UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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LG ENERGY SOLUTION, LTD.,
Petitioner

v.

MOLECULAR REBAR DESIGN, LLC,
Patent Owner

_____

Case IPR2024-01012
U.S. Patent 10,608,282

_____

PATENT OWNER'S RESPONSE

LGES 1060
LGES v. MRD
IPR2024-01006

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EXHIBIT LIST

Exhibit No.	Description
MRD-2004	Declaration of Dr. Deborah D.L. Chung, Ph.D.
MRD-2005	Deposition Transcript of Dr. Samuel P. Gido in IPR2024-01012, dated March 20, 2025
MRD-2006	Streit et al., *Measuring Single-Walled Carbon Nanotube Length Distributions from Diffusional Trajectories* Vol. 6, No. 9 ACS NANO 8424 (2012) ("Streit").
MRD-2007	Cabana et al., *The Role of Steam Treatment on the Structure, Purity and Length Distribution of Multi-Walled Carbon Nanotubes* 63 CARBON 1059 (2015) ("Cabana").
MRD-2008	WEBSTER'S NEW WORLD COLLEGE DICTIONARY (4th ed. 1999), definition of discrete
MRD-2009	Declaration of Dr. Yu Zhu in IPR2024-01013, dated June 12, 2024
MRD-2010	Deposition Transcript of Dr. Yu Zhu in IPR2024-01013, dated March 14, 2025

I. Introduction

Patent Owner presents substantial new evidence and arguments demonstrating that Petitioner fails to carry its burden of proving unpatentability of any claim.

Ground 1 (Bosnyak-392 and Son) is fundamentally flawed. First, Petitioner overlooks the fact that Son does not teach discrete carbon nanotubes ("CNTs") for its upper range of aspect ratios, it in fact specifically teaches as non-discrete. *Infra* Sections V.A.2 and V.D. Second, because Son does teach discrete CNTs through both sub-ranges of values for the CNTs' aspect ratios, a POSITA would have no reason to combine Son with Bosnyak-392, if, as Petitioner alleges, a POSITA was attempting to fit the CNTs of Bosnyak-329 with a bimodal aspect ratio range. *Infra* Section V.B. Third, Petitioner has failed to demonstrate that the combination teaches CNTs in the concentrations required by the claims. Son's concentrations are given in weight percentages, while the claims' concentrations are given in number percentages, and it is impossible to convert from one to the other with the limited information provided in Son. *Infra* Section V.E. Fourth, Son teaches a vast range for the sub-range of its larger aspect ratios that is orders of magnitude larger than the claims of the '282 Patent. A POSITA would understand that a range of aspect ratio values as large as Son's would comprise many compositions with dramatically

different structures and behaviors, and that "experimenting" to find an optimum range would be no routine matter. *Infra* Section V.F.

Ground 2 (Bosnyak-129 and Albuerne) is also deeply flawed. First, Petitioner is forcing a single graph from Albuerne to "teach" something it cannot, and that no POSITA would believe it did. *Infra* Section VI. Albuerne does not teach a bimodal aspect ratio of CNTs, and because a POSITA would understand that it does not, a POSITA would have no reason to combine it with Bosnyak, if as the Petitioner alleges, the POSITA was seeking to add a bimodal distribution of aspect ratios to Bosnyak-129's CNTs. *Infra* Section VI.A. Second, Albuerne cannot be said to teach the concentrations of the claims, as Petitioner again attempts to force a "teaching" from Albuerne's data that is simply not there. *Infra* Section VI.B. Third, even if a POSITA believed as Petitioner contends, the POSITA would have no expectation of success in repeating findings that, if they exist, are the result of random chance.

II. Level of Ordinary Skill

Patent Owner applies Petitioner's proposed definition of a POSITA for purposes of this proceeding only. Patent Owner's technical expert, Dr. Deborah Chung, has a Bachelor's Degree in Engineering and Applied Science and a Master's Degree in Engineering Science from the California Institute of Technology. MRD-

2004 ¶5. Dr. Chung also has a Master's Degree in Materials Science and a Doctorate in Materials Science from the Massachusetts Institute of Technology. *Id.* A central focus of Dr. Chung's decades of technical experience has been studying CNTs. *Id.* ¶¶14-17. Thus, she qualifies as a POSITA.

III. Overview of Technology

United States Patent No. 10,608,282 (the '282 Patent) is directed to a composition of discrete CNTs that can serve different functions within an energy storage or collection device, such as batteries or capacitors. LGES-1001, Abstract. Depending on the specific concentrations and aspect ratios of CNTs, the composition can be used as binder material, electrolyte material, or separator film material of the energy storage device. *Id.* To fully understand the scope and novelty of the claimed invention, it is important to understand each of these different functions.

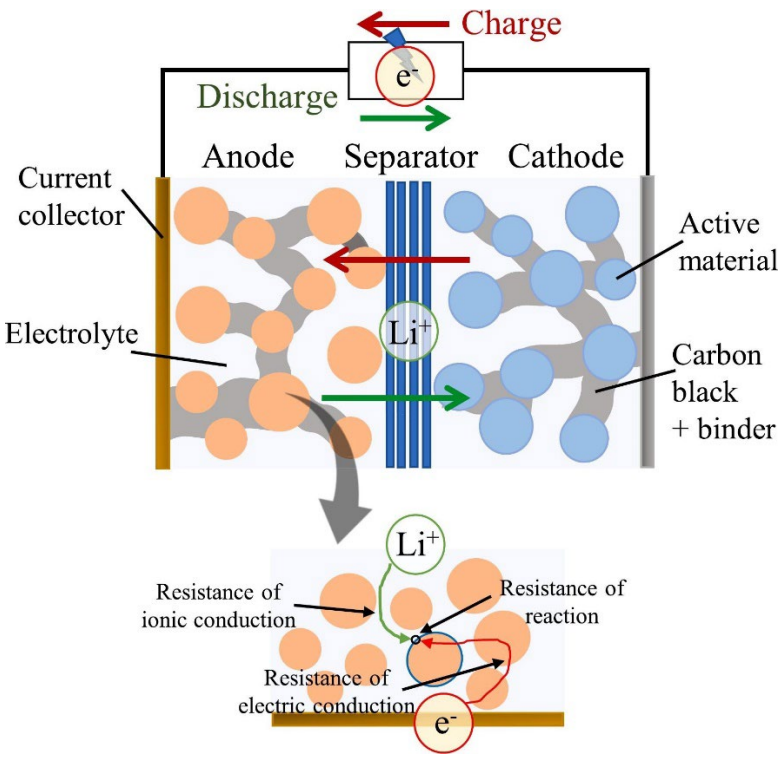
First, it is helpful to understand how electrical charge flows. MRD-2004 ¶62. Electric current is often described as charged particles such as electrons moving along a conductive path in response to an applied voltage (or an electric field). *Id.* An example of a well-known conductor that involves electrons moving in response to a voltage is copper. *Id.* Conductors that involve electrons or electron holes (which refer to unoccupied electron states) moving in response to a voltage are known as electronic conductors. *Id.* However, electric current can alternatively involve the

movement of ions in response to an applied voltage. *Id.* Conductors that involve ions moving in response to a voltage are known as ionic conductors. *Id.* The ions can be positively charged or negatively charged and can be derived from atoms or molecules. *Id.* An example of an ionic conductor is salt water, i.e., water with dissolved sodium chloride, which provide Na^+ and Cl^- ions. Another example of an ionic conductor is poly(ethylene oxide) with dissolved lithium perchlorate, which provide Li^+ ions.

This separation of the flow of current into two types—(1) flow of electrons, and (2) flow of ions—is particularly important in understanding the function of certain parts of an energy storage device. *Id.* ¶63. While it is vital for many parts of an energy storage device to allow electric current to flow, certain parts need to be as highly conductive as possible in one type of flow (e.g., ion flow) while simultaneously being as minimally conductive as possible in the other type of flow (e.g., electron flow). *Id.* In the parlance of the ’282 Patent, permitting the flow of electrons is “electronic conductivity” (often loosely referred to as electrical conductivity), while permitting the flow of ions is “ionic conductivity.” *Id.* (citing LGES-1001, 2:51-52).

Below is a generalized image of a battery and its constituent components. *Id.*

¶64. It illustrates, in a general way, the location and function of the battery's constituent components, including the electrodes (with the anode and cathode being the two electrodes involved), binder, electrolyte, and separator:



Id.

The first composition disclosed in the '282 Patent is a binder. *Id.* ¶65 (citing LGES-1001, 8:44-58). In energy storge devices such as batteries, a binder acts as a "glue" to mechanically hold together the discontinuous parts of an electrode. *Id.* These parts include the electrochemically active material (commonly in the form of particles). *Id.* If the electrochemically active material is not sufficiently electronically

conductive, an electronically conductive additive (such as carbon black and carbon nanotube) can also be added as needed to render the electrode electronically conductive. *Id.* An electrode that is nonconductive cannot function as it creates an open circuit in the electrochemical system of the battery and thus prevents current to flow through the battery. *Id.*

Oxide particles (e.g., lithium iron oxide particles) are commonly used as the electrochemically active material (often called the ion active material) in an electrode, but they are typically poor electronic conductors. *Id.* ¶66. Thus, including a conductive additive in an electrode comprising oxide particles is often necessary. *Id.* In addition, a binder may serve as a joining medium (like an adhesive) that binds the discontinuous constituents of an electrode together, in addition to adhering an electrode to a current collector. *Id.* (citing LGES-1001, 2:6-19). Moreover, it is desirable to use a small amount of binder, because minimizing the amount of the surface area of the electrochemically active particles taken up by the binder maximizes the surface area available for the electrochemically active particles to participate in the electrochemical process that enables the battery to work. *Id.*

The second composition disclosed in the ’282 Patent is an electrolyte. *Id.* ¶67 (citing LGES-1001, 8:59-9:6). In energy storage devices, an electrolyte sits between,

and is in physical contact with, both the anode and the cathode. The electrolyte must be an ionic conductor while not being an electronic conductor. *Id.* Good ionic conductivity improves the performance of the device, while electronic conductivity causes a degree of short-circuiting between the two electrodes, thereby degrading the performance of the device. *Id.* (citing LGES-1003, 8:59-9:6). Electrolytes can be solids but are more often in liquid form. *Id.*

The third composition disclosed in the ’282 Patent is a separator, which is commonly in the form of a film. *Id.* ¶68 (citing LGES-1001, 9:7-31). A separator is also positioned between the two electrodes (the anode and the cathode) but does not need to be in contact with either electrode. *Id.* (citing LGES-1001 9:7-21). A separator’s function is to prevent the electrolyte in the vicinity of the anode to mix with the electrolyte in the vicinity of the cathode. *Id.* Like an electrolyte, a separator must be an ionic conductor so that the electrochemical process required to perform the function can occur. *Id.* However, a separator must be an electronic non-conductor, as the electronic conductivity may contribute to electrical short-circuiting between the two electrodes. *Id.*

The claims of the ’282 Patent are directed to a composition comprising discrete CNTs that can be used for binders, electrolytes, or separators. *Id.* ¶69 (citing

