

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ENERGY SOLUTION, LTD.,
Petitioner,

v.

MOLECULAR REBAR DESIGN LLC,
Patent Owner.

Case IPR2024-01011
Patent 8,968,924

PETITIONER'S REPLY TO PATENT OWNER'S RESPONSE

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LIST OF 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”)
- LGES-1038-1039 Reserved
- LGES-1040 Electronic Supplementary Information of LGES-1032
- LGES-1041 “Electrode Composite LiFePO₄@Carbon: Structure and Electrochemical Performances.” L. Huynh, *Journal of Nanomaterials*, 2463920 (2019) (“Huynh”).
- LGES-1042 “Synthesis of porous carbon nanotubes foam composites with a high accessible surface area and tunable porosity.” Y. Liu, *Journal of Materials Chemistry* (2013), 1, 9508 (“Liu”)
- LGES-1043 “Preparation of LiFePO₄/C Cathode Materials via a Green Synthesis Route for Lithium-Ion Battery Applications.” R. Liu, *Materials* (2018), 11, 2251 (“R. Liu”)
- LGES-1044-1052 Reserved
- LGES-1053 Deposition Transcript of Dr. Deborah Chung in IPR2024-01011, dated July 1, 2025
- LGES-1054 Deposition Transcript of Dr. Deborah Chung in IPR2024-01006, dated July 1, 2025
- LGES-1055 Deposition Transcript of Dr. Deborah Chung in IPR2024-

01005, dated June 25, 2025

- LGES-1056 Supplemental Declaration of Dr. Yu Zhu
- LGES-1057 Patent Owner's Response in IPR2024-01005
- LGES-1058 Declaration of Dr. Yu Zhu in IPR2024-01013
- LGES-1059 "Increase the Mechanical Performance of Polyvinylidene Fluoride (PVDF)." M. Hou. Cheng. Advanced Materials Research Vols. 393-395 (2012).
- LGES-1060 Patent Owner's Response in IPR2024-01012 ('282 Patent)
- LGES-1061 U.S. Patent Pub. No. 2007/0060708 ("Wang")
- LGES-1062 "Alternative solvents for Lithium-Nickel-Cobalt-Manganese-Oxide electrode fabrication for lithium-ion-cells." F. Heim et al. Journal of Power Sources 558 (2023) 232546 ("Heim")

The Patent Owner Response (“POR”) fails to rebut the Petition’s showing that claims 1-5 are unpatentable over both Ohata-Kavan and Cheng-Gan. Patent Owner’s (“PO”) arguments are based on technically inaccurate explanations, misinterpretations or misrepresentations of the relied-upon references, and legally deficient rebuttals to positions advanced in the Petition. For these and the reasons explained further below, PO’s arguments are unavailing and the Challenged Claims should be found unpatentable.

I. CLAIM CONSTRUCTION – “DISCRETE”

The Petition did not present a claim construction for the term “discrete.” Although PO similarly did not explicitly offer a construction in its Patent Owner Response (POR), it contends—incorrectly—that Petitioner did, asserting that Petitioner’s position is that “discrete” nanotubes must be “‘fully isolated’ or ‘separated’ from one another.” POR, 52. PO then adopts this purported construction and applies it throughout the POR.

First, this is a blatant misrepresentation of Petitioner's position. Second, it is inconsistent with the '924 Patent itself, which provides no support for such a narrow interpretation.¹

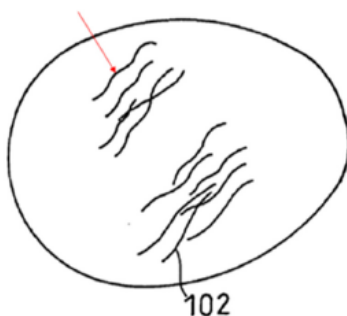
A. PO quotes Petitioner's expert out of context in attempting to substantiate its position

PO's citation to statements made by Petitioner's expert, Dr. Zhu, regarding the term "discrete" omits critical context. *See* POR, 52. Dr. Zhu's agreement that he was "identifying that nanotube [marked with the red arrow in the figure *infra*] as discrete because it's fully isolated from the other nanotubes" (MRD-2024, 10:21-11:12) is not, as PO would like to believe, an admission that a nanotube necessarily must be isolated to be discrete. Instead, it is a description

¹ Notably, in IPR2024-01005, PO does offer an explicit construction for the term "discrete" as meaning "carbon nanotubes that are separate and distinct from other nanotubes; not attached to other nanotubes." LGES-1057, 8; *see* LGES-1060, 14 (presenting a similar construction in IPR2024-01012). When questioned at deposition in IPR2024-01005, PO's expert, Dr. Chung confirmed that she applied the same definition of "discrete" in that proceeding as she has done here. *See* LGES-1055, 118:14-24. To the extent that this explicit construction, instead, is PO's interpretation of the term "discrete," it, too, is inconsistent with the plain language of the '924 Patent and should not be adopted.

of the particular illustrated example. In fact, while the term “discrete” surely encompasses individually isolated nanotubes, the term “discrete” is not limited to only individually isolated nanotubes. LGES-1056, ¶5; *see infra* §§I.B-C.

