

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ENERGY SOLUTION, LTD.,
SAMSUNG ELECTRONICS CO., LTD. and
SAMSUNG ELECTRONICS AMERICA, INC.,
Petitioner

v.

MOLECULAR REBAR DESIGN, LLC,
Patent Owner

Case IPR2024-01011¹

U.S. Patent 8,968,924

PATENT OWNER'S SUR-REPLY

¹ Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. were joined as parties to this proceeding via a Motion for Joinder in IPR2025-00357.

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EXHIBIT LIST

Exhibit No.	Description
MRD-2001	Denial of Motion to Stay in parallel civil suit in EDTX
MRD-2002	Docket Control Order in parallel civil suit in EDTX
MRD-2003	Micah J. Green, “Analysis and measurement of carbon nanotube dispersions: nanodispersion <i>versus</i> macrodispersion.” <i>Polym Int</i> 2010; 59; 1319-1322
MRD-2004	H. Golnabi, “Carbon nanotube research developments in terms of published papers and patents, synthesis and production,” <i>Scientia Iranica</i> , Vol. 19, Issue 6, Dec. 2012, pp. 2012-2022
MRD-2005	Excerpts from Defendants’ P.R. 3-3 Invalidity Contentions in parallel civil suit in EDTX
MRD-2006	Declaration of Dr. Deborah D.L. Chung, Ph.D.
MRD-2007	WEBSTER’S NEW WORLD COLLEGE DICTIONARY (4th ed. 1999), various definitions
MRD-2008	U.S. Patent No. 8,703,009 (“Liu-009”)
MRD-2009	Mengxuan Zhang et al., <i>Binder Assisted Dispersion of Agglomerated Carbon Nanotubes for Efficiently Establishing Conductive Networks in Cathodes of Li-Ion Batteries</i> , 8 ENERGY TECHNOLOGY 2000589 (2020).
MRD-2010	Varrla Eswaraiah et al., <i>Morphological, Thermal, Electrical and Electromechanical Properties of Polyvinylidene Fluoride (PVDF)-Functionalized Carbon Nanotube Composites (Preprint)</i> , AFRL-RX-WP-TP-2012-0277 INDIAN INSTITUTE OF TECHNOLOGY CHENNAI (2012).

Exhibit No.	Description
MRD-2011	B. V. Bahaskara Rao et al., <i>Fabrication and Evaluation of Thin Layer PVDF Composites Using MWCNT Reinforcement: Mechanical, Electrical and Enhanced Electromagnetic Interference Shielding Properties</i> , 6 AIP ADVANCES 065107 (2016).
MRD-2012	Viraj Bhingardive et al., <i>Polyvinylidene Fluoride Based Lightweight and Corrosion Resistant Electromagnetic Shielding Materials</i> , 5 RSC ADV. 35909 (2015).
MRD-2013	Ming Wang et al., <i>The Influence of Polyvinylidene Fluoride (PVDF) Binder Properties on $\text{LiNi}_{0.33}\text{Co}_{0.33}\text{Mn}_{0.33}\text{O}_2$ (NMC) Electrodes Made by a Dry-Powder-Coating Process</i> , 166 JOURNAL OF THE ELECTROCHEMICAL SOCIETY A2151 (2019).
MRD-2014	Soumyaranjan Mishra et al., <i>Synthesis of PVDF/CNT and Their Functionalized Composites for Studying Their Electrical Properties to Analyze Their Applicability in Actuation & Sensing</i> , 509 COLLOIDS AND SURFACES A: PHYSICOCHEMICAL AND ENGINEERING ASPECTS 684 (2016).
MRD-2015	U.S. Patent No. 6,869,724
MRD-2016	Lizhi Wen et al., <i>Effect of Conductive Material Morphology on Spherical Lithium Iron Phosphate</i> , 8 NANOMATERIALS 904 (2018).
MRD-2017	U.S. Patent Application Publication No. 2014/0319429 (“Nicolas-429”)
MRD-2018	U.S. Patent Application Publication No. 2011/0256454 (“Nicolas-454”)
MRD-2019	RESERVED
MRD-2020	Wener Bauer et al., <i>Rheological Properties and Stability of NMP Based Cathode Slurries for Lithium Ion Batteries</i> , 40 CERAMICS INTERNATIONAL 4591 (2013).

Exhibit No.	Description
MRD-2021	RESERVED
MRD-2022	RESERVED
MRD-2023	Declaration of Dr. Yu Zhu in IPR2024-01013, dated June 12, 2024
MRD-2024	Deposition Transcript of Dr. Yu Zhu in IPR2024-01013, dated March 14, 2025
MRD-2025	Deposition Transcript of Dr. Yu Zhu in IPR2024-01006, dated March 21, 2025
MRD-2026	Deposition Transcript of Dr. Yu Zhu in IPR2024-01011, dated March 21, 2025
MRD-2027	RESERVED
MRD-2028	U.S. Patent Application Publication No. 2024/0274804
MRD-2029	Niurka Barrios-Bermúdez et al., <i>Amino-Functionalized Multiwall Carbon Nanotubes as Efficient Basic Catalysts for the Formation of γ-Lactams: Synthesis of N-1-Heptenyl-2-pyrrolidinone</i> , 12 NANOMATERIALS 684 (2022).
MRD-2030	Shankhamala Kundu et al., <i>Thermal Stability and Reducibility of Oxygen-Containing Functional Groups on Multiwalled Carbon Nanotube Surfaces: A Quantitative High-Resolution XPS and TPD/TPR Study</i> , 112 J. PHYS. CHEM. 16869 (2008).
MRD-2031	S.A. Chernyak et al., <i>Mechanism of Thermal Defunctionalization of Oxidized Carbon Nanotubes</i> , 120 THE JOURNAL OF PHYSICAL CHEMISTRY 17465 (2016).
MRD-2032	Nathan Hordy et al., <i>Thermal Stability of Plasma Generated Oxygenated Functionalities on Carbon Nanotubes</i> , 12 PLASMA PROCESS. POLYM. 533 (2015) 533.

Exhibit No.	Description
MRD-2033	ICSC: 1577 – FERRIC OXIDE (2004)
MRD-2034	Haitao Wang et al., <i>In Situ TiC-Reinforced Ni-Based Composite Coating Prepared by Flame Spraying Using Sucrose as the Source of Carbon</i> , 18 JOURNAL OF THERMAL SPRAY TECHNOLOGY, 103 (2009).
MRD-2035	RESERVED
MRD-2036	RESERVED
MRD-2037	Aleksander Cholewinski et al., <i>Polymer Binders: Characterization and Development toward Aqueous Electrode Fabrication for Sustainability</i> , 13 POLYMERS 631 (2021).
MRD-2038	Xiaoping Shui et al., <i>High-Strength High-Surface-Area Porous Carbon Made From Submicron-Diameter Carbon Filaments</i> , (2016).
MRD-2039	RESERVED
MRD-2040	R. Piat et al., <i>Identification of Coefficients of Thermal Expansion of Pyrolytic Carbon with Different Texture Degrees</i> , 251-252 KEY ENGINEERING MATERIALS 333 (2003).
MRD-2041	Keiichi Shirasu et al., <i>Negative Axial Thermal Expansion Coefficient of Carbon Nanotubes: Experimental Determination Based on Measurements of Coefficient of Thermal Expansion for Aligned Carbon Nanotube Reinforced Epoxy Composites</i> , 95 CARBON 904 (2015).
MRD-2042	Tobias Gensch et al., <i>Approach to Comparing Functional Group Tolerance of Reactions</i> , 82 THE JOURNAL OF ORGANIC CHEMISTRY 9154 (2017).
MRD-2043	Deposition Transcript of Dr. Yu Zhu in IPR2024-01013, dated August 11, 2025

