

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Clive P. Bosnyak, et al.
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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. 8,968,924 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42**

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EXHIBITS

LGES-1001	U.S. Patent No. 8,968,924 (“the ’924 Patent”)
LGES-1002	Excerpts from Prosecution History of the ’924 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. 101714627 (“Cheng”)
LGES-1007	Certified English Translation of CN 101714627 and Translator’s Declaration (“Cheng”)
LGES-1008	U.S. Patent Pub. No. 2010/0124713 (“Farrugia”)
LGES-1009	“Chemical oxidation of multiwalled carbon nanotubes.” V. Datsyuk et al. Carbon 46 (2008) 833-840 (“Datsyuk”)
LGES-1010	“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-1011	“Carbon Nanotubes Properties and Applications.”

<https://www.cheaptubes.com/carbon-nanotubes-properties-and-applications/> (“Cheaptubes”)

LGES-1012-1013 Reserved

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 Reserved

LGES-1017 Chinese Patent Pub. No. 102136576 (“Zhao”)

LGES-1018 Certified English Translation of CN 102136576 and Translator’s Declaration (“Zhao”)

LGES-1019-1020 Reserved

LGES-1021 U.S. Patent Pub. No. 2012/0058255 (“Gan”)

LGES-1022 Reserved

LGES-1023 Int’l Patent Pub. No. WO 2010/117392 (“Bosnyak”)

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 “Enhanced photocatalytic activity of mesoporous TiO₂ aggregates by embedding carbon nanotubes as electron-transfer channel.” J. Yu, T. Ma, S. Liu. *Phys. Chem. Chem. Phys.* 13 (2011) 3491–3501 (“Yu”)
- LGES-1028 “Hydrothermal synthesis of lithium iron phosphate.” J. Chen, M. Whittingham. *Electrochemistry Communications* 8 (2006) 855-858 (“Chen”)
- LGES-1029 “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-1030 “Incorporation of MWCNTs into leaf-like CuO nanoplates for superior reversible Li-ion storage.” J.Y. Xiang, J.P. Tu, J. Zhang, J. Zhong, D. Zhang, J.P. Cheng. *Electrochemistry Communications* 12 (2010) 1103-1107 (“Xiang”)
- LGES-1031 A. Hirsch. “Functionalization of Single-Walled Carbon Nanotubes” *Angew. Chem. Int. Ed.* 2002, 41, No. 11, 1853-1859 (“Hirsch”)
- LGES-1032 “A porous LiFePO₄ and carbon nanotube composite.” Y. Zhou, J. Wang, Y. Hu, R. O’Hayre, Z. Shao, *Chemical Communications* (2010), 46, 7151-7153 (“Zhou”)
- LGES-1033 *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-1034 Declaration of June Ann Munford (Kavan)
- LGES-1035 *Molecular Rebar Design, LLC, et al. v. LG Energy Solution, Ltd.*,
Sample Docket Control Order, 2:24-cv-00107-JRG
- LGES-1036 U.S. Provisional Application No. 61/500,560 (“560 Application”)
- LGES-1037 International Application No. PCT/US2012/043534 (“PCT
Application”)

CLAIM LISTING

Limitation	Claim Language
[1pre]	A composition used in lithium ion batteries comprising
[1a]	discrete carbon nanotubes
[1b]	having ion active material attached to their surface . . . wherein the 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
[1c]	wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and
[1d]	oxidation levels from 1% to 15% by weight of the carbon nanotube
[2]	The composition of claim 1, further comprising graphene or oxygenated graphene.
[3]	The composition of claim 2, wherein the weight ratio of graphene to carbon nanotube is in the range of 0.1:99.9 to 99.9:0.1
[4]	The composition of claim 1, wherein the carbon nanotubes are present in a weight percentage of 0.1% to 10% by weight of the ion active material.
[5]	The composition of claim 1, comprising uniformly dispersible oxidized carbon nanotubes having ion active materials attached to their surface.

I. INTRODUCTION

LG Energy Solution, Ltd. (“Petitioner”) petitions for IPR of claims 1-5 (“Challenged Claims”) of U.S. Patent No. 8,968,924 (“the ’924 Patent”).

The ’924 Patent relates to “[c]ompositions ... useful for lithium ion batteries comprising discrete oxidized carbon nanotubes having attached to their surface lithium ion active materials.” LGES-1001, Abstract. However, as will be shown here, such composites were well-known in the art at the time of filing of the ’924 Patent. And additional features recited in the claims—including the aspect ratio and oxidation levels of the nanotubes—were also conventional characteristics of nanotubes that are insufficient to justify patentability of the claims.

II. REQUIREMENTS FOR IPR

A. Grounds for Standing

Petitioner certifies that the ’924 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.

LGES-1003, ¶¶1-174.

Ground	Claims	Basis for Rejection
1	1, 4, 5	§103: Ohata and Kavan
2A	1, 4, 5	§103: Cheng and Gan
2B	2, 3	§103: Cheng, Gan, and Zhao

The '924 Patent was filed on 7/8/2014 as a divisional application of U.S. Application No. 14/128,392 (“’392 Application”), filed on 12/20/2013, which was a National Stage application under 35 U.S.C. §371 of International Application No. PCT/US2012/043534 filed on 6/21/2012 (“PCT Application”), which claims the benefit of U.S. Provisional Application No. 61/500,560 (“’560 Application”), filed on 6/23/2011. But, as explained in §II.C, the '924 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 claim features.

Accordingly, and as explained in §II.C, the earliest possible priority date for all the challenged claims of the '924 patent is June 21, 2012 (“Critical Date”).¹

As seen below, each reference applied in this Petition predates the Critical Date and qualify as prior art.

¹ In the May 15, 2024 infringement contentions in the co-pending district court case, Patent Owner alleges 32 alternative priority dates that the '924 Patent may be entitled to. LGES-1033, 9-11. While such allegations do not appear to be justified—among other things because of failure to demonstrate possession of the aspect ratio and oxidation level features as claimed—Petitioner reserves the right to respond to any such similar allegations made in this IPR proceeding.

Reference	Date	Section
Ohata	8/19/2004 (published)	102(b)
Kavan	3/12/2010 (published)	102(b)
Cheng	10/8/2008 (filed) 5/26/2010 (published)	102(b)
Gan	9/8/2010 (filed) 3/8/2012 (published)	102(a), 102(e)
Zhao	1/28/2011 (filed) 7/27/2011 (published)	102(a)

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 subject matter that was not disclosed or taught by the '560 Application, filed on June 23, 2011, to which the '924 Patent claims priority. Patent Owner first introduced the subject matter in the then-pending claims of the PCT Application, filed on June 21, 2012. LGES-1037, [0009]-[0011], claim 5, 7, 8, 9.

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. The ’560 Application Does Not Provide Support for (i) “aspect ratio of 10 to 500” and (ii) “weight ratio of graphene to carbon nanotube ... 0.1:99.9 to 99.9:0.1”

First, independent claim 1 of the ’924 Patent recites that “[a] composition used in lithium ion batteries” includes “discrete carbon nanotubes hav[ing] an aspect ratio of 10 to 500.” However, the ’560 Application, to which the ’924

Patent claims priority, lacks written description support for the limitations that are directed toward the claimed aspect ratio range of “10 to 500.”

Contrary to the claimed aspect ratio range of “10 to 500” of the independent claim 1 of the ’924 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 ’560 Application specification limits its discussion of the aspect ratio to its Examples 1-3 and claim 5, which 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-1036, 3, 4, claim 5. 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.

Accordingly, given the complete lack of guidance in the specification, not only does the ’560 Application fail to provide support for [1] the criticality of the aspect ratio range 25-500, but further fails to provide support for [2] the aspect ratio of 10-500 of independent claim 1 in the ’924 Patent.

Second, claim 3 of the ’924 Patent recites that “the weight ratio of

graphene to carbon nanotube is in the range of 0.1:99.9 to 99.9:0.1.” However, the ’560 Application, to which the ’924 Patent claims priority, lacks written description support for this weight ratio of graphene to carbon nanotube limitation.

For instance, there is nothing in the text of the ’560 Application that mentions or provides guidance for the weight ratio of graphene to carbon nanotube in the claimed range of “0.1:99.9 to 99.9:0.1” in the ’924 Patent. The only place where graphene is mentioned in the ’560 Application is original claim 6, which states “[a] composition of claim 1 further comprising graphene or oxygenated graphene,” without any discussion on the weight ratio of graphene to carbon nanotube or implications of these components. LGES-1036, claim 6.

Thus, the ’560 Application lacks written description support for the weight ratio of graphene to carbon nanotube limitation in claim 3 of the ’924 Patent.

Because the ’560 Application does not provide support for (i) “aspect ratio of 10 to 500” and (ii) “weight ratio of graphene to carbon nanotube ... 0.1:99.9 to 99.9:0.1,” the challenged claims are not entitled to the benefit of priority to the ’560 Application. Accordingly, the earliest possible priority date for each of the claims (claim 1 and claim 3) of the ’924 patent is June 21, 2012, the date when the Patent Owner first introduced these two limitations in the then-pending claims of the PCT Application. Further, because claims 2, 4, and 5 of the ’924 Patent

depend from independent claim 1, the earliest possible priority date for these claims should also be June 21, 2012.

III. SUMMARY OF THE '924 PATENT

A. Brief Description

The '924 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. The claims of the '924 Patent additionally introduces ranges for aspect ratios and oxidation levels (each relating to nanotubes) as well as a subset of ion active material options. In particular, the claims recite "discrete carbon nanotubes having ion material attached to their surface," where "the discrete carbon nanotubes have an aspect ratio of 10 to 500," "oxidation levels from 1% to 15% by weight of the carbon nanotube," and "ion active materials comprise a lithium metal salt and an element selected from the group consisting of: iron, manganese, cobalt, copper, nickel, vanadium, titanium, and mixtures therefore." The claims of the '924 Patent further recite that "the carbon nanotubes are present in a weight percentage of 0.1% to 10% by weight of the ion active material," and that the composition can further include "graphene or oxygenated graphene," where "the weight ratio of graphene to carbon nanotube is in the range of 0.1:99.9 to 99.9:0.1."