LGES-1001, claims 1-16). Furthermore, the ’282 Patent teaches ranges of aspect ratios and concentrations of the discrete CNTs that form a bimodal distribution. *Id.* (citing LGES-1001, Tables 1-3, 11:36-41, 12:5-8). The claims require discrete CNTs having aspect ratios between 10 and 500 and comprise two sub-ranges of aspect ratios (30-70 and 80-140) having specific concentration requirements (i.e., the number of discrete CNTs in a particular sub-range divided by the total number of discrete CNTs). *Id.* (citing LGES-1001, 14:2-12). Specifically, the claims require discrete CNTs with aspect ratios between 30-70 comprising between 40% and 90% of the total discrete CNTs, and discrete CNTs with aspect ratios between 80-140 comprising 1% to 30% of the total discrete CNTs. *Id.* A POSITA would understand that one can then alter the relative proportions of discrete CNTs in the two sub-ranges to better suit one of the three purposes described above. *Id.*

It is generally understood by a POSITA that, for the same CNT diameter and the same CNT volume fraction (i.e., the volume of CNTs divided by the volume of a composition comprising the CNTs), CNTs with a higher aspect ratio tend to provide higher electrical conductivity. *Id.* ¶70. Thus, adjusting the concentration of the higher aspect ratio CNTs (with aspect ratio sub-range 80-140) of the claimed composition closer to 30% (which is the high percentage end for this sub-range)

tends to result in higher electrical conductivity for the claimed composition. *Id.* On the other hand, reducing the concentration of the higher aspect ratio CNTs of the claimed composition closer to 1% (which is the low percentage end for this sub-range) will likely reduce the electrical conductivity of the claimed composition. *Id.* For a particular CNT diameter, the volume fraction and aspect ratios of the CNTs within each sub-range can thus be adjusted accordingly to suit the particular function of the composition, whether it be as a binder, electrolyte or separator. *Id.*

IV. Claim Construction

The Board is required to construe "'only those terms … that are in controversy, and only to the extent necessary to resolve the controversy.'" *Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1375 (Fed. Cir. 2019) (quoting *Vivid Techs., Inc. v. Am. Sci. Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)). Because there is a controversy regarding the meaning of "discrete carbon nanotube fibers" (Claim 1) and that controversy is material to whether Petitioner has carried its burden of showing unpatentability, claim construction is necessary.

The specification teaches that "discrete carbon nanotubes of this invention can improve ion transport yet still provide the necessary electrical insulation between the electrodes." LGES-1001, 4:18-21. A POSITA would understand that discrete CNTs can provide electrical insulation because they are not attached to one another,

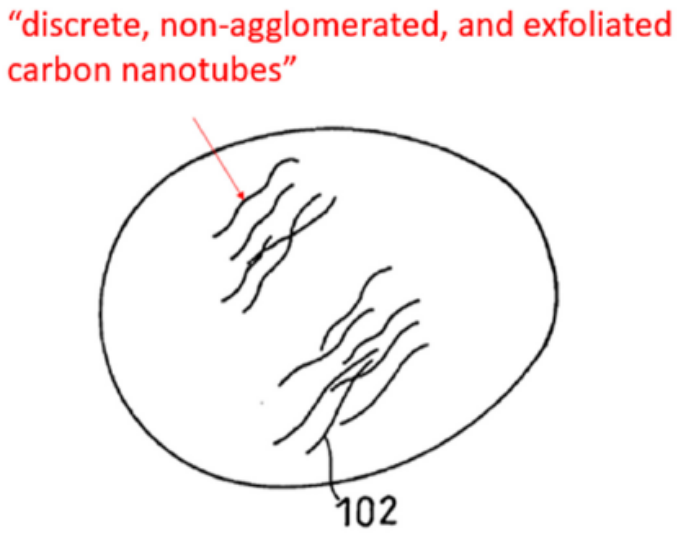
creating gaps that greatly increase the electrical resistance. MRD-2004 ¶54. The specification also teaches that "discrete oxidized carbon nanotubes" are alternatively termed "exfoliated." LGES-1001, 6:50-54. A POSITA would understand that discrete CNTs can be alternatively termed "exfoliated" because discrete CNTs had to be disentangled or unbundled from other CNTs to become discrete. *Id.*. In other words, a discrete CNT is by definition "exfoliated" because exfoliation is required to separate the CNTs from one another. *Id.* Consistent with this understanding, the specification describes "discrete" CNTs as having to be disentangled or de-bundled from other CNTs as part of achieving discrete status such that the CNTs do not form "discernable aggregates." LGES-1001, 11:61-12:32.

The plain and ordinary of meaning of "discrete carbon nanotube fibers" is carbon nanotube fibers that are separate and distinct from other nanotube fibers—not attached to other nanotubes. MRD-2004 ¶55. This is consistent with the common meaning of discrete. MRD-2008, 4 (defining "discrete" to mean "separate and distinct; not attached to others; unrelated").

This meaning is also consistent with the plain and ordinary meaning of "discrete carbon nanotubes" offered by Petitioner's expert, Dr. Yu Zhu, in co-pending IPRs challenging three other CNT-related patents of Patent Owner. For

example, in reference to the annotated figure below Dr. Zhu testified:

> And looking again to Ohata's illustrative example, provided below, it can be seen that ***most*** of the nanotubes are depicted as being discrete, non-agglomerated, and exfoliated. Indeed, a POSITA would have understood a carbon nanotube that is, as shown below, ***fully isolated*** from each other to be discrete, non-agglomerated, and exfoliated.[1]



Excerpt from Ohata, Fig. 1(b) (annotated)

MRD-2009 ¶83. Dr. Zhu thus considers the CNTs that are individual, distinct and not attached (i.e., "fully isolated") to other CNTs (i.e., "most" of them) to be "discrete." MRD-2004 ¶56. This is consistent with his deposition testimony, where he testified that the nanotube pointed to by a red arrow was identified as "discrete"

[1] All emphasis is added unless otherwise indicated.

by him "because it's fully isolated from the other nanotubes." MRD-2010, 10:21-11:6; *see also id.*, 12:17-13 (testifying that discrete CNTs "have been separated from each other"); *id.*, 13:13-22 (responding "yeah" to being asked "Your testimony was that discrete carbon nanotubes are non-bundled nanotubes that are separate from each other, correct?"). MRD-2004 ¶56.

Although Petitioner does not expressly propose this term for construction, Petitioner and its expert implicitly suggest that "discrete carbon nanotube fibers" means that "at least one of the carbon nanotubes are not aggregated and are individually distinct in that they lack direct association with one another ***along substantially the length of the nanotube***." Pet., 15 (citing LGES-1003 ¶42). MRD-2004 ¶57. Petitioner's bizarrely specific yet subjective construction should be rejected for several reasons.

For one, it is inconsistent with the common meaning of discrete and the testimony of Petitioner's own expert, Dr. Zhu, on the meaning of "discrete carbon nanotubes," who testified that discrete CNTs are CNTs that are fully isolated and separate from one another. *Id*. ¶58. The only purported evidence that Petitioner cites to support its construction is a statement from the specification: "discrete oxidized carbon nanotubes, alternatively termed exfoliated carbon nanotubes." *Id.* (citing

LGES-1001, 6:50-54). According to Petitioner, this statement defines "discrete" to mean "exfoliated." *Id*. However, as explained above, discrete CNTs are necessarily exfoliated because such CNTs have to be disentangled from the raw bundle of CNTs to be fully isolated or detached from one another. *Id*. Consequently, discrete CNTs are necessarily exfoliated but exfoliated CNTs are not necessarily discrete because they can remain attached to another CNT (e.g., via Van der Waals forces). *Id*.

Additionally, Petitioner provides no explanation as to how or why this phrase allows for *some* "direct association" with other CNTs but not "along substantially the length of the nanotube." There is no plausible explanation. Instead, this interpretation was contrived by Petitioner so that it could ensnare CNTs from the prior art that do not legitimately qualify as discrete because they are attached to another CNT. Indeed, Dr. Gido struggled mightily during his deposition to explain how a POSITA would even determine whether CNTs qualify as "discrete" under his unsubstantiated, subjective interpretation. MRD-2005, 8:11-19 ("Q. And what is a substantial portion of its length? A. That is not well, you know, defined, necessarily. ***You just have to look at these things*** and see whether they look like they're aggregating or associating, and, you know, it's not along a substantial or most of its length or a significant part of its length."); *id.*, 9:1-11 ("Q. 50 percent. Would that be

substantial? A. I didn't really think -- I mean I was not asked to think about and attach a number to a particular, you know, a particular amount of association. I would say that 50 percent is a fair amount of association."). In fact, Dr. Gido even testified that under his interpretation CNTs that are entangled could be "discrete." *Id.*, 9:24-10:10 ("Q. Does a discrete carbon nanotube fiber have to be disentangled from another carbon nanotube? To the extent that entanglement might involve them being associated with one another along a substantial part of their length, you know, they shouldn't be, although certainly in some cases, you know, particularly long fibers might loop around one another without actually being stuck together.").

Petitioner and Dr. Gido's proposed construction is inconsistent with the common meaning of "discrete," the usage of "discrete" throughout the specification, and the understanding of "discrete" offered by Dr. Zhu in other CNT patents. Their proposal should be rejected, and the plain and ordinary meaning of separate, distinct, and not attached to others should apply.

V. Grounds 1A-1C: The Combinations Based on Bosnyak-392 and Son Do Not Render Any of the Claims Obvious.

A. Overview of the Prior Art and Proposed Combination

1. Bosnyak-392

Bosnyak-392 is a PCT publication of a different application by the same inventors of the '282 Patent. LGES-1005. In general, it describes a method previously used by the inventors for generating exfoliated CNTs in a solid state. MRD-2004 ¶71 (citing LGES-1005 ¶[0008]). The described methods attempt to avoid the "damage" to the CNTs that exfoliation via functionalization causes and provide material for battery components, including putting them in polymers, while maintaining their exfoliated state. *Id.* (citing LGES-1005 ¶¶[0006]-[0007]).

2. Son

Son describes polymer composites using CNTs and seeks to produce higher electrical conductivity in these polymers through the use of very high aspect ratio CNTs. MRD-2004 ¶72 (citing LGES-1008 ¶[0003]). Son's method seeks to minimize the dispersibility problems found when using high aspect ratio CNTs and avoid the problems created when achieving dispersion of CNTs through functionalization, such as reduced electrical conductivity and shortened nanotubes. *Id.* (citing LGES-1008 ¶¶[0003]-[0005]).

The goal of Son is specifically seeking to maintain an "electrical network" that involves the presence of "contact between tubes." *Id.* ¶73 (citing LGES-1008 ¶[0005]). In other words, Son seeks to achieve a network of interconnected CNTs, which can provide increased electrical conductivity. *Id.* Due to the limited length of each CNT compared to the length of the needed conduction path, the networking is necessary to provide conductivity for the plurality of CNTs. *Id.* (citing LGES-1008 ¶¶[[0005], [0032], [0032], [0054], an [0055]).

However, a key problem that Son is attempting to overcome is the tendency for large aspect ratio CNTs to break when they are incorporated in a polymer. *Id.* ¶74 (citing LGES-1008 ¶[0006]). An advantage of using CNTs with a large aspect ratio is that they can provide improved electrical conductivity by providing the needed long conduction path without involving a large number of CNTs, i.e., without involving a large number of CNT-to-CNT contact points. *Id.* Since each CNT-to-CNT contact point involves a substantial electrical resistance, having fewer contact points helps reduce the resistance of the overall conduction path. *Id.* Son tries to solve the abovementioned problem of the fracture tendency of CNTs with a large aspect ratio by functionalizing the CNTs within his aspect ratio ranges before including them in the polymer. *Id.* (citing LGES-1008 ¶¶[0007]-[0008]).