Exhibit No.	Description
MRD-2044	Deposition Transcript of Dr. Yu Zhu in IPR2024-01006, dated August 12, 2025
MRD-2045	Deposition Transcript of Dr. Yu Zhu in IPR2024-01011, dated August 12, 2025

I. CLAIM CONSTRUCTION

Petitioner interpreted “discrete” CNTs as those “fully isolated” from others, consistent with the plain and ordinary meaning of *separate*, distinct and *not attached* to one another. Patent Owner Response (Paper 17, “POR”), 14, 52.² PO demonstrated that Ohata-Kavan fails to teach this, so Petitioner now seeks to retroactively broaden “discrete” CNTs to mean those merely “*capable of* being separated to give individual tubes” so that *any* CNT qualifies. Petitioner Reply (Paper 22, “Reply”), 3.³ This improper new construction is contradicted by all evidence.

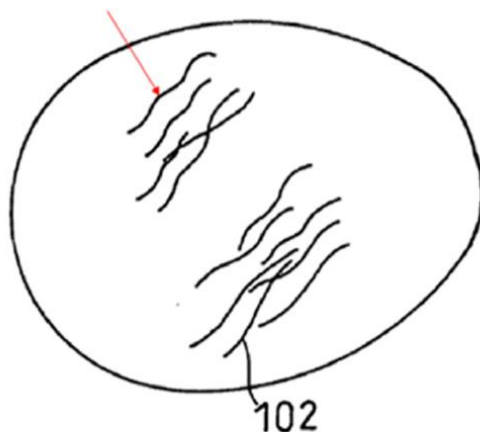
A. Petitioner Attempts to Rewrite Dr. Zhu’s Unequivocal Testimony.

Dr. Zhu testified that he identified the CNT in Ohata’s Figure 1(b) (reproduced below) as “discrete” “because it’s fully isolated from the other nanotubes.” MRD-2024, 10:21-11:12.

² Contrary to Petitioner’s suggestion (Reply, 2 n.1), PO’s original assertion that “‘discrete’ CNTs are those that are individually dispersed and *separate from* other CNTs” (POR, 14) is consistent with its express construction in IPR2024-1005 and this sur-reply. Express construction was originally unnecessary because the Petition, POR and Dr. Zhu applied the term consistently. POR, 14, 52.

³ All emphases herein added, unless otherwise indicated.

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



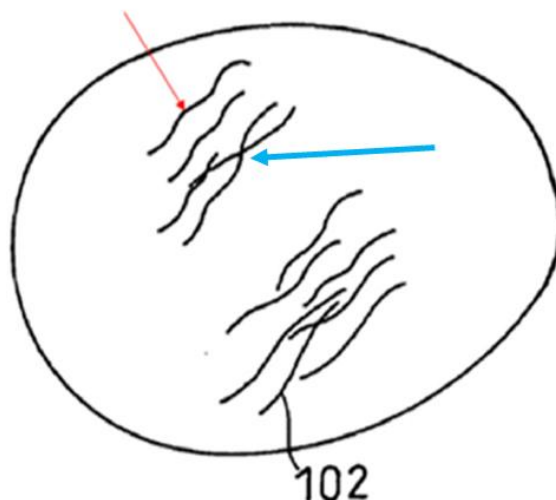
LGES-1004, Fig. 1(b) (annotated)

He further testified that discrete CNTs “have been ***separated from each other***” (i.e., not attached to one another) and responded “yeah” when asked “discrete [CNTs] are non-bundled nanotubes ***that are separate from each other***, correct?” *Id.*, 12:20-13:20.

Dr. Zhu was not quoted “out of context.” Reply, 2. He was given multiple opportunities to provide the meaning of discrete CNTs “in [his] own words” but avoided responding, stating “I think ***we don’t really need to have a definition for this.***” MRD-2024, 8:15-9:15. His understanding of “discrete” was thus elicited using his application to the prior art, which constitutes a clear “admission that a nanotube necessarily must be isolated to be discrete.” Reply, 2. Indeed, he did not testify that he identified the CNT “because” it is “***capable of*** being separated.” Were that his

understanding, he would have identified the CNTs that appear to be attached (blue arrow):

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



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

Dr. Zhu’s supplemental testimony on “discrete” should be given no weight—it contradicts his prior testimony, is ambiguous and wrong. For example, he noncommittally testifies that “a fully isolated carbon nanotube that is not touching any other nanotube is *likely* ‘discrete’” and “*can be* discrete” (LGES-1056 ¶7), even though such a nanotube *is clearly* discrete under either party’s interpretation. Moreover, in an effort to undo the damage from his prior testimony, he offered the absurd opinion that “*fully* isolated” CNTs can be attached to other CNTs. MRD-

2043, 11:2-20. But even Petitioner admits that “**fully** isolated” CNTs are “**individually isolated** nanotubes.” Reply, 3.

B. Petitioner’s New Construction is Implausible.

Despite the evidence overwhelmingly supports PO’s construction (POR, 14, 52), Petitioner now argues “discrete” CNTs are merely “**capable of** being separated to give individual tubes.” Reply, 3. But under this construction **any** CNT would qualify, as any CNT is “capable of” being separated. MRD-2043, 12:7-13, 13:13-20 (admitting the CNTs in Ohata’s Figure 1(a) are not “discrete” but there “**is always a potential**” to be). Petitioner’s new construction would thus render “discrete” meaningless. *See Info-Hold v. Muzak LLC*, 783 F.3d 1365, 1373 (Fed. Cir. 2015)(“Claims must be interpreted with an eye toward **giving effect** to all terms in the claim.”).