As will be shown below, each and every element set forth in the claims were well-known in the art. LGES-1003. Importantly, while the claims recite specific ranges of values for these characteristics, the '924 Patent fails to demonstrate, or even suggest, at least that these ranges of aspect ratios, oxidation level, weight percentage of carbon nanotubes by weight of the ion active material, and weight ratio of graphene to carbon nanotube are critical to enhancing electrical conductivity of lithium ion batteries or improving uniform dispersion of carbon nanotubes.

B. Prosecution History

The '924 Patent issued from U.S. Patent App. No. 14/325,414. The claims that issued in the '924 Patent were not subject to substantive rejections by the U.S. Patent Office.

C. Level of Ordinary Skill in the Art

A person of ordinary skill in the art relating to the subject matter of the '924 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.

D. Claim Construction

Based on the prior art's description of the claimed elements being similar to that of the '924 Patent specification, no formal claim constructions are necessary in this proceeding because "claim terms need only be construed to the extent necessary to resolve the controversy." *Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011).

IV. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. [GROUND 1] – CLAIMS 1, 4, AND 5 ARE OBVIOUS OVER OHATA-KAVAN

The sections below provide an introduction to Ohata, Kavan, and their combination.²

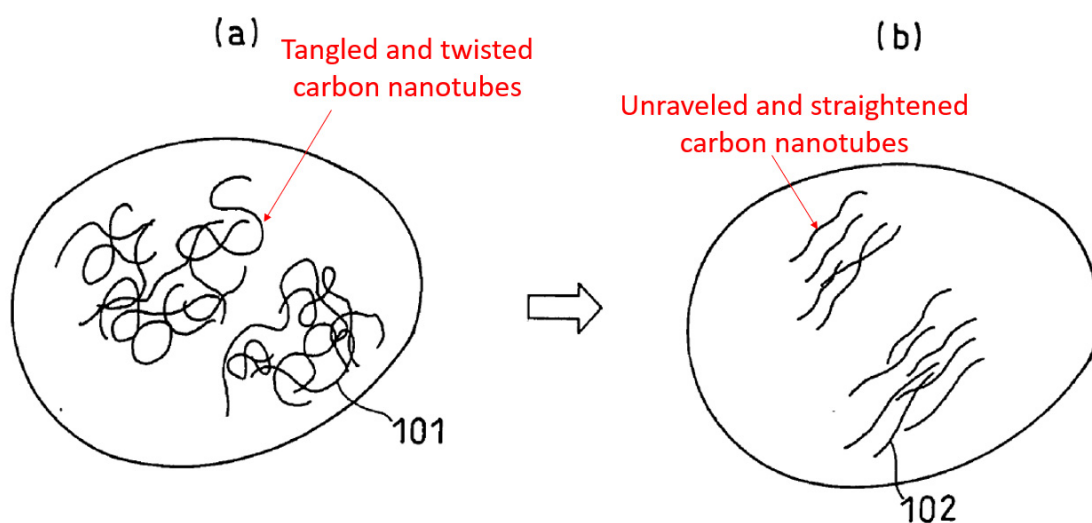
1. Ohata describes a nanotube-containing paste for lithium ion batteries

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, ¶19.

² Petitioner incorporates this discussion into Ground 1.

Ohata prepares its composites by first “producing a masterbatch by blending at least carbon nanotubes with a resin.” LGES-1004, [0015], [0022]. In this process, 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), *infra*). *Id.*, [0016]-[0017]; LGES-1003, ¶20.

FIG. 1



Ohata, FIG. 1 (annotated to demonstrate a masterbatch (b) produced by blending carbon nanotubes with a resin)

An “electrode material mixture paste” is formed by mixing “the masterbatch and an electrode active material with a dispersion medium and is applied “onto an electrode substrate” for use in a lithium secondary battery. LGES-1004, [0023], [0025]-[0027]; LGES-1003, ¶¶21-22.

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

Kavan describes composites of functionalized multi-walled carbon nanotubes (MWNTs) electrode active materials, for use in lithium ion batteries. *See* LGES-1005, 1-2; LGES-1003, ¶23.

Kavan performs “oxidative functionalization” on the MWNTs to produce “MWNT-ox” (“material functionalized by oxidation with HNO₃. LGES-1005, 4; LGES-1003, ¶24. Oxidized nanotubes were mixed with “a powder material (TiO₂, LiMnPO₄ or LiFePO₄),” and pastes were prepared using the resulting material. LGES-1005, 2. The structure, composition, and electrochemical behavior of the resulting composites were characterized, showing performance advantages resulting from interactions between oxidized nanotubes and the positive or negative active material. *See* LGES-1004, 3-5, 7-9; LGES-1003, ¶¶25-32.

3. The Ohata-Kavan combination

The Ohata-Kavan combination composition uses Ohata as a starting point. LGES-1003, ¶33. 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 nanotubes dispersed in a resin, where the aspect ratio of the nanotubes and the ratio of nanotubes to electrode active material are as taught by Ohata. *See id.*, [0015], [0020], [0024]; LGES-1003, ¶33.

Based on the teachings of Kavan, the carbon nanotubes used in the masterbatch of the combination are oxidized, as discussed *infra*. See LGES-1005, Abstract, 2, 4; LGES-1003, ¶34. 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, ¶34.

In the combination, the nanotubes used in preparation of the masterbatch (see LGES-1004, [0015]) are functionalized, *e.g.*, “by carboxylic groups,” as taught by Kavan, such that “[t]he amount of atomic oxygen present” on the nanotube surface is “7%.” LGES-1005, Abstract, 2, 4. These oxidized nanotubes are then “unraveled and straightened by blending them with a resin” to form a masterbatch, based on Ohata. LGES-1004, [0016]; *see* [0021]; LGES-1003, ¶¶34-36.

Based on 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]. 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 incorporates

a phosphate olivine, *e.g.*, LiFePO_4 or LiMnPO_4 , as the positive electrode active material, as taught by Kavan. LGES-1005, 2; LGES-1003, ¶¶37-38.

4. 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, ¶¶39-47.

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 oxidized nanotubes. LGES-1003, ¶40. 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* 8 (“It is obvious that the functionalization of nanotubes is, indeed, crucial for enhancing the electrochemical activity of the composite materials with LiFePO_4 ”), 7, Figs. 8 and 10. A POSITA would have been motivated to use oxidized nanotubes in the combination paste to achieve the apparent dramatic performance advantages taught in Kavan. LGES-1003, ¶40.

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, ¶41. 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 may be able to 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, ¶41. Oxidized nanotubes are consistent with this objective: they can be more readily dispersible than unfunctionalized nanotubes, as explained by Dr. Zhu. LGES-1003, ¶¶42-43 (citing LGES-1031, 1854; LGES-1014, 821-822; LGES-1015, 4186-4187; LGES-1008, [0027]). A POSITA would have been motivated to use oxidized nanotubes because, at least in some cases, doing so is consistent with, and can enhance, Ohata's goal of dispersed nanotubes in the masterbatch. LGES-1003, ¶44.

Third, a POSITA would have been motivated to use oxidized nanotubes in the combination paste because oxidative treatments can "remove amorphous carbon and metallic impurities, thus leading to a higher-purity starting material. LGES-1010, 2; LGES-1003, ¶45.

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, ¶46; *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 using oxidized nanotubes in the Ohata-Kavan paste for at least the following reasons. LGES-1003, ¶¶48-50.

First, use of oxidized nanotubes in compositions for lithium ion battery electrodes was conventional. *See* LGES-1003, ¶49 (citing LGES-1005, Abstract, 9; LGES-1025, 3:28-52).

Second, the composition of Kavan's slurry is generally similar to the composition of Ohata's electrode material paste, as explained by Dr. Zhu. LGES-1003, ¶50; LGES-1004, [0022], [0024], [0032]; LGES-1005, 2, 7. These similarities 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, ¶50.

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 paste for at least the following reasons. LGES-1003, ¶¶51-58.

First, a POSITA would have recognized phosphate olivines—*e.g.*, specifically LiFePO_4 —as desirable positive electrode active materials specifically in the Ohata-Kavan paste because of their good electrochemical performance when combined with oxidized nanotubes, as described by Kavan. LGES-1003, ¶52. Kavan notes that “the LiFePO_4 olivine exhibits excellent [electrochemical] performance in a composite with MWNT-ox.” LGES-1005, 7; *see* Abstract; LGES-1003, ¶52 (citing LGES-1029, 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]; LGES-1003, ¶53.

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]; LGES-1028, 1; LGES-1029, 1; LGES-1003, ¶54.

Fourth, phosphate olivines are desirable 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* LGES-1028, 1; LGEs-Feng, 1; LGES-1003, ¶55.

Fifth, phosphate olivines such as LiFePO_4 have good electrochemical performance, such as high capacity, long cycle life, and stability. *See* LGES-1028, 1; LGES-1029, 1; LGES-1003, ¶56.

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, ¶57; *see KSR*, 550 U.S. at 417.

A POSITA would have expected success in incorporating a phosphate olivine (for a positive electrode material mixture) into the Ohata-Kavan electrode material mixture paste for at least the following reasons. LGES-1003, ¶¶58-61.

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] (“As an alternative positive electrode active material to lithium cobaltate, lithium

phosphates with an olivine structure are receiving attention”); LGES-1028, Abstract; LGES-1003, ¶59.

Second, Ohata indicates that various electrode active material compositions can be used with its 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 paste. LGES-1003, ¶60.

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, ¶61. This 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, ¶61.

