

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 IPR2024-01013¹

U.S. Patent 10,153,483

PATENT OWNER'S SUR-REPLY

¹ Samsung Electronics Corporation, Ltd. and Samsung Electronics America, Inc. were joined as petitioners in this proceeding based on a petition and motion for joinder filed in IPR2025-00359, which was granted.

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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 LiNi_{0.33}Co_{0.33}Mn_{0.33}O₂ (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	U.S. Patent Application Publication No. 2012/0058255 ("Gan")
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	RESERVED
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	U.S. Patent No. 8,974,957
MRD-2028	U.S. Patent Application Publication No. 2024/0274804
MRD-2029 to MRD-2034	RESERVED
MRD-2035	U.S. Patent No. 10,273,403
MRD-2036	U.S. Patent No. 10,374,254
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	RESERVED
MRD-2039	U.S. Patent No. 8,557,351
MRD-2040 to MRD-2042	RESERVED

Exhibit No.	Description
MRD-2043	Deposition Transcript of Dr. Yu Zhu in IPR2024-01013, dated August 11, 2025
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 other CNTs, consistent with the plain and ordinary meaning of *separate*, distinct and *not attached* to one another. Patent Owner Response (Paper 16, “POR”), 13, 52-53.² PO demonstrated that Ohata-Kavan fails to teach this, and 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 21, “Reply”), 3.³ This improper new construction is contradicted by the intrinsic and extrinsic evidence.

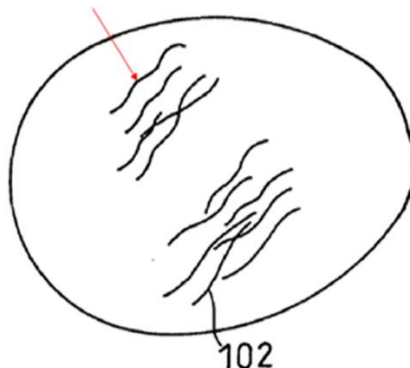
A. Petitioner Attempts to Rewrite Dr. Zhu's Unequivocal Testimony.

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, 13) 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, 16, 52.

³ All emphases herein added, unless otherwise indicated.

"discrete, non-agglomerated, and exfoliated
carbon nanotubes"



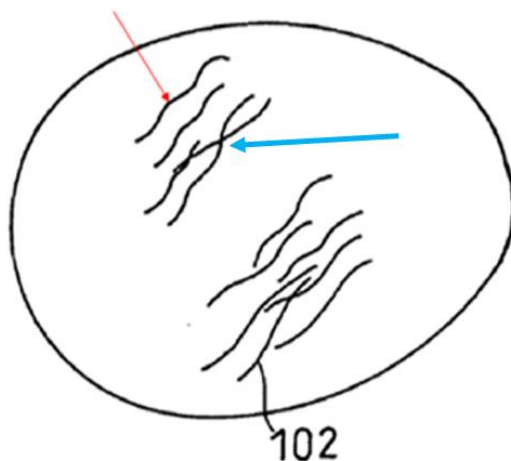
LGES-1004, Fig. 1(b) (annotated)

This question was not objected to and Dr. Zhu clearly understood it. Indeed, 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?” MRD-2024, 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 actively avoided responding, going so far as to state “I think *we don’t really need to have a definition for this.*” MRD-2024, 8:15-9:15. Given this refusal, his understanding of “discrete” was elicited using his application to the prior art. Contrary to Petitioner’s assertion, his testimony constitutes a clear “admission that a nanotube necessarily must be isolated to be discrete.” Reply, 2. Indeed, Dr. Zhu

did not testify that he identified the CNT with a red arrow “because” it is “**capable of** being separated.” If that was 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 belated, supplemental testimony on “discrete” should be given no weight—it not only contradicts his prior testimony but is ambiguous and objectively wrong. For example, he offers the noncommittal testimony 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 caused by 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 On Its Face.

The evidence overwhelmingly supports PO's position on “discrete.” POR, 13, 52-53. Despite this, Petitioner now argues that “discrete” CNTs are merely “**capable of** being separated to give individual tubes.” Reply, 3. But under this construction **any and all** CNTs would qualify, as any CNT is “capable of” being separated from other CNTs. MRD-2043, 12:7-13, 13:13-20 (admitting the CNTs in Figure 1(a) of Ohata are not “discrete” but that there “**is always a potential**” to be). Petitioner's new construction would thus render the term “discrete” meaningless. *See Info-Hold, Inc. 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. For example, the specification teaches that there is a “**process of making** discrete carbon nanotubes”—not that CNTs are “discrete” based on their intrinsic “capability” of being separated. LGES-1001, 4:6-9. In fact, the specification teaches that “the carbon nanotubes previously employed are **not considered to be** essentially discrete, i.e., **individual** uniformly dispersed tubes. *Id.*, 1:41-43. This demonstrates that “discrete” CNTs must *actually be* separate individual tubes, consistent with Dr. Zhu's original—and then unequivocal—testimony. Indeed, the inventors knew how to claim *actuality* (e.g., “uniformly

disperseded" in claim 8) versus *capability* (e.g., "uniformly dispersible" in claim 9).