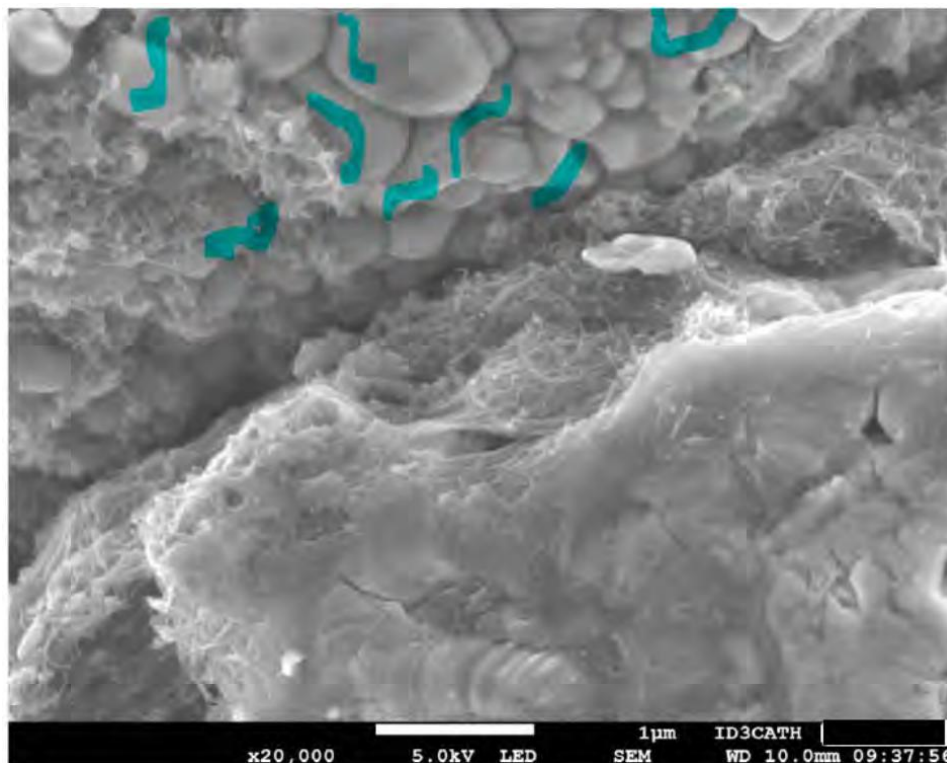
Moreover, the usage of “discrete” throughout the specification is inconsistent with this new construction. The specification teaches there is a “**process of making** discrete carbon nanotubes”—not that CNTs are “discrete” based on their intrinsic “capability” of being separated. LGES-1001, 4:4-8. In fact, the specification teaches “the carbon nanotubes previously employed are **not considered to be** essentially discrete, i.e., **individual** uniformly dispersed tubes. *Id.*, 1:47-49. This demonstrates “discrete” CNTs must *actually be* separate individual tubes, consistent with Dr. Zhu’s admissions.

Petitioner's new construction also contradicts the position of it and its expert in IPR2024-01005. *See* IPR2024-01005, Paper 2, 12-13 (alleging "discrete" CNTs "***lack[] direct association with other nanotubes*** along substantially the length of the nanotubes."); IPR2024-1005, MRD-2011, 8:3-9:22. While "discrete" CNTs are not attached to other CNTs along any length, Petitioner's position in IPR2024-01005 nonetheless demonstrates that it understands "discrete" CNTs are not simply "capable of" being separated.

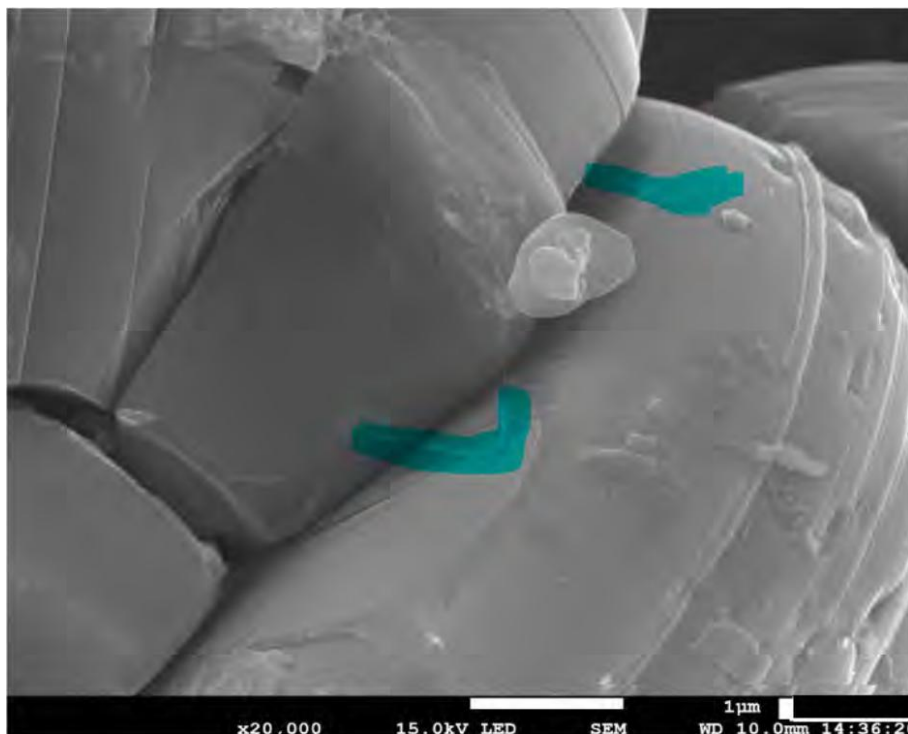
C. Petitioner Mischaracterizes the Infringement Contentions.

Petitioner's reliance on the infringement contentions is misleading. Reply, 4. SEM images are two-dimensional images of ***a three-dimensional space***, which means that at lower-magnifications CNTs that *appear* to be attached because they overlap are not necessarily attached or touching. LGES-1055, 127:21-128:12. Petitioner "agree[s]" (*id.*, 128:3-9) and relies on this "commonsense principle" in IPR2024-01005 (Paper 23, 19-20).

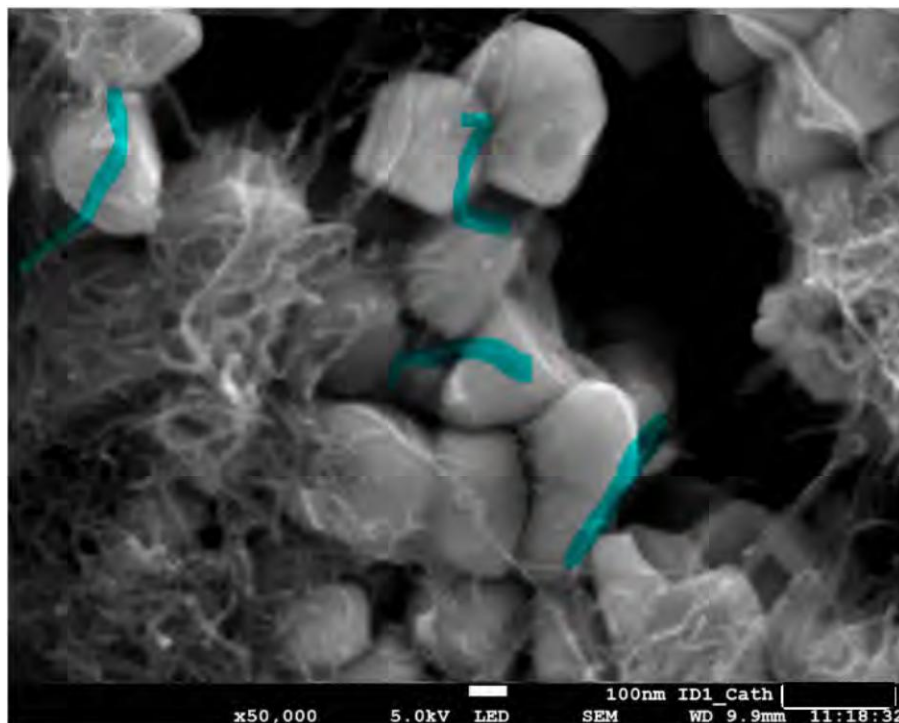
Despite this, Petitioner disingenuously cherry-picks lower-magnification SEM images from the many taken and misleadingly relies on this optical illusion. Reply, 4. However, the other images show that PO consistently identified "discrete" CNTs (blue) in accordance with the plain and ordinary meaning:



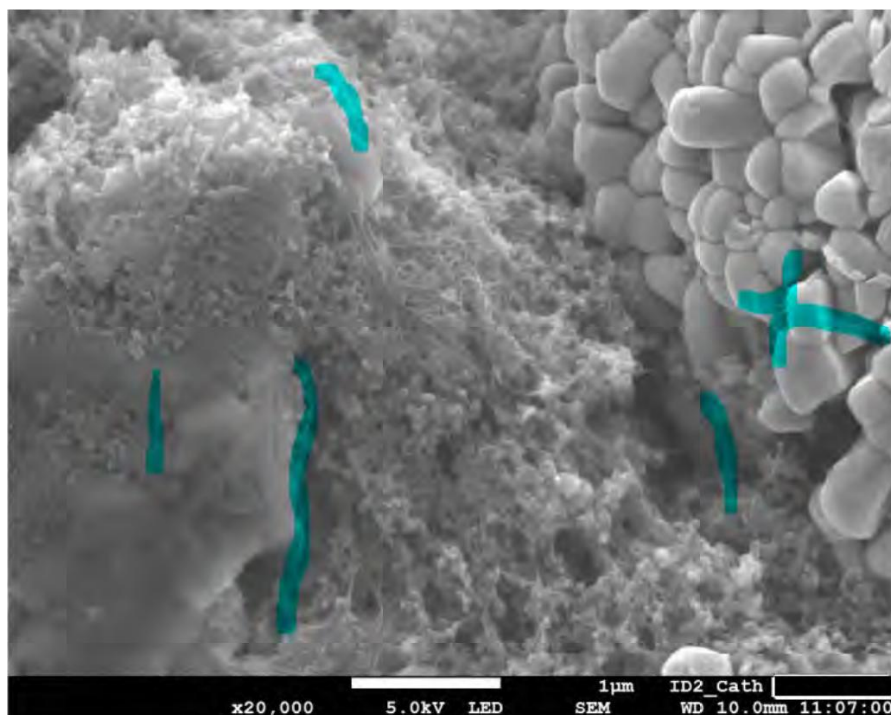
LGES-1033, 31.

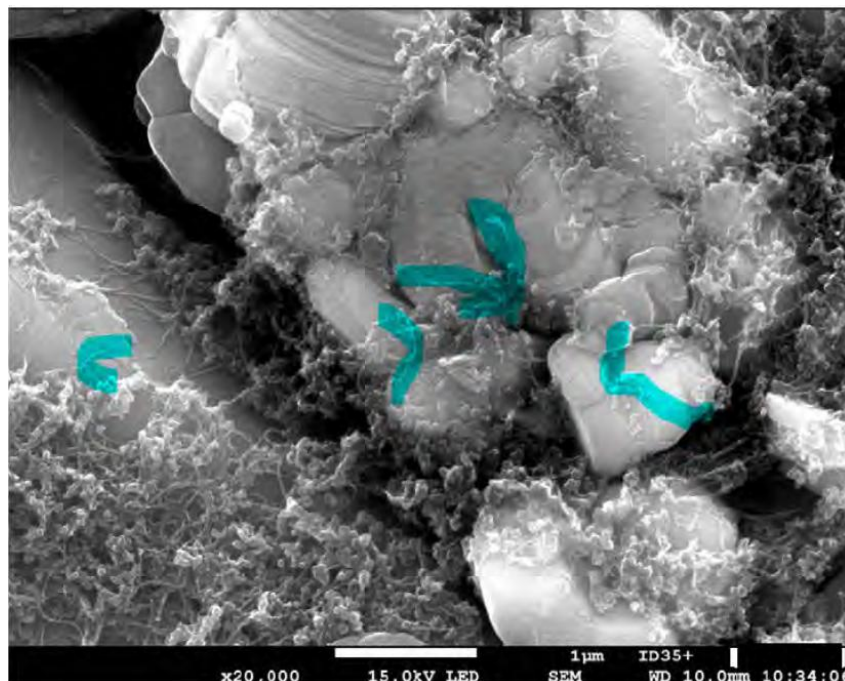


Id., 32.



Id., 29.



Id., 30.*Id.*, 34.

The Board should thus “decline to adopt Petitioner’s conclusory assumptions regarding what it purports to be [PO]’s applied construction” based on these contentions. *Globus Medical v. Spinelogik*, IPR2025-00226, Paper 9, 11 (July 14, 2025).

II. OHATA-KAVAN

A. Petitioner Fails to Demonstrate Ohata-Kavan Achieves CNTs Having “Active Material ... Attached to Their Surface.”

Petitioner does not dispute that if the CNTs of the electrode-paste are fully coated by resin, Ohata-Kavan fails to achieve the claimed “attachment.” Petitioner instead argues they cannot be fully coated because (1) there must be direct **physical**

contact for electrical conductivity and (2) the solvent of Ohata-Kavan would dissolve the resin from the CNTs. Reply, 5-9.

1. Petitioner’s “physical contact” and “insulation” theories are false.

Petitioner alleges there must be “**physical** contact” between active material and conductive additive to enable electrical flow, and that a resin-layer cannot separate active material and CNTs because “PVDF binder is non-conductive.” *Id.*, 5-8. While “[i]t is well-established that ... there must be electrical contact between the active material and the conductive additive, to enable current flow” (*id.*), Petitioner disingenuously conflates electrical contact with **physical** contact by arguing that the latter is required for the former. However, **Physical** contact is not required for there to be electrical contact. Petitioner’s theory disregards the scientific principles of “electron tunneling” and “the percolation threshold,” which allow electrons to transfer across non-conductive layers.

a. Petitioner ignores “electron tunneling.”

MRD-2010 is a scientific journal publication involving functionalized CNTs (2 wt%) immersed in PVDF (98 wt%). MRD-2010, 9. Despite the CNTs being fully embedded in PVDF, “electronics can *easily* travel from one tube to another tube without any obstacle (*through tunneling*)” when the “CNTs are touching each other *or very close ([<]2nm [sic] in distance)*.” *Id.*, 12; *see also* MRD-2012, 5 (describing “tunneling of electrons” as a “conduction mechanism” in PVDF-CNT mixtures);

MRD-2043, 14:8-16 (explaining electron tunneling). Electron tunneling thus allows electrons to pass from point-to-point even when separated by a resin layer.

MRD-2010 is consistent with the testimony of Dr. Chung, who explained that “for nanotube A and nanotube B to be in electrical contact, they have to be **extremely close** to one another.... I just mean **not exactly contacting**, just ... a tiny little microscopic **gap** at the point of so called touching.” LGES-1055, 114:19-115:20; *see also id.* at 122:24-123:9.

Electrical conductivity thus occurs through PVDF in PVDF-CNT binder via electron tunneling, despite the lack of **physical** contact. Indeed, a composite comprising a very high ratio of PVDF:CNTs—as in Ohata-Kavan’s masterbatch—would not adequately function if **physical** contact was required.

b. Petitioner ignores “the percolation threshold.”

It is undisputed that Ohata-Kavan embeds CNTs within PVDF to form a composite (PVDF-CNT binder) exhibiting increased electrical conductivity. POR, 20-21. This involves mixing a sufficient amount of CNTs (conductive filler) with PVDF (non-conductive binder) to reach the “percolation threshold”—*i.e.*, where conductivity is increased such that the **overall** composite exhibits “metal-like behavior” rather than the “insulator-like dielectric property” of PDVF. *See* MRD-2011, 2, 4, 7-8 (“This theory of percolation threshold is well documented”); MRD-2044, 8:15-9:18 (explaining percolation threshold); MRD-2014, 4 (describing

“percolation threshold”); LGES-2021 ¶[0035]. This threshold is satisfied by very small amounts of CNT in PVDF. MRD-2011, 7 (threshold “approache[d]” at **5wt% CNTs** in PVDF); MRD-2012, 5 (“electrical conductivity of insulating PVDF has increased” by seven orders of magnitude “with the addition of **3wt% CNTs**”); LGES-2021 ¶[0027] (explaining **5wt%** achieves “significant increases in the electrical conductivity”).

