

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Clive P. Bosnyak, et al.
U.S. Patent No.: 10,608,282 Attorney Docket No. 18768-0210IP8
Issue Date: Mar. 31, 2020
Appl. Serial No.: 15/881,071
Filing Date: Jan. 26, 2018
Title: BINDERS, ELECTROLYTES AND SEPARATOR FILMS FOR
ENERGY STORAGE AND COLLECTION DEVICES USING
DISCRETE CARBON NANOTUBES

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**PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT
NO. 10,608,282 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42**

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	REQUIREMENTS FOR IPR	1
	A. Grounds for Standing.....	1
	B. Challenge and Relief Requested.....	1
	C. Priority Date.....	2
III.	SUMMARY OF THE '282 PATENT	5
	A. Brief Description.....	5
	B. Prosecution History.....	6
	C. Level of Ordinary Skill in the Art.....	7
	D. Claim Construction	7
IV.	THE CHALLENGED CLAIMS ARE UNPATENTABLE.....	8
	A. [GROUND 1A] – CLAIMS 1-16 ARE OBVIOUS OVER BOSNYAK-392 AND SON.....	8
	1. Overview of Bosnyak-392	8
	2. Overview of Son.....	9
	3. Combination of Bosnyak-392 and Son	11
	4. Analysis	13
	B. [GROUND 1B] – CLAIM 4 IS OBVIOUS OVER BOSNYAK-392, SON, AND SO.....	40
	C. [GROUND 1C] – CLAIM 11 IS OBVIOUS OVER BOSNYAK-392, SON, AND GU	42
	D. [GROUND 2A] – CLAIMS 1, 5-9, AND 12-16 ARE OBVIOUS OVER BOSNYAK-129 IN VIEW OF ALBUERNE	43
	1. Overview of Bosnyak-129	43
	2. Overview of Albuerne.....	46
	3. Combination of Bosnyak-129 and Albuerne.....	48
	4. Analysis	50
	E. [GROUND 2B] – CLAIMS 2-4 AND 10-11 ARE OBVIOUS OVER BOSNYAK-129 IN VIEW OF ALBUERNE AND GU	67
	1. Overview of Gu	67
	2. Combination of Bosnyak-129, Albuerne, and Gu.....	67
	3. Analysis	68
V.	PTAB DISCRETION SHOULD NOT PRECLUDE INSTITUTION.....	73
	A. The <i>Fintiv</i> Factors Favor Institution—§314(a)	73

B.	The <i>Advanced Bionics</i> Test Favors Institution—§ 325(d)	74
1.	Grounds and Obviousness Rationale Advanced in This Petition Were Not Previously Considered by the Office.....	76
2.	The Office Erred in Granting the '282 Patent.....	77
VI.	PAYMENT OF FEES – 37 C.F.R. § 42.103	78
VII.	CONCLUSION.....	78
VIII.	MANDATORY NOTICES UNDER 37 C.F.R § 42.8(a)(1).....	78
A.	Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1).....	78
B.	Related Matters Under 37 C.F.R. § 42.8(b)(2)	78
C.	Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3).....	79
D.	Service Information	79

EXHIBITS

LGES-1001	U.S. Patent No. 10,608,282 to Bosnyak, et al. (“the ’282 Patent”)
LGES-1002	Excerpts from the Prosecution History of the ’282 Patent (“the Prosecution History”)
LGES-1003	Declaration of Dr. Sam Gido
LGES-1004	Curriculum Vitae of Dr. Sam Gido
LGES-1005	PCT Publication WO 2010/117392 (“Bosnyak-392”)
LGES-1006	PCT Publication WO 2011/163129 (“Bosnyak-129”)
LGES-1007	Korean Patent Publication KR 10-2010-0086854
LGES-1008	Certified English Translation of KR 10-2010-0086854 (“Son”)
LGES-1009	“Modification of Multiwall Carbon Nanotubes by <i>Grafting from</i> Controlled Polymerization of Styrene: Effect of the Characteristics of the Nanotubes,” J. Albuerne, et al., <i>Journal of Polymer Science Part B: Polymer Physics</i> , 48(2020), 1035-1046 (“Albuerne”)
LGES-1010	U.S. Patent Publication No. 2012/0052363 (“Fleischer”)
LGES-1011	“Cap removal and shortening of double-walled and very-thin multi-walled carbon nanotubes under mild oxidative conditions,” R. Marega, et al., <i>Carbon</i> , 47(2009), 675-682 (“Marega”)
LGES-1012	U.S. Patent Publication No. 2008/0192407 (“Lu”)
LGES-1013	Japanese Patent Publication JP 2005-262391
LGES-1014	Certified English Translation of JP 2005-262391 (“So”)
LGES-1015	U.S. Patent No. 9,896,341 to Noyes (“Noyes”)
LGES-1016	“Layered and interfacially blended polyelectrolyte multi-walled carbon nanotube composites for enhanced ionic conductivity,” X. Gu et al., <i>Thin Film Solids</i> , Vol. 520, Issue 6, (January

2012), pp. 1872-1879 (“Gu”)

LGES-1017	PCT Publication WO 2013/192513
LGES-1018	U.S. Provisional Application No. 61/662,393
LGES-1019	U.S. Provisional Application No. 61/663,513
LGES-1020	Declaration of June Munford (Albuerne)
LGES-1021	RESERVED
LGES-1022	“The effect of carbon nanotube aspect ratio and loading on the elastic modulus of electrospun poly(vinyl alcohol)-carbon nanotube hybrid fibers,” K. K. H. Wong et al., <i>Carbon</i> 47 (2009) 2571-2578 (“Wong”)
LGES-1023	“Dispersion State and Damage of Carbon Nanotubes and Carbon Nanofibers by Ultrasonic Dispersion: A Review,” H. Rennhofer et al., <i>Nanomaterials</i> 2021, 11, 1469 (“Rennhofer”)
LGES-1024	“Nanocomposites from styrene-butadiene rubber (SBR) and multiwall carbon nanotubes (MWCNT) part 1: Morphology and rheology,” S.K. Pedini et al., <i>Polymer</i> 55 (2014) 258-270 (“Peddini”)
LGES-1025	File History of European Patent No. 2,865,031 (EP counterpart to the ’282 Patent)
LGES-1026	U.S. Patent Application Publication US2009/0242850 (“Park”)
LGES-1027	<i>Molecular Rebar Design, LLC, and Black Diamond Structures, LLC v. LG Energy Solution, Ltd.</i> , Plaintiffs’ Disclosure of Asserted Claims and Infringement, 2:24-cv-00107-JRG
LGES-1028	<i>Molecular Rebar Design, LLC, et al. v. LG Energy Solution, Ltd.</i> , Sample Docket Control Order, 2:24-cv-00107-JRG

CLAIM LISTING

Limitation	Claim Language
[1pre]	A composition for use as a binder material, an electrolyte material or a separator film material of an energy storage or collection device, comprising:
[1a-i]	a plurality of discrete carbon nanotube fibers,
[1a-ii]	said fibers having an aspect ratio of from about 10 to about 500, and
[1a-iii]	wherein at least a portion of the discrete carbon nanotube fibers are open ended and
[1b]	wherein 40% to 90% by number of the discrete carbon nanotubes have an aspect ratio of 30-70 and wherein from 1% to 30% by number of discrete carbon nanotubes have an average aspect ratio 80-140.
[2]	The composition of claim 1, wherein the portion of discrete carbon nanotubes that are open ended are ion conducting.
[3]	The composition of claim 2, further comprising additional inorganic structures comprising elements of the groups two through fourteen of the Periodic Table of Elements.
[4]	The composition of claim 2, further comprising non-fiber carbon structures selected from the group consisting of carbon black, graphite, graphene, oxidized graphene, fullerenes, and mixtures thereof.
[5]	The composition of claim 1, further comprising at least one polymer.

Limitation	Claim Language
[6]	The composition of claim 5, wherein the polymer is selected from the group consisting of vinyl polymers, poly(styrene-butadiene), partially or fully hydrogenated poly(styrene butadiene) containing copolymers, functionalized poly(styrene butadiene) copolymers such as carboxylated poly(styrene butadiene), poly(styrene-isoprene), poly(methacrylic acid), poly(methylmethacrylate), poly(acrylic acid), poly(vinylalcohols), poly(vinylacetates), fluorinated polymers, polyvinylpyrrolidone, conductive polymers, polymers derived from natural sources, polyethers, polyesters, polyurethanes, and polyamides; homopolymers, graft, block or random co- or ter-polymers, and mixtures thereof.
[7]	The composition of claim 1, wherein the carbon nanotubes are further functionalized.
[8]	The composition of claim 1, further comprising at least one dispersion aid.
[9]	The composition of claim 1, further comprising at least a portion of discrete carbon nanotubes interspersed between graphene and/or oxidized graphene plates.
[10]	The composition of claim 1, wherein the binder material has an impedance of less than or equal to about one billion ohm-m.
[11]	The composition of claim 1, where the electrolyte material or separator film has a charge transfer resistance of less than or equal to about 10 million ohm-m.
[12]	The composition of claim 1, wherein the carbon nanotubes are oriented.
[13]	The composition of claim 12, wherein the orientation is accomplished in a sheet, micro-layer, micro-layer with vertical film orientation, film, molding, extrusion, or fiber spinning fabrication method.

Limitation	Claim Language
[14]	The composition of claim 12, wherein orientation includes post fabrication methods, such as tentering, uniaxial orientation, biaxial orientation and thermoforming.
[15]	The composition of claim 1, which further comprises electrolyte.
[16]	The composition of claim 15, wherein the electrolyte comprises a polymer or a liquid.

I. INTRODUCTION

LG Energy Solution (“LGES” or “Petitioner”) petitions for IPR of claims 1-16 (“Challenged Claims”) of U.S. Patent No. 10,608,282 (“the ’282 Patent”). As explained in this Petition, there exists a reasonable likelihood that LGES will prevail with respect to at least one of the Challenged Claims.