LGES-1001, 8:6, 8:14-15.

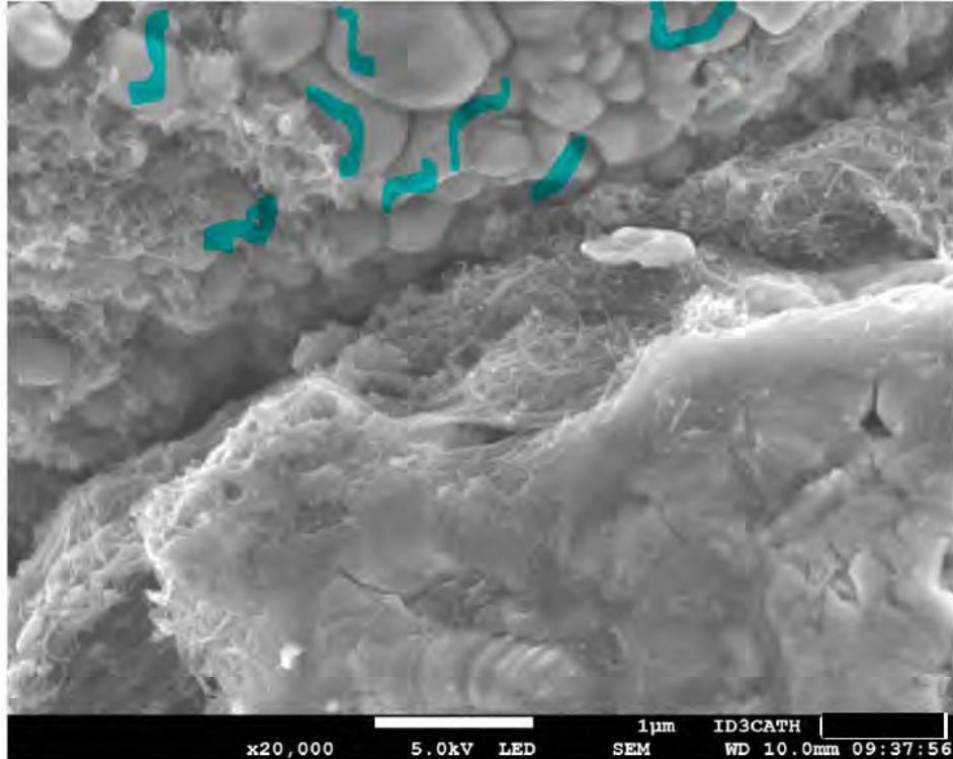
Petitioner's new construction also contradicts the position of it and its expert in IPR2024-01005. *See* IPR2024-01005, Paper 2, 12-13 (alleging "discrete" CNTs are those "***lacking direct association with other nanotubes*** along substantially the length of the nanotubes."); IPR2024-1005, MRD-2011,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

C. Petitioner Mischaracterizes the Infringement Contentions.

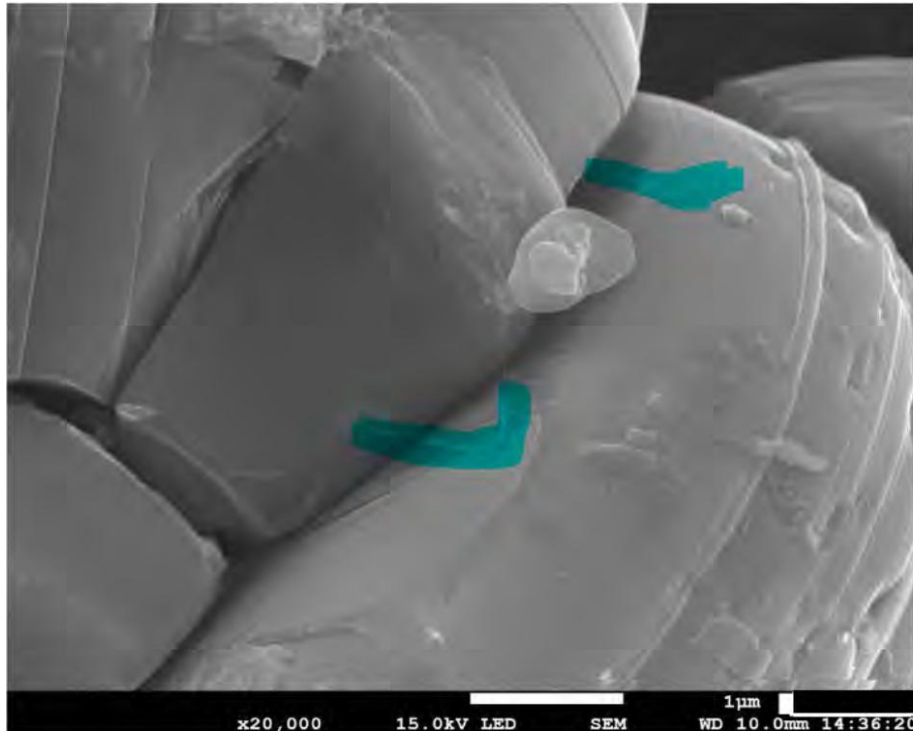
The reliance on PO's infringement contentions is misplaced and misleading. Reply, 4. SEM images are two-dimensional images of ***a three-dimensional space***, which means that in lower-magnification SEM images CNTs that *appear* to be attached because they overlap are not necessarily attached or touching. LGES-1055, 127:21-128:12. Counsel for Petitioner "agree[s]" (*id.*, 128:3-9) and Petitioner 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 relies on this optical illusion to mischaracterize PO's positions. Reply, 4. However, the other images show that PO