Specifically, Son proposes a polymer composite material comprising CNTs with a mix of aspect ratios that have at least two peaks in a distribution graph of their weight ratio versus their aspect ratio. *Id.* ¶75 (citing LGES-1008 ¶[0006]). Son claims that this graph results in two peaks in the weight ratio, one for aspect ratios between 10-65 and another for aspect ratios between 130-10,000. *Id.* (citing LGES-1008 ¶[0009]). Within the CNTs, the CNTs corresponding to those two peaks are 80% or more by weight of the CNTs present, and the weight percentage of the smaller aspect ratio CNTs (referred to as "first") is 0.1 to 10 times the weight of the larger aspect ratio CNTs (referred to as "second"). *Id.* (citing LGES-1008 ¶¶[0014], [0016]). Son further describes the difference between the aspect ratios of those peaks as being very large, with one being 2 to 1,000 times greater than the other. *Id.* (citing LGES-1008 ¶[0011]).

FIGs. 1-3 (reproduced below) are all directed to the same embodiment:

FIG. 1

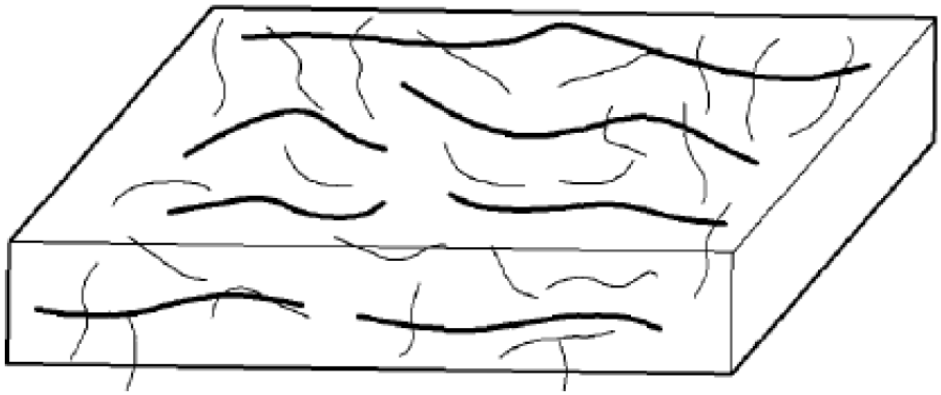
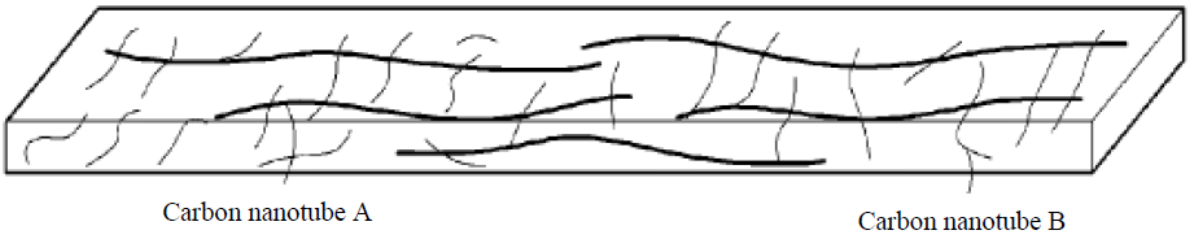
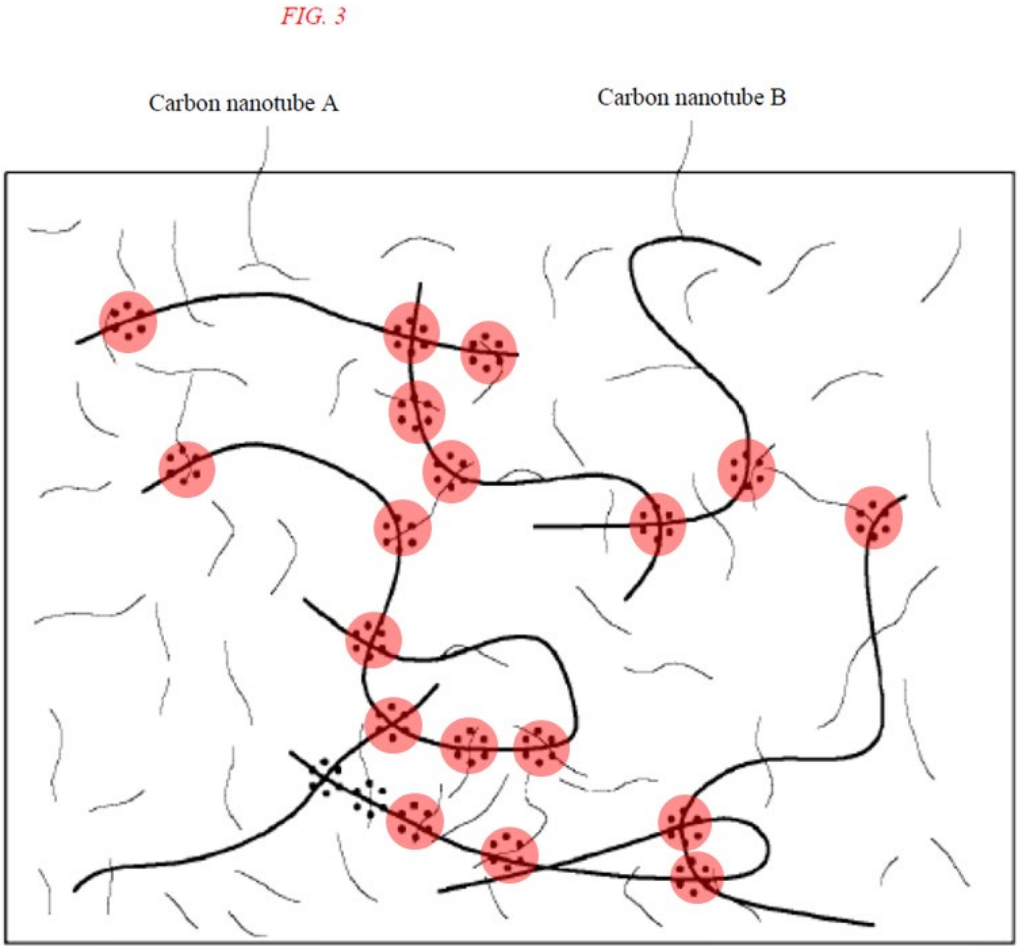

Carbon nanotube A
Carbon nanotube B

FIG. 2


Carbon nanotube A
Carbon nanotube B



LGES-1008, FIG. 3 (annotated by Patent Owner)

Id. ¶76 (citing LGES-1008 ¶¶[0020]-[0022], 9-10)).[2] As shown, this embodiment represents the smaller aspect ratio CNTs as thinner, shorter lines and the larger aspect ratio CNTs as thicker, longer lines. Son explains that the larger aspect ratio CNTs

[2] Son's identification of "Carbon nanotube A" and "Carbon nanotube B" in FIG. 3 appear to have been inadvertently switched. MRD-2004 ¶76, n.2. Petitioner's expert, Dr. Gido, agrees. MRD-2005, 32:6-43:22.

provides improved "electrical properties" and that the smaller-aspect ratio CNTs provide "excellent dispersibility" and that by using both together, the benefits are "simultaneously expressed." *Id.* ¶77 (citing LGES-1008 ¶[0021]). Son further explains, in reference to FIG. 3, that "[t]he portion marked with dots in FIG. 3 is a position where an electrical contact is made" between CNTs. *Id.* (quoting LGES-1008 ¶[0022]). These interconnections are clearly identified by Son using black dots (identified in red in FIG. 3, above). *Id.*

It is important to understand that FIG. 3 is the same embodiment depicted in FIGs. 1 and 2. *Id.* ¶78 (citing LGES-1008 ¶¶[0020]-[0022]). FIG. 3 clearly shows that each and every one of the larger aspect ratio CNTs in FIG. 1 is purposefully interconnected with another larger CNT (and in some with smaller aspect ratio CNTs), thereby forming a ***continuous*** conductive network throughout the polymer. *Id.* (citing LGES-1008 ¶¶[0020]-[0022]). Indeed, Son explicitly teaches:

> Therefore, as shown in FIG. 2, it is possible to prevent the rupture of the carbon nanotubes even through the injection process, **so that the electrical network before injection can be *maintained***. As shown in FIG. 3, the electrical network is mainly composed of carbon nanotubes having a large aspect ratio. The portion marked with dots in FIG. 3 is a position ***where an electrical contact is made***.

Id. (quoting LGES-1008 ¶[0022]).

As this makes clear, the connections (such as those in the red circles, above) are intentionally maintained connections between the CNTs. *Id.* ¶79. The larger aspect ratios CNTs, are therefore, not discrete—they are interconnected by design. *Id.*

Although many of the smaller aspect ratio CNTs are discrete to help provide "excellent dispersibility," the longer CNTs clearly are not. *Id.* ¶80. As an analogy, the larger aspect ratio nanotubes are designed to act as continuous "highways" that provide improved electrical conductivity across the composition as a whole, and the smaller aspect ratio CNTs are designed to be better dispersed into the areas that are not covered by those highways. *Id.* Consequently, while Son does in fact disclose using two sub-ranges of aspect ratios, one sub-range is specifically designed to maintain connectivity between the CNTs—i.e., not be discrete. *Id.*

3. The Bosnyak-392-Son combination

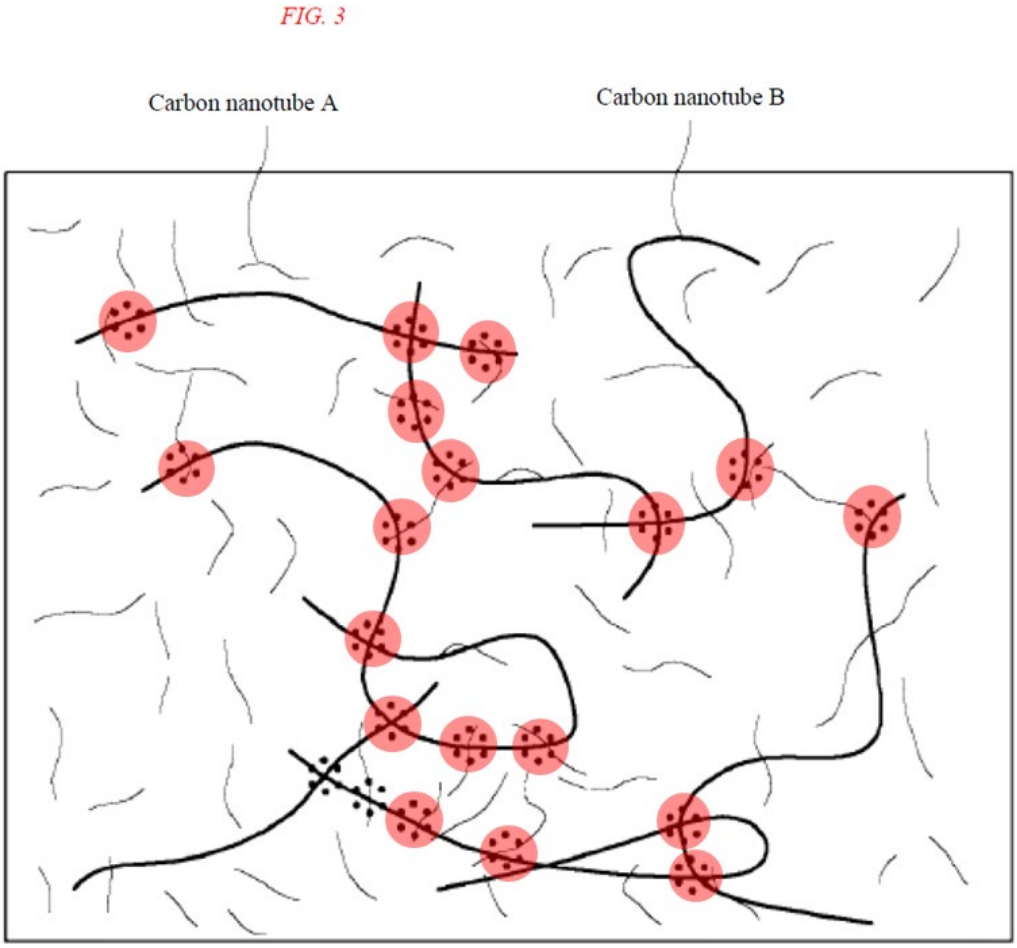
Petitioner relies on Bosnyak-392 for all limitations of the independent claims, except for the required bi-modal aspect ratio ranges. Pet., 11-13. To try and supply that limitation, Petitioner alleges that a POSITA would have found it obvious to use bi-modal aspect ratio ranges taught by Son, resulting in discrete CNTs as claimed. MRD-2004 ¶81.