In fact, the Challenged Claims mostly relate to generic features that were well-known in the art at the time of filing of the ’282 Patent, including having been disclosed in earlier patent publications by the Patent Owner. *See, e.g.*, LGES-1005, LGES-1006. And recited features that led to allowance—including the distribution of aspect ratios—were also conventional characteristics of nanotubes that are insufficient to justify validity of the Challenged Claims.

II. REQUIREMENTS FOR IPR

A. Grounds for Standing

Petitioner certifies that the ’282 Patent is available for IPR. Petitioner is not barred or estopped from requesting this review.

B. Challenge and Relief Requested

Petitioner requests IPR of the Challenged Claims on the below grounds.
LGES-1003, ¶¶1-160.

Ground	Claims	Basis for Rejection
1A	1-16	§103: Bosnyak-392 and Son
1B	4	§103: Bosnyak-392, Son, and So
1C	11	§103: Bosnyak-392, Son, and Gu
2A	1, 5-9, 12-16	§103: Bosnyak-129 and Albuerne
2B	2-4, 10-11	§103: Bosnyak-129, Albuerne, and Gu

C. Priority Date

The '282 Patent claims priority to U.S. Patent Application No. 15/881,071 filed on January 26, 2018. LGES-1001, cover. The '282 Patent also claims priority to and is a continuation of PCT/US2013/047029 (LGES-1017; “parent PCT application”), which was filed on June 21, 2013. The '282 Patent also claims priority to U.S. Provisional Application No. 61/662,393 (LGES-1018), filed on June 21, 2012, as well as U.S. Provisional Application No. 61/663,513 (LGES-1019), filed on June 22, 2012 (collectively “the provisional applications”).

As further explained below, the abovementioned provisional applications fail to provide written support for the claims of the '282 Patent, and the earliest possible priority date is June 21, 2013, provided by the later filed parent PCT application. Indeed, if a claim in later-filed application is not supported by an earlier application, then its effective filing date is the actual filing date of the later-filed application. 35 U.S.C. §100(i)(1)(A).

Here, independent claim 1 of the '282 Patent—and as a consequence the remaining claims 2-16 that depend from it—does not have written-description

support in the provisional applications. For reference, claim 1 of the '282 Patent reads as follows:

1. A composition for use as a binder material, an electrolyte material or a separator film material of an energy storage or collection device, comprising:

a plurality of discrete carbon nanotube fibers, said fibers having an aspect ratio of from about 10 to about 500, and wherein at least a portion of the discrete carbon nanotube fibers are open ended and

wherein 40% to 90% by number of the discrete carbon nanotubes have an aspect ratio of 30-70 and wherein from 1% to 30% by number of discrete carbon nanotubes have an average aspect ratio 80-140.

LGES-1001, Claim 1.¹

In other words, claim 1 appears directed to, among other things, a so-called bimodal distribution of carbon nanotube aspect ratios. Yet there is no written description support for this feature anywhere in the provisional applications. *See generally* LGES-1018 and LGES-1019. Rather, the first application in the priority chain of the '282 Patent to arguably contain a relevant disclosure is the parent PCT application, which was filed on June 21, 2013. *See, e.g.*, LGES-1017, [29], FIG. 1.

¹ All emphasis added unless otherwise noted.

Accordingly, for at least these reasons, the earliest priority date to which the '282 Patent is entitled priority ("Critical Date") is June 21, 2013.

As seen below, each reference applied in this Petition predates the Critical Date and qualify as prior art.² *See generally* LGES-1005, LGES-1006, LGES-1008, LGES-1009, LGES-1014, LGES-1016, LGES-1020.

Reference	Date	Section
Bosnyak-392	Oct. 14, 2010 (published)	§102(a)(1)
Bosnyak-129	Dec. 29, 2011 (published)	§102(a)(1)
Son	Aug. 2, 2010 (published)	§102(a)(1)
So	Sep. 29, 2005 (published)	§102(a)(1)
Albuerne	April 7, 2010 (published)	§102(a)(1)
Gu	Jan. 1, 2012 (published)	§102(a)(1)

² In the May 15, 2024 infringement contentions in the co-pending district court case, Patent Owner alleges 32 alternative priority dates that the '282 Patent may be entitled to. LGES-1027, 5-7. While such allegations do not appear to be justified—among other things because of failure to demonstrate possession of the claimed aspect ratios—Petitioner reserves the right to respond to any such similar allegations made in this IPR proceeding.

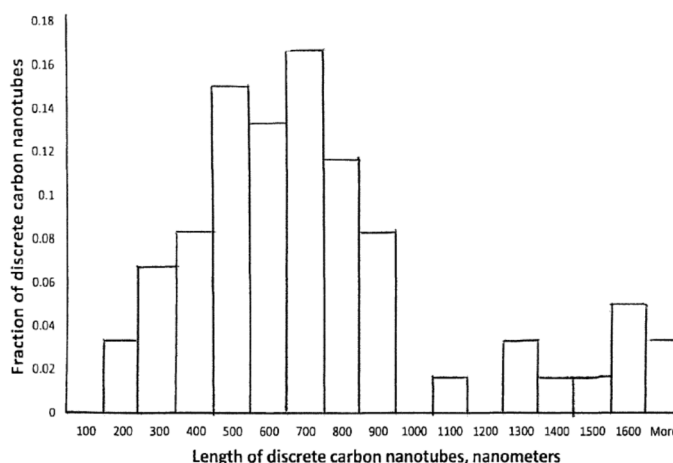
III. SUMMARY OF THE '282 PATENT

A. Brief Description

The '282 Patent is directed to “an improved binder composition, electrolyte composition and a separator film composition using discrete carbon nanotubes” that can be used in “energy storage and collection devices, like batteries, capacitors and photovoltaics.” LGES-1001, Abstract, 4:22-26; LGES-1003, ¶22.

Regarding its “discrete carbon nanotubes,” which the '282 Patent describes as “alternatively termed exfoliated carbon nanotubes,” the specification notes that such nanotubes are “obtained from as-made bundled carbon nanotubes by methods such as oxidation using a combination of concentrated sulfuric and nitric acids and sonication” and further that the “bundled carbon nanotubes can be made from any known means such as, for example, chemical vapor deposition, laser ablation, and high pressure carbon monoxide synthesis.” LGES-1001, 6:50-57; LGES-1003, ¶23.

The '282 Patent further notes that “[i]n statistics, a bimodal distribution is a continuous probability distribution with two different modes.” LGES-1001, 5:50-52. Along these lines, the '282 Patent shows, as an example and with reference to FIG. 1, discrete carbon nanotubes having “a bimodal length distribution where the maximum of one peak is about 700 nanometers and the maximum of the second peak is about 1600 nanometers.” *Id.*, 6:18-24; LGES-1003, ¶24.



LGES-1001, FIG. 1.

B. Prosecution History

The '282 Patent issued from U.S. Patent App. No. 15/881,071 (“the '071 application”). In the one and only office action of October 17, 2019, the Examiner noted that the “cited art does not ... appear to teach or fairly suggest the limitations of claims 18, (i.e. a distribution of carbon nanotube aspect ratios, wherein 40 to 90% of the nanotubes have an aspect ratio of 30 to 70, and wherein 1 to 30% of the carbon nanotubes has an aspect ratio of 80 to 140)....” LGES-1002, 129-130. The applicant amended claim 1 to incorporate this feature, and a Notice of Allowance subsequently issued on December 18, 2019. *See id.*, 8-16.

However, and as further detailed below, the examiner did not consider either Son or Albuerne, each of which provides a clear disclosure of this feature and, in combination with other references, render the Challenged Claims obvious.

C. Level of Ordinary Skill in the Art

A person of ordinary skill in the art relating to the subject matter of the '282 Patent as of the Critical Date (a "POSITA") would have had at least a Master's degree in materials science, chemistry, chemical engineering, a field relevant to polymer science and engineering, or the equivalent, and at least three years of experience in nanomaterials, electrochemistry, batteries, or polymer related activities. Additional work experience can compensate for less formal education, and vice versa. LGES-1003, ¶¶19-21.

D. Claim Construction

Petitioner submits that all claim terms should be construed according to the Phillips standard. *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005); 37 C.F.R. § 42.100. Here, based on the evidence below and the prior art's description of the claimed elements being similar to that of the '282 Patent's specification, and because the Challenged Claims are obvious under any reasonable interpretation, no formal claim constructions are necessary in this proceeding because "claim terms need only be construed to the extent necessary to resolve the controversy." *Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011).

IV. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. [GROUND 1A] – CLAIMS 1-16 ARE OBVIOUS OVER BOSNYAK-392 AND SON

The sections below provide a brief introduction to Bosnyak-392, Son, and the Bosnyak-392-Son combination.³

1. Overview of Bosnyak-392

Bosnyak-392 is directed to use of “exfoliated carbon nanotubes” and describes their use in, among others, “energy storage devices and polymer composites.” LGES-1005, Abstract, [0037]. Bosnyak-392 describes that “exfoliat[ing] bundles of carbon nanotubes” produces “individualized carbon nanotubes,” which can create various benefits. LGES-1005, [0003]; LGES-1003, ¶¶25-26.