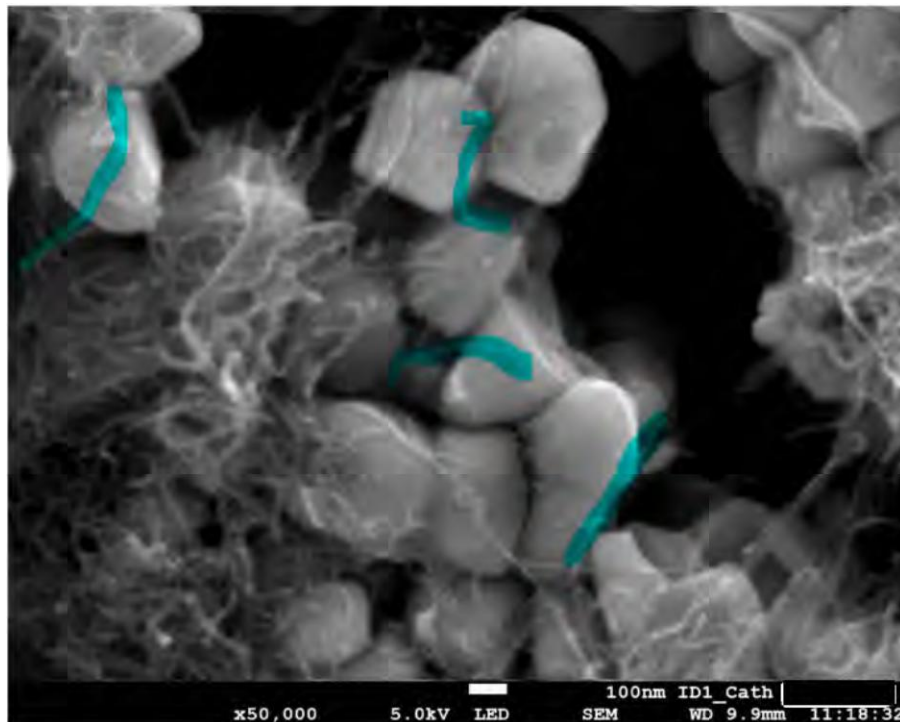
consistently identified “discrete” CNTs (blue) in accordance with the plain and ordinary meaning:



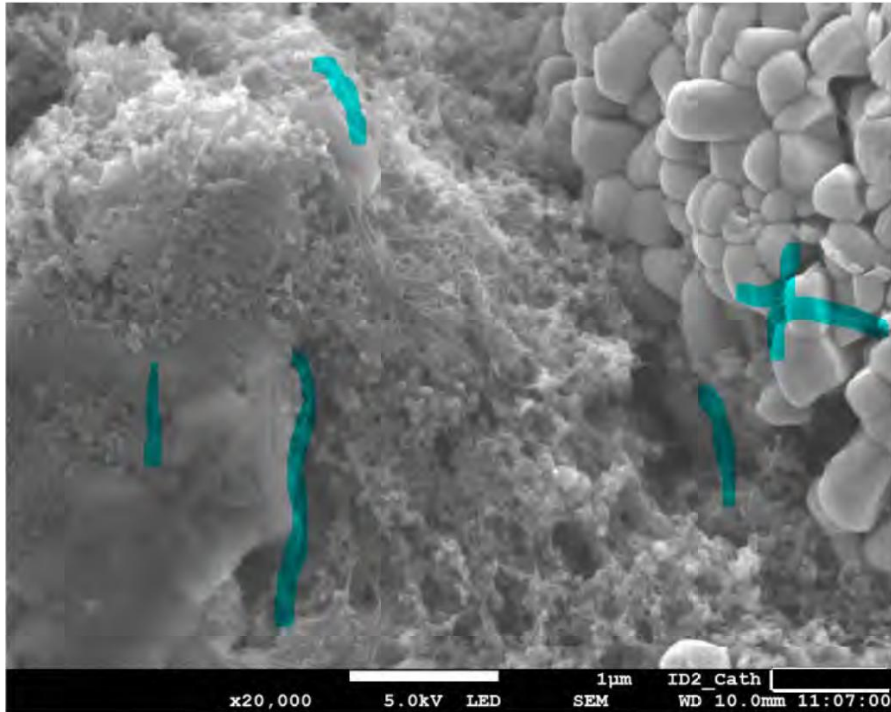
LGES-1050, 31.