5. Analysis

(i) Claim 1

[1pre] A composition used in lithium ion batteries comprising:

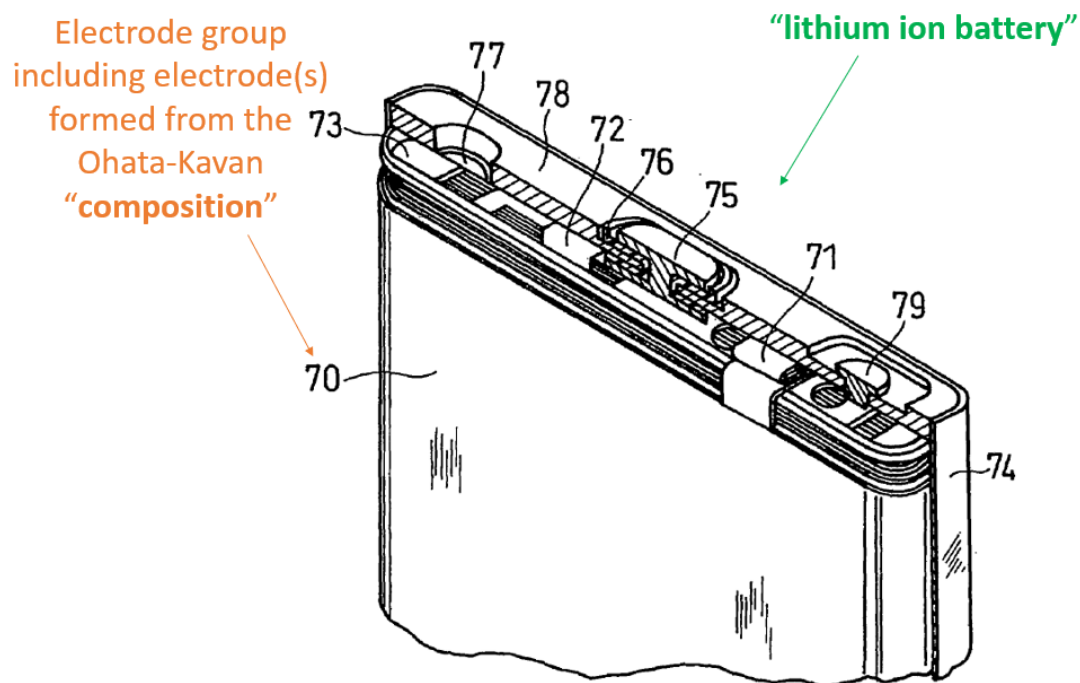
To the extent the preamble is deemed to be limiting, Ohata-Kavan renders it obvious. LGES-1003, ¶62-65.

First, Ohata-Kavan renders obvious a **composition** based on Ohata’s “electrode material mixture paste.” LGES-1004, Abstract; *see* [0005]; LGES-

1003, ¶63. 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* Abstract, [0016], [0021]-[0022], [0030]-[0032], [0040]-[0042], [0046], claim 1; LGES-1003, ¶63. Consistent with Ohata, the electrode active material of the combination composition can be “a positive electrode active material,” implemented as a phosphate olivine, based on Kavan. LGES-1004, [0007]-[0008]; *see* [0026]-[0027], claim 4; LGES-1005, Abstract, 2; *see* [1b], *infra*; LGES-1003, ¶63.

Based on Ohata, the combination electrode material mixture paste (a **composition**) is **used** to produce “[a]n electrode for a battery superior in conductivity.” LGES-1004, Abstract; *see* [0005], [0015], [0017], claim 1; LGES-1003, ¶64. 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, ¶¶64-65 (citing LGES-1005, 2; LGES-1026, [0004]). This secondary battery includes a positive electrode formed from the combination electrode material mixture. *See* LGES-1004, [0026], [0032], [0037], [0039].

FIG. 2

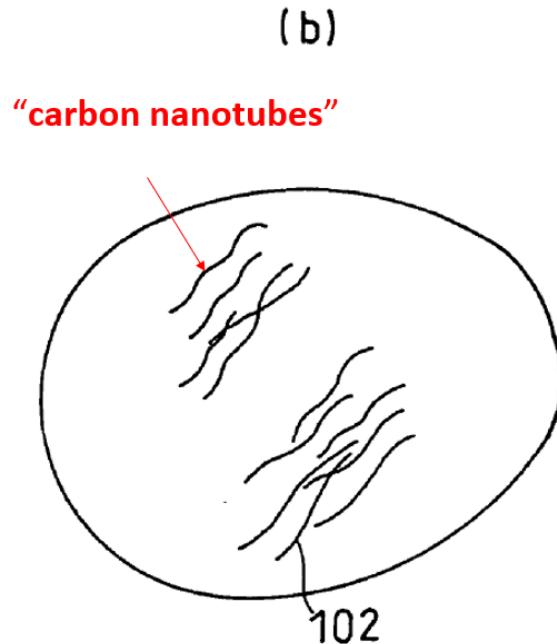


Ohata, FIG. 2 (annotated)

[1a] discrete carbon nanotubes

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]-[0022], [0005]-[0006], [0030], claim 1, claim 3; LGES-1003, ¶66.



Ohata, 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." LGES-1004, Abstract; *see* [0005], [0023], [0032], claim 1; LGES-1003, ¶67. Because the masterbatch in the combination includes **carbon nanotubes**, the combination electrode material mixture paste (*e.g.*, the Ohata-Kavan **composition**) likewise includes **carbon nanotubes**. *See* LGES-1004, [0024], [0007]-[0008], [0060]-[0061]; LGES-1003, ¶¶67-68.

The carbon nanotubes in the combination composition are discrete

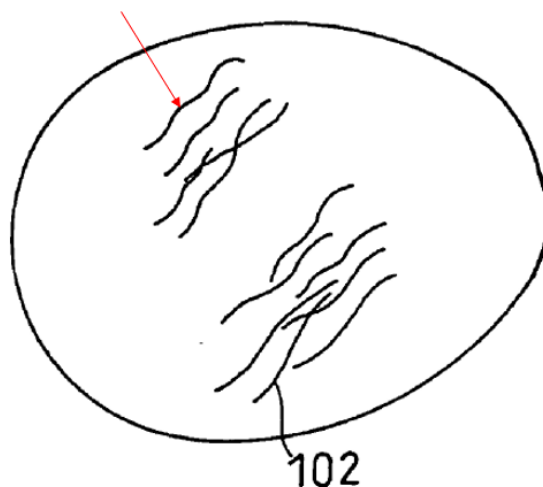
The Ohata-Kavan **composition** includes the masterbatch, which contains **discrete** nanotubes, as taught by Ohata. LGES-1003, ¶69. Ohata describes

“producing a masterbatch by blending at least carbon nanotubes with a resin.”

LGES-1004, [0015]. Prior to this blending, the nanotubes “are tangled and twisted with one another.” *Id.*, [0016]; *see* FIG. 1(a). By “blending them with a resin” to form the masterbatch, “[t]he carbon nanotubes are ***unraveled and straightened***.”

Id., FIG. 1(b), *infra*. The result is a “resin with the unraveled and straightened carbon nanotubes ***dispersed therein***,” *e.g.*, a masterbatch containing **discrete carbon nanotubes**. *Id.*, [0017]; *see* [0016], [0022] (“As the resin in which ***the carbon nanotubes are dispersed***, a fluorocarbon resin can be used”), [0002] (“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***”); LGES-1003, ¶69. For instance, to the extent **discrete** is interpreted as referring to nanotubes that are generally individually distinct, a POSITA would have found it obvious that at least some of these “unraveled and straightened carbon nanotubes” are **discrete** because they are generally “dispersed” as individual nanotubes in the resin, as described and illustrated by Ohata. LGES-1004, [0017]; *see* LGES-1001, 3:52-54; LGES-1003, ¶69.

“discrete carbon nanotubes”



Ohata, Fig. 1(b) (annotated)

Alternatively/additionally, a POSITA would have understood or found obvious that the nanotubes in the combination composition are **discrete** because, at least in some instances, oxidation of nanotubes can help promote non-agglomeration of nanotubes. *See* [1d], *infra*; LGES-1003, ¶70. 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-1008, [0027]-[0028]; LGES-1003, ¶71. 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, ¶71. In light of this behavior of oxidized nanotubes, a POSITA would have understood or found obvious that oxidized nanotubes in the

combination can be present as generally individually distinct nanotubes, *e.g.*, that the nanotubes are **discrete**. LGES-1003, ¶72.

[1b] having ion active material attached to their surface . . . wherein the 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

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." 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," corresponds to **ion active material**.³ LGES-

³ The claim states that the ion active material includes both a lithium metal salt and an element selected from the specified group. This element can either be a constituent of the lithium metal salt or another component of the ion active material. For instance, none of the relevant experimental examples in the specification disclose extra "element" in addition to the lithium metal salt and it merely states that "[e]xamples of ion active materials are lithium iron phosphate, lithium manganese phosphate, lithium cobalt oxide, silica, manganese dioxide,

1004, [0026]-[0027]; LGES-1003, ¶73. The specific composition of the positive electrode active material as a phosphate olivine is based on the teachings of Kavan, as discussed *infra*. LGES-1003, ¶73.

The positive electrode active material (the **ion active material**) in the Ohata-Kavan electrode material mixture paste 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, ¶74; *see* LGES-1004, [0026]; LGES-1005, 2 (describing use of "carbon-free olivines, LiFePO_4 or LiMnPO_4 in fabricating samples), 4, 6-9. LGES-1003, ¶75.

Phosphate olivines such as LiMnPO_4 and LiFePO_4 are each an **ion active material**, as confirmed by Kavan: 2 ("***LiMPO₄ olivines are promising cathode materials***"), 1; LGES-1003, ¶75.⁴ Phosphate olivines such as LiMnPO_4 and LiFePO_4 each include a lithium metal salt having an element selected from the

cadmium, titanium dioxide and carbon." LGES-1001, 2:40-45, 4:34-37; LGES-1003, ¶75.

⁴ The '924 Patent identifies "lithium iron phosphate" or "lithium metal salt with an olivine crystal structure" as examples of an "ion active material." LGES-1001, 2:40-45, 4:34-37.

group consisting of: **iron, manganese**, cobalt, copper, nickel, vanadium, titanium, and mixtures thereof. LGES-1003, ¶75.

Therefore, because the ion active material in the Ohata-Kavan electrode material includes phosphate olivines such as LiMnPO_4 and LiFePO_4 , which are well-known examples of lithium metal salts, and further because such phosphate olivines further contain an element selected from the group consisting of: **iron, manganese**, cobalt, copper, nickel, vanadium, titanium, and mixtures thereof, Ohata-Kavan renders obvious this limitation. LGES-1003, ¶75.

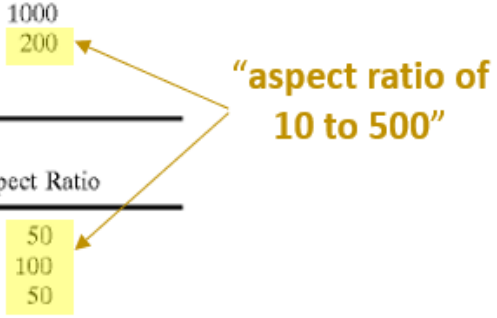
Moreover, based on Kavan, the nanotubes in the combination electrode material paste have phosphate olivine crystals (**crystals of ion active material attached to their surface**). LGES-1003, ¶76. The phosphate olivine crystals are attached to the nanotube surface due at least in part to the surface oxidation of the nanotubes (*see* [1d], *infra*): “The surface oxidation of carbon nanotubes ... was sometimes mentioned to improve *the anchoring of ... LiMnPO₄*.” LGES-1005, 2; *see id.* (“MWNT functionalization (by surface oxidation forming carboxyls) for *optimum attachment of MWNT towards ... olivine surfaces*”), 4; LGES-1003, ¶76.