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



LGES-1058, 50

B. The '924 Patent does not support that discrete nanotubes must be fully isolated or separated from one another

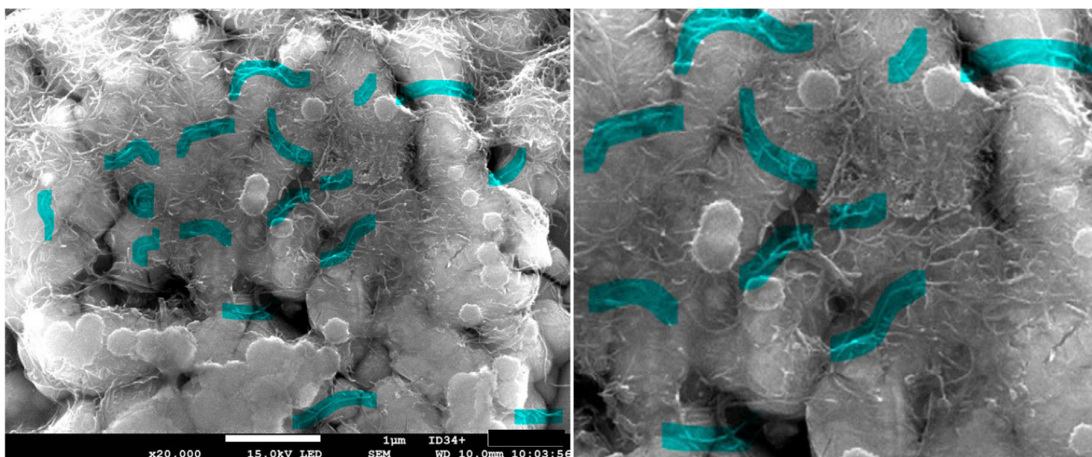
The '924 Patent is unambiguous: “[t]he term ‘discrete carbon nanotubes’ as used herein refers to carbon nanotubes *capable of being separated* to give individual tubes.” LGES-1001, 3:52-54 (emphasis added). Tellingly, PO quotes this very sentence from the '924 Patent, but only in part, stating that the '924 Patent confirms that “‘discrete’ CNTs are ‘separated to give individual tubes.’” POR, 52. PO’s stealthy omission of the key phrase “*capable of*” (LGES-1001, 3:52-54) unjustifiably changes the meaning of this statement, which, when read in its entirety, cannot support PO’s narrow interpretation of the term “discrete.”

Notably, while this statement in the '924 Patent encompasses nanotubes that are already separated, it is not so limited. Both PO’s implicit construction

(framed misleading as Petitioner’s position) and PO’s construction advanced explicitly in IPR2024-01005 are inconsistent with this statement in the ’924 Patent, and instead present an overly narrow interpretation that should not be adopted.

C. Requiring “discrete” nanotubes to be isolated contradicts PO’s own positions in co-pending litigation

PO’s narrow construction is further undermined by its own infringement contentions, in which PO alleged that the SEM images below depict “discrete” carbon nanotubes; the allegedly discrete nanotubes they highlight clearly depict nanotubes touching each other (original highlighting by PO). *See* LGES-1050, 33; LGES-1056, ¶¶6-7.



LGES-1050, 33 (original at left, cropped and magnified at right)

PO has thus acknowledged that “discrete” nanotubes need not be physically separated. PO cannot maintain such contradictory positions simultaneously—advocating for one interpretation here and an entirely different interpretation in district court proceedings. This contradiction alone highlights

the implausibility and inconsistency of PO's assertion that discrete nanotubes must be individually isolated.

II. OHATA-KAVAN

A. PO's assertions that the electrode active material is not in contact with the nanotubes in the Ohata-Kavan composition are unphysical and inconsistent with Ohata's disclosure

PO's interpretation of Ohata's morphology as having nanotubes fully embedded in the electrode material, thus precluding attachment between nanotubes and active material particles, runs counter to Ohata's objective of using nanotubes to provide "an excellent conductive path in an electrode." Ohata, [0016]. In fact, it was well-understood—and indeed acknowledged by Dr. Chung—that contact between nanotubes and active material is necessary for functional electrode materials. *See* LGES-1054, 17:1-15, 16:2-12; LGES-1056, ¶8.

1. PO's theory that there is no contact between nanotubes and electrode active material is illogical and technically inaccurate

PO argues that the Ohata-Kavan nanotubes are "fully embedded within and coated by the resin matrix," which "prevent[s] the active material from attaching to the surface of the CNTs." POR, 35, 44-45. This is illogical. A composition in which there was no contact between nanotubes and active material, as PO proposes, would simply be non-functional as a battery electrode material. LGES-1056, ¶9.