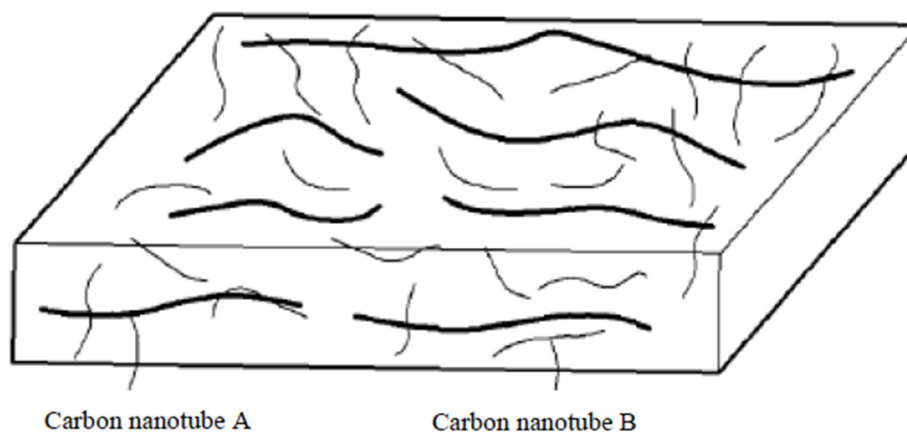
According to Bosnyak-392, “[t]he exfoliated carbon nanotubes ... take advantage of physical properties offered by individual carbon nanotubes that are not apparent when the carbon nanotubes are aggregated into bundles.” LGES-1005, [0037]. According to Bosnyak-392, such “exfoliated carbon nanotubes may be single-wall carbon nanotubes, double-wall carbon nanotubes, multi-wall carbon nanotubes and various combinations thereof.” *Id.*, [0038]; LGES-1003, ¶27.

³ Petitioner incorporates this discussion into Grounds 1A-1B.

Bosnyak-392 further recognizes that concurrently using both short and long carbon nanotubes (and by extension having different aspect ratios) can result in a composite with improved “electrical conduction or mechanical reinforcement” properties. LGES-1005, [0073]; LGES-1003, ¶28.

2. Overview of Son

Son is generally directed to “a polymer composite material using carbon nanotubes and a method for manufacturing the same.” LGES-1008, [0001].⁴ More specifically, as shown in FIG. 1 below, Son describes a polymer composite where “carbon nanotubes with a large aspect ratio ... and carbon nanotubes with a small aspect ratio ... are used together.” *Id.*, [0020]; LGES-1003, ¶29.

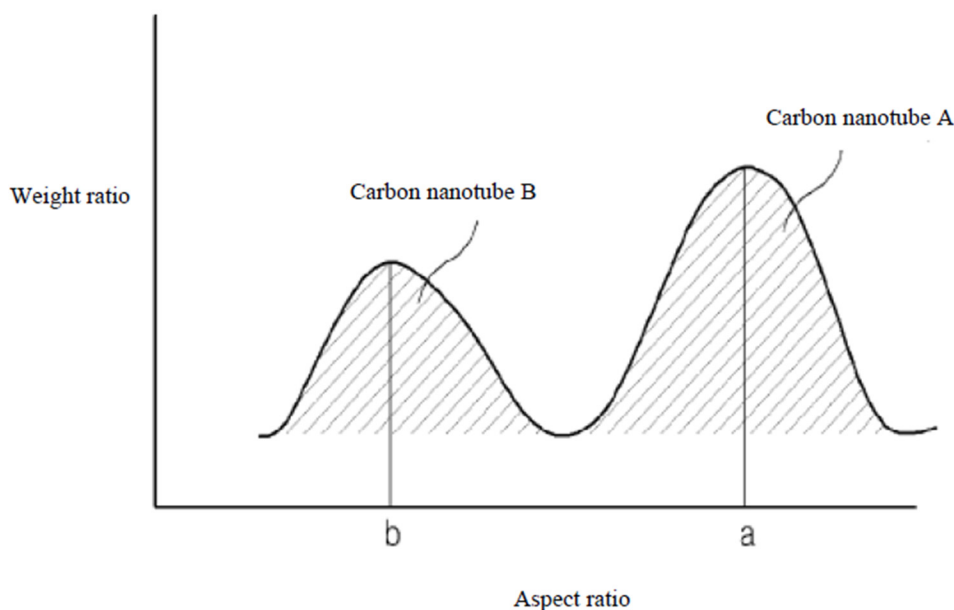


LGES-1008, FIG. 1.

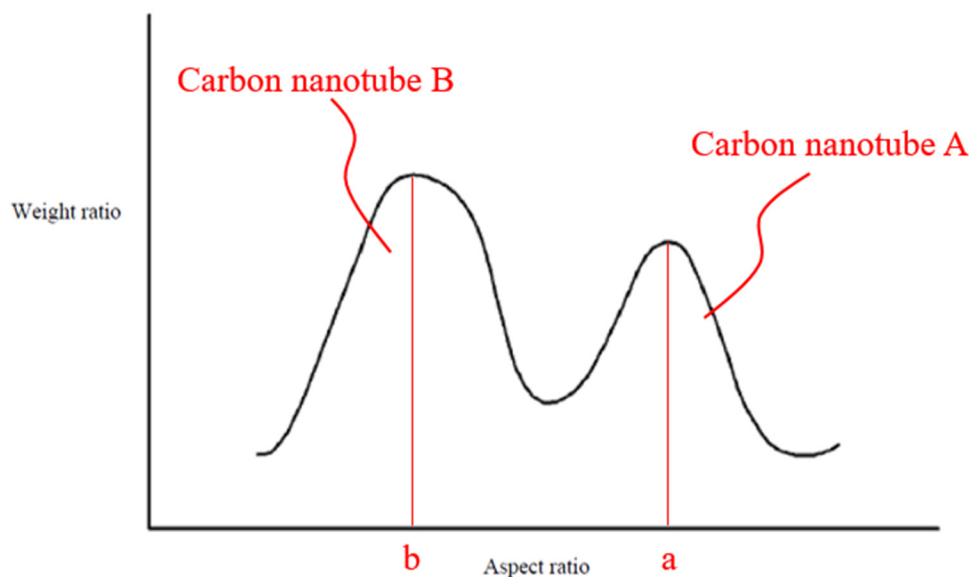
⁴ KR10-2010-0086854 to Son (LGES-1007) was published in Korean. Thus, all citations to Son are to its certified English translation (LGES-1008).

By using two different types of discrete, individually dispersed carbon nanotubes (*i.e.*, one type having a higher aspect ratio than the other type), Son expressly recognizes that improved electrical and mechanical properties of the composite material can be achieved. *Id.*, [0003]-[0005], [0021]; LGES-1003, ¶30.

In particular, and as demonstrated in FIGS. 4 and 6 below, Son expressly recognizes that such improvements, which stem from the use of carbon nanotubes having different aspect ratios, can be “achieved by having at least two peaks in a distribution graph of a weight ratio to an aspect ratio of the carbon nanotubes in a polymer composite material comprising carbon nanotubes.” LGES-1008, [0008]; LGES-1003, ¶¶31-32.



LGES-1008, FIG. 4.



LGES-1008, FIG. 6 (annotated).

3. Combination of Bosnyak-392 and Son

As described in Section IV.A.1, Bosnyak-392 disclose making “energy storage devices and polymer composites” using “exfoliated carbon nanotubes” and further that concurrently using carbon nanotubes having two different aspect ratios can help create composite materials with improved mechanical and electrical properties. LGES-1005, Abstract, [0037], [0073]. However, Bosnyak-392 does not expressly disclose the specific nanotube aspect ratios to use, instead leaving such implementation details to a POSITA. LGES-1003, ¶¶33-34. Yet a POSITA would have nevertheless considered using the claimed aspect ratio distributions (*i.e.*, “wherein 40% to 90% by number of the discrete carbon nanotubes have an aspect ratio of 30-70 and wherein from 1% to 30% by number of discrete carbon

nanotubes have an average aspect ratio 80-140”) to be obvious for reasons that include but that are not limited to these being routine and conventional design choices as evidenced, for example, by the express teachings of Son. LGES-1003, ¶35.

Indeed, Son, similar to Bosnyak-392, is directed to “a polymer composite material using carbon nanotubes and a method for manufacturing the same” and more specifically describes a polymer composite where “carbon nanotubes with a large aspect ratio (hereinafter, referred to as carbon nanotube A and second carbon nanotube) and carbon nanotubes with a small aspect ratio (hereinafter referred to as carbon nanotube B and first carbon nanotube) are used together.” LGES-1008, [0004], [0020]. FIG. 1; LGES-1003, ¶36. That is, similar to Bosnyak-392, Son recognizes that concurrently using discrete carbon nanotubes with two different aspect ratios within a composite material can yield improved mechanical and electrical properties. LGES-1003, ¶36. Son further describes that finding the right ratio is a routine/conventional process that can be “easily determined by a person skilled in the art.” LGES-1008, [0033]; LGES-1003, ¶36.

By looking to apply the specific aspect ratio distribution teachings of Son to Bosnyak-392, a POSITA would have recognized that the electrical/mechanical properties of Bosnyak-392’s nanocomposite material can be further improved

through the specific bimodal distribution teachings of Son. *See* LGES-1008, [0008], [0021]; LGES-1003, ¶37.

A POSITA would have been further prompted to pursue this implementation of Son's specific bimodal distribution into Bosnyak-392's nanocomposite material as doing so is merely the application of known techniques (*e.g.*, using carbon nanotubes having two different aspect ratios in a composite material) to a known structure (*e.g.*, composite material containing discrete carbon nanotubes) to yield predictable results (*e.g.*, improved electrical/mechanical properties). LGES-1003, ¶52; *see KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). And a POSITA would have expected success in the Bosnyak-392-Son combination given that both Bosnyak-392 and Son already describe using discrete carbon nanotubes having two different aspect ratios for improved electrical/mechanical properties. *See* LGES-1005, [0058]; LGES-1014, [0018]; LGES-1003, ¶38.