B. A POSITA Would Have Had No Motivation to Combine

The Petition argues that "a POSITA would have nevertheless considered using the claimed aspect ratio distributions [of Son] . . . to be obvious for reasons that include but that are not limited to these being routine and conventional design choices a***s evidenced, for example, by the express teachings of*** Son." Pet., 11-12. However, the express teachings of Son fundamentally undermine Petitioner's motivation to combine. MRD-2004 ¶82.

Petitioner inaccurately describes Son as "using two different types of ***discrete***, individually dispersed carbon nanotubes" and focuses on Fig. 1 as visually depicting these "two different types." *Id.* ¶83 (citing Pet., 9-10). However, Son's larger aspect ratio CNTs are not discrete. *Id.* To the contrary, the larger aspect ratio CNTs are purposefully not discrete, because a primary goal of Son's method is to make sure they are ***connected***. *Supra* Section V.A.2.

Petitioner cherry-picks FIG. 1 to support its assertion, but improperly ignores that FIG. 3 depicts the same embodiment and visually confirms that the larger aspect ratio CNTs are *not* discrete but rather are interconnected with one another (at red circles, below):



LGES-1008, FIG. 3 (annotated by Patent Owner)

MRD-2004 ¶84 (citing LGES-1008, FIG. 3).

Indeed, Son explicitly teaches:

> Therefore, as shown in FIG. 2, it is possible to prevent the rupture of the carbon nanotubes even through the injection process, so that the electrical network before injection ***can be maintained***. As shown in FIG. 3, the electrical network is mainly composed of carbon nanotubes having a large aspect ratio. The portion marked with dots in FIG. 3 is a position where ***an electrical contact is made***.

Id. ¶85 (quoting LGES-1008 ¶[0022]). As this makes clear, the connections (red circles, above) are intentionally maintained connections between the CNTs. *Id.* The larger aspect ratio CNTs are therefore not discrete--they are interconnected by design. *Id.* Petitioner's expert concedes this. MRD-2005, 35:21-37:5; MRD-2004 ¶85.

Petitioner's motivation to combine is fundamentally flawed, because it is premised on a POSITA being motivated to rely on ***both*** of Son's bi-modal aspect ratio ranges to achieve "discrete" CNTs. Pet., 18; MRD-2004 ¶86. However, Son unequivocally teaches that its larger aspect ratio range is purposefully designed to ***not*** achieve discrete CNTs. MRD-2004 ¶86 (citing LGES-1008 ¶[0022]). Rather, the larger aspect ratio range is designed to achieve a continuous network of interconnected CNTs throughout the composition. *Id.* Although Son does appear to teach that the smaller aspect ratio range can achieve discrete CNTs, the challenged claims require that the CNTs in ***both*** ranges be "discrete." *Id*. Petitioner is required to consider the prior art for all that it teaches in full, and Son plainly teaches that the larger aspect ratio range CNTs are not discrete. *PGS Geophysical AS v. Iancu*, 891 F.3d 1354, 1366 (Fed. Cir. 2018) ("[T]he prior art must be considered 'as a whole, including portions that would lead away from the invention in suit.'" (quoting

Panduit Corp. v. Dennison Mfg. Co., 810 F.2d 1561, 1568 (Fed. Cir. 1987)).

Petitioner fails to explain why a POSITA attempting to achieve discrete CNTs within two bi-modal aspect ratio sub-ranges would have been motivated to select an aspect ratio sub-range that is specifically disclosed as achieving *non-discrete* CNTs. MRD-2004 ¶87. This is because there is no logical basis for such a motivation. *Id.* A POSITA would have had no motivation to rely on the larger aspect ratio sub-range disclosed in Son, because Son itself teaches that the sub-range would result in non-discrete CNTs. *Id.* For this same reason, a POSITA would be discouraged from relying on the larger aspect ratio sub-range of Son to achieve "discrete" CNTs, because Son expressly teaches that they achieve an interconnected network of CNTs. *Id.* Consequently, Petitioner's motivations to combine are fundamentally undermined by the express teachings of Son. *Id*.

C. A POSITA Would Have Had No Reasonable Expectation of Success

There must be a reasonable expectation of success in achieving ***the claimed invention***, not some general success. *See Intelligent Bio-Systems, Inc. v. Illumina Cambridge, Ltd.*, 821 F.3d 1359, 1367 (Fed. Cir. 2016) ("The reasonable expectation of success requirement refers to the likelihood of success in combining references to meet the limitations of the claimed invention…. The Board seemed to believe that

the 'reasonable expectation of success' inquiry looked to whether one would reasonably expect the prior art references to operate as those references intended once combined. That is not the correct inquiry—one must have a motivation to combine accompanied by a reasonable expectation of achieving what is claimed in the patent-at-issue."); *see also Depuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1326 (Fed. Cir. 2009) ("[T]he 'predictable result' discussed in [*KSR Int'l Co. v. Teleflex Inc*.] refers not only to the expectation that prior art elements are capable of being physically combined, but also that the combination would have worked for its intended purpose.") (referencing *KSR Int'l Co. v. Teleflex Inc*., 550 U.S. 398, 127 S. Ct. 1727, 1739-40, 167 L. Ed. 2d 705 (2007)).

Petitioner fails to demonstrate that a POSITA would have reasonable expectation of success in achieving the claimed invention—requiring two "***discrete***" bimodal CNT ranges—by relying on the smaller and larger aspect ratio sub-ranges of Son. MRD-2004 ¶89. No such expectation would have existed, because Son expressly teaches that its larger aspect ratio CNTs are not discrete but rather are interconnected with other CNTs resulting in a continuous network with higher electrical conductivity. *Id*. Indeed, a POSITA would clearly have *expected* that using the CNTs in the larger aspect ratio sub-range of Son would result in non-discrete

CNTs, because that is what Son explicitly teaches and shows in its embodiments. *Id.* (citing LGES-1008 ¶[0022].

D. Even if Combined, Petitioner Fails to Demonstrate That the Combination Results in "Discrete" CNTs in Both Claimed Sub-Ranges

Petitioner discusses Bosnyak-392's use of the term "exfoliated" CNTs at length, arguing that this language mirrors the terminology of the '282 Patent. Pet., 15; MRD-2004 ¶90. This is unsurprising since both documents have the same authors. *Id*. Petitioner goes on to say that "Son similarly relies on the use of such discrete nanotubes having 'excellent dispersibility.'" *Id.* But this "excellent dispersibility" Son is relying on is for ***the smaller aspect*** ratio CNTs, not the large aspect ratio CNTs. MRD-2004 ¶90 (citing LGES-1008 ¶[0021]). Dispersibility and discreteness are not the same thing, and Son relies on the larger aspect ratio CNTs to provide the conductive "highways" through its composition. *Id.*

Most importantly, the methodology of Son purposefully relies on larger aspect ratio CNTs that are ***not*** discrete. *Supra* Section V.A.2; MRD-2004 ¶91. Even though Son proposes a "bimodal" solution, only the smaller aspect ratio CNTs are taught as being discrete. MRD-2004 ¶91. Thus, even if it were appropriate to combine Bosnyak-392 and Son, the combination would not result in discrete nanotubes for *both* the smaller and larger aspect ratio CNTs. *Id.* Moreover, Petitioner makes no

effort to say, show or explain how discreteness would be maintained in Bosnyak-392 by using the larger aspect ratio disclosed by Son, which is purposely designed to generate CNTs that are not discrete.

E. Bosnyak-392 and Son Do Not Teach Discrete CNTs in the Claimed Concentrations

As described above, the composition of claim 1 can be used for binders, electrolytes or separator films, which a POSITA would have understood to have different electronic conductivity and ionic conductivity requirements in order to operate effectively in energy storage devices. MRD-2004 ¶92. Thus, the concentrations of the claim are important. *Id.* The ’282 Patent describes, at length, the properties of **binders** (LEGS 1001, 5:8-25, 8:13-20, 9:18-31), **electrolytes** (5:26-60, 8:25-39, 9:32-60) and **separator film**s (5;26-60, 8:25-39, 9:51-60). *Id*. ¶92. Further, the ’282 Patent discusses 15 experiments that vary the concentrations of CNTs and discusses the properties provided by the different concentrations and other controlled parameters, with said properties being relevant to the use of the CNTs in binders (experiments 1-5), electrolytes (experiments 7-15), and separator films (experiments 1-3). *Id.* (citing LGES 1001 10:34–13:20).

A POSITA would readily understand that the claimed concentrations for each specific aspect ratio sub-range (i.e., the percentage abundance range for each aspect

ratio sub-range) are important part of making a composition capable of being used in a binder, electrolyte, or separator. *Id.* ¶93. They are not, as Petitioner alleges, a simple design choice nor are they "easily determined by a person skilled in the art." *Id.* (citing Pet., 19 (quoting LGES-1008 ¶[0032])). Indeed, even if the selected concentrations were easily discernible for Son's applications (in fact they are not), Son's applications are for the purpose of making a conductive polymer composite, not making specific functional components (e.g., separator film) within an energy storage device. *Id.* (citing LGES-1008 ¶¶[0007], [0008]).