[1c]⁵ wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and

In the Ohata-Kavan 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, ¶77. 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, ¶77.

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”

⁵ 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-1033.

Ohata, Table 2

The specific aspect ratios of **50**, **100**, and/or **200** (*see* LGES-1004, [0030], Table 2) for nanotubes of the Ohata-Kavan combination fall within the recited range of aspect ratios (**10 to 500**). LGES-1003, ¶78. 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 renders obvious that the nanotubes in the combination composition have **an aspect ratio of 10 to 500**.

Alternatively/additionally, the range of aspect ratios (“**not less than 100**” and “**not greater than 1000**”) for the nanotubes of the Ohata-Kavan combination partially overlaps with the recited range of aspect ratios (**10 to 500**). LGES-1003, ¶¶79-80. The ’924 Patent provides no indication of criticality or unexpected results associated with the claimed range of aspect ratios. LGES-1003, ¶79. Thus, the partially overlapping range of ratios of the nanotubes of the Ohata-Kavan combination presents 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) (“When an applicant seeks to overcome a prima facie case of obviousness by showing improved performance in a range that is within or overlaps with a range disclosed in the prior art, the applicant must “show that the [claimed] range is *critical*, generally by showing that the claimed range achieves unexpected results relative to the prior art range,” quoting *In re Woodruff*, 919 F.2d 1575, 1578 (Fed. Cir. 1990) (alteration and emphasis in original))).

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

The carbon nanotubes in the combination composition are **oxidized** based Kavan. LGES-1003, ¶81. For instance, the nanotubes are “*functionalized by oxidation* with HNO₃.” LGES-1005, 2. The result of this oxidation process is “nanotubes functionalized by carboxylic groups.” *Id.*, Abstract; *see* 2, 4, 9. These oxidized nanotubes are used in preparation of the masterbatch based on Ohata and thus are present in the combination composition. LGES-1003, ¶81.

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, ¶104. 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, ¶¶14-17. 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**. LGES-1003, ¶¶82-84.

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, ¶85. 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**.

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, ¶83. As Dr. Zhu explains, other approaches are also available to calculate oxidation levels by weight. LGES-1003, ¶¶14-17. While the '924 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 nanotubes. LGES-1003, ¶¶14-17. Again, while the '924 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). LGES-1003, ¶¶14-17 (citing LGES-1010, 6; LGES-1009, 4).

(ii) Claim 4

[4] The composition of claim 1, wherein the carbon nanotubes are present in a weight percentage of 0.1% to 10% by weight of the ion active material.

In the Ohata-Kavan 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.*” LGES-1004, [0024]. Notably, this range of “0.2 to 3 parts by weight” applies to both

positive electrode active materials (*see id.*, [0007], [0009], claim 4) and negative electrode active materials (*see id.*, [0008], [0010], claim 5). LGES-1003, ¶86.

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 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, ¶87. Alternatively/additionally, to the extent the weight percentage is based on the total weight of both nanotubes and ion active material,⁶ Ohata's weight percentage range corresponds to the 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, ¶87.

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. LGES-1003, ¶88. As such, in Ohata-Kavan, this specific range of weight percentages disclosed by Ohata is a relevant disclosure for the recited weight percentage range, and

⁶ The '924 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, 3:64-67; LGES-1003, ¶87.

Ohata-Kavan thus renders obvious the claimed range of weight percentages. *See Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782.

Ohata also provides specific examples of “[p]ositive electrodes” having compositions shown in Table 1, *infra*. LGES-1004, [0040]. Each of the 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, ¶¶89-90.

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

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, ¶88.

(iii) **Claim 5**

[5] The composition of claim 1, comprising uniformly dispersible oxidized carbon nanotubes having ion active materials attached to their surface.

The combination composition includes oxidized (*see* [1d], *supra*) carbon nanotubes (*see* [1a], *supra*) having ion active materials attached to their surface (*see* [1b], *supra*). LGES-1003, ¶91.

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, ¶92. This masterbatch, with “uniformly predispersed” nanotubes, is then mixed with an electrode active material and a dispersion medium to form the combination paste. LGES-1004, [0002]; *see* [0023]; LGES-1003, ¶92.

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, ¶93. 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, ¶93.

Accordingly, the nanotubes of the combination composition are **uniformly dispersed**. 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, ¶¶94-95. Alternatively/additionally, the nanotubes are **dispersible** because they are not attached to a substrate. LGES-1003, ¶96.

**B. [GROUND 2A] – CLAIMS 1, 4, and 5 ARE OBVIOUS OVER
CHENG-GAN**

The sections below provide an introduction to Cheng, Gan, and their combination.⁷

1. Cheng describes obtaining carbon nanotube composite based on conducting agent and lithium iron phosphate

Cheng describes issues regarding poor conductivity of electrode material of lithium ion batteries and dispersion of carbon nanotubes. *See* LGES-1007⁸, [0003], [0008], [0010], [0012]; LGES-1003, ¶98.

In particular, Cheng describes that the issues include [1] carbon nanotubes not being “fully dispersed” [2] carbon nanotubes “being distributed only on the surface of the electrode material,” [3] carbon nanotubes not “form[ing] a continuously connected three-dimensional electrically conductive network structure both in the interior and on the surface of the material.” *See* LGES-1007, [0010], [0012]. LGES-1003, ¶99.

Cheng focuses on addressing the above-mentioned issues by improving carbon nanotube dispersion (dispersion of carbon nanotubes themselves and

⁷ Petitioner incorporates this discussion into Grounds 2A-2B.

⁸ CN 101714627 to Cheng (LGES-1006) was published in Chinese. Thus, all citations to Cheng are to its English translation (LGES-1007).

dispersion in a precursor), such that the carbon nanotubes can “form a continuously connected three-dimensional electrically conductive network structure both in the interior and on the surface of the material,” thereby improving electrical conductivity of the positive electrode composite material and the lithium ion batteries. LGES-1007, Abstract, [0005], [0007], [0008], [0010], [0012], [0021], [0030]-[0033]; LGES-1003, ¶100.

Cheng focuses on improving the dispersion of carbon nanotubes, both among the nanotubes themselves and in a precursor, by providing carbon nanotube/lithium iron phosphate composite material used for producing a positive electrode of the lithium ion battery. LGES-1007, [0010]. As discussed further *infra*, the composite material is prepared by at least making the carbon nanotubes, acetylene black (conducting agent), and dispersant mixture “in water or an organic solvent” based on ultrasonic dispersion, mixing the mixture with “a lithium source, an iron source and a phosphate salt,” and performing further mixing and processing steps. *See id.*, [Abstract], [0012]–[0020], [0040], [0041], [0044], [0048], [0049], [0063], [0064], [0071], [0072], [0076], [0077], claim 2, claim 8; LGES-1003, ¶101. Cheng describes that the obtained carbon nanotube composite material [1] provides “carbon nanotube dispersion (dispersion of carbon nanotubes and dispersion in a precursor),” [2] exhibits a uniform distribution of carbon nanotubes both “on the surface of and in the lithium iron phosphate material,” [3] forms

“effective conductive network” or “a uniformly distributed network structure,” thereby enhancing the electrical conductivity of the carbon nanotube composite material. *See* LGES-1007, [Abstract], [0012], [0021], [0023], [0030]–[0033]. LGES-1003, ¶101.

2. Gan describes obtaining carbon nanotube composite based on conducting agent and functionalization of the carbon nanotube

Gan “relates to composites of carbon nanotubes and conductive polymer materials [corresponding to conducting agents].” LGES-1021, [0002], LGES-1003, ¶102. In particular, Gan describes “functionalized carbon nanotubes” that are mixed with conducting agents to obtain “composites that exhibit increased electrical conductivity.” *Id.*, [Abstract]. “Generally such mixing can be achieved by adding the functionalized CNTs [carbon nanotubes] to the conductive polymer material directly and sonicating the mixture to uniformly disperse the functionalized CNTs in the conductive polymer material.” LGES-1021, [0026].

Gan attributes this “increased electrical conductivity” of the functionalized carbon nanotube / conductive polymer composite to the improved dispersibility of nanotubes in water or polymer, resulting in a better constructed electrically conductive network structure (or “percolated network”) of carbon nanotubes within the composite. *See id.*, Abstract, [0018]–[0024], [0041]; LGES-1003, ¶103. To achieve improved dispersibility of the carbon nanotubes, Gan controls the

functionalization level (e.g., oxidation level) of the carbon nanotubes, as demonstrated *infra*. See LGES-1021, [0018]-[0024]; LGES-1003, ¶103.

In addition to attributing the “increased electrical conductivity” of the carbon nanotube / conductive polymer composite to the improved dispersibility of nanotubes in water or polymer, Gan further attributes the “increased electrical conductivity” to the reduced contact resistance between the nanotubes, as demonstrated *infra*. See LGES-1021, [0020]-[0023]; LGES-1003, ¶¶104, 105.

Gan explains that [1] improved dispersibility and [2] reduced contact resistance are due to the functionalization of carbon nanotubes with carboxyl and/or hydroxyl groups, and Gan claims both the “carboxyl groups compris[ing] at least about 2.5 weight percent of the carbon nanotubes” and the “hydroxyl groups compris[ing] at least about 2.5 weight percent of the carbon nanotubes.” See LGES-1021, claims 4, 7, [0018]-[0024]; LGES-1003, ¶105.

Further, Gan emphasizes controlling the degree of functionalization of the carbon nanotubes with carboxyl and/or hydroxyl groups to obtain [1] improved dispersibility of nanotubes in water or polymer, [2] reduced contact resistance of

the carbon nanotubes, and [3] preservation of the intrinsic properties of the carbon nanotubes⁹. *See* LGES-1021, [0019]-[0024]; LGES-1003, ¶¶105, 106.