It is well-established that in battery electrode material, there must be electrical contact between the active material and the conductive additive, to enable current flow through the electrode. *See* LGES-1056, ¶10 (citing MRD-2017, [0094]; MRD-2018, [0092]). Indeed, Dr. Chung readily acknowledged this to be the case, explaining at deposition that “the conductive additive ***needs to be in physical contact with the active material*** so that the charges can come out or go in of this active material particle.” LGES-1054, 17:1-15. Said another way, without contact between the conductive additive (*e.g.*, nanotubes) and the active material, the electrode material would be inoperable in a battery. *See* LGES-1054, 16:2-12, 36:18-37:5 (you need to have a plurality of nanotubes coming together and making electrical contact between one another -- that is, touching one another ... so as -- as a whole, the network would provide a continuous electrically conductive path.”).

Given this basic physical operation of battery electrodes, the folly of PO’s position becomes apparent. PO argues that a “resin layer separat[es] the active material from the surface of the CNTs” such that “it is impossible for the active material to attach to the surface of the CNTs.” POR, 45. This makes no sense. PO acknowledges that PVDF binder is non-conductive. *See* LGES-1054, 37:22-25 (“PVDF is not conductive”); POR, 19. A configuration in which CNTs are fully embedded within a non-conductive resin and thus electrically isolated from the active material is not viable and is inconsistent with battery fabrication

practices that are specifically intended to enhance conductivity. LGES-1056, ¶¶11, 15-16.

Moreover, PO's position is incompatible with Ohata's stated goal of improving electrical conductivity of electrode materials. *See* LGES-1004, Abstract, [0004]. Ohata aims to use nanotubes to "form an excellent conductive path in an electrode." LGES-1004, [0016]. Yet this could not happen in PO's hypothetical structure: nanotubes that are "fully embedded" within a non-conductive binder and thus not able to contact one another or the active material particles, as PO proposes (*see* POR, 19), would be unable to provide such a conductive path. LGES-1056, ¶12. Instead, as Dr. Zhu explains and as acknowledged by Dr. Chung, an electrode material without contact between nanotubes and active material simply would be non-functional. LGES-1056, ¶12; LGES-1054, 14:15-18:16; LGES-1004, Table 3; LGES-1056, ¶12;.

2. The solubility of Ohata's binder in NMP belies PO's argument that Ohata's nanotubes remain fully embedded in the binder matrix

Even to the extent that Ohata's nanotubes are fully embedded within the PVDF binder of the masterbatch, that embedding would not withstand the processing of the masterbatch to prepare the electrode material mixture paste. LGES-1056, ¶21. Ohata's masterbatch is mixed with active material particles and NMP, and "[t]he masterbatch *was easily dissolved* in [NMP]." LGES-1004, [0032]. Indeed, that the PVDF binder of Ohata's masterbatch is readily soluble in NMP was well-known. LGES-1056, ¶21 (citing LGES-1061, [0004]; LGES-

1062, 2); ¶¶13-20 (citing, LGES-1061, LGES-1062, LGES-1004, LGES-1059).

The solubility of PVDF in NMP refutes PO's allegation that even after processing with NMP, the nanotubes remain "fully embedded within and coated by the resin matrix." POR, 44-45. And in fact, dissolution of PVDF makes sense given the need for physical contact between the nanotubes and active material discussed *supra*. LGES-1056, ¶22.

Moreover, PO's position that "the PVDF coating would be more strongly bound to the oxidized CNTs" is inconsistent with literature reports of a weak interaction between functionalized nanotubes and PVDF. LGES-1056, ¶23 (citing LGES-1059, 5). Given this weak interaction, and the high solubility of PVDF in NMP, a POSITA would have recognized that NMP can in fact substantially remove PVDF from the CNT surface, enabling attachment of active material particles to the nanotubes. *Id.*

3. PO's own corroborating references refute its theory of complete embedding of Ohata's nanotubes in the binder material

PO's mechanistic explanation for why Ohata's nanotubes purportedly remain embedded in the binder is also refuted by general knowledge of the art, evidenced even by PO's own corroborating references. LGES-1056, ¶24.

For instance, PO cites MRD-2017's Figure 2 to argue that carbon nanotubes remain embedded in PVDF "domains," even after NMP dissolution, thereby preventing contact with active material. MRD-2006, ¶123. But PO's interpretation of this figure is speculative and contradicted by MRD-2017's own

disclosure. Specifically, MRD-2017 explains that CNTs “form electrical bridges between the active material particles,” and this explanation is supported by experimental results indicating that the CNTs are not, in fact, electrically isolated. MRD-2017, [0094], *see* [0123]-[0125]; LGES-1056, ¶25. That is, in MRD-2017, CNTs physically contact the active material, rather than being insulated from the active material, as PO contends. LGES-1056, ¶¶25-26; *see also* MRD-2018, [0092], [0131].

Dr. Chung’s own testimony confirms that PO’s interpretation of MRD-2017 cannot be sustained. She admitted that Figure 2 is “not very clear,” and indeed was unable to identify a single carbon nanotube in the image. LGES-1054, 53:7-57:2. Dr. Chung’s statement that CNTs are “hidden inside these domains” is not grounded in what the figure shows, but rather on speculation that contradicts both the image and the specification. LGES-1054, 53:7-57:2. Nor does interpreting Figure 2 in light of the specification, as Dr. Chung proposes, save PO’s position. *See* LGES-1054, 54:16-55:10. The specification of MRD-2017 confirms that CNTs are not embedded and isolated, but instead dispersed and connected to the active material. MRD-2017, [0094], [0123].