In any event, Petitioner concedes that the concentrations disclosed in Son are not expressed as percentage numbers of CNTs as the '282 Patent's claims are, but rather as weight ratios of CNTs. Pet., 19; MRD-2004 ¶94. Because Son does not discuss what the diameters are for the CNTs that he uses, it is simply not possible for a POSITA, Dr. Gido, or even Son himself, to determine what concentrations in percentage number of CNTs he has actually used. *Id.* In other words, it is impossible for *anyone* to determine the concentrations (in percentage numbers of nanotubes) used in Son, because Son does not provide enough information to do so. *Id.*

Recognizing this, Petitioner's expert hypothesizes three different methodologies of turning Son's weight ratios into number percentage of nanotubes,

but all three of the expert's methodologies are fundamentally flawed. *Id*. ¶95 (citing LGES-1003 ¶¶52-54, 55-57, 58-80). As he concedes, much larger CNTs are more heavily "counted" in weight percentages than they would be in number percentages. *Id*. (citing LGES-1003 ¶51; Pet., 10). Retroactively turning weight percentages into number percentages requires detailed knowledge of the lengths and diameters of the CNTs involved, and how those parameters change with the aspect ratio in the aspect ratio range. *Id.* The mass of a CNT is largely dependent on its specific diameter and length. *Id.* These are two parameters that can differ widely even between two nanotubes with identical aspect ratios. *Id.* Two nanotubes can have exactly the same aspect ratio (length/diameter), yet have ***vastly*** different masses, because of the difference in diameter. *Id.* Son gives no indication at all what diameters and lengths his nanotubes have; he only provides aspect ratios. *Id.*

Petitioner tries to sidestep this insurmountable problem in each of its expert's methods by *assuming* that the diameter of all of the CNTs in Son are ***the same***. *Id.* ¶96. Not only is this assumption unwarranted by anything from Son's disclosure itself, a POSITA would view such an occurrence as implausible. *Id.* Commercially available CNTs are available in sets that are specified to have a substantial range of diameters. *Id.* The average diameter is often provided by a commercial CNT source

for describing each of its CNT products, while some CNT sources provide a range of diameters for each of their CNT products. *Id.*

In practice, to create a set of CNTs that range in aspect ratios but have "identical diameters" would require measuring the diameter of individual CNTs within a CNT set that includes CNTs of various values of the aspect ratio, and then purposefully hand selecting individual CNTs with a single specific diameter for all the values of the aspect ratio in the entire aspect ratio range under consideration. *Id.* ¶97. Not only is it implausible that Son did this tedious work without ever mentioning it, but it is a task that is not feasible for any meaningful or useful number of CNTs. *Id.* A POSITA would thus understand the assumption that all the CNTs are of the same diameter is not reasonable. *Id.* A POSITA would further understand that, in reality, CNTs are produced in highly entangled bundles where the structure of the CNTs varies across a non-trivial range, including ranges of length and diameter dimensions. *Id.* This is precisely why the prior art describes CNTs using *ranges*—because it is simply not possible to obtain CNTs having the exact same length, diameter, or aspect ratio. *Id.*

The problem with Petitioner's assumption is only further exacerbated by the fact that Son gives no indication as to whether his CNTs are multiwall, single wall,

or a mix of both. *Id.* ¶98. This also makes Petitioner's assumption of a fixed CNT diameter unworkable, as further explained below. *Id.* Given the difficulty and impracticality of hand-selecting CNTs from a set based on individually measured diameters, a POSITA would understand Son to be using a mix of CNTs with differing numbers of walls (double-wall and triple-wall, for example), because Son intentionally uses CNTs with a very large range of the aspect ratio, from 10 all the way up to 10,000. *Id.* (citing LGES-1008 ¶[0009]).

To maintain the CNT diameter fixed for all values in a large range of aspect ratio, the length would have to differ for each of the different values of the aspect ratio, i.e., the length would have to be specifically chosen to provide a specific value of the aspect ratio. *Id.* ¶99. This would require the measurement of the diameter ***and*** length of each CNT in a set of CNTs, and hand-selecting of CNTs with the same diameter but different specific lengths that correspond to the different specific aspect ratios desired. *Id.* This task would be immensely time-consuming and is not feasible in reality, particularly since a CNT set necessarily involves a very large number of CNTs (for example., more than a billion CNTs). *Id.* If the CNT set is too small, by contrast, it would not be possible to obtain CNTs with different combinations of specific diameter and specific length, simply because there are not enough CNTs to

choose from. *Id.*

Furthermore, the importance of larger diameters (increased number of walls) increases through the aspect ratio range. The longer a CNT is, the more likely it is to have a defect (i.e., an imperfection), and more of them, along its length, and hence a higher tendency to break. *Id.* ¶100. This breakage is even more likely in the extrusion process (a mechanically intensive process) that Son teaches. *Id.* Since a POSITA knows that the connections among the CNTs in the CNT network are maintained through the extrusion process, and that a larger diameter makes a CNT more robust and less likely to break, a POSITA would conclude that larger diameters would be preferred for longer length CNTs. *Id.* (citing LGES-1008 ¶[0022]). Thus, A POSITA would see the aspect ratio ranging from 10-10,000 and would expect to see coupled changes in the CNT diameter and the CNT lengths, as the aspect ratio changes through this aspect ratio range. *Id.* ¶¶101-102.

The assumption that Son would use "nanotubes that are not vastly different from one another in terms of size/mass," is premised on a misreading of Son. *Id.* ¶103 (citing Pet., 21; LGES-1003 ¶53). According to Petitioner, "Son provides an explicit basis for this assumption by describing the existence of two types of aspect ratios: a 'number average' aspect ratio and a 'weight average' aspect ratio" and

"[c]ritically, Son notes that, regardless of whether a number-based or a weight-based ratio is used, the preferred aspect ratios are '130 to 1000 or 130 to 10,000' for nanotube A and "10 to 65" for nanotube B **under either domain**." *Id.* (citing Pet., 21; LGES-1003 ¶53 (emphasis in original and both citing LGES-1008 ¶[0029] as the only source of this statement)).

That assertion is unfounded when *the entirety* of the paragraph cited is considered:

> In another embodiment, the aspect ratio of carbon nanotube A may be 130 to 1000 or 130 to 10000, and the aspect ratio of carbon nanotube B may be 10 to 65. In another embodiment, the average aspect ratio of carbon nanotube A may be 130 to 1000 or 130 to 10000, and the average aspect ratio of carbon nanotube B may be 10 to 65. In the present invention, the average aspect ratio is a number average aspect ratio rather than a weight average.

Id. ¶104 (quoting LGES-1008 ¶[0029]).

This paragraph does two things. *Id.* ¶105. First, it states that, in one embodiment, the aspect ratio range for either A or B may be the range for all the nanotubes associated with either A or B. *Id.* For another embodiment, only the "average aspect ratio" of the nanotubes associated with each of A and B is described. *Id.* The second thing this paragraph does is to make certain that the reader knows that *for this invention* the average aspect ratio is a number average and not a weight

average. *Id.*

For the sake of calculation, the entire range of aspect ratio values may be divided into a finite number of aspect ratio classes, such that each class is represented by the average aspect ratio for the class. *Id.* ¶106. The number fraction for a particular class refers to the number of CNTs in the class divided by the total number of CNTs in the entire CNT set. *Id.* The weight fraction for a particular class refers to the weight of all the CNTs in the class divided by the total weight of CNTs in the entire CNT set. *Id.*

In the alternative embodiment Son describes as using the average aspect ratio, the "average aspect ratio" corresponds to the number average value rather than the weight average value. *Id.* ¶107. This means that the average aspect ratio is the weighted average, as obtained by summation over all the classes, such that the weighting factor in the averaging is the number fraction. *Id.* In contrast, the weight-average value of the average aspect ratio is the weighted average, as obtained by summation over all the classes, such that the weighting factor in the averaging is the weight fraction. *Id.*

In general, the number-average and weight-average values of the average aspect ratio differ, because the aspect ratio differs among the various classes. *Id.*

¶108. Petitioner's assumption that the number-average and weight-average values of the average aspect ratio are equal cannot be correct, unless the number fraction and weight fraction are equal. *Id.* But this equality requires that the various classes exhibit the same average aspect ratio. *Id.* It would be beyond fortuitous to have different combinations of length and diameter happen to result in the same aspect ratio (e.g., a length of 100 nm with a diameter of 2 nm and a length of 200 nm with a diameter of 4 nm, such that both have an aspect ratio of 50). Thus, requiring the same aspect ratio effectively means requiring the same length and the same diameter. *Id.* As explained above, however, it is practically infeasible for the requirement of the same length and the same diameter for all the classes to be satisfied. *Id.* In fact, having no variation in the average aspect ratio among all the classes is incompatible with the occurrence of a distribution of aspect ratio values. *Id.*

In spite of this, Petitioner *has* to make the abovementioned unsupportable assumption for any of its calculation methodologies to apply, because Son fails to provide any value for the diameter or length of its CNTs. *Id.* ¶109. To support that incorrect assumption, the Petition alleges in conclusory fashion that the nanotubes "are not vastly different from one another in terms of size/mass," Pet., 21 (citing LGES 1003 ¶53); MRD-2004 ¶109. In other words, all of the nanotubes are about

the same in diameter and length, and hence about the same in the aspect ratio. *Id*. This cannot be true, however, as the entire point of Son is to have a *distribution* of aspect ratios. *Id.*

Petitioner also makes the underlying assumption of a 1:1 conversion between weight fraction (equivalently weight ratio) and number fraction (equivalently number ratio). *Id*. ¶110 (citing Pet., 20-22). However, this would necessarily mean there is a 1:1 conversion between weight-average aspect ratio and number-average aspect ratio.*Id*. As shown above, however, this assumption simply cannot be supported and Petitioner's first methodology thus necessarily fails. *Id.*

The Petition's second method demands "an essentially constant average tube diameter among the nanotubes." *Id.* ¶111 (citing Pet., 23). But again, this assumption is unwarranted, as it is practically infeasible to obtain a CNT set in which all the CNTs have essentially the same diameter. *Id.* Therefore, the second method fails. *Id*.

The Petition's third method again relies on "assum[ing] that the distribution of carbon nanotube diameters is similar across the range of aspect ratios." *Id.* ¶112 (citing Pet., 26). It further states that "[o]ne way to characterize this carbon nanotube diameter distribution is by its average <d>." *Id.* (quoting LGES-1003 ¶63). It is practically infeasible to obtain a CNT set in which the CNTs in all the classes have

similar values of the average diameter. *Id.* It is also practically infeasible to obtain a CNT set in which the CNTs in all the classes have similar diameter distributions. *Id.* Because this assumption is unsupportable and unwarranted, the Petition's third method also fails. *Id.*

Concentrations of CNT's can be expressed in terms of either a weight fraction or a number fraction. *Id.* ¶113. Without specific, detailed information that Son does not provide, it is not possible to convert Son's weight fraction to number fraction for any of the classes. *Id.* While Petitioner could have attempted to rely on additional prior art that *actually* discloses what is required by this claim language, Petitioner instead chose to rely on scientifically implausible assumptions, resulting in weight calculations that are completely inaccurate. Petitioner thus fails to carry its burden of demonstrating by a preponderance of the evidence that this limitation is satisfied.

F. The Combination of Bosnyak-392 and Son Do Not Render the Claimed Aspect Ratio Sub-Ranges Obvious

All claims of the '282 Patent require that 1% to 30% of the discrete carbon nanotubes have aspect ratios between 80-140. LGES-1001, claims 1-16; MRD-2004 ¶115. To meet this limitation, the Petition relies solely on Son disclosing a "second nanotube group ('carbon nanotube A') has an aspect ratio between 130 to 1000." Pet., 17-18; MRD-2004 ¶115. The Petition truncates this quote, as Son discloses "the

aspect ratio a may be 130 to 1000 ***or 130 to 10000***." LGES-1008 ¶[0028]; MRD-2004 ¶115.

But Petitioner cannot rely on Son's incredibly broad aspect ratio range to render the '282 Patent claims as obvious. The actual range of aspect ratios disclosed by Son are enormous. If the claimed range is narrow (in the claims of the '282 Patent to 80-140) and the prior art range is overlapping and broad (here about 130 to ***10,000***), such broad range is insufficient to show *prima facie* obviousness, if the *structure* associated with the broad range is different from the *structure* of associated with the narrower range. *See Genetics Inst., LLC v. Novartis Vaccines & Diagnostics, Inc.,* 655 F. 3d 1291, 1304-07 (Fed. Cir. 2011). "Our case law is clear that the structure of a claimed compound and its properties are inseparable for purposes of § 103." *Id.* at 1307 (citing *Sanofi-Synthelabo v. Apotex, Inc*., 550 F.3d 1075, 1086 (Fed. Cir. 2008) ("For chemical compounds, the structure of the compound and its properties are inseparable considerations in the obviousness determination.")).