4. Analysis

(i) Claim 1

[1pre]

To the extent the preamble is deemed to be limiting, Bosnyak-392-Son renders obvious [1pre]. For example, Bosnyak-392 discloses “*compositions of exfoliated carbon nanotubes*” and is more specifically directed to “improved *energy storage devices* containing exfoliated carbon nanotubes and . . . *batteries* having components containing exfoliated carbon nanotubes.” LGES-1005, [0008],

[0074]. In particular, Bosnyak-392 describes “current collectors, electrodes, insulators, *electrolytes and separators, each capable of containing exfoliated carbon nanotubes.*” *Id.*; *see also id.*, [0014], Claim 37; LGES-1003, ¶39.

[1a-i], [1a-ii], [1a-iii]

Bosnyak-392-Son renders obvious [1a-i], [1a-ii], [1a-iii]. LGES-1003, ¶¶40-81. For example, Bosnyak-392 describes that its “carbon nanotubes have a length to diameter ratio (aspect ratio) of least about 100 in some embodiments....” LGES-1005, [0042]. Moreover, the combination based on Son renders obvious using two different types of carbon nanotubes, the first nanotube group having an **aspect ratio** between 10 to 65 and the second nanotube group having an aspect ratio between 130 to 1000. *See* LGES-1008, [0028]-[0029]; *see also id.*, [0009], [0014], [0016], FIG. 4, Claims 2, 7, 9; LGES-1003, ¶40. The resulting/combined aspect ratio of about 10 to 1000, as disclosed in Son, overlaps considerably with the claimed aspect ratio range of “about 10 to about 500.” LGES-1003, ¶40.

Incidentally, the '282 Patent provides no discussion, let alone any evidence, of unexpected results or criticality associated with nanotubes having an aspect ratio within the claimed range. *See* LGES-1001, 7:48-56; LGES-1003, ¶41. Thus, a POSITA would have further considered the use of carbon nanotubes having the disclosed range of aspect ratios to be obvious and also a routine and conventional design choice. LGES-1003, ¶41. Moreover, the Federal Circuit has “consistently

held that even a slight overlap in range establishes a prima facie case of obviousness.” *In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003).

As for the nanotubes being “**discrete**,” Bosnyak-392 utilizes “**exfoliated** carbon nanotubes” to provide “individual carbon nanotubes” as opposed to those nanotubes that are “aggregated into bundles.” LGES-1005, [0037]; *see also id.*, [0006], [0008], [0036]. That is, Bosnyak-392 uses “**separated, exfoliated carbon nanotubes** [that] exist in a disordered but non-aggregated state,” much like in the ’282 Patent. *Id.*, [0054]; LGES-1003, ¶42. Indeed, the ’282 Patent expressly recognizes that “[i]n the present invention, **discrete oxidized carbon nanotubes, alternatively termed exfoliated carbon nanotubes**” are disclosed.” LGES-1001, 6:50-54. Son similarly relies on the use of such discrete nanotubes having “excellent dispersibility.” LGES-1008, [0021]. In short, in the combination, 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. LGES-1003, ¶42.

Regarding the discrete nanotubes being “**open ended**,” Bosnyak-392 discloses the same. For example, Bosnyak-392 expressly recognizes using “carbon nanotubes that have open ends.” LGES-1005, [0038]. Moreover, well before the Critical Date, it was well-known to a POSITA that the kinds of carbon nanotubes like those used in the composites of Bosnyak-392-Son can have close ends or open

ends, depending for instance on the particular manufacturing method and/or user preference. LGES-1003, ¶43. Among other things, a POSITA would have recognized and/or found it obvious that carbon nanotubes can be “capped with a fullerene-like structure” to “have closed ends” or, in the alternative, “remain open-ended.” LGES-1010, [0067]. Even when the nanotubes are close-ended, they can be opened, for instance, through well-recognized oxidizing processes. *See id.*; *see also* LGES-1011, 675-676, 679; LGES-1003, ¶43.

[1b]

As an initial matter, Petitioner notes that “it is not inventive to discover the optimum or workable ranges by routine experimentation.” *In re Applied Materials*, 692 F.3d 1289, 1295 (Fed. Cir. 2012) (citation omitted). Indeed, a range that relates to device performance is only patentable if it produces a “new and unexpected result” that differs in kind and not merely in degree from the prior art. *Id.* at 1297; *see In re Geisler*, 116 F.3d 1465, 1469-70 (Fed. Cir. 1997) (“[T]he applicant must ‘show that the [claimed] range is critical, generally by showing that the claimed range achieves unexpected results relative to the prior art range.’” (citation omitted)). No such “unexpected results” associated with the claimed nanotube aspect distribution ratio is provided by the ’282 Patent. LGES-1003, ¶45. To the extent [1b] describes the range of *two* variables, even such simultaneous optimization of more than one variable does not change that analysis. *See Applied*

Materials, 692 F.3d at 1298. Moreover, any unexpected results must be unexpected throughout the entire range claimed, not just a portion of it. *See E.I. DuPont de Nemours & Co. v. Synvina C.V.*, 904 F.3d 996, 1011-12 (Fed. Cir. 2018); *In re Peterson*, 315 F.3d 1325, 1330 (Fed. Cir. 2003).

Further, as described above in Section IV.A.3, a POSITA would have been motivated to pursue the bimodal aspect ratio distribution of carbon nanotubes, such as per Son, into the nanotube composite structure of Bosnyak-392 to, among other things, concurrently achieve the “excellent dispersibility” of nanotubes “with a small aspect ratio” and the excellent “electrical properties” of nanotubes “with a large aspect ratio.” LGES-1008, [0008], [0021]; LGES-1003, ¶46. Indeed, Bosnyak-392 similarly and expressly recognizes the desire to use a bimodal aspect ratio distribution in its composition, disclosing that “[i]n certain applications, particularly those involving electrical conduction or mechanical reinforcement,” both shorter and longer carbon nanotubes can be used together. LGES-1005, [0073]; LGES-1003, ¶46. Bosnyak-392 does not, however, disclose a specific criteria for selecting the nanotube aspect ratios and their relative percentages, as it leaves that implementation detail to the POSITA. LGES-1003, ¶46.

Son, on the other hand, expressly discloses using two different types of carbon nanotubes (*i.e.*, bimodal distribution) where the first nanotube group (“carbon nanotube B”) has an aspect ratio between 10 to 65 and the second

nanotube group (“carbon nanotube A”) has an aspect ratio between 130 to 1000.

See LGES-1008, [0028]-[0029]; *see also id.*, [0009], [0014], [0016], [0020],

Claims 2, 7, 9; LGES-1003, ¶47. Here, Son’s second nanotube group (carbon

nanotube A) overlaps with and corresponds to the claimed “discrete carbon

nanotubes hav[ing] an aspect ratio of 80-140,” and Son’s first nanotube group

(carbon nanotube B) overlaps with and corresponds to the claimed “discrete carbon

nanotubes hav[ing] an average aspect ratio 30-70.” LGES-1003, ¶48. As noted for

[1a], the Federal Circuit has “consistently held that even a slight overlap in range

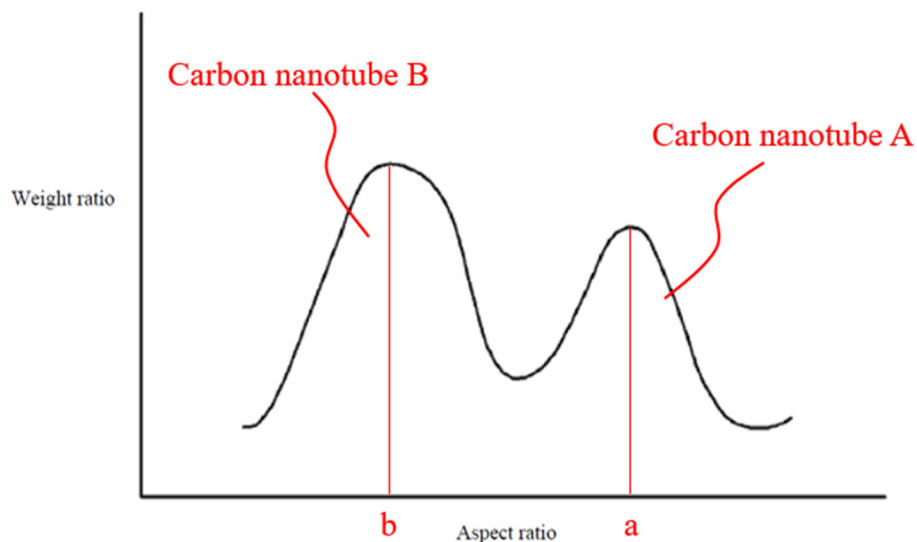
establishes a prima facie case of obviousness.” *In re Peterson*, 315 F.3d at 1329.

An example of Son’s bimodal aspect ratio distribution of its two nanotube groups

can be seen in the following distribution graph, where, as in the ’282 Patent, it can

be seen that there is more of the lower aspect ratio nanotubes compared to the

higher aspect ratio nanotubes. LGES-1003, ¶49.



LGES-1008, FIG. 6 (LGES-1003, ¶49).

Thus, having one group of discrete carbon nanotubes with an aspect ratio of 30-70 and another group of carbon nanotubes having an average aspect ratio 80-140 is rendered obvious by Bosnyak-392-Son. LGES-1003, ¶¶45-49.

Regarding the particulars of its bimodal distribution, Son describes that finding the right balance depends on various factors but that it can be “easily determined by a person skilled in the art” and that “[t]he *weight ratio* of carbon nanotube A/carbon nanotube B may be *0.1 to 10*.” LGES-1008, [0032], [0033]; *see also id.*, [0014], [0044]-[0046], Claim 7; LGES-1003, ¶50. According to Dr. Gido, this means that you can have ten times more (by weight) of one group than the other group—and vice versa—which is a broad range that will render obvious the particular distribution provided in limitation [1b], even if Son’s ratio is provided as a weight percentage and the claim is written as a number percentage. LGES-1003, ¶50. Critically, as noted above, Son explicitly discloses having a larger percentage of nanotubes with a smaller aspect ratio and a smaller percentage of carbon nanotubes (CNTs) having a higher aspect ratio, just as claimed in the ’282 Patent. LGES-1003, ¶50.