Other references PO attempts to use to corroborate its embedded nanotubes theory are likewise insufficient. For instance, MRD-2018 states that CNTs “form electrical bridges between the particles of active material.” (MRD-2018, [0092], [0131]), undermining PO’s assertion that the CNTs become embedded or isolated within the PVDF matrix. LGES-1056, ¶26.

PO's reliance on MRD-2008 is likewise misplaced and contradicted by the reference itself. PO cites MRD-2008 as describing a "glue-like" process in which carbon black is "embedded in PVDF resin," analogizing it to the Ohata-Kavan structure. POR, 22. But if the conductive carbon black were truly embedded within PVDF to the point of being isolated from the active material—as PO suggests—the resulting structure would lack the necessary conductivity to function as an electrode. LGES-1056, ¶¶27-29.

B. The nanotubes in the Ohata-Kavan composition are discrete

PO argues that the Ohata-Kavan composition would not include discrete nanotube, but this argument relies on overly restrictive construction for "discrete." The term "discrete" does not preclude a network of nanotubes, *e.g.*, in point-to-point contact, providing a conductive pathway through the electrode material, as is the case in Ohata-Kavan. Indeed, the '924 Patent itself indicates that discrete nanotubes enhance conductivity, well-aligned with the purpose of the Ohata-Kavan nanotubes. *See* LGES-1056, ¶31; LGES-1001, 1:49-55, 2:29-33, 2:9-16, 2:17-21, 5:51-53, Table 1.

PO takes issue with the Petition's "reliance on cartoon Figure 1 of Ohata." POR, 53. To be sure, Figure 1 is just a schematic diagram, but one that the Petition demonstrated would have been understood as representing the discrete nanotubes of Ohata's composition. *See* Petition, 22-23. Regardless, PO's myopic focus on Fig. 1 ignores what the Board already recognized at institution (Institution Decision, 17-18): the Petition relied upon not only Ohata's Fig. 1, but

also numerous other citations, bolstered by explanation and expert corroboration, to demonstrate that the nanotubes in the combination are discrete. *See* Petition, 21-24; LGES-1003, ¶¶69-72. Indeed, PO's main objection to the Petition's showing of discreteness in the Ohata-Kavan nanotubes appears to be based not in any criticism of Ohata, but instead in its own excessively narrow interpretation of what constitutes a discrete nanotube.

PO further attempts to argue against the discreteness of the Ohata-Kavan nanotubes fail in their reliance on Gan (LGES-1021)—an entirely different reference. For instance, in addressing the Petition's explanation that oxidation further promotes that the nanotubes are discrete, PO cites to Gan, which, it alleges, "teaches that functionalized CNTs within a polymer will be drawn closer together ... facilitating the formation of a continuous network." POR, 59-60 (citing LGES-1021, [0018]-[0021]). Yet as noted *supra*, a continuous, conductive network of nanotubes is consistent with a population of discrete nanotubes, *e.g.*, nanotubes in point-to-point contact. Even to the extent that Gan is relevant to the structure of the Ohata-Kavan composition (which PO has not established), the morphology of Gan's nanotube network does not demonstrate absence of discrete nanotubes in Ohata-Kavan. LGES-1056, ¶32.

Separately, PO also appears to argue that the Ohata-Kavan nanotubes would be arranged as shown in Gan's SEM images. *See* POR, 53-54. But PO's reliance on Gan's FIG. 5, which illustrates networks of non-oxidized nanotubes has not been demonstrated by PO to inform POSITA's views as to oxidized

nanotubes within Ohata-Kavan composition. LGES-1021, [0014]. Indeed, a POSITA would not have drawn any conclusions about the arrangement of the Ohata-Kavan nanotubes from this image of an entirely different material, fabricated in an entirely different way. LGES-1056, ¶33.

C. PO fails to refute the Petition’s several distinct motivations for the Ohata-Kavan combination

The Petition presented four distinct motivations underpinning the Ohata-Kavan combination. PO’s sole objection to several of these motivations is rooted in its mischaracterization of the nanotubes as being fully embedded within the resin matrix, which, as discussed *supra*, is not the case. And PO’s arguments against the other motivations advanced in the Petition are also deficient, leaving PO with no viable rebuttal to the robust Ohata-Kavan combination.

1. PO’s objections to the Petition’s motivations to combine Ohata and Kavan are premised on its incorrect theory that nanotubes are fully embedded in the binder

PO’s argument that “[a] POSITA would have had no motivation to oxidize the CNTs of Ohata pursuant to Kavan, because ... the masterbatch process would destroy all oxidation benefits described by Kavan” (POR, 44-45) is premised on PO’s flawed understanding of the Ohata-Kavan nanotubes as being fully embedded in the resin. But as established above, this is not accurate. When the structure of the Ohata-Kavan composition is properly understood to involve contact between nanotubes and active material particles, PO’s objections to the motivations set forth in the Petition are revealed to be without merit.