Dr. Chung likewise explained that the CNT-PVDF masterbatch binder of Ohata-Kavan must be considered as “one unit” because it “is a composite material with the resin as the matrix and the nanotubes as a filler” such that the “electrical conductivity [of the composite] is much increased.” LGES-1054, 38:9-25; *id.*, 37:6-20, 39:2-40:20; LGES-1053, 31:1-32:14, 35:12-36:3.

Thus, contrary to Petitioner’s theory, Ohata-Kavan’s masterbatch binder would exhibit a “metal-like” conductive behavior due to the presence of billions of CNTs, allowing electrons to travel throughout the **entire** binder, including the PVDF layer between the active material and CNTs. LGES-1004 ¶[0021] (Ohata teaching about **5-20wt%** of CNTs in PVDF).

c. No credible evidence supports Petitioner’s “physical contact” or “insulation” theories.

Although Dr. Zhu acknowledges electron tunneling and the percolation threshold (MRD-2044, 7:21-9:18), neither he nor Petitioner accounts for them.

Instead, Petitioner offers the unsubstantiated theory that direct physical contact between active material and CNTs is required, relying on Dr. Zhu's testimony that this is "due to the relatively low intrinsic electrical conductivity of the active material." Reply, 6 (citing LGES-1056 ¶10).

For one, he provides no evidence that active material has "low intrinsic electrical conductivity." He quotes MRD-2017 and MRD-2018, but those quotes merely refer to "electrical bridges" not **physical** bridges. Moreover, he testified that active material can have "good" electrical conductivity, contradicting his definitive statement. MRD-2043, 15:9-22; MRD-2044, 10:4-10. Even if active material did have low conductivity, electrical conductivity would still exist due to electron tunneling and the percolation threshold, causing the binder to exhibit "metal-like" conductivity. *Supra* Section II.A.1.a-b.

Lacking any support, Petitioner resorts to an out-of-context quote to portray Dr. Chung as agreeing that "**physical** contact" is required for electrical conductivity. Reply, 6 (quoting LGES-1054, 17:1-15). However, as discussed above, she *unequivocally and repeatedly* testified that **physical** contact is not required for electrical conductivity. LGES-1055, 114:19-115:20, 122:24-123:9; LGES-1054, 37:6-20, 38:9-40:20. The evidence supports her. *See e.g.*, MRD-2010, MRD-2011, MRD-2012, MRD-2014.

Petitioner also omits context from its quote. Dr. Chung explained that the

physical term “touching” is sometimes loosely used to describe electrical contact between two points. See LGES-1055, 114:19-115:1 (explaining that even if there is a “little microscopic gap at the point of *so-called touching*” electrical conductivity exists), 47:4-10; LGES-1054, 36:24-37:5. Indeed, she explicitly answered “no” when asked if “nanotubes would also need to make contact with the active particle itself, right?” LGES-1054, 37:6-20; *see also* LGES-1053, 31:1-32:14, 35:12-36:3.

Petitioner also misleadingly quotes her testimony about “electrical conduction linkages,” an “electrically conductive path,” and “electrical contact” Reply, 6 (citing LGES-1054, 16:2-12, 36:18-37:5). But as explained above, electrical contact does not require **physical** contact.

Petitioner’s assertion that “PO’s position is incompatible with Ohata’s stated goal of improving conductivity” (Reply, 7) is premised on it disregarding the principles of electron tunneling and the percolation threshold, which provide electrical conductivity without **physical** contact.

Petitioner also relies extensively on Dr. Zhu’s unsubstantiated parroting of arguments in the Reply. *Compare* Reply, 5-7 with LGES-1056 ¶¶9-12. Such testimony is entitled to no weight. *See Xerox v. Bytemark*, IPR2022-00624, Paper 9 (Aug. 24, 2022) (precedential). Regardless, not only is his testimony contradicted by the evidence discussed above, the cited evidence provides no support.

MRD-2017 and MRD-2018 (cited by LGES-1056 ¶¶ 10-11) merely show that

electrical bridges—not **physical** bridges—are required. Dr. Zhu also cites to a single sentence from the '924 patent and portions of MRD-2008, LGES-1004, and LGES-1005 without explanation. LGES-1056, ¶11. But that sentence (LGES-1001, 2:9-10) merely states that discrete CNTs can help overcome low electrical conduction due to expansion and contract of active material particles, which occurs by preventing and reducing cracking. POR, 14-16 (explaining this). The cited portions of MRD-2008, LGES-1004, and LGES-1005 merely teach that improved conductivity is a goal of electrodes—they do not support the notion that CNTs must be in **physical** contact with active material to provide electrical conductivity.

Thus, Petitioner’s theory that the “basic physical operation of battery electrodes” requires physical contact between active material particles and CNTs is false. Reply, 6. Indeed, this theory is further undermined by Petitioner’s (incorrect) assertion in IPR2024-01013 (Paper, 2, 56-58) and IPR2024-01006 (Paper 2, 34-35) that Ohata-Kavan achieves CNTs that are spaced apart by at least 1 micrometer. If physical contact was required, Ohata-Kavan would not seek spaced apart CNTs (as Petitioner alleges). This theory is also undermined by Petitioner’s position in IPR2024-01012 (Paper 22, 18) that electrical contact exists between CNTs in the Son reference, even where they allegedly “***do not touch each other.***”

2. Petitioner’s “complete dissolution” theory is false.**a. No evidence supports this theory.**

Overwhelming evidence shows NMP would not remove PVDF from the surface of the oxidized CNTs of Ohata-Kavan, including MRD-2020, 6-7 (explaining the PVDF layer “*prevents direct contact* of particle surfaces”), MRD-2014, 1:31-34 (teaching PVDF dissolved in solvent tends *to coat* particles of the active material and *the conductive agent*”), and MRD-2014, 8 (showing PVDF domains as product of NMP dissolution). POR, 36-45.

Petitioner fails to address any of this evidence, instead mischaracterizing Ohata’s teaching that “the masterbatch was easily dissolved in [NMP]” as meaning the PVDF coating of resin is removed by the NMP. Reply, 7. However, the evidence shows that when NMP “dissolves” PVDF it does not remove the PVDF from the CNTs’ surfaces. Ohata describes NMP as a “dispersion medium” (LGES-1004 ¶[0046]), and the reference to “easily dissolv[ing]” refers to how the NMP disperses the PVDF *as domains* throughout the electrode material mixture paste so that they can act as globules of electrically conductive glue. MRD-2006 ¶¶118-126. These domains are plainly visible in numerous exhibits. POR, 36-44.

Petitioner’s cited exhibits provide no support for its dissolution theory. LGES-1061 and LGES-1062 merely teach PVDF is soluble in NMP. Reply, 7-8. But there is no dispute PVDF is soluble by NMP—that is what allows the PVDF to be

dispersed as globules (or domains) of glue. MRD-2006 ¶118. Neither reference proves otherwise.

