰ The '483 Patent states that "[t]he term 'weight percent' or 'percent weight' or '% by weight' as used herein is calculated by dividing the weight of a reagent by the total weight of a mixture to which it is added subsequent to the addition of the reagent." LGES-1001, 3:65-4:1; LGES-1003, ¶117.

Ohata also provides specific examples of “[p]ositive electrodes” in which “the content of the carbon nanotubes contained in the masterbatch and the amount of the carbon nanotubes or the masterbatch per 100 parts by weight of the positive electrode active material contained in the positive electrode material mixture paste were changed as shown in Table 1.” LGES-1004, [0040]. Each of the example weight percentages given in Table 1 (highlighted in purple) falls within the claimed **0.1% to 10% by weight** range recited in claim 4. LGES-1003, ¶118.

To the extent that fewer than all of the nanotubes in the Ohata-Kavan composition are discrete carbon nanotubes, a POSITA would have found obvious, given their oxidation level, that they nevertheless constitute a substantial portion of entire population of nanotubes. Thus, a POSITA would have understood, or at least found obvious, that the recited range of weight percentages (“0.1 to 10% by weight”) still overlaps with, and thus is rendered obvious by, the weight percentage of that subset of the nanotubes that are discrete. LGES-1003, ¶¶118-119.

TABLE 1

	Amount of CNT Per 100 parts by weight of active material (parts by weight)	Amount of MB per 100 parts by weight of active material (parts by weight)	CNT content in MB (wt %)
Ex. 1	0.5	3.3	15
Ex. 2	0.2	1.3	15
Ex. 3	0.3	2	15
Ex. 4	0.8	5.3	15
Ex. 5	1.0	6.7	15
Ex. 6	1.5	7.5	20
Ex. 7	2.0	10	20
Ex. 8	3.0	15	20

CNT: Carbon nanotube
MB: Masterbatch

LGES-1004, Table 1 (annotated)

[8e] wherein the carbon nanotubes are uniformly dispersed without clustering on a dimension scale of less than about 1 micrometer and

Ohata-Kavan-Gong/Liu renders obvious [8e]. For example, in Ohata's masterbatch process, "a conductive material is *uniformly predispersed* in a binder." LGES-1004, [0002]. In the combination, this "conductive material" is the oxidized carbon nanotubes, and via Ohata's masterbatch process, the nanotubes are "*uniformly predispersed*" in the resin. *Id.*, [0002]; *see* [0005], [0015]; LGES-1003, ¶128. This masterbatch, with "uniformly predispersed" nanotubes, is then mixed with an electrode active material and a dispersion medium to form the electrode material mixture paste of the combination. LGES-1004, [0002]; *see* [0023]; LGES-1003, ¶128.

In the combination, a POSITA would have understood, or at least found obvious, that the nanotubes remain **uniformly dispersed** in the combination paste. LGES-1003, ¶129. For instance, a POSITA would have recognized that the combination manufacturing process based on Ohata, in which the masterbatch is blended with “an electrode active material” and “a dispersion medium” to form an electrode material mixture paste (LGES-1004, [0023]), would allow the nanotubes in the resulting paste to remain **uniformly dispersed**, as they are in the masterbatch. LGES-1003, ¶129.

Additionally, a POSITA would have understood, or at least found obvious, that the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**.¹¹ Ohata’s Fig. 1(b), again *infra*, which a POSITA would have understood as representative of the nanotube arrangement in the combination paste, as discussed in the previous paragraph, shows that the nanotubes are dispersed **without clustering**, *e.g.*, in that the nanotubes are present as generally individual nanotubes. LGES-1003, ¶130. Thus, because there is no clustering, a POSITA

¹¹ The ’483 Patent provides no substantive discussion of this feature. It is inappropriate to hold the prior art to a stricter standard of disclosure than what is disclosed in the specification of the patent itself. *See In re Epstein*, 32 F.3d 1559, 1568 (Fed. Cir. 1994).

would have understood that the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**. *Id.*

Moreover, although no scale is provided for the Fig. 1(b) schematic illustration, a POSITA would have been able to estimate the scale based on Ohata's disclosure that the nanotubes "have an average length of 1 to 100 μm ." LGES-1004, [0019]; LGES-1003, ¶130. For instance, for nanotubes having a length of 100 μm , the space between the nanotubes is depicted as greater than 1 μm , *e.g.*, the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**. LGES-1003, ¶130. Alternatively/additionally, as confirmed by Ohata's disclosure that the nanotubes are "dispersed," a POSITA further would have understood that the nanotubes in the Ohata-Kavan-Gong/Liu composition do not form clusters of greater than 1 micrometer in size, *e.g.*, the nanotubes are dispersed **without clustering on a dimension scale less than 1 micrometer**. LGES-1003, ¶130.