Indeed, PO specifically acknowledges that its sole objection to the “first reason” for the combination advanced in the Petition is because “[t]his reason is premised on the active material being able to ‘anchor’ to the functional groups of the oxidized CNTs” while Ohata-Kavan nanotubes are allegedly fully embedded in resin. POR, 46-47. But as discussed *supra* (see §II.A), this is not correct: the active material is, in fact, able to anchor to the functional groups on the nanotubes. Accordingly, PO’s objections amount to nothing more than a non-sequitur.

The Petition also explained that oxidized nanotubes would promote dispersion of the nanotubes in the composite. Petition, 13-14. PO asserts that this improved dispersibility is because the functional groups “enhance[] the CNTs’ interaction with water,” while in the Ohata-Kavan composition, “the naked oxidized CNTs are not exposed to water, but instead are first covered in resin,” and thus that “Kavan does not support the assertion that oxidizing the resin-covered CNTs of Ohata-Kavan would improve dispersibility.” POR, 47-48.

PO’s argument is wrong. First, the Ohata-Kavan nanotubes are not embedded in resin, as discussed above. Second, PO is factually wrong in stating that Kavan uses only water as the dispersion medium. In fact, Kavan uses NMP as the solvent for PVDF and for slurry formation during electrode fabrication. See LGES-1005, 2. Third, in the Ohata-Kavan combination, the masterbatch is mixed with NMP and active material, as taught by Ohata. See LGES-1004, [0032]; Petition, 11-13; LGES-1056, ¶35. To the extent that PO views Kavan as

teaching dispersibility in water alone, this is nonetheless relevant to the dispersibility of oxidized nanotubes in NMP given that both NMP and water are polar solvents. LGES-1056, ¶35. That is, a POSITA would have recognized that functionalized nanotubes have improved dispersibility not only in water, but also in other polar solvents such as NMP. LGES-1056, ¶35.

With regard to the dispersion of nanotubes, MRD also argues that “Ohata alone already achieves uniform dispersal without oxidation,” and thus “there would have been no motivation to oxidize to improve dispersion.” POR, 48. But PO cites to Ohata’s description of uniform dispersion of nanotubes in its masterbatch. Even if there were no room for improvement in the dispersion of nanotubes in the masterbatch (which is not necessarily true), PO ignores that the presence of oxidative functionalities on the nanotubes would still promote dispersion of the nanotubes in the later-formed NMP slurry. LGES-1056, ¶36.

Notably, PO’s only arguments against the first two motivations advanced in the Petition assume there is no contact between nanotubes and active material particles; PO does not even attempt to argue that the Petition’s motivations would be inapplicable to a composition in which nanotubes are in contact with the active material particles. And because this is the morphology of the Ohata-Kavan composition, these three motivations stand effectively unrebutted.

2. PO's objection to the Petition's identification of purification as a motivation for the Ohata-Kavan combination is legally improper

Regarding the Petition's explanation that oxidation can remove impurities (*see* Petition, 14), PO argues that “nothing in Ohata or Kavan teaches or suggests that the CNTs have impurities.” POR, 48. This is not the correct analysis. Ohata need not have recognized that its nanotubes possess impurities for the reduction of impurities to motivate the combination. *See Intel Corp. v. PACT XPP Schweiz AG*, 61 F.4th 1373, 1380 (Fed. Cir. 2023) (“Additionally, ‘universal’ motivations known in a particular field to improve technology provide ‘a motivation to combine prior art references *even absent any hint of suggestion* in the references themselves.’” (citing *Intel Corp. v. Qualcomm Inc.*, 21 F.4th 784, 797 (Fed. Cir. 2021)) (emphasis original)).

And as to PO's statement that impurities are not a concern because “Kavan teaches that it uses ‘purified’ CNTs” (POR, 48), this is beside the point: the Petition “uses Ohata as a starting point,” not Kavan. Petition, 11.

3. PO overlooks that the Petition's motivations for the Ohata-Kavan combination are rooted in specific oxidation levels

PO's argument that “Petitioner cannot rely on motivations to oxidize generally” without addressing “whether there was a motivation to use oxidized CNTs at the claimed level of 1% to 15%” (POR, 49) ignores the context underpinning the motivations advanced in the Petition. That is, PO overlooks that the first reason advanced in the Petition (*see* Petition, 13) is drawn

specifically from Kavan's results, which indicate performance improvements achieved not when using generic oxidized nanotubes, but when using nanotubes oxidized at particular oxidation levels falling within the claimed range.

4. Ohata does not discourage or teach away from oxidation of nanotubes

PO's assertion that "oxidizing CNTs adversely affects their desirable intrinsic properties, further discouraging a POSITA from oxidizing per Kavan" (POR, 46; *see* 50) is not sufficient to undermine the Ohata-Kavan combination. But a POSITA would have known how to balance competing advantages and disadvantages. *See* LGES-1003, ¶49. More generally, the mere existence of a disadvantage to a modification does not negate other established motivations for a POSITA to pursue a combination, here the the Ohata-Kavan combination. *See Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1165 (Fed. Cir. 2006) ("a given course of action often has simultaneous advantages and disadvantages, and this does not necessarily obviate motivation to combine"); *Winner Int'l Royalty Corp. v. Wang*, 202 F.3d 1340, 1349 n.8 (Fed. Cir. 2000).