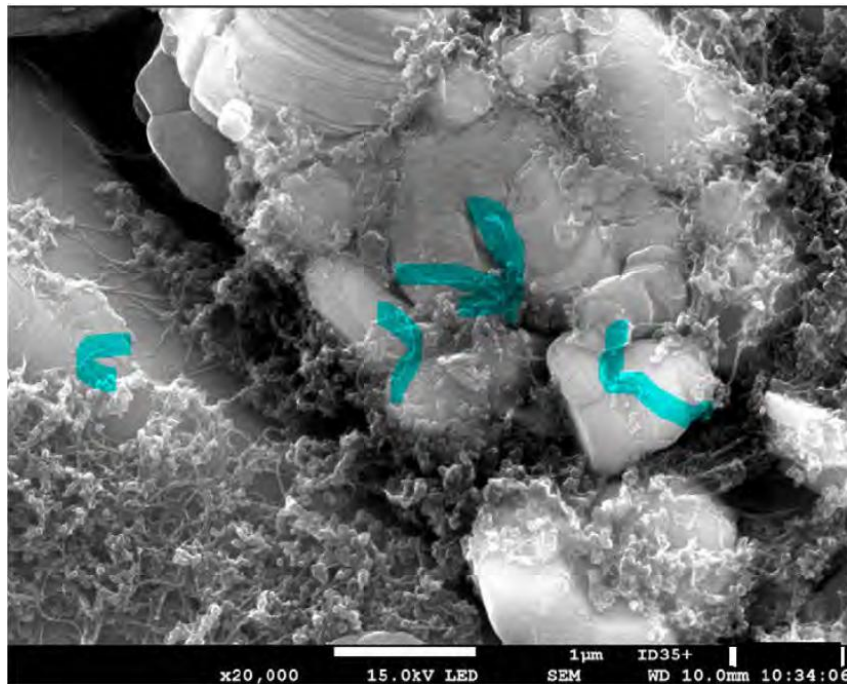
Id., 32.



Id., 36.



Id., 45.



Id., 83.

The Board should thus “decline to adopt Petitioner’s conclusory assumptions

regarding what it purports to be [PO]'s applied construction" based on preliminary infringement contentions that, when properly viewed, contradict those assumptions. *Globus Medical, Inc. v. Spinelogik, Inc.*, IPR2025-00226, Paper 9, 11 (July 14, 2025).

II. OHATA-KAVAN

A. Petitioner Fails to Demonstrate that Ohata-Kavan Achieves CNTs With "Active Material ... Attached to Their Surface."

Petitioner does not dispute that if the CNTs of the electrode-paste of Ohata-Kavan 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 to provide electrical conductivity and (2) the solvent of Ohata-Kavan would dissolve the resin coating from the CNTs. Reply, 5-13.

1. Petitioner's "physical contact" and "insulation" theories are false.

Petitioner asserts that there must be "**physical** contact" between active material and conductive additive to enable electrical flow, and that a resin layer cannot separate the 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. **Physical** contact is not required for there to be electrical contact—*i.e.*, such that electrons can travel across

a non-conductive resin layer. Petitioner's theory improperly disregards the scientific principles of "electron tunneling" and "the percolation threshold," which allow electrons to transfer across non-conductive layers in PVD-CNT binders.

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 composites); MRD-2043, 14:8-16 (explaining electron tunneling). Electron tunneling thus allows electrons to pass from one point to another 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 ("If the ... gap is more than ... 10 angstroms, then there's no electrical contact."); 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 —e.g., as in Ohata-Kavan's masterbatch—would not adequately function if **physical** contact was required due to the very large PVDF:CNTs ratio.

b. Petitioner ignores “the percolation threshold.”

It is undisputed that Ohata-Kavan embeds CNTs within PVDF to form a composite material (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.*, the point at which conductivity is increased such that the **overall** composite exhibits “metal-like behavior” rather than the “insulator-like dielectric property” of PDVF alone. *See* MRD-2011, 2, 4, 7-8 (explaining that the “theory of percolation threshold is well documented in the literature”); MRD-2044, 8:15-9:18 (Dr. Zhu explaining the percolation threshold); MRD-2014, 4 (“The critical content of CNTs that characterizes a drastic increase in conductivity is commonly termed as the electrical percolation threshold (EPT)”); MRD-2019 ¶[0035]. This threshold is satisfied by very small amounts of CNT in PVDF. MRD-2011, 7 (explaining that the percolation threshold is “approache[d]” at **5% wt CNTs** in PVDF); MRD-2012, 5 (explaining that “the electrical conductivity of insulating PVDF has increased” by seven orders of magnitude “with the addition of **3 wt% CNTs**”); MRD-2019 ¶[0027] (explaining **5 wt% or less** achieves “significant increases in the electrical

conductivity”).