Gan emphasizes that the degree of “suitable functionalization with carboxyl or hydroxyl groups ranged from about 2.5 to about 10 wt%” and that:

The degree to which the CNTs are functionalized is a balance between introducing the desired functional groups into the CNTs to achieve one or more of the three objectives, while minimizing the effect on the desirable intrinsic properties of the CNTs. For example, while a greater degree of functionalization may improve the dispersibility of the CNTs, such improvement may come at a decrease in intrinsic properties of the pristine CNTs.

LGES-1021, [0024].

Regarding “one or more of the three objectives,” Gan describes that functionalization of the carbon nanotubes ranging from “about 2.5 to about 10 wt%” achieves an objective of “improv[ing] the solubility and dispersibility of the CNTs in water and conductive polymer materials.” *Id.*, [0019]; LGES-1003, ¶105. For instance, Gan attributes this solubility and dispersibility of the carbon nanotubes to the “carboxyl groups (—COOH) [, which] are a preferred functional group that can be chemically attached to the CNT's because they render the CNT more soluble in water and conductive polymer materials” and the “[h]ydroxyl

⁹ As explained by Dr. Zhu, intrinsic properties of carbon nanotubes include electrical conductivity of pristine carbon nanotubes. LGES-1003, ¶106

groups,” which “are effective at increasing the solubility and dispersibility of the CNTs.” LGES-1021, [0022]; LGES-1003, ¶105.

Gan further describes another objective that can be achieved by functionalization: “reduc[ing] contact resistance between CNTs” that are incorporated into conducting agent (e.g., conductive polymer), thereby enhancing the conductivity of the nanotube composite. *Id.*, [0020], [0021], LGES-1003, ¶105. For instance, Gan attributes this enhanced conductivity at least to the ability of carboxyl groups to “form hydrogen bonds between carbonyl and hydroxyl groups of two different CNTs that contain carboxyl groups,” which “effectively reduc[es] electrical contact resistance between the CNTs.” LGES-1021, [0022]; LGES-1003, ¶105.

3. The Cheng-Gan combination

In the Cheng-Gan combination, the carbon nanotubes in Cheng’s carbon nanotube/lithium iron phosphate composite would have carbon nanotubes that are functionalized or oxidized with carboxyl or hydroxyl groups at “about 2.5 to 10 wt%” based on Gan’s disclosure.¹⁰ LGES 1001, 3:60-64; LGES-1021, [0024];

¹⁰ The ’924 Patent defines the term “oxidized carbon nanotubes” as carbon nanotubes oxidized to have “carboxylic, ketone or hydroxyl functionalities.” LGES-1001, 3:60-63; LGES-1003, ¶107.

LGES-1003, ¶107. As explained by Dr. Zhu, the term “functionalization” can be interchangeably used with “oxidation,” at least in the instances relating to functionalizing the carbon nanotubes with functional groups having carboxylic, ketone or hydroxyl functionalities. LGES-1003, ¶107.

As demonstrated *infra*, the composition of the Challenged Claims is rendered obvious by [1] functionalizing the carbon nanotubes of Cheng using well-known methods, as described in Gan, or [2] obtaining the functionalized carbon nanotubes from commercial sources, as described in Gan, and applying such functionalized nanotubes in preparing the composite described in Cheng. *See* LGES-1021, [0018]-[0024]; LGES-1003, ¶108.

4. Reasons for the combination

A POSITA would have been motivated to use oxidized nanotubes (or oxidized nanotubes having oxidation levels such as those described in Gan) in the Cheng’s nanotube composite for at least the following reasons. LGES-1003, ¶¶109-116.

First, a POSITA would have been motivated to use [1] oxidized carbon nanotubes or [2] oxidized carbon nanotubes having the oxidation levels taught in Gan **to achieve a better constructed electrically conductive network of nanotubes within Cheng’s nanotube / lithium iron phosphate composite**, which is a design objective in Cheng. *See* LGES-1007, [Abstract], [0003]-[0010], [0021],

[0030]–[0033]; LGES-1003, ¶110. Bearing in mind the well-known role of **functionalization** of the carbon nanotubes in improving their dispersibility in an aqueous solution and the well-known fact that the **functionalized carbon nanotubes** can “retain their dispersion” and “incorporate[] directly into the porous LiFePO₄ particulates . . . resulting in an intimately interlaced 3D composite network” which “yields promising electrode performance” of the lithium ion batteries, a POSITA would have looked to Gan for **guidance as to the functionalization level or oxidation level** appropriate for this objective. LGES-1032, 1; LGES-1003, ¶110.

For instance, a POSITA would have recognized Gan’s teachings about using carbon nanotubes that are functionalized with carboxyl or hydroxyl groups at “about 2.5 to 10 wt%,” and would have applied this knowledge to the nanotubes in Cheng according to Gan’s guidance. *See* LGES-1021, [0018]–[0024]; LGES-1003, ¶111. As described *supra*, Gan’s guidance regarding “2.5 to 10 wt%” oxidation level is highly relevant to obtaining a better constructed electrically conductive network of the carbon nanotubes within the composite. *See* LGES-1021, Abstract, [0018]–[0024], [0041]; LGES-1003, ¶111.

Second, a POSITA would have been motivated use [1] oxidized carbon nanotubes or [2] oxidized carbon nanotube having the oxidation levels taught in Gan, to enhance **dispersion of carbon nanotubes in water** and/or conducting

agent in Cheng. LGES-1003, ¶112. For instance, enhancing dispersion of carbon nanotubes in water and/or conducting agent in Cheng would have facilitated the steps that contribute to a design objective in Cheng, which relates to “carbon nanotube dispersion (dispersion of carbon nanotubes and dispersion in a precursor).” *See* LGES-1007, [Abstract], [0010]-[0014]. For instance, Cheng makes mixture of carbon nanotubes, acetylene black (conducting agent), and dispersant by “ultrasonically dispersing the same in **water**,” and after dispersion, mixes the mixture with “a lithium source, an iron source and a phosphate salt” and “organic carbon source” using the mixing medium such as “**deionized water**.” *Id.* [0013]-[0017], claim 2. Regarding this context, Gan notes that the functional groups such as carboxyl groups or hydroxyl groups “are effective at increasing the solubility and dispersibility of the CNTs in **water**.” *See* LGES-1021, [0018]-[0021]. Moreover, it was well-known to a POSITA that the carboxyl or hydroxyl groups are “hydrophilic substituents [that are incorporated] into the exterior CNT sidewalls,” which improve the hydrophilicity and “create CNTs that disperse in **water**.” *See* LGES-1010, 1, 2; LGES-1003, ¶¶112.

Third, Gan teaches that oxidizing carbon nanotubes with carboxyl or hydroxyl group at levels of “**about 2.5 to 10 wt%**,” **remains within a safe threshold that preserves “the desirable intrinsic properties of the CNTs.”** *Id.*, [0024]. For instance, Gan emphasizes that, when finding a suitable level for

functionalization, the goal is to “**minimiz[e] the effect on the desirable intrinsic properties of the CNTs.**” For instance, Gan teaches **the suitable level of oxidation at “about 2.5 to 10 wt%” and that “while a greater degree of functionalization may improve the dispersibility of the CNTs, such improvement may come at a decrease in intrinsic properties of the pristine CNTs.**” LGES-1021, [0024]. This indicates that the oxidation level of “about 2.5 to 10 wt%,” remains within the safe threshold of not compromising “the desirable intrinsic properties of the CNTs.” *Id.*; LGES-1003, ¶113.

Fourth, a POSITA would have been prompted to pursue this implementation because extensive application of oxidized or functionalized carbon nanotubes were well-known in various fields including lithium ion battery industry. *See* LGES-1023, Abstract, [0005], [0014], [0032], [0037]; LGES-1024, [0006] [0056] [0101]; *see* discussion *supra* Part IV.A.2. & A.5.(i).(1d). For instance, Gan identifies multiple commercial sources where oxidized nanotubes having specific oxidation levels can be obtained. These sources highlight their broad applications, particularly including “lithium-ion batteries.” LGES-1021, [0018]; LGES-1011; LGES-1003, ¶114. Further, for instance, the Patent Owner of the ’924 patent describe, in a patent application that is a prior art herein, use of exfoliated oxidized carbon nanotube in electrodes for lithium ion batteries. *See* LGES-1023, Abstract, [0005], [0014], [0032], [0037], [0074], [0077], [0078]; LGES-1003, ¶114.

Fifth, it was well-known that [1] “the role of oxidation is to create ‘foothold’ functional groups, such as carboxyl groups, which then serve as attachment points to anchor . . . nanoparticles [e.g., LiFePO₄],” and [2] oxidized carbon nanotubes improve the “colloidal stability of CNTs,” ensuring their uniform dispersion. *See* LGES-1010, 2; LGES-1003, ¶115. For instance, it was well-known that the “surface oxidation has been shown to **exert a pronounced effect** on both the sorption properties and colloidal stability of CNTs.” *Id.* Based on this knowledge, along with teachings of Cheng and Gan, a POSITA would have understood that the functional groups on oxidized nanotubes [1] facilitate the bonding between carbon nanotubes and nanoparticles (such as lithium iron phosphate) and [2] improve the “colloidal stability of CNTs.” *Id.*; LGES-1003, ¶115. This supports Cheng’s design objective of achieving better dispersion of both the carbon nanotubes themselves and throughout the lithium iron phosphate. *See* LGES-1007, [0010]–[0014]. Further, Gan specifies a suitable degree of oxidation level (e.g., “2.5–10 wt%”), which would have motivated a POSITA, as they would have understood that this level of oxidation [1] is within the safe threshold that preserves “the desirable intrinsic properties of the CNTs,” [2] improves the dispersibility of the carbon nanotubes in water, and [3] aids in reducing electrical resistance between the carbon nanotubes to boost conductivity, as noted *supra*.

Sixth, a POSITA would have been motivated to pursue this implementation because doing so is merely [1] obtaining “functionalized SWNTs and MWNTs . . . from commercial sources” or [2] the application of “known techniques such as by sonicating pristine CNTs in an acid bath of sulfuric acid and nitric acid” to a known structure (carbon nanotube) to yield predictable results. LGES-1021, [0018]. For instance, the predictable results based on functionalization of the carbon nanotubes include at least the following:

[a] improving dispersibility of the carbon nanotubes;

[b] retaining carbon nanotubes dispersion and incorporation into LiFePO_4 particulates, which in turn result in a better constructed electrically conductive network of the carbon nanotubes within the composite and “yields promising electrode performance” of lithium ion batteries;

[c] reducing contact resistance between the carbon nanotubes to thereby enhance electrical conductivity of the nanotube composite;

[d] improving the “colloidal stability of CNTs” to further ensure uniform dispersion of carbon nanotubes; and

[e] facilitating the bonding between carbon nanotubes and nanoparticles (such as lithium iron phosphate) while not harming “the desirable intrinsic properties of the CNTs.” LGES-1010, 1, 2; LGES-1021, [0018]-[0024], [0029], [0030]-[0033]; LGES-1032, 1; LGES-1003, ¶116; *see KSR*, 550 U.S. at 417.