Moreover, PO is incorrect in asserting that Ohata "teaches away from exposing the naked CNTs to the active material." POR, 49. As already discussed, Ohata does, in fact, expose the CNTs to the active material by way of the dissolution of the masterbatch resin by NMP, and a reference cannot teach away from its own teaching. But the details of PO's argument reveal PO's attempt to obscure this reality. In presenting its teaching away argument, PO cites to

Ohata's indication that when incorporating a resin "during the step of preparing an electrode material mixture paste, the addition of the carbon nanotubes is difficult." POR, 50, citing LGES-1004, [0021]. But while this speaks to challenges of adding nanotubes after masterbatch formation, it nevertheless affirmatively anticipates their addition. As Dr. Zhu explained, resin can be applied at any stage based on "common sense" and that there is no "definitive order." *See* MRD-2024, 50-51.

D. PO's arguments against the POSITA's expectation of success are rooted in its misunderstanding of the Ohata-Kavan composition

PO argues that "implicit in all of Petitioner's 'reasons' for a reasonable expectation of success is the incorrect assumption that Ohata-Kavan exposes the CNTs to the active material." POR, 51-52. But because the nanotubes are, in fact, directly exposed to the active material, as discussed above, PO's objections are unjustified. And PO fails to provide any rebuttal to the Petition's proposition that a POSITA would have expected success in the context of oxidized nanotubes promoting better attachment with active material particles, as is the case in the properly framed Ohata-Kavan combination.

III. CHENG-GAN

A. PO's assertion that Cheng-Gan combination fails to meet the claimed oxidation levels is unsupported

PO asserts that "Cheng-Gan does not teach or render obvious the claimed oxidation levels, because the combination calcines the oxidized carbon nanotubes at a temperature of 600°C+ for 4+ hours" and "[t]his would remove

essentially all oxidation and discourage a POSITA from even considering oxidizing.” POR, 8, 62-69. But PO’s argument is based on a misapplication of prior art references and an incomplete understanding of the thermal behavior of ox-CNT precursor mixture (including lithium (Li), iron (Fe), or phosphate (PO₄) precursors) in Cheng-Gan combination.

1. PO’s cited references are inapplicable to the ox-CNT precursor mixture in Cheng-Gan, and expert testimony, corroborated by references, confirms functional group retention

All references relied on by PO regarding the thermal treatment of oxidized CNTs—including MRD-2029, 2030, 2031, 2032, and LGES-1009—pertain to pure ox-CNTs or plasma-treated CNTs that do not contain Li/Fe/PO₄ precursors. POR, 63-65; LGES-1056, ¶¶37-38.

As an initial matter, regarding pure ox-CNTs, Dr. Zhu explains that loss of oxidized functional groups can be minimal, even under higher temperature thermal treatment conditions than those referred to by PO. POR, 62-64. For example, LGES-1042 discloses that pure oxidized CNTs with an initial oxygen content of 12.9 wt% exhibited only a slight reduction to 10.4 wt% after annealing at 900 °C for 2 hours under helium inert atmosphere. LGES-1056, ¶39 (citing LGES-1042, 7, 3, FIG. 6(e)). Here, Dr. Zhu demonstrates the unsustainability of PO’s assertion that high-temperature calcination necessarily removes “essentially all” functional groups. As Dr. Zhu notes, oxygen retention depends on multiple factors including degree of carbon structural order and

experimental conditions (including inertness of atmosphere). Accordingly, even in the context of pure-ox CNTs, PO's conclusions are inapplicable and contradicted by evidence. LGES-1056, ¶39.

Moreover, as noted above, none of PO's references involve precursor mixture of Cheng-Gan, which combines oxidized CNTs with Li/Fe/PO₄ precursors prior to thermal treatment. Petition, 53-54, 56-58. PO's reliance on the above-noted references is wrong, as they are directed to materially different systems which do not address the thermal behavior of Cheng-Gan's ox-CNT precursor mixture. LGES-1056, ¶40.

Indeed, Dr. Zhu addressed this distinction during his deposition. In particular, in response to questions about this, Dr. Zhu addressed the difference in thermal behavior between pure ox-CNTs and Cheng-Gan's ox-CNT precursor mixture. MRD-2026, 41:5-42:14; *see also id.*, 40:11-47:7.

Specifically, Dr. Zhu explained that lithium iron phosphate (LFP) forms from Li/Fe/PO₄ precursors and the functional groups on the CNTs become attached to the formed LFP, rather than being removed. LGES-1056, ¶41; MRD-2026, 41:5-43:2, 45:15-47:7 (e.g., "reactions ... happen between your lithium iron phosphate precursor and other things existing in the ... solution," and that "there's a high likelihood to actually bonding those things together"). Further, as discussed above, the degree of inertness of the calcination atmosphere (e.g., inert gas type, flow rate), among other things, contributes to the retention of

oxidized groups on CNTs—factors that are directly relevant to Cheng’s in situ LFP-forming reactions. LGES-1056, ¶40 (citing LGES-1007, [0019]).