[9a] uniformly dispersible oxidized, non-agglomerated carbon nanotubes having a surface, and

As discussed above for [1a] and [1e], the Ohata-Kavan-Gong/Liu combination provides oxidized and non-agglomerated carbon nanotubes having a surface. LGES-1003, ¶135. As for such nanotubes being "uniformly dispersible," Ohata describes that in a masterbatch process, "a conductive material is *uniformly*

predispersed in a binder.” LGES-1004, [0002]. Thus, in the combination, this “conductive material” is the oxidized carbon nanotubes, and via Ohata’s masterbatch process, the nanotubes are “**uniformly predispersed**” in the resin. *Id.*, [0002]; *see* [0005] (“producing a masterbatch comprising at least carbon nanotubes and a resin”), [0015] (“producing a masterbatch by blending at least carbon nanotubes with a resin”); LGES-1003, ¶135. This masterbatch, with “uniformly predispersed” nanotubes, is then mixed with an electrode active material and a dispersion medium to form the electrode material mixture paste of the combination. LGES-1004, [0002]; *see* [0023]; LGES-1003, ¶135.

In the combination, a POSITA would have understood, or at least found obvious, that the nanotubes remain **uniformly dispersible** in the combination composition. LGES-1003, ¶136. For instance, a POSITA would have recognized that the combination manufacturing process based on Ohata, in which the masterbatch is blended with “an electrode active material” and “a dispersion medium” to form an electrode material mixture paste (LGES-1004, [0023]), would allow the nanotubes in the resulting paste to remain **uniformly dispersed**, as they are in the masterbatch. LGES-1003, ¶136.

Accordingly, the nanotubes of the combination composition are **uniformly dispersible**. Moreover, the nanotubes are **dispersible** because the combination composition is a paste (based on Ohata’s electrode material mixture paste) that is

“prepared by blending an electrode material mixture containing the masterbatch and an electrode active material with a dispersion medium,” *e.g.*, the masterbatch (containing the dispersed nanotubes) and the electrode active material are dispersible in the dispersion medium at least because the mixture can be blended. LGES-1004, [0023]; LGES-1003, ¶137. Alternatively/additionally, the nanotubes are **dispersible** because they are not attached to a substrate. LGES-1003, ¶138.

(vi) Claim 10

[10] The composition of claim 9, wherein the crystals or layers of lithium ion active materials are chemically attached to the surface of the dispersible oxidized carbon nanotubes.

As explained above for [1d]/[9d], a POSITA would have recognized or otherwise found it obvious that the ion active materials of Kavan (*e.g.*, LiFePO_4) would be ionically attached to the surface of Ohata-Kavan’s nanotubes via an electrostatic interaction. LGES-1003, ¶145. As explained by Dr. Zhu, materials that are “chemically attached” are well understood to be those that are attached covalently, ionically, or by Van der Waals, among others. LGES-1003, ¶145. In other words, ionic bonding is a type of chemical bonding. LGES-1003, ¶145 (citing LGES-1033). Indeed, in its infringement contentions, Patent Owner acknowledges that materials that are “chemically attached” are those that are attached “covalently, ionically, or by Van der Waals.” LGES-1050, 194. Additionally/alternatively, when oxygen groups become attached to the nanotube

surface as per Kavan, “oxygen is chemically bonded with the ends or defects of carbon networks during the oxidation process.” LGES-1030, 2. Thus, the phosphate olivine can be chemically attached to the nanotubes via the oxygen groups. LGES-1003, ¶145.