This is consistent with the testimony of Dr. Chung, who testified that the CNT-PVDF masterbatch binder of Ohata-Kavan has to be viewed 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; *see also id.*, 37:6-20, 39:2-40:20. Thus, contrary to Petitioner’s theory, the masterbatch binder of Ohata-Kavan 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 **5-20 wt%** of CNTs in PVDF).

c. Petitioner provides no credible evidence supporting its “physical contact” or “insulation” theories.

Although Dr. Zhu acknowledges electron tunneling and the percolation threshold (MRD-2044, 7:21-8:10, 8:15-9:18), neither he nor Petitioner accounts for them. Instead, Petitioner offers the vague 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 itself.” Reply, 6 (citing LGES-1056 ¶10).

For one, Dr. Zhu 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, Dr. Zhu testified that active material can have “good” electrical conductivity, contradicting his definitive statement. MRD-2043, 15:9-22; MRD-2044, 10:4-10. And even if the active material did have low conductivity, electrical conductivity would still exist due to electron tunneling and the percolation threshold, which would cause the binder to exhibit “metal-like” conductivity. *Supra* Section II.A.1.a-b.

Lacking any supporting evidence, 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 in Sections II.A.1.a-b, Dr. Chung *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 uncontested evidence supports her. *See e.g.*, MRD-2010, MRD-2011, MRD-2012, MRD-2014.

Petitioner also omits context from its quote. As Petitioner is aware, Dr. Chung explained that the **physical** term “touching” is sometimes loosely used to describe electrical contact between two points. For example, she explained that even if there is a “little microscopic gap at the point of *so-called touching*,” electrical conductivity would still exist. LGES-1055, 114:19-115:1, 47:4-10 (“That is forming a continuous electrical network because of *the touching* of one nanotube with another nanotube.”); *see also* LGES-1054, 36:24-37:5 (“[Y]ou need to have a plurality of nanotubes

coming together and making electrical contact between one another -- that is, *touching* one another....”). Indeed, Dr. Chung explicitly answered “no” when asked “this network of nanotubes would also need to make contact with the active particle itself, right?” LGES-1054, 37:6-20.

Petitioner also misleadingly quotes Dr. Chung’s testimony about “electrical conduction linkages,” an “electrically conductive path,” and “electrical contact” Reply, 6-7. 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 and with the actual electrochemical results” (Reply, 7), is premised on Petitioner ignoring the scientific 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, 6-8 with LGES-1056 ¶¶9-12. Such testimony is entitled to no weight. *See Xerox Corp. v. Bytemark, Inc.*, IPR2022-00624, Paper 9 (Aug. 24, 2022) (precedential). Regardless, not only is his testimony contradicted by the evidence discussed above, the evidence he cites provides no support for his assertions.

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

electrical bridges—not **physical** bridges—are required as previously discussed. Dr. Zhu also cites to a single sentence from the '483 patent and portions of MRD-2008, LGES-1004, and LGES-1005 (LGES-1056, ¶11) without explanation. But that sentence (LGES-1001, 2:4-5) merely states that discrete CNTs can help overcome low electrical conduction due to expansion and contract of active material particles. POR, 12-14 (explaining this benefit). The cited portions of MRD-2008, LGES-1004, and LGES-1005 merely teach that improved electrical conductivity is a goal of composite electrodes—they provide no support for the notion that CNTs must be in **physical** contact with active material to provide improved electrical conductivity.

In view of the above, Petitioner's position that the "basic physical operation of battery electrodes" requires direct physical contact between active material particles and CNTs is false. Reply, 7. Indeed, Petitioner's theory is also contradicted by Petitioner's (incorrect) assertion that Ohata-Kavan achieves CNTs that are spaced apart by at least 1 micrometer. *Infra* Section II.E.2. If "physical contact" was required, Ohata-Kavan would not seek spaced apart CNTs, as Petitioner inconsistently alleges in trying to invalidate claim 8. 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 the tubes allegedly "***do not touch each other.***"

2. Petitioner's "complete dissolution" theory is false.**a. No evidence supports this theory.**

PO offered overwhelming evidence that NMP does not remove PVDF from the oxidized CNTs of Ohata-Kavan. POR, 36-44. That evidence includes *inter alia*: (1) MRD-2020, 6-7 that explicitly teaches a "PVDF polymer layer" "**prevents direct contact** of particle surfaces" even after mixing with NMP; (2) MRD-2015, 1:31-34 plainly teaching that "PVDF dissolved in the organic solvent tends **to coat particles of the active material and the conductive agent**"; and (3) MRD-2014, 8 showing that domains (or "islands") of PVDF are the product of dissolution in NMP.

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, 8. 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 references cited by PO. POR, 37-43.