A broad range is insufficient to show obviousness, because such a broad range does not provide an ordinary motivation to optimize the broad range. *Id.* at 1306-07 (holding that ordinary motivation to optimize did not apply where disclosure was

68,000 truncated protein variants, comprising 2,332 amino acids, which were structural differences); *contra In re Peterson*, 315 F.3d 1325, 1330 n.1 (Fed. Cir. 2003) ("Although ranges that are not especially broad invite routine experimentation to discover optimum values, rather than require nonobvious invention, we do not have here any assertion that the disclosed range is so broad as to encompass a very large number of possible distinct compositions.").

In *Genetics*, the Federal Circuit found that proteins in the claimed patent versus the prior art patent, differed *structurally* in terms of the size of the permitted amino acid deletions, the location of the permitted amino acid deletions, and the degree of allowable amino acid substitutions. *Genetics*, 655 F.3d at 1306. Because of such *structural* differences, and considering that the prior art patent disclosed a broad range of 68,000 protein variants comprising 2,332 amino acids, there was no motivation for a POSITA to be invited to perform routine experimentation to discover an optimum range. *Id.* In affirming the district court, the Federal Circuit found that where the disclosed range was so broad as to encompass a very large number of possible distinct compositions a showing of obviousness was not made. *Id.* at 1306-07.

Here, at a minimum, Son discloses 9,870 values of the aspect ratio (10,000 -

130 = 9,870) with the highest end being 10,000 for the upper sub-range, compared with the claims' 60 values of the aspect ratios (140-80 = 60) with the highest end at 140—***a key structural difference***—so Son teaches 9,810 (9,870 – 60 = 9,810) more potential values of the aspect ratio for the sub-range than the claims. MRD-2004 ¶116. Additionally, the largest aspect ratio in Son is potentially 125x larger than the aspect ratio in the claimed invention (10,000 / 80 = 125). *Id.* The ***9,810 more potential values of the aspect ratio*** and the aspect ratio being up to potentially ***125 times larger*** are significant and create numerous differences in the ***structure and behavior*** of the oxidized CNTs of Son versus the oxidized CNTs in the claimed invention. *Id.*

In general, a POSITA would understand that at a single given CNT diameter, having a larger aspect ratio CNT (e.g., 10,000) versus a smaller aspect ratio CNT (e.g., 140), is not only a key structural difference in the CNTs, but can lead to the following effects on the structure and behavior of the CNTs: (1) increase in the number of bends, including increase in the likelihood of bending; (2) increase in the number of entanglements; (3) increase in the number of CNT-CNT contact points; (4) increase in the likelihood of achieving a percolated network (i.e., a continuous conductive path due to the CNT-CNT contact points); (5) increase in electrical

conductivity; (6) decrease in dispersibility, reducing the likelihood of achieving discrete or uniformly dispersed CNTs; and (7) increase in the number of CNT defects. *Id.* ¶117. If the diameters and the lengths of the CNTs vary unknowably throughout the range of aspect ratios, as they almost certainly do in Son, the differences resulting from disparate lengths remain, such that they are scattered unpredictably across the entire range, making it even more difficult to account for their effects. *Id.*

But even if we take the nearly impossible case described by Petitioner and assume the CNTs have the same diameter, a comparison of a composition that comprises CNTs with an aspect ratio of 10,000 as in Son with a composition that comprises CNTs with an aspect ratio of 140 as in the claimed invention , will show the 10,000 aspect ratio CNT composition in Son has an ***increase*** in: the number of bends, likelihood of bending, number of entanglements, likelihood of entangling, number of CNT-CNT contact points, likelihood of having CNT-CNT contact points, likelihood of reaching percolation, electrical conductivity of the CNT network due to the increase in percolation, number of defects, and likelihood of having defects. *Id.* ¶118.

In addition, the CNTs in the 10,000 aspect ratio composition of Son versus the

CNTs in the 140 aspect ratio composition in the claimed invention, means the CNTs in the 10,000 aspect ratio composition of Son have a ***decrease*** in dispersibility, reducing the likelihood of having discrete CNTs or uniformly dispersed CNTs—due to the increase in the number of entanglements of the CNTs, which causes the formation of agglomerates of CNTs. *Id.* ¶119.

And again, as is almost certainly true in Son—when the diameters and lengths vary unpredictably across the aspect ratio range—there will be unpredictable increases and decreases in the structural parameters and behavior throughout the range. *Id.* ¶120.

Further, the CNTs in the 10,000 aspect ratio composition of Son have a ***higher*** chance of being in contact with adjacent CNTs, making the composition have a higher electrical conductivity compared to the claimed composition comprising the 140 aspect. *Id.* ¶121. This increase in electrical conductivity is due to the greater number of CNT-CNT contact points, which increases the likelihood of percolation in the CNT network. *Id.*

Finally, again taking the Petition's unsupportable assumption and assuming that the CNTs have the same diameter, in the 10,000 aspect ratio composition of Son compared to the 140 aspect ratio composition of the claimed invention, the 10,000

aspect ratio composition of Son has a longer length of CNTs compared to the length of the CNTs in the 140 aspect ratio composition. *Id.* ¶122. A CNT that has a longer length, as in Son, would tend to have an increase in the number of defects and also a higher likelihood of having at least one defect along its length compared to a CNT that has a shorter length as in the claimed invention. *Id.*

Once again, that's just for the simplified case of uniform diameter. If the diameter varies unpredictably through the range, disparate lengths will be unpredictably dispersed across the range, thereby making the determination of what's "optimal" even more difficult. *Id.* ¶123.

As in *Genetics*, due to the numerous and significant differences in the structure and behavior of a 10,000 aspect ratio CNT composition (e.g., Son) compared to a 140 aspect ratio CNT composition (e.g., claimed invention), there is no motivation for a POSITA to try to optimize to find a narrower aspect ratio within Son's massively disclosed range. MRD-2004 ¶124. Due to the numerous and significant differences in the structure and behavior of a 10,000 aspect ratio CNT composition (e.g., Son) compared to a 140 aspect ratio CNT composition (e.g., claimed invention), a POSITA would understand that it would take extensive experiment to find a potentially narrower aspect ratio range within Son's huge disclosed range. *Id.*

Son's teaching of 9,810 more values of the aspect ratio and a potentially 125x larger aspect ratio, when compared to the claimed values of the aspect ratio, means there are a very large number of possible distinct compositions comprising CNTs with various aspect ratios—similar to the broad range that *Genetics* found could not support *prima facie* obviousness. *Id*. Indeed, the numerous differences in structure and behavior of CNTs at these widely different aspect ratios are not trivial and directly affect the resulting structure and behavior of the CNTs. *Id*.

Indeed, just as in *Genetics*, the numerous differences in structure and behavior of CNTs at these widely different aspect ratios are "nontrivial differences" that directly affect the resulting structure and behavior of the CNTs. *Genetics*, 655 F.3d at 1306 ("On the facts of this case, the nontrivial differences in the proteins at issue compel the requirement of identifying a reason for the chemical modification."). Accordingly, Petitioner fails to demonstrate that Son renders the claimed range of values for the aspect ratio obvious, based on Son's remarkably broad range of 130 to 10,000. Indeed, Son cannot deprive the inventors of their invention by blindly disclosing an excessively broad and unhelpful aspect ratio range.

VI. <u>Grounds 2A-2B</u>: The Combinations Based on Bosnyak-129 and Albuerne Do Not Render Any Claim Obvious

Petitioner attempts to combine Bosnyak-129 with Albuerne, a scientific paper

describing an improved method of polymerizing MWCNTs. MRD-2004 ¶125 (citing Pet., 48). Because Bosnyak-129 does not teach any aspect of a bimodal distribution of aspect ratios, Petitioner argues that a POSITA would have been motivated to use the "interchangeable" acid solution discussed in Albuerne to achieve the benefit of improved preservation of the carbon nanotubes' structures and lengths." *Id.* (quoting Pet., 48). But this is a thinly veiled strawman. Petitioner relies on Albuerne almost exclusively, not for its acid treatment, but for a "bimodal aspect ratio distribution." Petitioner frames its motivation as being premised on "acid treatment" and avoids discussing "bimodal aspect ratio distribution" because Albuerne very clearly does *not* disclose the claimed bimodal distribution. *Id.* (citing Pet., 46, 48-49, 56-58).

In only one portion of one graph (i.e., FIGURE 5(b)), Albuerne displays an aspect ratio distribution that, if one persists on making unwarranted assumptions about what it actually shows, can be mischaracterized as evidencing a bi-modal aspect ratio distribution that *just so happens* to meet the limitations of the claims. *Id.* ¶126 (citing LGES-1009, 6). But that graph does not actually show a bimodal aspect ratio distribution at all. *Id.* Nor is it intended by Albuerne to suggest or imply that one was generated. *Id.* No reasonable POSITA would believe it teaches creating one. *Id.* But even if a POSITA did, he or she would immediately recognize that those

findings are in no way repeatable. *Id.*

In short, Albuerne does not teach a bi-modal aspect ratio distribution. *Id.* ¶127. A POSITA would have no motivation to look to Albuerne for the teaching of one. *Id.* And, even if a POSITA was illogically motivated to do so, there would be no expectation of success in generating the bi-modal distribution of the claims. *Id.*

A. A POSITA Would Have No Motivation to Combine Albuerne With Bosnyak-129 for the Purpose of Generating a Bimodal Aspect Ratio Distribution

Bosnyak-129 is another PCT application publication authored by the inventors of the '282 Patent. LGES-1006. Its teachings are similar to Bosnyak-392 but include more detail on the specific aspect ratios and weight percentages of the CNTs the methodology produces. MRD-2004 ¶128 (citing LGES-1006).

Albuerne discusses a particular methodology for "grafting from" or polymerization from the CNTs after some pre-functionalization. *Id.* ¶129 (citing LGES-1009, Introduction, 1-2). Albuerne does not purport to use a bimodal distribution of CNT aspect ratios. *Id.* Nor does Albuerne allege to have created a bimodal distribution of aspect ratios or discuss any benefits of a bimodal distribution of aspect ratios. *Id.* A POSITA seeking information on bimodal distribution of the CNT aspect ratios would have no reason to look to Albuerne for anything. *Id.*

The preliminary functionalization of the CNTs is presented as:

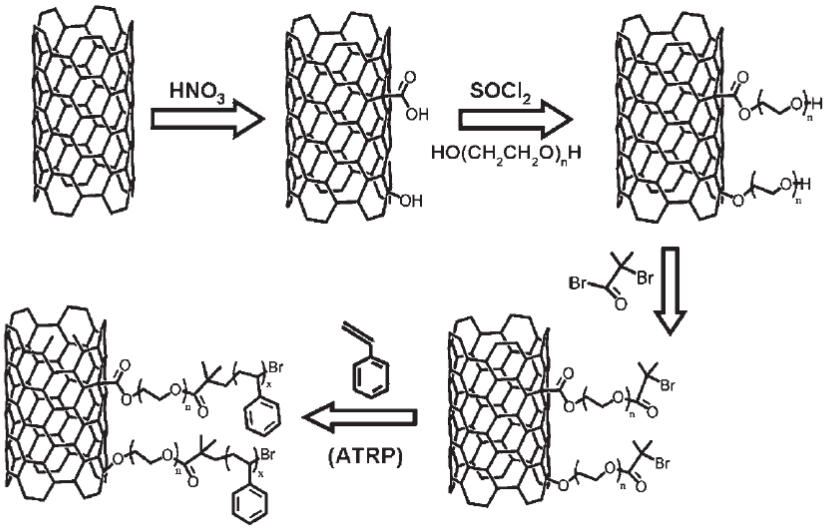


FIGURE 1 Schematic representation of the surface modification reactions carried out on MWCNTs.