(vii) Claims 11-18

Ohata-Kavan-Gong/Liu renders obvious Claims 11-18 for the same reasons discussed above for [1c]. LGES-1003, ¶146. For example, as noted above for [1c] and incorporated herein, the Ohata-Kavan-Gong combination (Ground 1A) provides a ratio of lithium ion to other total ions in the ion active materials that ranges, in one example, from 9:1 to 24:1. LGES-1003, ¶146. Similarly, the Ohata-Kavan-Liu combination (Ground 1B) provides the claimed ratio in the range of 10:1 to 25:1. *Id.* Thus, the overlapping range of ratios of the nanotubes of the Ohata-Kavan-Gong/Liu combinations present a *prima facie* case of obviousness of the claimed range. *Id.*; see *In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

B. [GROUND 2] – CLAIMS 1, 2, and 7-18 ARE OBVIOUS OVER OHATA, KAVAN, AND ICHINOSE

As noted above, a POSITA would have understood “a ratio of lithium ion to other total ions in the ion active materials” to refer to the ratio of lithium ions to other (*i.e.*, non-lithium) migratable ions. Indeed, this construction is most

consistent with the '483 Patent itself. *See, e.g.*, LGES-1001, 4:53-59; LGES-1003, ¶¶147-148.

However, in their recently filed infringement contentions of May 15, 2024, Patent Owner appears to advance an apparent construction of this ratio term as meaning a ratio of Li^+ ions to “ PF_6^- or similar Li^+ counter-ion[s].” LGES-1050, 85. Here, PF_6^- (or PF_6^- to be more technically correct) refers to the anion component of LiPF_6 , which is a commonly used *electrolyte* in lithium-ion battery systems. LGES-1003, ¶149. Of course, there is no mention of LiPF_6 or “ PF_6^- or similar Li^+ counter-ion” anywhere in the '483 Patent. *Id.* Moreover, because the electrolyte is not an “ion active material,” it is unclear how Patent Owner can point to anions within the electrolyte as correlating to “other total ions in the ion active materials” as required by the claim language. *See* LGES-1001, 4:23-26; LGES-1003, ¶149. An anion of liquid electrolyte can neither be attached to the carbon nanotubes nor support ion migration into and out of the ion active material’s structure. LGES-1003, ¶149. Indeed, the only examples of ion active materials provided in the '483 Patent are well-known cathode/anode particles such as “lithium iron phosphate, lithium manganese phosphate, lithium cobalt oxide, silica, manganese dioxide, cadmium, titanium dioxide and carbon.” LGES-1001, 4:34-37; *see Synqor, Inc. v. Artesyn Techs., Inc.*, 709 F.3d 1365, 1378-79 (Fed. Cir. 2013) (“A claim construction that excludes the preferred embodiment is rarely, if

ever, correct...) (internal quotations omitted); LGES-1003, ¶149. It is also worth pointing out that the claims of the '483 Patent are merely directed to a “composition useful for lithium ion batteries” and not a full lithium-ion battery (“LIB”) with electrolyte, separator, and a whole host of other battery components. *Id.*

Yet the Patent Owner alleges, in the infringement contentions, that “[g]iven the migratable nature of the Li^+ , its concentration within the cathode varies during charge and discharge processes but is configured to be within a 2:1 to 25:1 ratio at least when at approximately a 44% to 98% state of charge.”¹² LGES-1050, 85. Based on this apparent construction of the ratio term, the ratio limitation is rendered so overly broad that it would be basically be covered by all pre-existing lithium-ion batteries, including those that predate the '483 Patent by over a decade. LGES-1003, ¶150. That is, to the extent Patent Owner argues that the claimed ratio refers to the ratio of Li^+ to PF_6^- or similar Li^+ counter-ions, which Petitioner

¹² Since a “98% state of charge” refers to a state in which most of the migratable Li^+ ions have intercalated into the anode (such that there are fewer Li^+ ions, rendering the ratio of Li^+ to other ions in the cathode lower), PO appears to have meant to say “98% state of *discharge*” (rendering the ratio of Li^+ to other ions in the cathode higher). LGES-1003, ¶150.

does not agree is a proper interpretation of the ratio term in view of the specification, such interpretation would result in the claimed ratio being satisfied by basically all lithium-ion batteries ever in existence. *Id.*

Nevertheless, Petitioner provides here an alternative ground/analysis based on Ohata, Kavan, *and Ichinose* in view of Patent Owner's apparent construction of the ratio term. LGES-1003, ¶¶147-151.

Briefly, Ichinose is generally directed to a “non-aqueous electrolyte secondary battery including an electrode assembly [and] a non-aqueous electrolyte.” LGES-1034, Abstract, [0001]. Notably, Ichinose describes a LIB system that uses electrolyte made from “lithium salt such as LiPF_6 .” *Id.*, [0043], [0002]. More specifically, Ichinose discloses an example electrolyte volume to battery capacities as 0.18 to 1.117 ml/Ah, where the electrolyte used in this patent is 1M LiPF_6 in a mixture of ethylene carbonate and ethyl methyl carbonate (volume ratio 1:3), and where the cathode used in the study is LiCoO_2 , with a theoretical specific capacity of 142 mAh/g. *Id.*, [0049], [0111], [0112]; LGES-1003, ¶152.