Petitioner also argues “that the PVDF binder of Ohata’s masterbatch is readily soluble in NMP ***was well-known.***” Reply, 7-8 (citing LGES-1056 ¶¶ 13-20). However, the Reply does not explain this argument at all, instead offhandedly citing paragraphs 13-20 of Dr. Zhu’s declaration. This constitutes improper incorporation-by-reference—a clear effort to rely on large swaths of Dr. Zhu’s testimony as the explanation ***required to be in the Reply.*** See *Cisco Sys., Inc. v. C-Cation Techs.*, IPR2014-00454, Paper 12, 10 (Aug. 29, 2014) (designated precedential).

Even if considered, these paragraphs offer nothing but unsubstantiated assertions. Dr. Zhu’s conclusory testimony that “PVDF is fully dissolvable in NMP at concentrations greater than or equal to 10% by weight” should be given no weight. LGES-1056 ¶13. Although he cites LGES-1062, 2 and LGES-1004, neither supports his statement and he fails to provide *any* explanation as to how they purportedly do.

Dr. Zhu next alleges that “aggregated undissolved [PVDF] particles in NMP solution ... is a strict condition that a POSITA would try to avoid.” LGES-1056 ¶14. However, he fails to provide ***any explanation or evidence*** to support this statement. That is because his conclusory assertion defies common sense. The aggregates of PVDF-CNT (i.e., CNT-containing domains of PVDF) are *necessary* for the binder to serve its primary function of holding the constituent parts of the electrode together.

POR, 36-37; LGES-1054, 13:5-20. If the PVDF was fully dissolved it would be too thinly dispersed in the electrode material mixture paste as individual molecules incapable of holding anything together.

Even if PVDF “aggregates” were something “to avoid,” Dr. Zhu still fails to provide any evidence or explanation that NMP would remove the “molecular layer” of resin coating the CNTs’ surfaces. POR, 45 (citing MRD-2006 ¶126); *See also e.g.*, MRD-2009, 2 (“PVDF ... would **coat onto CNT surface** due to the strong interaction between PVDF and CNTs.”); LGES-1014, 3 (functionalized CNTs become “**completely covered** with matrix” in resin). And although Dr. Zhu stopped short of admitting that the entire surface of CNTs would be covered in resin, he acknowledged that PVDF would cover “a **significant** amount” of CNT surface. MRD-2024, 65:21-66:9. This testimony is inconsistent with his new position that the PVDF is fully dissolved.

Dr. Zhu’s contention that there is a “weak interaction between PVDF and oxidized CNTs” (LGES-1056 ¶17) is based on a misleading quote from LGES-1059, 5 stating that “the interaction between CNTs and PVDF was **relative[ly]** weak.” But the key word here is “relatively,” i.e., weak **as compared to** (not generally) the mechanical interaction between OMLS/PVDF. LGES-1059, 4-6. Indeed, other evidence confirms he is mistaken. *See* MRD-2009, 2 (describing “**the strong interaction** between PVDF and CNTs”); MRD-2006 ¶115 (unrebutted testimony

about strong dipole-to-dipole interaction between PVDF-CNTs). And even if he was correct, that would not demonstrate what Petitioner must prove—*i.e.*, that NMP would remove PVDF from the surface of the CNTs.

Dr. Zhu's supplemental testimony about MRD-2010 is a red herring. LGES-1056 ¶¶19-20. PO did not rely on MRD-2010 to evidence the effects of NMP, but rather to show that the masterbatch process of Ohata-Kavan would fully embed the oxidized CNTs in resin. PO, 30-31. PO cited numerous **other** exhibits showing that NMP disperses PVDF as domains or "islands," which Dr. Zhu tellingly does not address or discuss in paragraphs 19-20. *Id.*, 36-44.

b. Petitioner fails to refute PO's objective evidence.

MRD-2014 to MRD-2018 and MRD-2020 demonstrate that NMP disperses PVDF as domains. POR, 36-44. Petitioner alleges that "PO's own corroborating references refute its theory," yet fails to address much of this evidence. Petitioner instead focuses on select exhibits out of context.

Petitioner argues that MRD-2017's reference to "electrical bridges between the active material particles," and the conductivity level reflected in the experimental results, proves that there must be **physical** contact. Reply, 9. However, **physical** contact is not required for electrical bridges to be formed. *Supra* Section II.A.1. Indeed, MRD-2017 teaches "CNTs are well dispersed **around** the micrometric LiFePO₄/C particles," not that they are **on** or **attached to** the particles. MRD-2017

¶[0123].

Dr. Chung’s testimony is not “grounded ... on speculation that contradicts both the image and specification” of MRD-2017. Reply, 9. In attacking Dr. Chung for testifying that Figure 2 is “not very clear” and she was “unable to identify a single carbon nanotube,” Petitioner misses the point. The reason CNTs are not visible is because the “***domains include in them the CNTs***... and these domains are dispersed around the lithium-ion phosphate.” LGES-1054, 54:6-15. This is itself evidence they are fully embedded within the PVDF-matrix.

Likewise false is Petitioner’s assertion that paragraphs [0094] and [0123] of MRD-2017 “confirm[] that CNTs are not embedded and isolated, but instead dispersed and connected to the active material.” Reply, 9. Dr. Zhu’s entire argument is that the “reasonable conductivity” discussed in [0123] “would be impossible if the CNTs were completely electrically isolated.” LGES-1056 ¶25. But PO has never taken the position that the CNTs and active material are “electrically” isolated—merely that **physical** contact between them is not required for there to be improved electrical conductivity.⁴

Petitioner’s focus on MRD-2008 is an intentional distraction from addressing

⁴ Petitioner’s attacks against MRD-2018 are substantively identical to those against MRD-2017 and are flawed for the same reasons.

PO's other dispositive evidence. Reply, 10. MRD-2008 was relied on solely as evidence that (1) mixing PVDF with conductive agent (e.g., carbon black) results in conductive glue-like globules even after mixing with NMP and (2) PVDF "bonds" to conductive agent. POR, 22, 34. PO did not rely on MRD-2008 to show that the oxidized CNTs of the Ohata-Kavan masterbatch would be fully embedded in the resin, because MRD-2008 uses **significantly smaller** ratios of PVDF-to-conductive filler than Ohata-Kavan. MRD-2008, 9:6-9 (discussing carbon black:PVDF ratios of 0.5:1, 0.8:1, and 1:1). In any event, Petitioner's argument that if the conductive carbon black were truly embedded within PVDF the carbon black it would be "isolated ... from the active material" simply recycles the incorrect theory that direct **physical** contact is required for electrical conductivity to be achieved. Reply, 10.

Similarly, nothing in MRD-2008 "makes clear" that its conductivity improvements come from physically contacting the carbon black with the active material. LGES-1056 ¶¶27-29 (improperly incorporated-by-reference by Reply, 10). To the contrary, MRD-2008 explains that "[c]onventional thinking is that when the ratio of **non-conductive** binder is increased, at a given acetylene black concentration, **the interface impedance will increase.**" MRD-2008, 10:33-36. However, the "findings shown here **indicate the opposite of conventional thinking.**" *Id.*, 10:36-47. Consequently, when MRD-2008 teaches that the "improvement in performance realized when using **greater amounts of binder** relative to CB ... may be attributed

to the improved **interface electronic conductivity**” (MRD-2008, 10:27-32), it is referring to the fact that percolation threshold improves the conductivity of the entire binder, such that the interface between the binder and the active material increases in conductivity. And, again, even if MRD-2008 did teach that the conductive black particles **physically** contact the active particles (it does not), MRD-2008 uses significantly smaller ratios of PVDF:conductive-filler than Ohata-Kavan. *Id.*, 9:6-9. Thus, it is not evidence that the same alleged contact would occur in Ohata-Kavan.