For instance, a POSITA would have merely obtained the functionalized carbon nanotube from commercial sources prior to performing initial steps of making the carbon nanotube, acetylene black, and dispersant mixture at water based on ultrasonic dispersion in Cheng. LGES-1003, ¶116.

Further, a POSITA would have expected success in using nanotubes having the oxidation levels such as those described by Gan in the Cheng-Gan combination for at least the following reasons. LGES-1003, ¶¶117-123.

First, as described *supra*, the oxidized carbon nanotubes or the oxidation levels taught in Gan: [1] remain within the safe threshold that preserves the desirable intrinsic properties of the carbon nanotubes; [2] help producing better constructed electrically conductive network of carbon nanotubes within the composite; [3] help reduce electrical resistance between carbon nanotubes to thereby enhance conductivity of the nanotube composite; [4] improve the dispersibility of carbon nanotubes; [5] improve the “colloidal stability of CNTs” to further ensure uniform dispersion of carbon nanotubes; and [6] provide enhanced “sorption properties,” as they would offer further “attachment points to anchor” lithium iron phosphate. LGES-1010, 1, 2; LGES-1021, [0018]-[0024], [0029], [0030]-[0033]; LGES-1032, 1; LGES-1003, ¶118.

Second, oxidation of carbon nanotube with carboxyl or hydroxyl groups, or effect of such oxidation in enhancing electrical conductivity of electrode or

nanotube composite and improving dispersibility of the carbon nanotubes were well-known in lithium ion battery industry. *See* discussion *supra* Part IV.A.2. In particular, “[t]he improvement caused by surface oxidation of CNTs” was known to be “dramatic,” especially for carbon nanotube / lithium iron phosphate composite material, and “the functionalization of nanotubes [was known to be], indeed, crucial for enhancing the electrochemical activity of the composite materials with LiFePO₄,” for positive electrode of the lithium ion battery. This aligns with applying Gan’s oxidized nanotubes to Cheng’s carbon nanotube / lithium iron phosphate composite. *See* discussion *supra* Part IV.A.2; LGES-1003, ¶119.

Third, enhancing “sorption properties” between carbon nanotubes and ion active materials (or transition metal oxide) based on functionalization of carbon nanotubes was well-known in the lithium ion battery industry. *See* LGES-1010, 2; LGES-1030, 2; LGES-1027, 6. For instance, it was well-known that carboxyl or hydroxyl groups on functionalized nanotubes offer further “attachment points to anchor either larger biomolecular structures or nanoparticles.” *See* LGES-1010, 2. Further, it was demonstrated that ion active materials or transition metal oxide, such as copper oxide or titanium dioxide precursors or nanoparticles that are formed on the carbon nanotubes, interact or react with the carboxyl or hydroxyl

groups of the functionalized carbon nanotubes to form attachment or chemical bonding. LGES-1027, 6; LGES-1030, 2, 3; LGES-1003, ¶120.

Fourth, oxidation levels that fall within the range disclosed in Gan (2.5–10 wt%) were well-known to be used extensively in various technical fields, including lithium ion battery. *See* discussion *supra* Part IV.A.5.(i).(1d); *see also* LGES-1011; LGES-1003, ¶121.

Fifth, oxidation levels that fall within the range disclosed in Gan (2.5–10 wt%) were well-known to enhance electrochemical activity of the nanotube composite materials with LiFePO₄. *See* discussion *supra* Part IV.A.2 & A.5.(i).(1d); LGES-1003, ¶122.

Accordingly, a POSITA would have expected success in applying nanotubes having the oxidation level such as those described by Gan in the Cheng’s carbon nanotube/lithium iron phosphate composite. LGES-1003, ¶123.

5. Analysis

(i) Claim 1

[1pre] A composition used in lithium ion batteries comprising:

To the extent the preamble is limiting, Cheng-Gan renders it obvious. LGES-1003, ¶¶124-125.

In the Cheng-Gan combination, Cheng’s carbon nanotube/lithium iron phosphate composite is a composition used to produce the “cathode material” for positive electrode of the lithium ion battery. *See* LGES-1007, [Abstract].

[1a] discrete carbon nanotubes

The Cheng-Gan composition includes nanotube composite materials containing discrete carbon nanotubes, based on the reasons described below.

First, in the combination, Cheng describes and claims methods of “carbon nanotube dispersion,” in which the carbon nanotube disperses [1] themselves and [2] in a “precursor” that includes lithium iron phosphate. *See* LGES-1007, [Abstract], [0010], [0012]-[0015], claim 2. Cheng states that these methods address issues such as [1] carbon nanotubes not being “fully dispersed” [2] carbon nanotubes “being distributed only on the surface of the electrode material,” [3] carbon nanotubes not “form[ing] a continuously connected three-dimensional electrically conductive network structure both in the interior and on the surface of the material.” *See id.*, [0010]; LGES-1003, ¶127. Accordingly, Cheng focuses on solving the issues of nanotube dispersion and states that resulting composite material contains nanotubes that are “**uniformly dispersed.**” *See id.*, Abstract, [0010], [0012], [0041], claim 1; LGES-1003, ¶127.

For instance, Cheng describes that the steps for “carbon nanotube dispersion” include at least ultrasonically dispersing the carbon nanotubes, acetylene black, and dispersant “in water or an organic solvent to obtain a mixture.” LGES-1007, [0013], claim 2. Cheng describes that the steps for dispersing the carbon nanotube in “the precursor” include at least [1] mixing the

above “mixture” with “a lithium source, an iron source, and a phosphate salt at an atom ratio of Li : Fe : P = 1 : 1 : 1” and “organic carbon source” (e.g., sucrose, glucose or phenolic resins) using “mixing medium” (e.g., least one of “deionized water, industrial alcohol or the absolute ethyl alcohol”) and [2] ball milling and drying. *See id.*, [0013]-[0018], claim 2.¹¹ After ball milling, the precursor powder is calcined and sieved. *See id.*, [0019], claim 2. As a result of the carbon nanotube dispersion (the [1] “dispersion of carbon nanotubes” and [2] “dispersion in a precursor” that includes lithium iron phosphate), the carbon nanotubes are “**uniformly dispersed.**” *Id.*, Abstract, [0012], [0041], claim 1; LGES-1003, ¶128.

Second, in the combination, Cheng emphasizes that the carbon nanotube composite material obtained based on the disclosed methods result in **non-aggregated** and **uniform dispersion** of nanotubes. *See* LGES-1007, Abstract, [0007], [0010], [0021]. In addition to emphasizing that the nanotubes of

¹¹ Cheng fabricates its cathode active material using a “ball-milling” process.

LGES-1007, Abstract, [0015]. At least some of the accused products are fabricated using a ball milling process. *See* LGES-1033. To the extent milling is compatible with discrete carbon nanotubes (which Petitioner does not necessarily concede), Cheng’s milling process (e.g., as applied to the Cheng-Gan combination) is likewise consistent with discrete nanotubes. LGES-1003, ¶128.

composite are uniformly dispersed and form an uniformly distributed network structure, Cheng emphasizes that the nanotubes are in **non-aggregated state**. For instance, Cheng describes that when there is an “agglomerat[ion],” it is difficult to form an “effective conductive network” or an “uniformly distributed network structure.” *Id.*, Abstract, [0007], [0010], [0021], [0023], [0073; LGES-1003, ¶129.

Third, in the combination, Cheng describes use of diameter and length that contribute to **lesser aggregation** and **better dispersion** of carbon nanotubes, thereby contributing to the **uniform dispersion** and **non-aggregated state** of **nanotubes**. For instance, Cheng states that the described ranges of diameter (e.g., 10 to 200 nm) and length (e.g., 5 to 20 nm) contribute to forming of “effective conductive network,” where “the carbon nanotubes are **less entangled** with each other and are **more easily dispersed**.” LGES-1007, [0021]; LGES-1003, ¶130.

Fourth, in the combination, Cheng is modified to use **oxidized nanotubes** as in Gan , and the method of carbon nanotube dispersion (dispersion of carbon nanotubes and dispersion in a precursor) is similar to a dispersion method disclosed in the '924 patent. For instance, the '924 patent has two examples (Examples 2 & 3), which allegedly describe “Discrete Carbon Nanotubes with Lithium Iron Phosphate Coated on the Surface of the Tubes Suitable for a Lithium Ion Battery Cathode Material.” LGES-1001, 5:30-67, 6:1-4. Here, the Example 2 of the '924 patent describes sequential steps of [1] forming oxidized carbon

nanotube / solvent mixture based on ultrasonic dispersion, [2] mixing the mixture with lithium source, iron source and phosphate source with mixing medium (e.g. deionized water), and [3] heat treatment. Similarly, Cheng, modified to use oxidized nanotubes as in Gan, disclose each and all of the above-noted steps of Example 2 in sequential order. *See* LGES-1007, Abstract, [0013]-[0019], claim 2. As explained by Dr. Zhu, this suggests that similar steps in forming the composite would have likely yielded similar dispersion results. LGES-1003, ¶131.

Alternatively/additionally, a POSITA would have understood or found obvious that the nanotubes in the combination composition are **discrete** because, at least in some instances, oxidation of nanotubes can help promote **non-agglomeration of nanotubes**. LGES-1003, ¶132. 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-1008, [0027]-[0028]; LGES-1003, ¶132. 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, ¶71. In light of this behavior of oxidized nanotubes, a POSITA would have understood or found obvious that oxidized nanotubes in the

combination can be present as generally individually distinct nanotubes, *e.g.*, that the nanotubes are **discrete**. LGES-1003, ¶132.

At least for the reasons set forth above, the combination discloses or enders obvious discrete carbon nanotubes.