1. Analysis

[1c], [7c], [8c], [9c], and [11]-[19]

The Ohata-Kavan base combination, as described above in Section IV.A.4, renders obvious virtually all of the limitations of Claims 1, 2, and 7-19. LGES-

1003, ¶153. Indeed, with the exception of limitations [1c], [7c], [8c], [9c], and [11]-[19], which recite a specific “ratio of lithium ion to other total ions in the ion active materials,” Gong and Liu were not relied upon to reach the claim limitations addressed in Grounds 1A/1B. *Id.* That is, the base Ohata-Kavan combination renders obvious all limitations of Claims 1, 2, and 7-19 *except for* those limitations (*i.e.*, [1c], [7c], [8c], [9c], and [11]-[19]) that require a specific “ratio of lithium ion to other total ions in the ion active materials.” *Id.*

Limitations [1c], [7c], [8c], [9c], and [11]-[19] of Claims 1, 7, 8, 9, and 11-19 recite different ranges of the ratio of lithium ion to other total ions in the ion active materials, including 2:1 to 25:1, 3:1 to 25:1, and 10:1 to 25:1.

Based on example parameters provided in the LIB of Ichinose, Dr. Zhu provides the following exemplary steps to calculate the claimed ratio based on Patent Owner’s apparent construction. LGES-1003, ¶¶154-155.

1 Ah Calculation:

1 Ah equals to 0.0373 moles of electrons, calculated as follows:

$$1 \text{ Ah} = 3600 \text{ C} = 3600 \text{ s} * 1 \text{ A}$$

$$\text{Number of moles of electrons} = 3600 \text{ C} / (96485 \text{ C/mol}) \approx 0.0373 \text{ moles}$$

Lithium Utilization Calculation:

LiCoO₂ cannot use all Li for intercalation. Typically, only around 50% is used. The theoretical specific capacity considering all Li is 274 mAh/g. Ichinose specifies a theoretical specific capacity of 142 mAh/g, implying the cell uses:

$$142 \text{ mAh/g} / 274 \text{ mAh/g} \approx 52\%$$

Thus, 48% of Li cannot be removed from the cathode.

Total Li in Fully Discharged Cathode:

For a 1 Ah battery, the amount of utilized Li is 0.0373 moles. With the LiCoO₂'s specific capacity of 142 mAh/g, the total Li in LiCoO₂ is calculated as follows:

$$0.0373 \text{ moles} / 0.52 \approx 0.0717 \text{ moles}$$

This is the total Li in the fully discharged cathode.

State of Discharge (SoD) Considerations:

At SoD = 100%, all lithium ions are in the cathode. If 52% of Li can be utilized in the cathode, then at SoD = 48%, all removable Li has been removed from the cathode.

Specific SoD Calculations:

For a LIB of 1 Ah, when SoD = x, the total Li in the cathode is $0.0717 * x$ moles.

Among them, the movable Li in the cathode is calculated as:

$$0.0717 * x - 0.0717 * (1 - 0.52)$$

Li ion and counter ions in Electrolytes Calculations:

The Li ion and counter ion in electrolyte depends on the loading of electrolyte (low limit: 0.18 ml/Ah, high limit:1.117ml/Ah)

The Li ion in electrolyte is between:

$$0.18 \text{ ml} * 1 \text{ mol/L} / 1000 = 0.00018 \text{ moles (low limit) and}$$

$$1.117 \text{ ml} * 1 \text{ mol/L} / 1000 = 0.001117 \text{ moles (high limit).}$$

The counter ion PF_6^- in electrolyte is between:

$$0.18 \text{ ml} * 1 \text{ mol/L} / 1000 = 0.00018 \text{ moles (low limit) and}$$

$$1.117 \text{ ml} * 1 \text{ mol/L} / 1000 = 0.001117 \text{ moles (high limit).}$$

Total Movable Li Ion Calculation:

Total movable Li ion in the cathode at $\text{SoD} = x$ plus Li ion in the electrolyte:

Low limit:

$$0.00018 + 0.0717 * x - 0.0717 * (1 - 0.52) \text{ mole}$$

High limit:

$$0.001117 + 0.0717 * x - 0.0717 * (1 - 0.52) \text{ mole}$$

Ratio of Movable Li Ion to PF_6^- :