Dr. Zhu also quotes MRD-2008 at 11:13-17. LGES-1056 ¶29. But it plainly undermines him—the carbon black “branch structure” is “***integrate[d]***” ***into the “PVDF coatings”*** and “***is coated with PVDF polymer.***” Recognizing this, he suggests that this teaching somehow fails to evidence that CNTS would be “coated” in the same way (LGES-1056 ¶30), despite the evidence proving otherwise. *See* POR, 31-34, 37-44. Even if MRD-2008 is ignored, Petitioner fails to address much of the other evidence supporting PO’s position.

B. Petitioner’s Motivations to Combine Are Flawed.

Petitioner’s rebuttal arguments regarding the “motivations for the Ohata-Kavan combination” and “expectation of success” are premised on Petitioner carrying its burden of demonstrating that the CNTs of Ohata-Kavan would not be “fully embedded within the resin matrix.” Reply, 12-17 (Sections II.C-D). Given that Petitioner has not carried that burden (*supra* Section II.A), Petitioner’s rebuttal

arguments fail.

C. Petitioner Has Not Shown Ohata-Kavan Achieves “Discrete” CNTs.

Petitioner does not dispute that if the plain and ordinary meaning of “discrete” CNTs precludes attachment between CNTs, Ohata-Kavan fails to render this limitation obvious. Reply, 10-12. Petitioner instead continues to incorrectly maintain that “discrete” CNTs “do[] not preclude a network of nanotubes.” *Id.* But because they in fact do, Petitioner fails to show this limitation is taught. *Supra* Section I.

That “the ’924 Patent itself indicates that discrete nanotubes enhance conductivity” and Ohata-Kavan also seeks to “enhance conductivity” does nothing to support Petitioner’s position. Reply, 10. Discrete CNTs “enhance conductivity” primarily by ***preventing and bridging cracks*** in active material particles resulting from retardation during charging and discharging (POR, 14-17), which is fundamentally different than the “enhanced conductivity” Ohata-Kavan seeks via a ***via a network of interconnected CNTs*** (POR, 10-13).

Petitioner complains of “PO’s myopic focus on Fig. 1” of Ohata (Reply, 10), but Petitioner relied almost exclusively on that figure as evidence of “discrete” CNTs. Petition, 20-24. Regardless, Petitioner conspicuously avoids responding to a key rebuttal of PO—“Petitioner fails to demonstrate that [the masterbatch CNTs] would remain discrete after ***being further mixed*** with the active material to create the *electrode material mixture paste*.” POR, 55. Petitioner cannot carry its burden on

this issue because all of its arguments and evidence focus on the ***masterbatch*** of Ohata-Kavan, not the **electrode mixture paste** containing the active material.

Recognizing this, Petitioner seeks to improperly shift the burden to PO by arguing that Gan (LGES-1021) “does not demonstrate ***absence of*** discrete nanotubes” in the electrode material mixture. Reply, 11. However, it is Petitioner’s burden to first prove ***the presence of*** discrete CNTs in the *electrode material mixture*.

Because Gan disproves Figure 1(b) as representative of how the CNTs of Ohata-Kavan would appear in the *electrode material mixture*, Petitioner attempts to dismiss it as an “entirely different reference.” *Id.* But Petitioner relies on Gan with Cheng to try and invalidate the claims, proving Gan is far more relevant than Petitioner wants the Board to believe.

Petitioner argues that the arrangement of CNTs in Gan’s SEM images are irrelevant because they are not oxidized. Reply, 11-12. But a POSITA would have expected those CNTs to be *more interconnected* when oxidized because Gan teaches functionalization “draw[s] the ***CNTs closer together.***” POR, 57-58.

Petitioner’s assertion that a POSITA would not have “drawn any conclusions” based on Gan is premised entirely on Dr. Zhu’s conclusory parroting. *Compare* Reply, 11-12 with LGES-1056 ¶33. Indeed, just like Ohata-Kavan, Gan mixes a large volume of polymer with a small amount of CNTs for the purpose of forming an interconnected network of CNTs.

III. CHENG-GAN

A. Petitioner Fails to Demonstrate Cheng-Gan Achieves “Discrete” CNTs.

Petitioner does not dispute that Cheng-Gan fails to achieve “discrete” CNTs under the construction proposed by PO or that the goal of both Cheng and Gan is to achieve a “continuous” network—*i.e.*, the opposite of “discrete.” Reply, 25-26. Petitioner thus fails demonstrate invalidity.

Recognizing this, Petitioner contends that “discrete” CNTs must form a “continuous or percolated network of CNTs” because the ’924 Patent “repeatedly associates ‘discrete’ CNTs with enhanced electrical conductivity” and “emphasizes that discrete CNTs enhance electrical conductivity.” *Id.*, 25. However, “discrete” CNTs “enhance conductivity” primarily by ***preventing and bridging cracks*** in active material particles (POR, 14-16 (citing LGES-1001, 1:52-64)), which is fundamentally different than the “enhanced conductivity” Cheng-Gan seeks via ***a network of interconnected CNTs*** (POR, 12-13). As such, “discrete” CNTs (as taught by the ’924 Patent) and a “continuous network” of CNTs (as disclosed by Cheng-Gan) “enhance conductivity” in fundamentally different ways.

Petitioner further argues that the specification teaches “crystals [are] bound to and interconnected with discrete carbon nanotubes,” allegedly indicating the CNTs “still make point-to-point contact sufficient to interconnect active material particles.”

Reply, 25-26. This a misinterpretation of what the quote plainly says—it states the active material crystals are “bound to and interconnected with” discrete carbon nanotubes, not that the discrete carbon nanotubes are “bound to and interconnected” with one another. This is because the discrete CNTs are bound along the surface of the active material, which helps prevent and bridge cross cracking due to expansion and contraction. POR, 14-17, 35-36 (citing MRD-2028 ¶¶[0014]-[0015]).

Petitioner also argues that “discrete,” “non-agglomerated” and “exfoliated” are “interchangeable in the context of CNT dispersions.” Reply, 26. The only evidence cited is Dr. Zhu’s unsubstantiated testimony, which is contradicted by his other testimony. *Supra* Section I.A. His position is also contradicted by the common meaning of each term—MRD-2007, 5 (“agglomerate”), 8 (“discrete”) 11 (“exfoliate”)—and that “the use of two terms in a claim requires that they connote different meanings.” *Applied Med. Res. v. U.S. Surgical*, 448 F.3d 1324, 1333 n.3 (Fed. Cir. 2006). Indeed, the related ’483 Patent uses all three terms in independent claims. *See e.g.*, Claims 1, 7 of LGES-1001 in IPR2024-01013.

Moreover, Petitioner fails to demonstrate that Cheng-Gan achieves “discrete” CNTs *even under Petitioner’s broader interpretation*. POR, 73-83. The Board appeared to rely primarily Petitioner’s assertion that Cheng-Gan follows “similar” steps to Example 2 of the ’924 Patent and that PO did “not address Petitioner’s assertion.” *Id.*, 76-77 (citing DI, 30). PO has now thoroughly proven that the steps

of Cheng-Gan and the '924 Patent are significantly different and achieve materially different results (*Id.*, 76-83)—something Petitioner does not even attempt to dispute in the Reply. Reply, 25-26.