[1b] having ion active material attached to their surface . . . wherein the 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 combination, Cheng’s carbon nanotube/lithium iron phosphate composite is a composition used to produce the “cathode material” for positive electrode of the lithium ion battery and the lithium iron phosphate corresponds to an ion active material¹². LGES-1007, [Abstract]; LGES-1003, ¶133. The lithium

¹² The claim states that the ion active material includes both a lithium metal salt and an element selected from the specified group. This element can either be a constituent of the lithium metal salt or another component of the ion active material. For instance, none of the relevant experimental examples in the specification disclose extra “element” in addition to the lithium metal salt and it merely states that “[e]xamples of ion active materials are lithium iron phosphate, lithium manganese phosphate, lithium cobalt oxide, silica, manganese dioxide, cadmium, titanium dioxide and carbon.” LGES-1001, 2:40-45, 4:34-37.

iron phosphate includes a lithium metal salt having an element **iron**. LGES-1003, ¶133.

Therefore, because the ion active material in the Cheng-Gan electrode material includes lithium iron phosphate, which is a well-known example of lithium metal salts, and further because lithium iron phosphate further contains an element selected from the group consisting of: **iron**, manganese, cobalt, copper, nickel, vanadium, titanium, and mixtures thereof, Cheng-Gan renders obvious this limitation. LGES-1003, ¶133.

Further, lithium iron phosphate, as active ion materials, are attached to the nanotubes surfaces at least for the following reasons.

First, in the Cheng-Gan combination, Cheng's methods of forming the composite, including [1] mixing carbon nanotube, acetylene black, and dispersant mixture with lithium source, iron source, phosphate salt, and organic carbon source using mixing medium, [2] ball milling, [3] drying, [4] calcination, and [5] sieving indicate that the ion active material [lithium iron phosphate] is attached to the surfaces of carbon nanotubes. *See* LGES-1007, [0013]-[0018], claim 2; LGES-1003, ¶134. For instance, Cheng claims and describes "a carbon nanotube/iron phosphate composite," in which the carbon nanotubes are "uniformly dispersed in a bulk phase and on surfaces of lithium iron phosphate," and describes that "[t]he high-performance carbon nanotube lithium iron phosphate composite material

obtained” has features of the “carbon nanotubes or carbon nanofibers” being **“uniformly distributed on the surface of and in the lithium iron phosphate material** by means of an **in situ solid phase reaction.”** LGES-1007, Abstract, [0012], [0021], claim 1, 2. For instance, Cheng claims and describes that the **“in situ solid phase reaction”** includes certain steps including **[1]** calcining the dried precursor powder at 600-850 °C for 4-49 hours, **[2]** pulverizing the burned material, and **[3]** then sieving the same through a sieve of 150-400 meshes (here, the dried precursor powder refers to a powder that is obtained by [a] mixing carbon nanotube, acetylene black, and dispersant mixture with lithium source, iron source, phosphate, and organic carbon source using the mixing medium, [b] ball milling the mixture, and [c] drying the mixture). *See id.*, [0019], claim 2. As a consequence of above-noted steps, Cheng obtains “the particulate homogeneous composite of carbon nanotubes and the lithium iron phosphate cathode material,” where the carbon nanotubes “are not only present on the surface of the material, but also form a uniformly distributed network structure inside the material.” *Id.*, [0022], [0023]. LGES-1003, ¶134.

Accordingly, the above-noted steps in Cheng indicate that the **ion active material [lithium iron phosphate] are attached to the surface of the carbon nanotubes.** LGES-1003, ¶135.

Second, in the combination, Cheng is modified to use **oxidized nanotubes** as in Gan, and steps of attaching or coating the “**ion active material [lithium iron phosphate]**” to the surface of the carbon nanotubes are similar to those described in the '924 patent. For instance, the '924 patent has two examples (Examples 2 & 3), which allegedly describe “Discrete Carbon Nanotubes with Lithium Iron Phosphate *Coated on the Surface of the Tubes* Suitable for a Lithium Ion Battery Cathode Material.” LGES-1001, 5:30-67, 6:1-4. Here, the Example 2 of the '924 patent describes sequential steps of [1] forming oxidized carbon nanotubes / solvent mixture based on ultrasonic dispersion, [2] mixing the mixture with lithium source, iron source and phosphate source with mixing medium (e.g. deionized water), and [3] heat treatment. *See id.*, 5:30-53. Similarly, Cheng, utilizing the oxidized nanotube as taught by Gan, discloses each and all of the above-noted three steps of Example 2 in sequential order. *See* LGES-1007, Abstract, [0013]-[0019], claim 2. This suggests that **similar steps in “coat[ing]” or attaching the lithium iron phosphate would have likely yielded similar attachment results.** LGES-1003, ¶¶136, 137.

Third, in the combination, Cheng is modified to use **oxidized nanotubes** as in Gan, and it was well-known in the lithium ion battery industry that oxidized nanotube would improve the attachment of the ion active material (lithium iron phosphate or the like) to the carbon nanotube surface. LGES-1003, ¶138.

For instance, as described *supra*, it was well-known that the oxidation of nanotubes improves anchoring of LiFePO_4 and exert a pronounced effect on the sorption properties of nanotubes. LGES-1010, 2; LGES-1005, 2; LGES-1003, ¶139. It was well-known that one role of the oxidation was to create “foothold” functional groups, which “serve as attachment points to anchor either larger biomolecular structures or nanoparticles.” LGES-1010, 2; LGES-1003, ¶139.

Further, for instance, it was well-known, with regards to the battery electrode materials development, that ion active materials or transition metal oxide precursors or nanoparticles that are formed on the carbon nanotubes interact or react with the carboxyl or hydroxyl groups of the functionalized carbon nanotubes to form attachment or chemical bonding. LGES-1003, ¶140 (citing LGES-1027, 6 and LGES-1030, 2).

Further, for instance, it was demonstrated that the oxidized nanotubes “have a negative electrostatic charge on the outer surface of the nanotube wall” and a POSITA would have easily recognized that such “negative electrostatic charge on the outer surface of the nanotube wall” would be used to enhance attachment of the positive ion active material (e.g., LiFePO_4) to the nanotubes’ surfaces. *See* LGES-1024, [0057]; LGES-1003, ¶141.

[1c]¹³ wherein the discrete carbon nanotubes have an aspect ratio of 10 to 500 and

In the Cheng-Gan combination, Cheng describes nanotubes that have an aspect ratio in the preferred range of 67-300, which falls within the claimed range (“10 to 500”). For instance, Cheng describes that “the carbon nanotubes used in the present invention need to have the tube diameter of 10 to 200 nm and the length of 5 to 20 μ m, and the optimal effect is achieved when the carbon nanotubes have the tube diameter of 50 to 150 nm and the length of 10 to 15 μ m. Compared with carbon nanotubes having a smaller tube diameter and a greater length, the carbon nanotubes are less entangled with each other and are more easily dispersed. Therefore, formation of an effective conductive network is facilitated.” LGES-1007, [0021]. That is, based on the well-known interpretation of the aspect ratio being length divided by diameter, Cheng’s carbon nanotube exhibits the aspect ratio in the preferred range of 67-300. LGES-1003, ¶142.

Accordingly, Cheng-Gan combination’s aspect ratio falls within the claimed range (“10 to 500”). In the Cheng-Gan combination, this specific range of aspect ratio disclosed by Cheng is a relevant disclosure for the recited aspect ratio, and the

¹³ 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-1033.

Cheng-Gan combination thus renders obvious the claimed range of aspect ratio.

See Ineos, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782.

Alternatively/additionally, taking into consideration the full range of aspect ratio taught in Cheng, Cheng-Gan combination's aspect ratio overlaps with the claimed range. For instance, the full range taught in Cheng ("the tube diameter of 10 to 200 nm and the length of 5 to 20 μm ") corresponds to the aspect ratio of 25-2000. LGES-1007, [0021]. Thus, the aspect ratio of 25-2000 overlaps with claimed range of 10 to 500. LGES-1003, ¶¶143, 144. And the '924 Patent provides no discussion, let alone any evidence, of unexpected results or criticality of the claimed range of aspect ratio. LGES-1003, ¶143. Thus, the Cheng-Gan combination renders obvious the claimed range of aspect ratio. *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70.

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

In the Cheng-Gan combination, the nanotubes (e.g., oxidized nanotubes) has an oxidation level of 2.5-10 wt%. For instance, Gan describes "carbon nanotube that is functionalized with carboxyl group at about 2.5 to 10 wt%," which equates to oxidation levels at about 2.5 to 10 wt%. LGES-1021, [0024]; LGES-1003, ¶145.

Gan emphasizes controlling the oxidation levels of the carbon nanotubes with carboxyl and/or hydroxyl groups "at about 2.5 to 10 wt%" to obtain [1]

improved dispersibility of nanotubes in water or polymer, [2] reduced contact resistance of the carbon nanotubes, and [3] preservation of the intrinsic properties of the carbon nanotubes, including the electrical conductivity of pristine carbon nanotubes. *See* LGES-1021, [0019]-[0024]; LGES-1003, ¶146.

For instance, as discussed *supra*, Gan describes that “the degree to which the CNTs are functionalized” achieves “one or more of the three objectives” including “improv[ing] the solubility and dispersibility of the CNTs in water and conductive polymer materials.” Gan attributes this solubility and dispersibility of the carbon nanotubes to the “carboxyl groups (—COOH) [, which] are a preferred functional group that can be chemically attached to the CNT's because they render the CNT more soluble in water and conductive polymer materials” and the “[h]ydroxyl groups,” which “are effective at increasing the solubility and dispersibility of the CNTs.” LGES-1021, [0022]; LGES-1003, ¶147.

Moreover, Gan describes another objective that can be achieved based on the functionalization corresponds to “reduc[ing] contact resistance between CNTs” that are incorporated into conducting agent (e.g., conductive polymer), thereby enhancing the conductivity of the composite network formed by carbon nanotubes. LGES-1021, [0020], [0021]; LGES-1003, ¶148. Indeed, Gan attributes this enhanced conductivity at least to the ability of carboxyl groups to “form hydrogen bonds between carbonyl and hydroxyl groups of two different CNTs that contain

carboxyl groups,” thereby “effectively reducing electrical contact resistance between the CNTs.” LGES-1021, [0022]; LGES-1003, ¶148.