To the extent that Patent Owner may argue that Son’s distribution and the ’282 Patent’s distribution are different, for example, because the former is given as a weight distribution (*i.e.*, what weight percentage of the nanotubes have certain

aspect ratios) while the latter is given as a number distribution (*i.e.*, what number percentage of the nanotubes have certain aspect ratios), this difference does not save the '282 Patent from obviousness, particularly when considering Son's comprehensive disclosure. LGES-1003, ¶51. In some cases, there may not be a one-to-one correspondence between weight percentage and number percentage. LGES-1003, ¶51. This is because, relative to one another, the weight distribution favors the larger species relative to the number distribution because larger species, being heavier, are counted more heavily in the weight distribution. For example, if each of Son's nanotubes A are heavier than each of Son's nanotubes B, the number percentage of nanotubes A will be less than the weight percentage of nanotubes A because, for a given mass of a material, heavier nanotubes will be present in fewer numbers compared to the lighter nanotubes. As explained below, Dr. Gido provides three different approaches, each more mathematically precise and rigorous than the previous, to confirm that that Son's aspect ratio distribution covers the claimed aspect ratio distribution in the '282 Patent. *Id.*

First, Dr. Gido explains that the weight ratio disclosed in Son can be approximated as a number ratio using a 1:1 conversion. LGES-1003, ¶¶52-54. Based on this approximation, having a first group of nanotubes that weighs 10x more than a second group of nanotubes by way of example, would mean that there are 10x more nanotubes in number (*i.e.*, by count) in the first group compared to

the second group. LGES-1003, ¶52. According to Dr. Guido, a POSITA would have viewed such 1:1 weight-to-number approximation as being reasonable in this context for various reasons. First, when making a CNT composite, especially for use in energy storage applications, a POSITA would have known to use nanotubes that are not vastly different from one another in terms of size/mass. LGES-1003, ¶53. They would not, for instance, use nanotubes with dimensions that are orders of magnitude different from one another. *Id.* Moreover, 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. LGES-1008, [0029]; LGES-1003, ¶53. Critically, 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**. LGES-1008, [0029]; LGES-1003, ¶53. Accordingly, a POSITA would have recognized that Son does not expect a weight-based aspect ratio distribution to vary drastically from a number-based one. Thus, a POSITA would have viewed the approximated 1:1 conversion between weight and number-based domains to be reasonable, and consistent with the teachings of Son. LGES-1003, ¶53.

Proceeding with the 1:1 approximation and based on the “0.1 to 10” weight ratio as noted above, a POSITA would have recognized that Son contemplates

having up to 10x more—by number—of high aspect ratio nanotubes compared to the low aspect ratio nanotubes, and vice versa. LGES-1003, ¶54. This is a wide range that clearly overlaps with the claimed percentage from the '282 Patent. For example, looking to Son's example of having a 3:7 weight ratio between its high aspect ratio nanotubes (carbon nanotube A) and low aspect ratio nanotubes (carbon nanotube B), this 3:7 weight ratio would translate to a 3:7 number ratio. *See* LGES-1008, Table 1. This means that the high aspect ratio nanotubes in Son would be present at a level of $3/(3+7) = \underline{30\%}$ by number, while the low aspect ratio nanotubes are present at a level of $7/(3+7) = \underline{70\%}$ by number. These number percentage values fall within the claimed "1% to 30% by number" and "40% to 90% by number," respectively, thereby satisfying limitation [1b]. LGES-1003, ¶54.

Second, Dr. Guido further explains that a POSITA would have recognized that Son contemplates changing the aspect ratios of its nanotubes by changing their lengths while keeping their diameters constant. *See* LGES-1008, [0005]; LGES-1003, ¶¶55-57. That is, a POSITA would have recognized that it is the length of CNTs that are often controlled by the users of CNTs to derive desired properties. *Id.* In fact, the '282 Patent explicitly recognizes and promotes this type dependence of aspect ratio on length: "Likewise, the lengths of the discrete carbon nanotubes can have a bimodal distribution such that one peak has a maximum

value in the range of 150 to 800 nanometers and the second peak has a maximum value in the range 1000 to 3000 nanometers.” LGES-1001, 5:61-65; LGES-1003, ¶55.

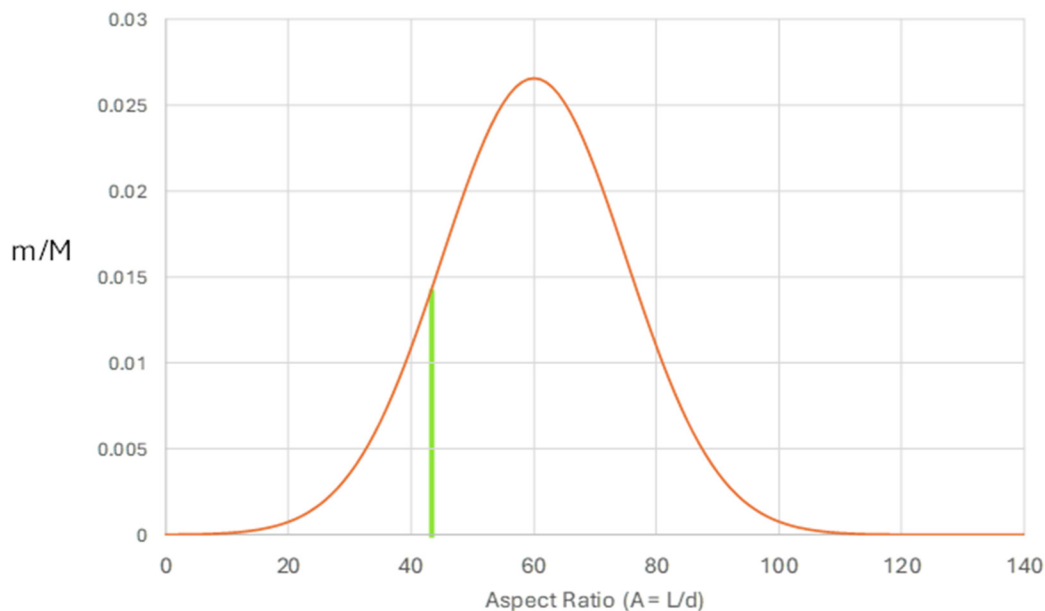
Based on this approximation, and referring again to the example provided in Son of having a 3:7 weight ratio between its high aspect ratio nanotubes (carbon nanotube A) and low aspect ratio nanotubes (carbon nanotube B), this 3:7 weight ratio can be readily converted into a number ratio. *See* LGES-1008, Table 1; LGES-1003, ¶56. Specifically, Son’s Embodiment 3 provides sample aspect ratios of 150 and 50, respectively, for its nanotubes A and nanotubes B. LGES-1008, [0042]. Assuming an essentially constant average tube diameter among the nanotubes, which a POSITA would have viewed to be reasonable for reasons noted above, the respective amounts of nanotubes A and B in the composition by number would be **12.5% of nanotubes A and 87.5% of nanotubes B**. LGES-1003, ¶56. This is because, given that Son’s nanotubes A would weigh three times as much as nanotubes B on average (since nanotubes A would be three times as long compared to nanotubes B while having the same diameter), the weight ratios in Embodiment 3 of (3 CNTs A):(7 CNTs B) would translate to a ratio by number of (3/3):(7/1), or 1:7. This means that nanotubes A would be present by number at a level of $1/(1+7) = 12.5\%$. Son’s nanotubes B would be present by number at a level of

$7/(1+7) = 87.5\%$. Both values again fall squarely within the range recited in limitation [1b]. LGES-1003, ¶56.

By similarly taking another sample point that falls within the range mentioned in Son, namely nanotubes having aspect ratios of 130 and 65, and performing the same calculations as above based on the 3:7 weight ratio results in having a number ratio of $(3/2):(7/1)$, or 1.5:7 (dividing the first value here by 2 instead of 3 as before since the higher aspect ratio nanotube now has twice the mass of the lower aspect ratio nanotubes). LGES-1003, ¶57. This means that nanotubes A would be present by number at a level of $1.5/(1.5+7) = \underline{17.65\%}$. Son's nanotubes B would be present by number at a level of $7/(1.5+7) = \underline{82.35\%}$. Both values again fall squarely within the claimed ranges of 1-30% and 40-90%, respectively, and confirm that the contemplated aspect ratio distribution ratios/ranges of Son encompass what is claimed in limitation [1b]. LGES-1003, ¶57.

Third, to help further validate the conversion approaches above, Dr. Gido provides a more mathematically rigorous approach to more precisely go from Son's weight distribution domain to the number distribution domain of the '282 Patent. See LGES-1003, ¶¶58-80.

To help illustrate, a simple mass distribution is shown below:



LGES-1003, ¶60.

Here, L = carbon nanotube length, d = carbon nanotube diameter, A = aspect ratio = L/d , $n(A)$ = number of carbon nanotubes having aspect ratio A , $m(A)$ = weight (*i.e.* mass) of all carbon nanotubes having a specific aspect ratio A , N = total number of all nanotubes of all aspect ratios, and M = total weight (mass) of all nanotubes of all aspect ratios. LGES-1003, ¶¶59-61. In the example distribution above, the vertical axis is the weight fraction of nanotubes at a particular aspect ratio, which is given by m/M . The vertical green line above represents a sliver of the distribution representing a population of nanotubes having a particular aspect ratio A and a particular mass fraction m/M . This third approach essentially entails converting this mass fraction into a number fraction n/N . *Id.*

To start, Dr. Guido explains that the weight of all the nanotubes in the slice of the distribution at aspect ratio A, is

$$m(A) = m_o(A) n(A) = \rho L \left(\frac{\pi d^2}{4} \right) n(A) ,$$

where $m_o(A)$ is the mass of a single nanotube having an aspect ratio A, ρ is the density of the nanotubes, L is the length of the nanotubes, and d is the diameter of the nanotubes. LGES-1003, ¶62.