The exhibits cited by Petitioner provide no support for its dissolution theory. LGES-1061 and LGES-1062 merely teach that PVDF is soluble in NMP. Reply, 8-

9. 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. Dr. Zhu's unsubstantiated testimony that "PVDF is fully dissolvable in NMP at concentrations greater than or equal to 10% by weight" is entitled to no weight because it is cited **nowhere** in the Reply. LGES-1056 ¶13 (citing LGES-1062, 2 without explanation). Even if it was, nothing in his cited evidence actually supports that assertion. Indeed, LGES-1062, 2 does not teach or suggest full dissolution, and the citations to Ohata simply describe the concentration of NMP used—not that the resin is fully dissolved.

Petitioner also argues "that the PVDF binder of Ohata's masterbatch is readily soluble in NMP was well-known, **as explained by Dr. Zhu.**" Reply, 8-9 (citing LGES-1056 ¶¶14-20). However, the Reply does not explain this argument at all, instead offhandedly citing paragraphs 14-20 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 first 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” (nothing supports this), Dr. Zhu still fails to provide any evidence or explanation that NMP would remove the “molecular layer” of resin coating the CNTs’ surfaces. POR, 44 (citing MRD-2006 ¶126); *See also e.g.*, MRD-2009, 2 (“PVDF molecular chains would **coat onto CNT surface** due to the strong interaction between PVDF and CNTs.”); LGES-1014, 3 (functionalized CNTs become “**completely covered** with matrix” when mixed with 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 the 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, meanwhile, 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, 29-31. PO cited numerous ***other*** exhibits showing that NMP dissolves PVDF into 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 or islands. 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 PO 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 that the “CNTs are well dispersed **around** the micrometric LiFePO₄/C particles,” not that the CNTs 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, 10-11. In attacking Dr. Chung for testifying that Figure 2 is “not very clear” and that she was “unable to identify a single carbon nanotube,” Petitioner completely 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, 11. 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 PO's other dispositive evidence. 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, 21, 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, 12.

Similarly, nothing in MRD-2008 "makes clear" that its conductivity improvements come from physically contacting the carbon black with the active material. *Id.* 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

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

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 (i.e., reduces impedance). 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.

Petitioner also quotes MRD-2008 at 11:13-17 as support. But it plainly undermines Petitioner—the quote states that the carbon black “branch structure” is “*integrate[d]*” into the “*PVDF coatings*” and “[t]he acetylene black rich region **is coated with PVDF polymer.**” Recognizing this, Petitioner argues that this teaching somehow fails to evidence that CNTS would be “coated” in the same way, despite the prior art proving otherwise. POR, 30-33, 37-43. And even if MRD-2008 is ignored, Petitioner fails 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, 15-21 (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, 13-14. 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 '483 Patent itself indicates that discrete nanotubes enhance conductivity" and Ohata-Kavan also seeks to "enhance conductivity" does nothing to support Petitioner's position. Reply, 13-14. Discrete CNTs "enhance conductivity" primarily by ***preventing and bridging cracks*** in active material particles resulting from retardation during charging and discharging (POR, 12-16), which is fundamentally different than the "enhanced conductivity" that Ohata-Kavan seeks to achieve via a ***via a network of interconnected CNTs*** (POR, 9-12).

Petitioner complains of “PO’s myopic focus on Fig. 1” of Ohata (Reply, 14), but it is Petitioner that relied almost exclusively on that figure as evidence that Ohata-Kavan achieves “discreteness.” Petition, 34-37. 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, 55-56. 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 (MRD-2019) “does not demonstrate *absence of* discrete nanotubes” in the electrode material mixture. Reply, 15. 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) of Ohata 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.” Reply, 14. But Petitioner relies on Gan to try and invalidate similar claims of a related patent, proving Gan is far more relevant than Petitioner wants the Board to believe. See IPR2024-01011, Paper 2, 36-42.

Petitioner argues that the arrangement of CNTs in Gan's SEM images are irrelevant because they does not include oxidized CNTs. Reply, 15. But as PO explained, a POSITA would have expected the CNT network in the SEM image to be *more interconnected* when oxidized because Gan teaches that functionalization of CNTs in resin "draw[s] the **CNTs closer together.**" POR, 58-59.

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, 14 with LGES-1056 ¶33. Indeed, just like Ohata-Kavan, Gan mixes a large volume of polymer with a small amount of CNTs to form an interconnected network of CNTs.

D. Petitioner Fails to Show Ohata-Kavan Achieves "Ionic" Attachment (Claims 1, 7, 9)

Petitioner's "ionic" attachment arguments are premised on the CNTs of Ohata-Kavan not being coated with resin. Reply, 21-22. Because the CNTs would be fully coated, these rebuttal arguments fail. *Supra* II.A.

E. Petitioner Fails To Show Ohata-Kavan Renders Claim 8 Obvious.

1. "uniformly dispersed"

Petitioner does not dispute that the reference to "uniformly predispersed" in Ohata (LGES-1004 ¶[0002])—which is the **sole** basis for Petitioner's position that Ohata-Kavan satisfies this limitation (POR, 63-65)—is from a sentence discussing carbon black used in a prior art masterbatch process, not the CNT-based masterbatch

process purportedly invented by Ohata. Reply, 22-25. Recognizing that it misunderstood that sentence as referring to CNTs, Petitioner mischaracterizes the Petition to try and improperly gap-fill with new invalidity theories.