B. Petitioner Fails to Demonstrate Cheng-Gan Achieves 1% to 15% Oxidation.

1. Petitioner improperly raises a new invalidity theory.

Recognizing that it failed to carry its burden of proof in light of Cheng-Gan's calcination step, Petitioner now argues that “the specific temperature or time values disclosed” by Cheng are not “limiting or required.” Reply, 22. But the issue is not whether they are scientifically “required”—the issue is what temperatures and time values are ***actually disclosed*** by Cheng.

The “Summary” of the invention in Cheng describes both the calcination temperature and time duration as a range—“600°C to 850°C in an inert protective atmosphere for 4 to 48 hours.” LGES-1007 ¶[0019]. Every disclosed embodiment calcinates within these ranges. *Id.* ¶¶[0019], [0045], [0049], [0053], [0057], [0060], [0064], [0068], [0072], [0077]. The calcination of Cheng-Gan is thus limited to temperatures and times ***disclosed***, which is the *only* calcination process relied on by the Petition. Petition, 52, 56-57 (expressly applying Cheng's time and temperature range).

Despite this, Petitioner now argues that a POSITA would have understood that

(1) “variations” of temperature and time “were ***within ordinary knowledge and skill*** of a POSITA,” (2) “optimization of known process parameters ... through routine experimentation is considered ***within the ordinary skill***”; and (3) “a POSITA ***would have, if needed, adjusted*** calcination conditions.” Reply, 22-23. These are improper new invalidity theories designed to retroactively address Petitioner’s failure to account for the effects of Cheng’s calcining conditions. Indeed, the Petition does not argue or even suggest that a POSITA would have deviated from the calcination process of Cheng. Petitioner is thus bound to the theory in its Petition, which expressly relied on the calcination conditions taught by Cheng. Pet., 57.

2. Petitioner attempts to improperly shift the burden to PO.

Petitioner does not dispute that essentially all oxidized functional groups can be removed under high temperature calcining conditions, but argues that in *some instances* the loss “can be minimal.” Reply, 18. Petitioner then criticizes PO for not demonstrating that essentially all oxidized functional groups would be removed in the LiFePO₄ electrode of Cheng-Gan. Reply, 18-20. However, it is the burden of **Petitioner** to demonstrate that Cheng-Gan would retain an oxidation level of 1% to 15% after the calcination treatment—it is not PO’s burden to prove that it would not. *See In re Magnum Oil Tools*, 829 F.3d 1364, 1380 (Fed. Cir. 2016) (“It is the petitioner that bears the burden of proof....”).

Although Petitioner criticizes PO’s evidence as directed toward “pure ox-

CNTs or plasma-treated CNTs that do not contain Li/Fe/PO₄ precursors,” Petitioner does not deny that high-temperature calcination can remove essentially all oxidation or that the level of “oxygen retention depends on multiple factors.” Reply, 18-19.⁵ This admission is fatal, because none of the Li/Fe/PO₄ precursor evidence offered shows the retention of any meaningful amount of oxidation after calcining.

Petitioner focuses heavily on Dr. Zhu’s testimony about LGES-1032, treating it as incontrovertible evidence that calcinating under the conditions of Cheng would retain the required oxidation level. *Id.*, 19-20. However, Dr. Zhu admits that neither LGES-1032 nor the supplemental information of LGES-1040 report oxidation levels. MRD-2045, 6:1-20. These exhibits merely evidence that “functionalized” CNTs may aid with “dispersion,” and that high-temperature and time calcination is useful to synthesize LiFePO₄-CNT composites, both facts not in dispute. LGES-1032, 1.

Petitioner turns next to LGES-1041 and LGES-1043 as supposed evidence

⁵ LGES-1042 does not demonstrate “minimal” oxidation loss. Reply, 18. LGES-1042 uses alumina (Al₂O₃) as the CNT growth catalyst and silica (SiO₂) is present as an impurity. LGES-1042, 3-4, 7. Both are high-temperature ceramics formed largely **of oxygen**. They remain after calcination making it impossible to determine the portion of remaining oxidation associated with functional groups versus the oxygen of alumina or silica.

that “functional groups present on carbon atoms were retained and attached to the LFP after calcination.” Reply, 20. But those exhibits also fail to provide any oxidation level measurements. LGES-1041 is focused on the amount of carbon that remains. LGES-1041, 5. The measurements of LGES-1043 are for “determin[ing] the valence state of each element of the samples” (LGES-1043, 3), and to the extent weak C-O and C=O peaks in Fig. 4 indicate anything (*Id.*, 7), it is that the functional groups are present at a very low concentration, not that there was “minimal” oxidation loss.

Tellingly, neither Petitioner nor Dr. Zhu actually explain how these exhibits support its position. They instead rely on an unexplained string cite spanning several pages from those exhibits, none of which makes mention of oxidation levels. Reply, 20-21. Petitioner argues that purpose of functionalizing is to create a “highly dispersed conductive network.” Reply, 20. But once that purpose is served, there is no need to retain the functional groups through completion of the synthesis process, which is why none of the purported “evidence” offered by Petitioner actually evidences a meaningful level of remaining functional groups. Indeed, as Dr. Chung explained, retaining the functional groups through the calcining conditions of Cheng-Gan would be detrimental to the formation of the lithium salt. MRD-2006 ¶¶182-84 (citing MRD-2042). Petitioner is ultimately left only with Dr. Zhu’s uncorroborated testimony that functional groups are mysteriously protected from high-heat removal

in the presence of LiFePO_4 , something *none* of his cited evidence corroborates.

C. Petitioner Fails to Demonstrate a Motivation to Combine or Expectation of Success

Petitioner's rebuttal is premised on PO's calcination arguments "rely[ing] on ... flawed assumptions." Reply, 23-24. Because PO's calcination arguments are not flawed, the rebuttal fails. *Supra* III.B.

Petitioner also argues that LGES-1032 evidences that a POSITA would have been motivated to oxidize the CNTs of Cheng-Gan for improved "dispersion." Reply, 24. However, the issue is whether there was a motivation to "arrive at *the claimed invention*," which requires the claimed oxidation level. *Metalcraft v. Toro Co.*, 848 F.3d 1358, 1366 (Fed. Cir. 2017). A POSITA would have had no motivation to, or expectation that it could, arrive *at the claimed invention* given that the calcination would remove essentially all of the added functional groups. Indeed, Dr. Zhu admits that neither LGES-1032 nor LGES-1040 discloses the oxidation levels before or after calcination. MRD-2045, 6:1-20.

Dated: August 25, 2025

Respectfully,

/Stephen Zinda/

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CERTIFICATE OF COMPLIANCE

The undersigned certifies that this document complies with the type-volume limitations set forth in 37 C.F.R. § 42.24 *et seq.* This document, excluding those portions excluded under § 42.24(a)(1), contains 5,596 words as calculated by the program used in creating it.

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Pursuant to 37 C.F.R. §§ 42.6(e)(4), the undersigned certifies that on August 25, 2025, the foregoing document was served via electronic mail on the following attorneys of record at the indicated e-mail address, which Petitioner has consented to electronic service for:

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