If we assume that the distribution of carbon nanotube diameters is similar across the range of aspect ratios then:

$$m(A) = \rho L \left(\frac{\pi \langle d \rangle^2}{4} \right) n(A) = \rho \left(\frac{\pi (L/d) \langle d \rangle^3}{4} \right) n(A) = \rho \left(\frac{\pi A \langle d \rangle^3}{4} \right) n(A) ,$$

where $\langle d \rangle$ is the average diameter of the nanotubes. LGES-1003, ¶63.

The total mass of all the nanotubes then becomes:

$$M = \int_0^\infty m(A) dA = \int_0^\infty \rho \left(\frac{\pi A \langle d \rangle^3}{4} \right) n(A) dA .$$

Subsequently, the number of nanotubes, n, at a particular aspect ratio (A) is calculated by dividing the amount in the weight distribution (m/M) by the weight m_o of the nanotube at A and multiplying by the weight of all the nanotubes in the distribution, M:

$$n = \left(\frac{m}{M}\right) \left(\frac{M}{m_o}\right) = \left(\frac{m}{M}\right) \frac{\int_0^\infty \rho \left(\frac{\pi A \langle d \rangle^3}{4}\right) n(A) dA}{\rho \left(\frac{\pi A \langle d \rangle^3}{4}\right)} = \left(\frac{m}{M}\right) \frac{\rho \left(\frac{\pi \langle d \rangle^3}{4}\right) \int_0^\infty n(A) A dA}{\rho \left(\frac{\pi \langle d \rangle^3}{4}\right) A} = \left(\frac{m}{M}\right) \frac{\int_0^\infty n(A) A dA}{A} .$$

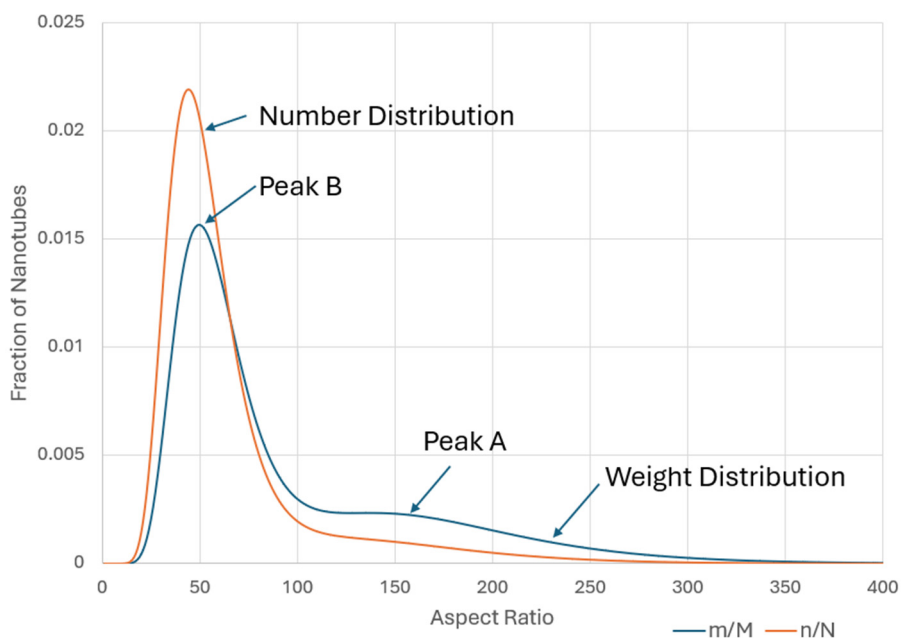
From this, it then follows that the following two formulas allow the conversion of a known number distribution (n/N) into the corresponding weight distribution (m/M), or a known weight distribution into a number distribution, respectively:

$$\left(\frac{m}{M}\right) = \left(\frac{n}{N}\right) A \frac{\int_0^\infty n(A) dA}{\int_0^\infty n(A) A dA}$$

$$\left(\frac{n}{N}\right) = \left(\frac{m}{M}\right) \left(\frac{1}{A}\right) \frac{\int_0^\infty m(A) dA}{\int_0^\infty \left(\frac{m(A)}{A}\right) dA} ,$$

LGES-1003, ¶¶64-67.

Ultimately, as Dr. Gido goes to explain in detail in his declaration, by assuming that the dispersed carbon nanotubes in Son have a lognormal distribution of lengths and, therefore, aspect ratios, and applying the formulas above to Son's Embodiment 3, the weight distribution provided in Son's Embodiment 3 (shown in blue below) can be converted to a number distribution as in the '282 Patent (shown in orange below). LGES-1008, [0041]-[0046], *See* LGES-1003, ¶¶68-80 (citing LGES-1022, 6-7, LGES-1023, 14; LGES-1024, Fig. 5(b)).



LGES-1003, ¶78.

Based on the conversion above, Embodiment 3 of Son corresponds to 69.4% of its nanotubes having an aspect ratio of 30-70 and 11.4% of its nanotubes having an aspect ratio of 80-140, which again fall squarely within the claimed ranges of 40-90% and 1-30%, respectively. *See* LGES-1003, ¶¶74-80. Based on Dr. Gido's calculations, the same is true for Son's Embodiment 2, which provides aspect ratios that fall within the claimed ranges. *See id.*

(ii) **Claim 2**

[2]

Bosnyak-392-Son renders obvious [2]. For example, Bosnyak-392 expressly recognizes that its battery, which can include exfoliated carbon nanotubes in its electrodes, electrolyte, and/or separator, allows ions to freely flow

between the electrodes (via the electrolyte and separator). *See* LGES-1005, [0076]-[0077]. Thus, the open ended carbon nanotubes of Bosnyak-392 are ion conducting, and indeed, such ion conducting properties of carbon nanotubes, in particular those that are open ended as in Bosnyak-392, would have been well known to a POSITA. LGES-1003, ¶82 (citing LGES-1012, [0013], [0017], [0034], [0227]). That is, the fact that open-ended carbon nanotubes, as those used in Bosnyak-392, are ion conducting was well-known to a POSITA. For example, Gu (Exhibit 1016) describes that carbon nanotubes incorporated into battery materials are ion conducting, expressly recognizing that “Li diffusion to the interior of SWNTs occurred through open ends” and that “blended film structure of incorporated MWNT may provide a pathway for both improved ion transfer through the polymer matrix and intra-MWNT ion transport.” LGES-1016, 1878, FIG. 5. Thus, a POSITA would have recognized that open ended carbon nanotubes are commonly used in battery applications and further that they are ion conducting. LGES-1003, ¶83.

(iii) **Claim 3**

[3]

Bosnyak-392-Son renders obvious [3]. For example, Bosnyak-392 describes that the exfoliated carbon nanotubes used in its composite materials “may be further associated or functionalized with an electroactive material” such as

“transition metals or oxides of transition metals such as, for example, Ru, Ir, W, Mo, Mn, Ni and Co,” which are inorganic structures/elements found in groups two through fourteen of the periodic table. LGES-1005, [0034]; LGES-1003, ¶84. Bosnyak-392 additionally describes that its “carbon nanotubes may also be modified within the spirit and scope of the disclosure to substitute other tubular nanostructures, including, for example, inorganic or mineral nanotubes” such as “silicon nanotubes, boron nitride nanotubes and carbon nanotubes having heteroatom substitution in the nanotube structure.” LGES-1005, [0034]; LGES-1003, ¶84.

(iv) **Claim 4**

[4].

Bosnyak-392-Son renders obvious [4]. For example, Bosnyak-392 describes “using a nanocrystalline material having a crystalline form such as, for example, nanorods, nanoplates, or nanowhiskers, to intersperse between individual carbon nanotubes.” LGES-1005, [0058]. Such nanocrystalline materials can include “clays, **graphite**, inorganic crystalline materials, organic crystalline materials and various combinations thereof.” *Id.* While Bosnyak-392 mentions that the residual nanocrystalline materials, such as graphite, can be removed/washed in an optional step, a POSITA would have recognized that these materials can be left in place to provide a fiber/non-fiber composite having good electrical/mechanical properties.

See id., [0056]; *see also* LGES-1003, ¶85 (citing LGES-1006, [0088]; LGES-1014,⁵ [0001], [0002], [0010], [0011], [0018], [0021], Fig. 1).

(v) **Claim 5**

[5]

Bosnyak-392-Son renders obvious [5]. Indeed, both Bosnyak-392 and Son are directed to the use of carbon nanotubes in a polymer composite material. LGES-1003, ¶86. For example, Bosnyak-392 describes mixing the exfoliated carbon nanotubes with a “polymer material” to form a “polymer composite.” LGES-1005, Abstract, [0015], [0089], [0090], Claim 44; LGES-1003, ¶86. Similarly, Son describes forming a “polymer composite comprising carbon nanotubes” by mixing “carbon nanotubes and polymers.” LGES-1008, [0016], [0039]; LGES-1003, ¶86.

(vi) **Claim 6**

[6]

Bosnyak-392-Son renders obvious [6]. For example, Bosnyak-392 describes that its carbon nanotubes can be mixed with various types of polymers including “*conducting polymer* such as, for example, polyaniline, *polyvinylpyrrole* or

⁵ JP2005-262301 to So (LGES-1013) was published in Japanese. Thus, all citations to So are to its certified English translation (LGES-1014).

polyacetylene.” LGES-1005, [0034]; LGES-1003, ¶87. Son similarly describes that the carbon nanotubes can be mixed with various types of polymers including “polyphenylene sulfide, polyphenylene oxide, liquid crystal polymer, *polyamide*, polycarbonate, polyester, polyvinylated fluorine or polyolefin.” LGES-1008, [0039]; LGES-1003, ¶87.