Petitioner now argues that “a POSITA would **have expected** the nanotubes in Ohata’s masterbatch to be uniformly predispersed.” *Id.*, 23 (citing Petition, 56-58). But that is not what the Petition argued—the Petition argued that Ohata **expressly teaches** “uniformly predispersed” CNTs based on a misreading of ¶[0002] and merely alleged it would be “obvious” that they would “***remain*** uniformly dispersed” after being mixed with the active material. Petition, 56-58.

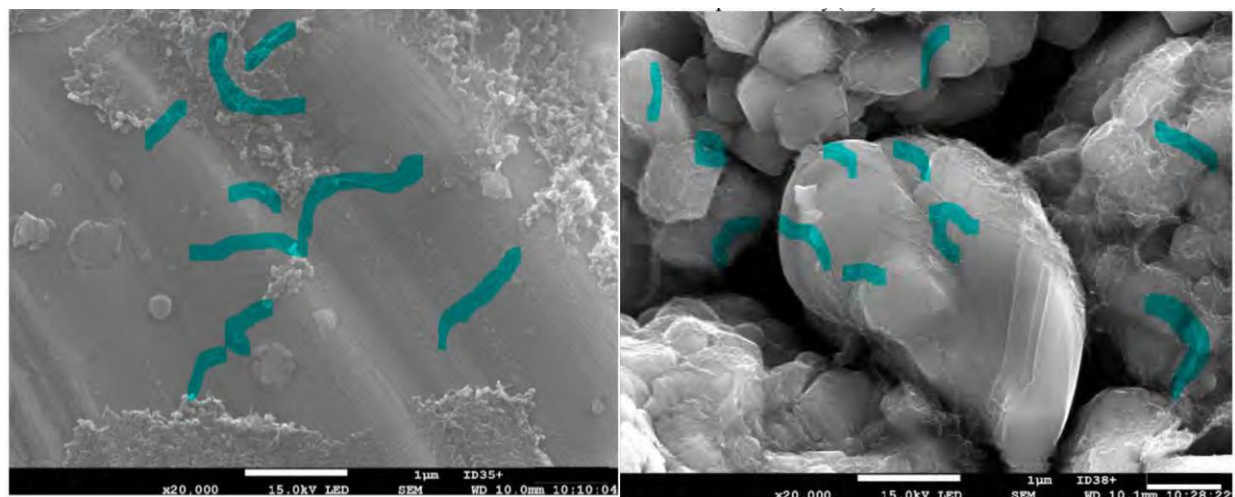
Petitioner also offers the new theory that “a masterbatch process is a conventional approach known to ‘uniformly disperse.’” Reply, 23 (citing LGES-1004 ¶[0003]; LGES-1063, 7:61-67). Petitioner does not cite the Petition, because this “conventional approach” theory was never advanced. Indeed, if Petitioner had included arguments and evidence on this point, Petitioner would not have needed to submit entirely new evidence (LGES-1063). And while the Reply cites to paragraph [0003] of Ohata, that paragraph is about carbon black, not CNTs.

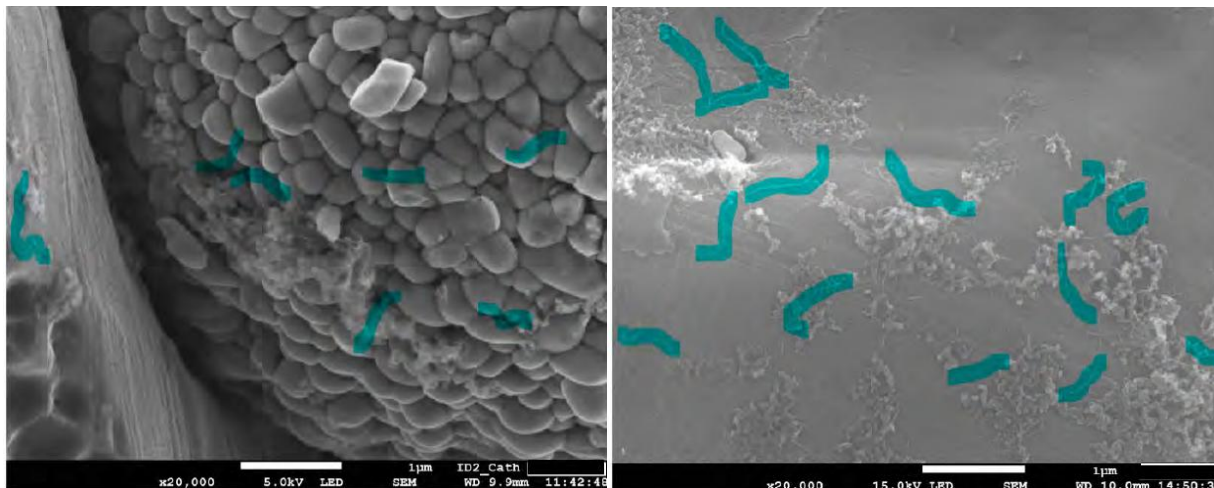
Petitioner attacks PO as “misrepresent[ing]” that “Ohata describes the difficulty of dispersing CNTs in resin,” despite PO quoting Ohata. Reply, 23. Regardless, it cannot be disputed that dispersing CNTs was notoriously difficult (even in resin), undermining Petitioner’s misguided effort to rely on a quote about

the dispersibility of carbon black as being indicative of the dispersibility of CNTs.