For $\text{SoD} = x$, the ratio of total movable Li ion to PF_6^- is calculated as follows:

Low limit:

$$(0.00018 + 0.0717 * x - 0.0717 * (1 - 0.52)) / 0.00018$$

High limit:

$$(0.001117 + 0.0717 * x - 0.0717 * (1 - 0.52)) / 0.001117$$

Calculation Results:

SoD	Total Movable Li (Lower Limit)	Total Movable Li (Upper Limit)	Ratio (Lower Limit)	Ratio (Upper Limit)
0.98	0.036030	0.036967	200.166667	33.094897
0.5	0.001614	0.002551	8.966667	2.283796

In view of the sample calculations above, a POSITA would have recognized that the ratio of **(active Li in cathode + Li in electrolyte): PF₆⁻** will, in essentially all standard lithium-ion batteries, eventually fall within the claimed ratio depending on the state of charge (or discharge). LGES-1003, ¶155.

Specifically, the resulting ratio range of ~2.3:1 to ~200:1 overlaps with the claimed ranges of 2:1 to 25:1, 3:1 to 25:1, and 10:1 to 25:1. Thus, such overlapping range of ratios presents a *prima facie* case of obviousness of the claimed range. *Id.*; see *In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

V. PTAB DISCRETION SHOULD NOT PRECLUDE INSTITUTION

A. The *Fintiv* Factors Favor Institution—§314(a)

The Board should not discretionarily deny based on the *Fintiv* factors.

Factor 1 is neutral; neither party has requested a stay in co-pending litigation.

Factor 2 is neutral based on an expected Final Written Decision date in December 2025, which is within a few weeks of the likely trial date. In particular, the median time-to-trial date for EDTX is currently 21.4 months, which would suggest a likely trial date in November 2025. *See*

https://www.uscourts.gov/sites/default/files/fcms_na_distprofile1231.2023_0.pdf,

35. Moreover, the Court set the trial date for December 2025. *See generally* LGES-1053.

Factor 3 favors institution; Petitioner has diligently filed this Petition months ahead of the one-year time bar, while the EDTX litigation is still in its early stages and investment minimal.

Factor 4 favors institution; if the Board institutes trial, Petitioner stipulates not to seek resolution in the district court of the same grounds presented in this Petition.

Factor 5 is neutral; parties in the parallel litigation are the same.

Factor 6 favors institution; the Petition presents a compelling case of invalidity.

B. The *Advanced Bionics* Test Favors Institution—§ 325(d)

This Petition presents new prior art and arguments against the Challenged Claims for which the file history contains no indication that the Office ever previously considered in connection with the '483 Patent. Indeed, none of Ohata,

Kavan, Gong, Liu, or Ichinose—the only references applied in this Petition against the Challenged Claims—were previously cited or applied in a rejection during prosecution of the '483 Patent.

VI. CONCLUSION

The Challenged Claims are unpatentable. Petitioner authorizes charge of fees to Deposit Account 06-1050.

VII. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(a)(1)

A. Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1)

Petitioner, LG Energy Solution, Ltd., is the real party-in-interest.

B. Related Matters Under 37 C.F.R. § 42.8(b)(2)

Petitioner is not aware of any disclaimers, reexamination certificates or petitions for *inter partes* review for the '483 Patent. The '483 Patent is the subject of a number of civil actions including: *Molecular Rebar Design, LLC et al v. LG Energy Solution, Ltd.*, 2-24-cv-00107 (EDTX) filed Feb. 16, 2024 (Pending) and *Molecular Rebar Design, LLC et al v. Samsung Electronics Co., Ltd. et al*, 2-24-cv-00108 (EDTX) filed February 16, 2024 (Pending).

C. Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)

Petitioner provides the following designation of counsel.

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D. Service Information

Please address all correspondence and service to the address listed above.

Petitioner consents to electronic service by email at IPR18768-0210IP6@fr.com
(referencing No. 18768-0210IP6 and cc'ing PTABInbound@fr.com).

Respectfully submitted,

Dated: June 12, 2024

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CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter Partes* Review totals 13,881 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

Dated: June 12, 2024

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on June 12, 2024, a complete and entire copy of this Petition for *Inter Partes* Review and all supporting exhibits were provided by Federal Express, to the Patent Owner by serving the correspondence address of record as follows:

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