(vii) **Claim 7**

[7]

Bosnyak-392-Son renders obvious [7]. Indeed, both Bosnyak-392 and Son describe the use of functionalized carbon nanotubes. LGES-1003, ¶88. For example, Bosnyak-392 describes that, in some cases, “the exfoliated carbon nanotubes are further functionalized” and further that “[f]unctionalization may take place either before or after exfoliation.” LGES-1005, [0044]; *see also id.*, [0032]-[0034], [0063]; LGES-1003, ¶88. Similarly, Son describes that its nanotubes may be “prepared through ... functionalization treatment.” LGES-1008, [0018], [0024]; LGES-1003, ¶88.

(viii) **Claim 8**

[8]

Bosnyak-392-Son renders obvious [8]. For example, Bosnyak-392 describes the use of various surfactants to help improve dispersion of the exfoliated carbon nanotubes. *See* LGES-1005, [0049], [0054]; LGES-1003, ¶89. Bosnyak-392 lists

various types of surfactants for aiding in the dispersion, including “ionic and non-ionic surfactants, sodium dodecyl sulfate, sodium dodecylbenzene sulfonate, and PLURONICS” as well as “chloroform and toluene” and “other types of molecules such as, for example, cyclodextrins, polysaccharides, polypeptides, water soluble polymers, DNA, nucleic acids, polynucleotides, and polymers such as polyimides and polyvinyl pyrrolidone.” LGES-1005, [0049], [0054]. In Bosnyak-392-Son, a POSITA would have known to retain improved dispersion of the discrete carbon nanotubes by using the dispersion aids such as those laid out in Bosnyak-392. LGES-1003, ¶89.

(ix) **Claim 9**

[9]

Bosnyak-392-Son renders obvious [9]. For example, Bosnyak-392 describes using “*nanoplates*” that are “*intersperse[d]* between individual carbon nanotubes” to help promote nanotube isolation, which would result in the claimed interspersed configuration. LGES-1005, [0058]; LGES-1003, ¶90. As explained for [4] *supra*, a POSITA would have recognized that such fiber/non-fiber composites can exhibit improved electrical/mechanical properties. LGES-1003, ¶90 (citing LGES-1006, [0088]; LGES-1014, [0001], [0002], [0010], [0011], [0018], [0021], Fig. 1). Specifically, Bosnyak-392 mentions that its nanoplates can be made from materials including “graphite,” and a POSITA would have understood that graphene is an

individual layer of the structure that makes up such graphite. LGES-1006, [0058]; LGES-1003, ¶90. Indeed, Bosnyak-129, which is a later patent publication from the same authors of Bosnyak-392, expressly recognizes the use of graphene nanoplates for being interspersed carbon nanotubes. *See* LGES-1006, [0088] (“The nanoplates can be, for example, ... graphene structures ... The nanotube fibers of this invention can disperse between the individual nanoplates.”); LGES-1003, ¶90.

(x) **Claim 10**

[10]

As an initial matter, Petitioner notes that element [10] is directed to narrower limitations concerning “a binder material,” which itself was only mentioned as being one of several optional uses in the preamble of claim 1. LGES-1001, Claim 1. While claim 10 arguably narrows the type of binder material, it does not actually require the use of such a binder material. Nor can the intended use as merely stated in the preamble be considered to be a limitation. *See Pitney Bowes, Inc. v. Hewlett-Packard Co.*, 182 F.3d 1298, 1305 (Fed. Cir. 1999). Thus, there is no need to reach the optional limitation of claim 10 related to a binder material, and Bosnyak-392-Son, as discussed above for claim 1, therefore also satisfies claim 10. LGES-1003, ¶91. Nevertheless, Bosnyak-392 discloses that exfoliated carbon nanotubes can be used in all aspects of batteries, including “electrodes

containing exfoliated carbon nanotubes.” LGES-1005, [0073], [0075], [0077]; LGES-1003, ¶93. A POSITA would have recognized that electrodes are made using binder materials to hold the active electrode materials together, and thus would have recognized that the exfoliated carbon nanotubes of Bosnyak-392 would be used as a binder material when incorporated into an electrode. *See, e.g.*, LGES-1001, 1:62-2:1, 2:6-14, 2:34-36; LGES-1003, ¶93.

Moreover, a POSITA would have recognized that the recited “impedance of less than or equal to about one billion ohm-m” is an extremely broad range that is likely to be satisfied by any material where, as in Bosnyak-392-Son, improved conductivity is desired.⁶ *See* LGES-1005, [0073]; LGES-1008, [0007]; LGES-1003, ¶92. For instance, Bosnyak-129 describes that a matt made of nanotubes can have a conductivity of “at least 0.1 Siemens/cm and as high as 100 Siemens/cm.” LGES-1006, [0008]. Such levels of conductivity correspond to an impedance of 0.0001 ohm-m to 0.1 ohm-m, which is far less than the claims value of one billion ohm-m. LGES-1003, ¶93. Similarly, Noyes lists example resistivities for bi-modal carbon nanotube samples of around 0.3 ohm-cm (which corresponds to

⁶ The ’282 Patent equates “improved electrical conductivity” and “reduced impedance.” LGES-1001, 2:26-30. Further, because conductivity is the inverse of resistivity, impedance corresponds to resistivity. LGES-1003, ¶92.

0.003 ohm-m). *See* LGES-1015 35:56-36:20. Such low resistivity/impedance is further aligned with the desire of Bosnyak-392 and Son to improve electrical conductivity through the use carbon nanotubes. *See* LGES-1005, [0073]; LGES-1008, [0007]; LGES-1003, ¶93.

(xi) **Claim 11**

[11]

As an initial matter, Petitioner notes that element [11] is directed to narrower limitations concerning “electrolyte material or separator film,” which were only mentioned as being one of several optional uses in the preamble of claim 1.

LGES-1001, Claim 1. While claim 11 arguably narrows the type of electrolyte material/separator film, it does not actually require the use of such electrolyte material/separator film. Nor can the intended use as merely stated in the preamble be considered to be a limitation. *See Pitney Bowes*, 182 F.3d at 1305 (Fed. Cir. 1999). Indeed, it is only later in claim 15 where “electrolyte” is positively recited as a limiting feature. LGES-1001, Claim 15. Thus, there is no need to reach the optional limitation of claim 10 related to a binder material, and Bosnyak-392-Son, as discussed above for claim 1, therefore also satisfies claim 11. LGES-1003, ¶94.

Moreover, as explained for element [10] (incorporated herein), a POSITA would have recognized that the recited “charge transfer resistance of less than or equal to about 10 million ohm-m” is an extremely broad range that is likely to be

satisfied by any material where, as in Bosnyak-392-Son, improved conductivity (*i.e.*, reduced resistivity) is desired. *See* LGES-1005, [0073]; LGES-1008, [0007]; LGES-1003, ¶¶95-96. For example, it was already well known to use carbon nanotubes in an electrolyte for improved conductivity. *See, e.g.*, LGES-1016, 1872; LGES-1003, ¶95. Such electrolyte materials made with carbon nanotubes typically have conductivity ranges from approximately 10^{-6} Siemens/cm to 10^{-5} Siemens/cm. LGES-1016, 1875, FIG. 2; LGES-1003, ¶95. Given the inverse relationship between conductivity and resistance, these conductivity values correspond to a charge transfer resistance of 1000 to 10,000 ohm-m, which is far less than 10 million ohm-m and thus fall within the claimed limitation. LGES-1003, ¶¶94-96.

(xii) **Claim 12**

[12]

Bosnyak-392-Son renders obvious [12]. For example, Bosnyak-392 describes that “the carbon nanotubes may be further oriented in an alignment step after isolating the exfoliated carbon nanotubes.” LGES-1005, [0048]; *see also id.*, [0068], [0086]; LGES-1003, ¶97.

(xiii) **Claim 13**

[13]

Bosnyak-392-Son renders obvious [13]. For example, Bosnyak-392 describes that “exfoliated carbon nanotubes can be aligned in forming electrodes for use in the energy storage devices” and that such orientation/alignment “may occur through melt *extrusion*.” LGES-1005, [0086]; LGES-1003, ¶98. Bosnyak-392 further describes that the exfoliated carbon nanotubes, which may be oriented/aligned, may further be “shaped into a form such as, for example, a mat, film, fiber, cloth, non-woven fabric or felt.” LGES-1005, [0048]; LGES-1003, ¶98.

(xiv) **Claim 14**

[14]

Bosnyak-392-Son renders obvious [14]. For example, Bosnyak-392 describes that orientation can occur in a post-fabrication step “after isolating the exfoliated carbon nanotubes” and further that “the exfoliated carbon nanotubes may also be used in fabrication and assembly techniques including, for example ... thermoforming[.]” LGES-1005, [0048], [0037]; LGES-1003, ¶99.

(xv) **Claim 15**

[15]

Bosnyak-392-Son renders obvious [15]. For example, Bosnyak-392 discloses composite materials in which exfoliated carbon nanotubes are mixed with electrolyte. *See* LGES-1005, [0074], [0076], [0077]; LGES-1003, ¶91. Bosnyak-392 further discloses that “[o]rganic electrolytes such as, for example tetraethylammonium tetrafluoroborate and tetrabutylammonium tetrafluoroborate, can simultaneously serve as an electrolyte and surfactant for dispersing and exfoliating carbon nanotubes in embodiments where carbon nanotubes are contained in the electrolyte.” LGES-1005, [0081]; LGES-1003, ¶100.