Id. ¶130 (citing LGES-1009, 4, FIGURE 1). After going through the pre-functionalization as an intermediate step, and then taking the functionalized CNTs through its polymerization steps, Albuerne found the following:

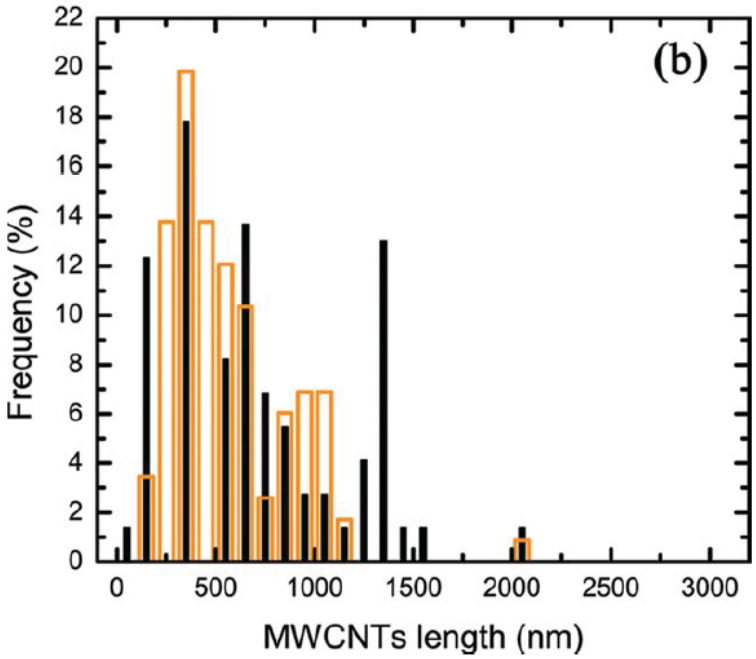


FIGURE 5 Carbon nanotube length distribution (nm) of (a) pristine MWCNTs and (b) oxidized MWCNTs, calculated from SFM phase images. Filled bars (black) correspond to $MWCNT_{BMS}$[95] and contour bars (orange) correspond to $MWCNT_{FC}$[99].

LGES-1009, FIG. 5(b)

Id. (citing LGES-1009, 6, Fig. 5(b)). Importantly, Albuerne makes no mention of this as a bimodal distribution of MWCNT lengths, does not state that it created a bimodal distribution of MWCNT lengths, does not state that these MWCNT lengths are a repeatable outcome of this technique, and makes no statement that a bimodal distribution of MWCNT length would be beneficial. *Id.* Simply put, Albuerne says absolutely nothing about bimodal distribution.

Despite this, Petitioner relies entirely on the histogram in Fig. 5(b) as not only

teaching the exact "bimodal" distribution of CNTs required by the claims, but also supporting that a POSITA would have been motivated to combine bimodal CNTs with Bosnnyak-129. *Id.* ¶131 (citing Pet., 59). This is hyper-technical nonsense. A POSITA reading Albuerne would interpret the ***less than 1%*** occurrence of CNTs at a length of 2000 nm as a "blip" attributable to data scatter resulting from the fact that Albuerne only took the length measurement of approximately 100 CNTs. *Id.* (citing LGES-1009, 6).

The experimental process of Albuerne starts with 1 g of MWCNTs that have lengths between 10 µm and 50 µm. *Id.* ¶132 (citing LGES-1009, 2). That amount of MWCNTs, at Albuerne's reported dimensions for the $MWCNT_{FC}$s used, would contain over 100,000,000,000,000 individual nanotubes. *Id.* Those nanotubes are dispersed in 40 ml of liquid, oxidized, and then dried. *Id.* (citing LGES-1009, 2). The resulting dried MWCNTs are then put through an esterification process and then functionalized with initiator groups suitable for grafting styrene. *Id.* A series of processes that see the MWCNTs dried and re-suspended in liquids multiple times, filtered and washed multiple times, and ending again in a dried state. *Id.* (citing LGES-1009, 2-3). For the $MWCNT_{FC}$, Albuerne prepared 7 samples. *Id.* (citing LGES-1009, 3, Table 1). Each dried sample was redispersed in an unknown volume

of liquid, sonicated for 1 minute, and then a single drop (5 μL) of that liquid was placed on a silicon wafer. *Id.*

The histogram (FIGURE 5(b)) the Petition focuses on is the result of measuring approximately 100 MWCNTs (i.e., 100 nanotubes ***out of the initial 100,000,000,000,000 nanotubes***). *Id.* ¶133 (citing LGES-1009, 6). The distribution of lengths shown in FIGURE 5(b) is not meant as, nor would any POSITA believe it to be, an accurate measure of the *actual length distribution* in any specific composition generated by Albuerne's process. *Id.* Moreover, Albuerne does not ever claim it to be or use it as such. *Id.* (citing LGES-1009, 6). As stated by Albuerne, "***the error*** on the measurements increases for the oxidized carbon nanotubes." *Id.* XX (quoting LGES-1009, 6). The *only* conclusions that Albuerne draws from Figure 5 are: (1) the two MWCNT sources appear to supply nanotubes (when pristine) of similar lengths; and (2) "[a]fter the acid treatment, the population of carbon nanotubes with shorter lengths decreases." *Id.* (quoting LGES-1009, 6).

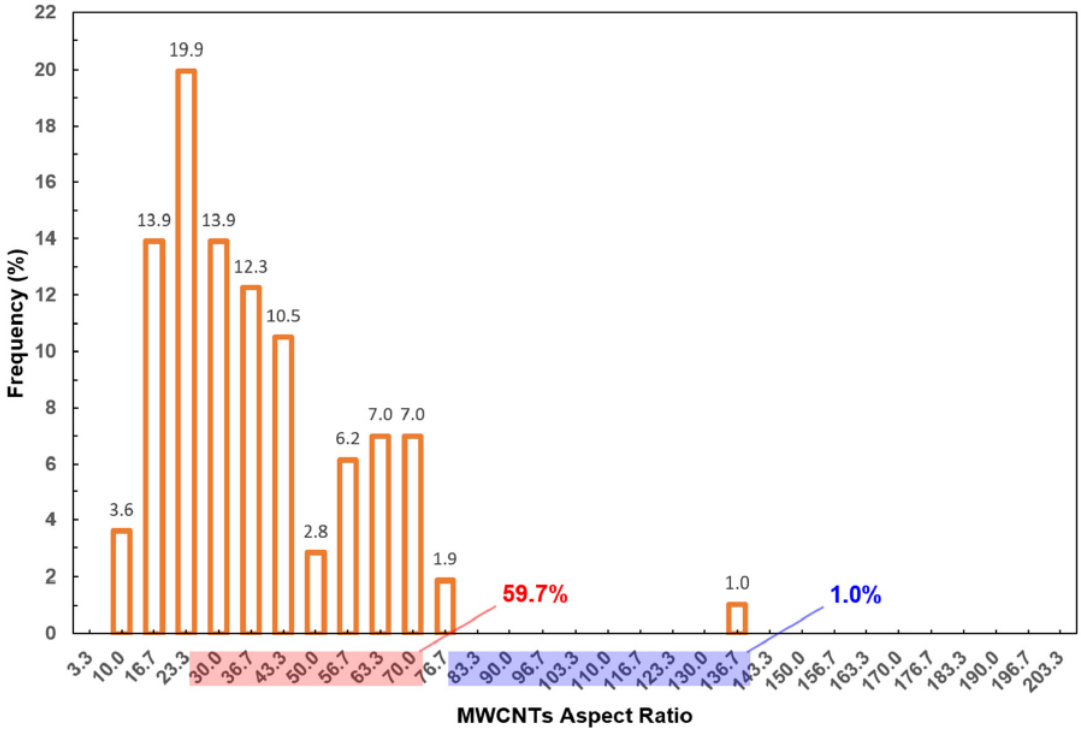
Given these facts, a POSITA would have no reason to consider Albuerne for providing a bimodal mechanism to Bosnyak's aspect ratio ranges—a POSITA would never see Albuerne as teaching a bimodal anything, as the 1% indication of 2,000 nm length CNTs is statistically insignificant. *Id.* ¶134. Indeed, if anything a POSITA

would instead understand the less than 1% indication to be a statistics-related error. *Id.*

B. The Combination of Bosnyak and Albuerne Fails to Disclose the Aspect Ratio Distribution and Concentrations Required By the Claims

Petitioner's sole argument for a bimodal distribution existing in the combination of Bosnyak-129 and Albuerne is the Petitioner's interpretation of the "blip" of Albuerne's Figure 5(b) data as an actual confirmed result. Pet., 59-61; MRD-2004 ¶135. Further, the Petition alleges that this data blip "teaches the specific percentages of the aspect ratio ranges claimed in limitations." Pet., 63; MRD-2004 ¶135. This is simply not a reasonable interpretation of Albuerne. *Id*.

Since Albuerne itself makes no use of the statistically insignificant data point, the Petition is forced to generate its own graph interpreting its meaning. *Id.* ¶136 (citing Pet., 63). Conveniently leaving out any results that would not fit its narrative, the Petition cherry-picks the $MWCNT_{FC}$ results and asserts that Albuerne's distribution teaches the following aspect ratio results:



LGES-1009, Figures 5(b) (replotted as a function of aspect ratio);

Id. (citing Pet., 61, 63).

As argued above, there is no evidence that the single data point that Petitioner latches onto exists as anything more than data scatter (or error) resulting from the small number of CNTs in the set of CNTs subjected to the length measurement. *Id.* ¶137. Indeed, a POSITA would understand that the outlier aspect ratio measurement of 136.7 is likely the result of a measurement or statistical error. *Id.* And even if it was not, a POSITA would not reasonably rely on the lengths taken from a sample of approximately 100 CNTs (taken from a drop of CNT dispersion) out of ***many***

trillions of CNTs from the original composition to be accurately representative of the concentration of those outlier CNTs in the overall composition. *Id.*

Petitioner is essentially trying to "will" the graph into teaching details that no POSITA would believe could be garnered from it. *Id.* ¶138. A POSITA understands that actual CNT length distributions in a sample cannot be exactly determined without measuring the length of every CNT in the drop mentioned above, something not feasible with CNTs numbering in the billions. *Id.* To estimate them, researchers' actual measurements are "compiled to generate a histogram representing the sample's length distribution," such as Streit et al. did for their measured CNT lengths when comparing different CNT length measuring methodologies, depicted in their Figure 2:

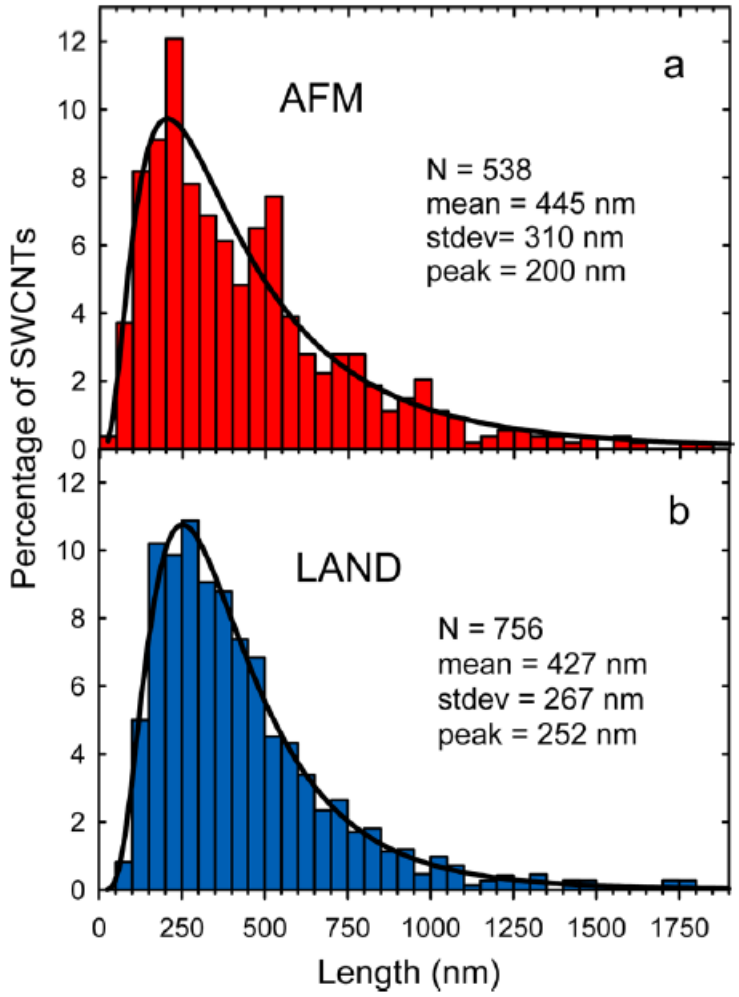


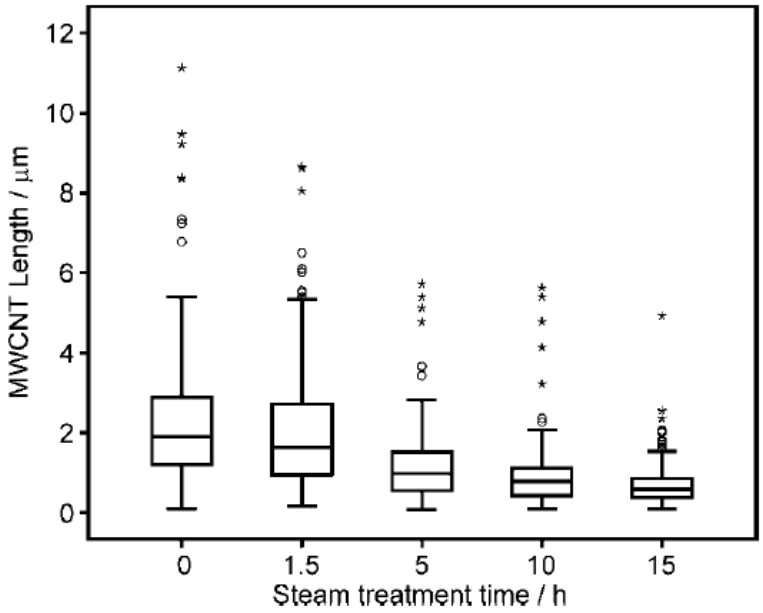
Figure 2. Comparison of length histograms found by (a) AFM and (b) LAND analyses of the same (6,5)-enriched SWCNT sample. Solid curves are log-normal fits (r^2 = 0.936 for AFM and 0.988 for LAND) used to estimate the peak values listed in the frame. The other statistical parameters were computed from the histogram data rather than from the fits.

MRD-2006, FIG. 2

Id. ¶138 (citing MRD-2006 ("Streit"), 4, FIG. 2.). To estimate actual percentages for any given length (such as estimating the peak percentage value), solid curves (such

as the log-normal fits used above) are applied. *Id.* ¶139 (citing MRD-2006, 4). A POSITA would, among other things, look to the sample sizes of the measurements (538 and 756 respectively for the two samples compared in Streit) and the data's fit to the approximation curve to understand what meaning could be concluded from the data. *Id.*

In addition, researchers may depict their measured data using box plots, such as what Cabana et al. did in comparing the effect of steam treatment duration on the distribution of CNT lengths for their Figure 6, which uses a box to delineate the statistically meaningful data points from data points that are less meaningful:

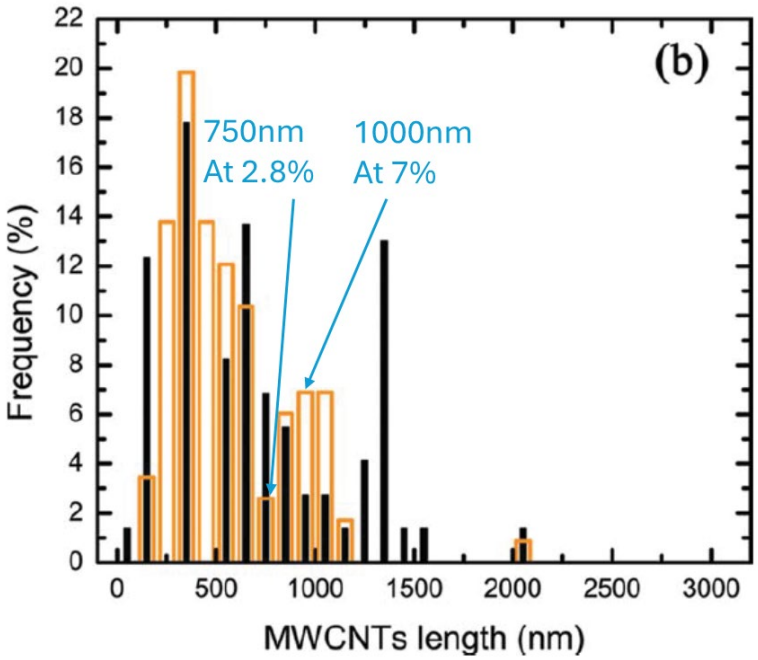


MRD-2007, FIG. 6

Id. ¶140 (citing MRD-2007, ("Cabana"), 19, Fig. 6). A POSITA understands that the box plot provides additional information useful for interpreting the meaning (or statistical insignificance) of any individual measurement as well as identifying outliers and far outliers (circles and asterisks in the above). *Id.* (citing MRD-2007, 19).

A POSITA would understand that the graph of Albuerne Figure 5(b) cannot be used to say that any of the compositions (from which a single drop was extracted and from each drop only around 100 CNTs were measured) has exactly 1% of its nanotubes at roughly 2000 nm length. *Id.* ¶141. A POSITA would see that the histogram is generated from a miniscule sample size (only approximately 100 CNTs), and that no attempt was made to fit a statistical curve to the obtained histogram data or to distinguish between data points that are statistically meaningful from those that are not statistically meaningful. *Id.* In addition, a POSITA would see that no box plot (or any other method) has been used to understand the statistical significance of any outlier. *Id.* From this a POSITA would understand that there is virtually no way to draw meaningful and quantitative conclusions for the concentrations of CNTs at any single length. *Id.* Indeed, concluding that Albuerne's histogram teaches that 1% of the CNTs have a 2000 nm length is as erroneous as

concluding (illustrated below) that Albuerne teaches that CNTs of 1000 nm occur more than twice as often as CNTs of 750 nm. *Id.*



LGES-1009, FIGURE 5(b) (annotated by Patent Owner).

But that is precisely the conclusion the Petition alleges a POSITA would have reached. Pet., 61-62.

This is far from the truth. A POSITA would look at FIGURE 5(b) of Albuerne and see a miniscule sample size, large counter-intuitive jumps between lengths measured rather than a smooth distribution curve, and no attempt to produce a box plot with consideration of sampling error, and see it for what it is—i.e., data that can at best be used (as Albuerne does) for inferring that "[t]he carbon nanotube length

distribution is slightly shifted to higher values after the acid treatment." *Id.* ¶142 (quoting LGES-1009, 6). A POSITA would not rely on an outlier result that has all the hallmarks of a statistical data error to determine what the length distribution actually is and certainly cannot be used to compare any single specific length to any other. *Id.*

Ultimately, the only "evidence" of bi-modal CNTs in Albuerne is the Petitioner's unreasonable reliance on the less than 1% result in the histogram of FIGURE 5(b), which no POSITA would reasonably believe to be indicative of bimodal distribution within the claimed range (and certainly not the claimed concentrations). Indeed, the fact that Petitioner has to go through the effort of creating its own graph re-characterizing the histogram in FIGURE 5 of Albuerne and then dedicates pages of explanation justifying its characterization, only further evinces that no reasonable POSITA would glean the claimed bi-modal distribution ranges from Albuerne.

In any event, even giving Petitioner the benefit of the doubt, whether the histogram shows what Petitioner alleges is at best a 50-50 proposition, which does not satisfy the greater than 50% "preponderance of the evidence" standard. Consequently, it cannot be said to be teaching the precise bimodal range and

concentrations required by the claims.

C. There is No Reasonable Expectation of Success for This Combination

An obviousness determination requires finding that a person of ordinary skill in the art would have had a reasonable expectation of success. *Regents of the Univ. of Cal. v. Broad Inst., Inc.,* 903 F.3d 1286, 1291 (Fed. Cir. 2018). Reasonable expectation of success refers to the likelihood of success in combining references to meet the limitations of the claimed invention. *Intelligent Bio-Systems, Inc. v. Illumina Cambridge, Ltd.*, 821 F.3d 1359, 1367 (Fed. Cir. 2016).

As explained above, a POSITA would have no confidence that the 2,000 nm length data point is a data point that is actually representative of the concentration of 2,000 nm long CNTs in Albuerne's sets of CNTs. MRD-2004 ¶XX. And even if a POSITA did mistakenly believe that the 2,000 nm long MWCNT concentration from that graph was an accurate measurement of Albuerne's resulting samples, there would be no reason to believe that this very specific aspect ratio distribution was in any way *repeatable*. *Id.*

Albuerne was not trying to create a bimodal distribution of lengths, and even if the "blip" is an actual bimodal result, Albuerne merely notes that "just the carbon nanotubes dispersed on the silicon wafers were taken into account for the

measurements" and "[l]onger carbon nanotubes are probably present on the samples included inside the aggregates." *Id.* ¶145 (quoting LGES-1009, 6). Further, the specific length of 2,000 nm is potentially the result of the ultrasonic treatment inducing cleavage of the carbon nanotubes at the random length of 2,000 nm. *Id.* "The error on the measurements increases for the oxidized carbon nanotubes." *Id.* ¶45 (quoting LGES-1009, 6). In other words, even if the data of FIGURE 5(b) did result in a bimodal distribution of lengths, it is likely the result of uncontrolled factors associated with the processing and/or testing procedures that caused those lengths to be present among the approximately 100 CNTs the study happened to measure. *Id.* This is not replicable even once without extraordinary luck. *Id.*

VII. Conclusion

For the reasons above, the Petition fails to demonstrate beyond a preponderance of the evidence that any Challenged Claim is unpatentable.

Dated: March 31, 2025

Respectfully submitted,

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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 11,551 words as calculated by the program used in creating it.

/James A. Glenn/
James A. Glenn

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6(e)(4), the undersigned certifies that on March 31, 2025, a copy of the foregoing document (*Patent Owner's Response*, including all Exhibits), was served via electronic mail on all attorneys of record at the email addresses provided for electronic service listed in Petitioner's mandatory notices, as set forth below:

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