POR, 9-12; LGES-1011 ¶[0073]; MRD-2019 ¶[0027].

Petitioner alleges that PO's infringement contentions are "inconsistent" with its position in these proceedings but does not explain how. Reply, 24-25. Petitioner's argument is nothing more than an attempt to detract from its misreading of paragraph [0002] of Ohata. Even assuming the SEM could be interpreted as *appearing* to be "inconsistent," that would be because Petitioner cherry-picked a single SEM focused on a very small area of a composition containing *billions* of CNTs. When the SEM images are viewed holistically, it cannot reasonably be disputed that the discrete CNTs (blue) are uniformly dispersed:





See e.g., LGES-1050, 147, 148, 163, 165.

Petitioner also continues its false and misleading characterization of *Epstein*. Reply, 24; POR, 65-67. This should weigh heavily when considering credibility of the parties.

2. “without clustering on a dimension scale of less than about 1 micrometer”

Petitioner does not dispute that this limitation requires a certain amount of spacing between CNTs. POR, 67-68; Reply, 22-25. Petitioner’s obviousness theory was premised on Ohata’s cartoon Figure 1(b) having “scale.” POR, 68-69. PO demonstrated, however, that nothing in Ohata teaches or suggests that this figure is intended to be drawn to scale. *Id.*, 68-71. Given that Reply does not dispute this, Petitioner’s invalidity theory fails as a matter of law. *Id.*, 69-70.

Recognizing this, Petitioner once again mischaracterizes the Petition to try to fill gaps. Petitioner first argues that “PO fails to address the Petition’s explanation

that a POSITA would have found this to be obvious given the size range of Ohata's nanotubes and Ohata's explicit disclosure that the nanotubes are 'dispersed.'" Reply, 23-24 (citing Petition, 57-58). But that is not what the Petition argued. The Petition argued that "although **no scale** is provided for the Fig. 1(b) schematic, ***a POSITA would have been able to estimate the scale*** based on Ohata's disclosures that the nanotubes 'have an average length of 1 to 100um'.... For instance, for nanotubes having a length of 100 μm , the space between the nanotubes ***is depicted as*** greater than 1 μm" Petition, 58. Thus, the Petition ***premised its argument on Figure 1(b)*** and only relied on the disclosed length of the CNTs to "**estimate the scale**" of that figure. The Petition did not rely on the size of the CNTs alone as Petitioner now falsely alleges.

Petitioner also argues that "PO fails to contend with the role of Ohata's masterbatch process in enabling dispersion of nanotubes, which again, given the size range of Ohata's nanotubes, ***would have rendered obvious the claimed scale of dispersion.***" Reply, 24 (citing Petition, 57-58). Again, Petitioner never argued that this limitation was obvious based solely on Ohata teaching "dispersion" and the disclosed size of the CNTs—Petitioner's argument was premised on Figure 1(b) providing some basis for "scale." Petition, 56-58.

Additionally, Petitioner's apparent position that the vague notion of "dispersing" CNTs necessarily renders obvious CNTs that are spaced ***at least 1um***

apart is implausible on its face. CNTs can be dispersed—even “uniformly dispersed”—while still forming a highly intertwined network of CNTs. *See e.g.*, MRD-2019 ¶¶[0026], [0041] (explaining that CNTs can be “uniformly dispers[ed]” in polymer to form a “random interconnected network” of CNTs).

Petitioner's theory that Ohata-Kavan teaches or renders obvious this limitation is also fundamentally undermined by its new arguments on the “attached” limitation. Petitioner argues (mistakenly) that **physical** contact (i.e., no space separation) is required to achieve electrical conductivity (Reply, 5), but for this limitation Petitioner argues that it is “obvious” that the CNTs would be spaced apart in Ohata-Kavan (i.e., not in physical contact). Reply, 24; Petition, 58. The latter argument is entirely inconsistent with the former—if “physical contact” was required, Ohata-Kavan would not be directed toward a composition where the CNTs are spaced apart.

Petitioner also fails to address that (1) under its 100µm assumption, the CNTs would have an aspect ratio outside the claimed range, or (2) even if the CNTs met this limitation in the “masterbatch,” that does not evidence they would meet this limitation in the electrode paste. POR, 70-71. Nor does Petitioner dispute that it *could have* performed experiments to try to demonstrate this limitation is met. *Id.*, 71-72.

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 5,575 words as calculated by the program used in creating it.

/Stephen D. Zinda/

Stephen D. Zinda

CERTIFICATE OF SERVICE

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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