Further, Gan emphasizes that “while a greater degree of functionalization may improve the dispersibility of the CNTs, such improvement may come at a decrease in intrinsic properties of the pristine CNTs.” LGES-1021, [0024]. This implies that at the oxidation level range of 2.5 to 10 wt% (based on Gan’s guidance and disclosure), the intrinsic properties of the carbon nanotubes would be preserved. *Id.*, [0024]; LGES-1003, ¶149.

As described *supra* with respect to the “Reasons for the combination” section (Part IV.B.4.), there would have been sufficient motivation for a POSITA to apply nanotubes having functionalization level (or oxidation level) such as those described by Gan to the Cheng’s nanotube composite, and, at the same time, would have expected success. *See* discussion *supra* Part IV.B.4; LGES-1003, ¶150.

Accordingly, this range of oxidation level recited in Gan (“2.5 to 10%”), as applied to the nanotubes of the combination, renders obvious a composition in which the nanotubes have oxidation levels from 1% to 15% by the weight of the carbon nanotube . LGES-1021, [0024]; LGES-1003, ¶151. *See Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782.

Alternatively/additionally, a POSITA would understand that oxidized nanotubes—e.g., including those with oxidation levels that fall within the claimed

range (“1% to 15%”), regardless of the method of measurement—were extensively used in various applications, including lithium ion batteries and further, the effect of oxidized nanotubes with oxidation level such as 9.1% was known to improve dispersibility of the carbon nanotubes and thus to enhance electrical conductivity of conductive network in the electrode composite in lithium ion battery industry. *See* discussion *supra* Part IV.A.5.(i).(1d); LGES-1003, ¶¶152-154.

Accordingly, the oxidized nanotubes with oxidation levels that fall within the claimed range in element [1d] (“1% to 15%”) were well-known for forming a carbon nanotube/lithium iron phosphate composite material used toward lithium ion battery positive electrode materials, which renders obvious a composition in which the nanotubes have oxidation levels from 1% to 15% by the weight of the carbon nanotube. LGES-1003, ¶155. *See Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782.

(i) Claim 4

[4] The composition of claim 1, wherein the carbon nanotubes are present in a weight percentage of 0.1% to 10% by weight of the ion active material.

In the Cheng-Gan combination, Cheng describes that the “composite cathode material obtained in the present invention is the particulate homogeneous composite of the carbon nanotubes and the lithium iron phosphate cathode material,” where the “carbon nanotubes account for 0.5-15% by weight, and the

lithium iron phosphate accounts for 85-99.5% by weight.” LGES-1007, Abstract, [0023], claim 1; LGES-1003, ¶156.

Further, Cheng describes that the preferable range is where the “carbon nanotubes accounts for 0.5-3% by weight, and the lithium iron phosphate accounts for 92-97% by weight, the coating carbon accounting for 1-5% by weight.” LGES-1007, [0023]; LGES-1003, ¶156.

Cheng’s preferred weight percentage range (0.5-3 % of carbon nanotube and 92-97 % of lithium iron phosphate) corresponds to the carbon nanotubes being present in a weight percentage (“wt%”) of 0.52 % to 3.26% by weight of the ion active material. LGES-1003, ¶157.

Alternatively/additionally, to the extent the weight percentage is based on the total weight of both nanotubes and ion active material,¹⁴ Cheng’s weight percentage range corresponds to the carbon nanotubes being present in a weight percentage of 0.51% to 3.16% by weight. LGES-1007, Abstract, [0023], claim 1; LGES-1003, ¶158.

¹⁴ The ’924 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, 3:64-67; LGES-1003, ¶158.

The range of weight percentages disclosed by Cheng (**0.52-3.26%**) falls within the claimed **0.1% to 10% by weight** range recited in claim 4. As such, in the Cheng-Gan combination, this specific range of weight percentages disclosed by Cheng is a relevant disclosure for the recited weight percentage range, and the Cheng-Gan combination thus renders obvious the claimed range of weight percentages. LGES-1003, ¶159. *See Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782.

(ii) Claim 5

[5] The composition of claim 1, comprising uniformly dispersible oxidized carbon nanotubes having ion active materials attached to their surface.

As described supra with respect to discussion of [1a], [1b], and [1d], the Cheng-Gan combination uses oxidized carbon nanotubes, in which the oxidized carbon nanotube disperses and is dispersible throughout both the [1] “carbon nanotubes” themselves and [2] “the precursor” that includes lithium iron phosphate. *See* discussion *supra* Part IV. B.4. & B.5.(i).[1a], [1b], [1d]. Such oxidized carbon nanotubes dispersion results in non-aggregated and uniform dispersion of CNTs. *See id.* As a result of, or evidenced by, “uniform dispersion,” “uniformly distributed network structure,” or non-aggregated state, the oxidized carbon nanotubes are uniformly dispersible tubes. *See id.*; LGES-1003, ¶160. Moreover, the oxidized nanotubes are **dispersible** because the combination composition is capable of being mixed. LGES-1003, ¶160.

**C. [GROUND 2B] – CLAIMS 2 AND 3 ARE OBVIOUS OVER
CHENG-GAN-ZHAO**

(i) Claim 2

[2] The composition of claim 1, further comprising graphene or oxygenated graphene.

“An objective” of Zhao “is to provide a conductive agent for a lithium-iron-phosphate battery, the conductive agent having high electron conductivity and uniform heat conductivity.” LGES-1018¹⁵, [0004]. “In order to achieve the above purpose,” Zhao describes addition of graphene to carbon nanotube/carbon black (e.g., acetylene black) composite material for positive electrodes of lithium ion batteries. *Id.*, Abstract, [0006], [0009], [0011]. For instance, here, Zhao refers to the “conductive agent” (hereinafter “composition”) as “carbon nanotube/carbon black composite material, graphene, and a binder.” *See id.*, Abstract. Zhao describes that such use of the composition “effectively utilizes respective advantages of fibrous carbon nanotubes, spherical carbon black, and sheet-like graphene, and cause the same to achieve a synergistic effect, thereby significantly improving electrochemical performance of the battery.” *See id.*, [0012]; LGES-1003, ¶¶161.

¹⁵ CN 102136576 to Zhao (LGES-1017) was published in Chinese. Thus, all citations to Zhao are to its English translation (LGES-1018).

For instance, Zhao explains that adding graphene to a carbon nanotube/carbon black composite material enhances electron transport, reduces internal resistance, and improves heat dissipation. LGES-1018, [0011]; LGES-1003, ¶¶162. Moreover, for instance, Zhao describes that “[a]fter combination of the graphene and the carbon nanotube/carbon black composite material, **multi-dimensional conduction of electrons between lithium iron phosphate as the active material can also be achieved**” and synergistic effects “**can be achieved by means of fibrous, spherical, and sheet-like characteristics achieved by the combination of the carbon nanotube/carbon black composite material and the graphene**, thereby improving physical and chemistry properties of the active material, and playing an **important role in the consistency [or uniformity] of the battery.**” LGES-1018, [0011]; LGES-1003, ¶¶162.

Given the above-noted advantages of graphene toward carbon nanotube / carbon black composite material, a POSITA would have been motivated to add graphene toward the carbon nanotube / acetylene black (specific form of carbon black) / lithium iron phosphate composite material in Cheng-Gan combination and would have expected success. LGES-1003, ¶163.

(ii) Claim 3

[3] The composition of claim 2, wherein the weight ratio of graphene to carbon nanotube is in the range of 0.1:99.9 to 99.9:0.1.

First, claim 2 features are taught as described *supra*, and further, Cheng-Gan-Zhao renders obvious a weight ratio of graphene to carbon nanotube that falls within the broad range of claimed weight ratio of graphene to carbon nanotube. For instance, the claimed weight ratio of graphene to carbon nanotube, which ranges from 0.1:99.9 to 99.9:0.1, indicates a broad range. This ratio indicates that the weight percentage of either graphene or carbon nanotube in sum of graphene and carbon nanotube corresponds to 0.1 wt% - 99.9 wt%. LGES-1003, ¶164.

Second, Zhao describes that the preferred weight percentage of graphene in sum of graphene and carbon nanotube is about 9 wt%, based on weight ratio of graphene to carbon nanotube (with carbon black) being 0.1 : 1. For instance, Zhao describes that “[t]he conductive agent . . . consists of a carbon nanotube/carbon black composite material, graphene and a binder” in the weight ratio of “1 : (0.001-0.1) : (0.01-1)” and states that “[p]referably, the weight ratio of carbon nanotube/carbon black composite material, graphene and the binder is . . . 1 : 0.1 : 1.” LGES-1018, Abstract, [0006], [0007], [0009], claim 1, claim 2. This indicates that the weight percentage of graphene in the sum of graphene and carbon nanotube/carbon black composite corresponds to about 9 wt% (0.1 graphene / (0.1

graphene + 1 carbon nanotube/carbon black composite) x 100% = 9 wt %). LGES-1003, ¶165.

Third, 9 wt% of graphene in the sum of graphene and carbon nanotube / carbon black composite should fall within the 0.1 wt% - 99.9 wt% of graphene in the sum of graphene and carbon nanotube, even excluding the carbon black. For instance, even if the carbon black is not considered when determining the weight percentage of graphene in the sum of graphene and carbon nanotube, it would have been obvious that the teaching of using a specific weight percentage of graphene would still be relevant and applicable within the broad claimed range. For instance, a POSITA would have recognized that the disclosed range for the weight ratio of graphene to carbon nanotube / carbon black composite in Zhao inherently encompasses various composite formulations, including those without carbon black. *Id.*; LGES-1003, ¶¶166, 167.

Accordingly, Cheng-Gan-Zhao renders obvious a composition in which weight ratio of graphene to carbon nanotube is in the range of 0.1:99.9 to 99.9:0.1. LGES-1003, ¶ 168.

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-1035.

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 '924 Patent. Indeed, none of Ohata, Kavan, Cheng, Gan, or Zhao — the only references applied in this Petition against the Challenged Claims—were previously cited or applied in a rejection during prosecution of the '924 Patent.

VI. PAYMENT OF FEES – 37 C.F.R. § 42.103

Petitioner authorizes the Patent and Trademark Office to charge Deposit Account No. 06-1050 for the fee set in 37 C.F.R. § 42.15(a) for this Petition and further authorizes payment for any additional fees to be charged to this Deposit Account.

VII. CONCLUSION

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

VIII. 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 '924 Patent. The '924 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 Feb. 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 IPR18768-0210IP5@fr.com (referencing No. 18768-0210IP5 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 13,987 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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