To further illustrate his point, when pressed, Dr. Zhu provided what was marked as Exhibit LGES-1032 as “exactly the examples you [opposing counsel] were asking for,” which serves as “any evidence that oxidized [] nanotube mixed with lithium iron phosphate precursors ... [are subject to] relatively high temperature [calcination and form LFP as in Cheng-Gan]” *See* LGES-1056, ¶42 (citing MRD-2026, 45:15-47:7; LGES-1032, 1; LGES-1040). As noted by Dr. Zhu (along with Petition and Declaration), LGES-1032 discloses an oxidized CNT precursor mixture undergoing, via the calcination (at 700 °C for 10 hours) in an inert atmosphere, an in-situ process forming LFP. LGES-1056, ¶42; LGES-1003, ¶110; *see also* Petition, 43.

Importantly, Dr. Zhu further indicates oxidized functional groups on carbon nanotubes are retained and attached to LFP during high-temperature calcination when combined with Li/Fe/PO₄ precursors. LGES-1056, ¶¶43-46. First, LGES-1032 discloses that highly dispersed conductive network was formed based on oxidation. LGES-1032, 1-2; LGES-1056, ¶43. Second, LGES-1043 and LGES-1041 demonstrate that oxidized functional groups present on carbon atoms were retained and attached to the LFP after calcination of a mixture including carbon (bearing oxidized functional groups) and Li/Fe/PO₄ precursors at 650°C for 10 hours (for LGES-1043) and 600-800 °C for 6 hours (for LGES-1041), respectively, under inert protective atmosphere.

LGES-1056, ¶¶44-46 (citing LGES-1043, 2-3, 6-7, FIGS. 4(e), 4(f); LGES-1041, 1, 2, 4-5, FIG. 4(d)). Thus, these examples directly contradict PO's core theory and supports Dr. Zhu's position that PO's cited references—focused on isolated pure ox-CNT systems—are not applicable to ox-CNT/LFP precursor mixtures, where oxidized functional groups are retained in the presence of Li/Fe/PO₄ precursors and attach to formed LFP, under examples of Cheng's calcination conditions. LGES-1056, ¶46.

In an attempt to remedy the deficiencies in PO's own position—Dr. Chung proposed a new “functional group tolerance” theory, arguing that “[t]he functional groups on the surface of a material [e.g., CNT] tend to hinder a reaction [e.g., LFP formation from Li/Fe/PO₄ precursors] that is intended to occur using reactants [e.g., Li/Fe/PO₄ precursors] that coexist with the material [e.g., CNT] with the functional groups.” MRD-2006, ¶182 (citing MRD-2042); POR, 64. However, as discussed above with respect to LGES-1032, LGES-1041, and LGES-1043, and further confirmed by Dr. Zhu, Dr. Chung's own testimony, and the '924 patent, this theory is incorrect—successful LFP formation occurs despite the presence of functional groups. LGES-1056, ¶¶47-49 (citing LGES-1053, 8:10-13:24, MRD-2042, 1).

Accordingly, Dr. Zhu's corroborated testimony, demonstrates that oxidized CNTs retain functional groups during high-temperature calcination when combined with Li/Fe/PO₄ precursors and indeed attach to LFP. In contrast, PO's position not only relies on inapplicable references but also

collapses under the weight of its own expert's contradictions. Thus, PO's arguments are irrelevant—exposing that their core theory rests on cherry-picked data and apples-to-oranges comparisons that ignore the actual chemistry at issue.

2. PO's assertion that Cheng's calcination conditions are limiting is unfounded

PO argues that specific calcination parameters disclosed in Cheng—"600°C+ for 4+ hours"—is a requirement. POR, 8, 62. However, neither Petition, nor Dr. Zhu's declaration, nor Cheng itself stated or implied that the specific temperature or time values disclosed in Cheng were limiting or required.

As Dr. Zhu explained, Cheng's conditions are disclosed as part of an example and are not presented as exclusive or limiting. MRD-2026, 40:11-41:4, 44:24-45:14). As noted by Dr. Zhu, these variations were within ordinary knowledge and skill of a POSITA. *See* MRD-2026, 40:4-42:14; 44:24-47:7.

In addition, Petition does not describe or suggest that a POSITA would have viewed Cheng's calcination conditions as a requirement. Rather, the Petition relies on Cheng as disclosing a process in which an ox-CNT precursor mixture is subjected to calcination, without asserting that the exact time or temperature values are limiting. There is no indication in the Petition or the Declaration that a POSITA would have understood Cheng's process to preclude alternative or routine variations in calcination parameters.

It is well established that optimization of known process parameters—such as temperature and duration—through routine experimentation is considered within the ordinary skill of a POSITA. *See Pfizer Inc. v. Sanofi Pasteur Inc.*, 94 F.4th 1341, 1347 (Fed. Cir. 2024) (quoting *In re Aller*, 220 F.2d 454, 456). Moreover, nothing in Cheng suggests that other temperature or time conditions are discouraged, inoperable, or excluded.

Last but not least, the Petition notes that “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.” Petition, 58 (citing LGES-1010, LGES-1005, LGES-1003). For example, the Petition explained that oxidized CNTs were well-known to provide a functional “foothold” for LFP attachment—supporting Dr. Zhu’s position that a POSITA would have, if needed, adjusted calcination conditions (e.g., temperature, duration) based on the materials and synthesis objectives. *See* MRD-2026, 40:4-42:14; 44:24-47:7.

B. PO’s assertion that Petitioner fails to demonstrate a motivation to oxidize or a reasonable expectation of success is unfounded

PO argues that “[a] POSITA had no motivation to oxidize CNTs of Cheng, because calcination would remove functional groups” and “destroy key benefits provided by added functional groups.” POR, 66-67. PO further asserts there was no reasonable expectation of success “in light of the calcining step.”

POR, 69-70. But these arguments rely on the same flawed assumptions rebutted above.

In particular, PO asserts that several motivations are premised on the benefits provided by functional groups associated with oxidation. POR, 66-68. PO then asserts that these benefits would be eliminated by calcination. *See id.* However, as explained above, this conclusion is not supported, and is inconsistent with the chemistry of the Cheng-Gan precursor mixture.

Further, PO overlooks the first motivation discussed in the Petition, which cites LGES-1032. LGES-1032 describes LFP synthesis and calcination process similar to that of Cheng-Gan, in which LGES-1032 describes functionalized CNTs were uniformly dispersed and attached into LiFePO_4 during calcination (e.g., 700 °C for 10 hours), forming “highly dispersed conductive networks,” while retaining their dispersion. Petition, 43; LGES-1003, ¶110; LGES-1032, 1; LGES-1040, 2. As the Declaration explains, “uniform dispersion of CNT networks into the LiFePO_4 is crucial for performance.” LGES-1003, ¶110

In sum, PO’s position fails to account for the nature of the Cheng-Gan precursor mixture and the in situ synthesis involved. At least for the reasons set forth above, a POSITA would not be discouraged from relying on Gan’s oxidized CNTs, and the technical objective of the combination would have been achieved. Petition, 41-44, 63. That is, as conceded by PO, “a POSITA would have had a reasonable expectation of success of achieving oxidation above

either level [claimed level or Gan's level] when considering the effects of calcination." POR, 68-69.

C. PO's assertion that Cheng-Gan does not achieve "discrete" CNTs is unsupported and contradicts the '924 Patent itself

PO's narrow interpretation of term "discrete" is inconsistent with both the '924 Patent and how a POSITA would understand the term.

Importantly, while PO asserts that a POSITA "would be led in a direction divergent from the path that was taken by the" inventors, because "Cheng and Gan seek a continuous or percolated network of CNTs **to improve conductivity—the opposite objective of ['926 patent]** achieving discrete CNTs ... **to retard cracking**"—this argument is directly contradicted by the '924 Patent itself. POR, 84. As Dr. Zhu explains, the '924 patent repeatedly associates "discrete" CNTs with enhanced electrical conductivity. LGES-1001, 1:49-55, 2:29-33, 2:9-16, 2:17-21, 5:51-53; Table 1; LGES-1056, ¶¶50-51.

The disclosures in the '924 Patent, noted by Dr. Zhu, are irreconcilable with PO's argument that "discrete" CNTs must be electrically isolated. The specification of the '924 Patent does not define "discrete" as excluding all contact between CNTs. To the contrary, it emphasizes that discrete CNTs enhance electrical conductivity, which requires at least some degree of interconnection of nanotubes. For instance, the '924 Patent states that the "crystals [are] bound to and interconnected with discrete carbon nanotubes," which indicates that the discrete CNTs form a conductive network—i.e., they

are not agglomerated, but still make point-to-point contact sufficient to interconnect active material particles. LGES-1001, 1:60-61, 2:22; LGES-1056, ¶52.

Further, as Dr. Zhu explained during the deposition, a POSITA would understand the terms “discrete,” “non-agglomerated,” and “exfoliated” as interchangeable in the context of CNT dispersions. MRD-2024, 16; *see generally id.*, 11-17. These terms refer to CNTs that are not bundled or entangled—not to CNTs that are electrically isolated. PO’s interpretation is therefore not only inconsistent with the ’924 patent itself, but also with the technical understanding of a POSITA. LGES-1056, ¶53.

IV. CONCLUSION

Patent Owner fails to rebut the invalidity grounds and prior art mappings in the Petition. Accordingly, the Board is requested to find all the Challenged Claims of the ’924 patent invalid.

Respectfully submitted,

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CERTIFICATION UNDER 37 CFR § 42.24(d)

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petitioners' Reply to Patent Owner's Response totals 5,589, which is less than the 5,600 allowed under 37 CFR § 42.24.

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR § 42.6(e), the undersigned certifies that on July 14, 2025, a complete and entire copy of the Petitioner's Reply to Patent Owner's Response and Accompanying Exhibits were provided by email to the Patent Owner by serving the correspondence addresses of record as follows:

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