(xvi) **Claim 16**

[16]

Bosnyak-392-Son renders obvious [13]. For example, Bosnyak-392 describes that “the electrolyte of the energy storage devices can be a solid or a fluid,” including “[a]queous electrolytes such as potassium hydroxide or sulfuric acid.” LGES-1005, [0081]. Bosnyak-392 further describes that “electrolytes can be of a polymer-gel type such as, for example, polyurethane-lithium perchlorate, polyvinyl alcohol-KOH-HaO and the related systems.” *Id.*; LGES-1003, 101.

B. [GROUND 1B] – CLAIM 4 IS OBVIOUS OVER BOSNYAK-392, SON, AND SO

Although, as described above in Ground 1A, Bosnyak-392-Son renders obvious claim 4, claim 4 is additionally rendered obvious in further view of So. LGES-1003, ¶¶102-105. To clarify, in addition to the application of Bosnyak-392-Son found in Ground 1A, it is revealed below how a POSITA would have additionally found claim 4 obvious in further view of So (“Bosnyak-392-Son-So”). In Bosnyak-392-Son-So, Bosnyak-392 and Son are applied in a similar manner to that discussed above in Section IV.A. Indeed, all of the analysis and citations to Bosnyak-392 and Son presented in Section IV.A apply equally to Ground 1B.

So is directed to a “nanocarbon composite material” having “excellent properties.” LGES-1014, [0018]. More specifically, So describes a composite material where “carbon nanotubes or carbon nanofibers ... are interconnected by carbon to form a three-dimensional network, and the voids in the porous material are impregnated with a resin, rubber, metal, or carbon-based material.” *Id.* Here, the “carbon” material that helps provide a “strongly bonded” structure can be “selected from among *fullerenes, carbon black*, cut carbon nanofibers, and cut carbon nanotubes[.]” *Id.*; *see also id.*, [0001], [0002], [0010], [0011], [0021], Fig. 1; LGES-1003, ¶103. As a result, “excellent electrical conductivity and mechanical properties” can be imparted to carbon nanotube composite materials. LGES-1014, [0002]; LGES-1003, ¶103.

A POSITA would have been motivated to further modify the Bosnyak-392-Son combination in view of So to provide “excellent electrical conductivity and mechanical properties” as per So’s teachings. LGES-1014, [0002]; LGES-1003, ¶104. Indeed, Bosnyak-392, similar to So, is directed to the use of a composite material having discretely dispersed carbon nanotubes to improve electrical and mechanical properties. *See* LGES-1005, [0006], [0087], [0105]; LGES-1003, ¶104.

By including additional carbon-based fillers such as fullerenes and carbon black, such as per So, into the nanotube composite of Bosnyak-392-Son, a POSITA would have recognized that the electrical/mechanical properties of Bosnyak-392-Son’s nanocomposite material can be further improved through enhanced bonding provided by Son’s fillers. LGES-1014, [0009], [0011], [0025]; LGES-1003, ¶105.

A POSITA would have been further prompted to pursue this implementation of Bosnyak-392-Son’s nanocomposite material by including the carbon-based fillers of So as doing so is merely the application of known techniques (*e.g.*, use of carbon-based fillers in a composite material containing discrete carbon nanotubes) to a known structure (*e.g.*, composite material containing discrete carbon nanotubes) to yield predictable results (*e.g.*, improved electrical/mechanical properties). LGES-1003, ¶105; *see KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398,

417 (2007). And a POSITA would have expected success in the Bosnyak-392-Son-So combination given that both Bosnyak-392 and So already describe using carbon-based fillers among its carbon nanotube structure for improved electrical/mechanical properties. *See* LGES-1005, [0058]; LGES-1014, [0018]; LGES-1003, ¶105.

C. [GROUND 1C] – CLAIM 11 IS OBVIOUS OVER BOSNYAK-392, SON, AND GU

Although, as described above in Ground 1A, Bosnyak-392-Son renders obvious claim 11, the limitations of claim 11 are further rendered obvious in view of Gu. LGES-1003, ¶¶106-107. To clarify, in addition to the application of Bosnyak-392-Son found in Ground 1A, a POSITA would have additionally found claim 11 obvious in further view of Gu (“Bosnyak-392-Son-Gu”)

In Bosnyak-392, it is disclosed that carbon nanotubes can be used to make electrolytes and further that there is a need to increase electrolyte conductivity (*i.e.*, lower the charge transfer resistance) for improved performance. LGES-1005, [0006], [0034]; LGES-1003, ¶107. While Bosnyak-392 doesn’t describe specific ways of making CNT-containing electrolyte to increase conductivity or what conductivity levels would be considered to be “improved,” a POSITA would have recognized that Gu fills in such details. LGES-1003, ¶107. For example, Gu teaches adding carbon nanotubes into an electrolyte material for numerous benefits, including increasing ionic conductivity of such electrolytes by up to two

orders of magnitude. *See* LGES-1016, 1872; LGES-1003, ¶107. And, as described above in Section IV.A.4, Gu further provides example conductivity (and thus charge transfer resistance) values that a POSITA can aim for in order to achieve “improved” conductivity for lithium-ion battery applications. LGES-1003, ¶107. Thus, a POSITA would have been motivated to incorporate Gu’s “PEO/PAA/PEO/(PAA + MWNT) electrolyte” composition and/or looked to emulate Gu’s CNT-enabled charge transfer resistance values of 1000~10000 ohm-m in designing Bosnyak-392-Son’s CNT-based electrolyte with improved conductivity. LGES-1016, 1875; LGES-1003, ¶107.

D. [GROUND 2A] – CLAIMS 1, 5-9, AND 12-16 ARE OBVIOUS OVER BOSNYAK-129 IN VIEW OF ALBUERNE

1. Overview of Bosnyak-129

Bosnyak-129, filed by two of the named inventors of the ’282 Patent, is a PCT publication published on December 29, 2011 (*i.e.*, more than one year from the earliest possible priority date of June 21, 2013). Bosnyak-129 purports to provide “exfoliation and dispersion of ... surface-modified carbon nanotubes that are readily dispersed in various media.” LGES-1006, Abstract, [0002]. The

nanotubes can be “single wall, double wall or multiwall carbon nanotube fibers”⁷ and “can have oxidation species comprising of carboxylic acid or derivative carboxylate groups.” *Id.*, [0007]; *see also id.*, [0064]-[0065]. These carboxylate groups can be formed on the sidewalls using an acid treatment (*e.g.*, using a sulfuric and nitric acid mixture). *See* LGES-1006, [0012], [0076], [0154]-[0155]; LGES-1003, ¶109.

Bosnyak-129 further discloses that its carbon nanotubes can be used to make “improved energy storage devices and particularly ... batteries having components containing exfoliated carbon nanotubes” to make “improved energy storage devices [that] include components such as, for example, current collectors, electrodes, insulators, electrolytes and separators containing exfoliated carbon nanotubes.” LGES-1006, [0131]; LGES-1003, ¶110.

For example, Figure 3 of Bosnyak-129 shows “an illustrative arrangement of the basic elements of a battery.” LGES-1006, [0134]. The battery includes “electrodes 21 and 23[, and] electrolyte 22.” *Id.* “In some embodiments, at least

⁷ Bosnyak-129 utilizes the terms “carbon nanotubes” and “carbon nanotube fibers” interchangeably. *See* LGES-1006, [0007] (“a plurality of carbon nanotubes is disclosed comprising single wall, double wall or multiwall carbon nanotube fibers...”), [0064].

one of the electrodes contains exfoliated carbon nanotubes.” *Id.* “In some embodiments, the electrolyte contains exfoliated carbon nanotubes.” *Id.* “The electrolyte 22 conveys ions [such as lithium ions] between electrodes 21 and 23.” *Id.*

Moreover, as shown in the file history of the counterpart European Patent, the Applicant did not contest the EPO International Preliminary Examining Authority’s finding based on Bosnyak-129. Specifically, the Authority noted:

[Bosnyak-129] is regarded as being the prior art closest to the subject-matter of claim 1, and discloses (the references in parentheses applying to this document) a composition *suitable* for use as a binder material, an electrolyte material or a separator film material of an energy storage or collection device, comprising: a plurality of discrete carbon nanotube fibers, said fibers having an aspect ratio of from about 10 to about 500 (cf. [7] and [64]), and wherein at least a portion of the discrete carbon nanotube fibers are open ended (cf. [8]).

LGES-1025, 79, 90, 114. In fact, the specification of the European Patent was amended to explicitly include the following statement in the Background section of the application.

①

Document WO 2011/163129 discloses a composition for use as a binder material, an electrolyte material or a separator film material of an energy storage or collection device, comprising: a plurality of discrete carbon nanotube fibres, said fibres having an aspect ratio of from about 10 to about 500 where at least a portion of the discrete carbon nanotube fibres are open ended.

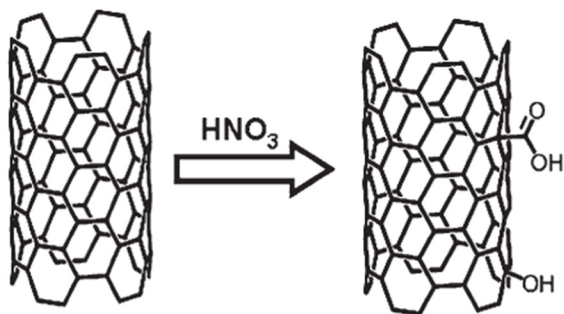
LGES-1025, 28; LGES-1006, [0017].

2. Overview of Albuerne

Albuerne discloses techniques to incorporate commercially available carbon nanotubes into composite materials, namely polymer matrices. LGES-1009, Abstract, 1035. To make such materials, Albuerne explains the need to improve the dispersion of the carbon nanotubes. *Id.*, 1035 (“Different strategies have been used to reduce the size of the aggregates or to improve the dispersion of individual carbon nanotubes.”); LGES-1003, ¶111.

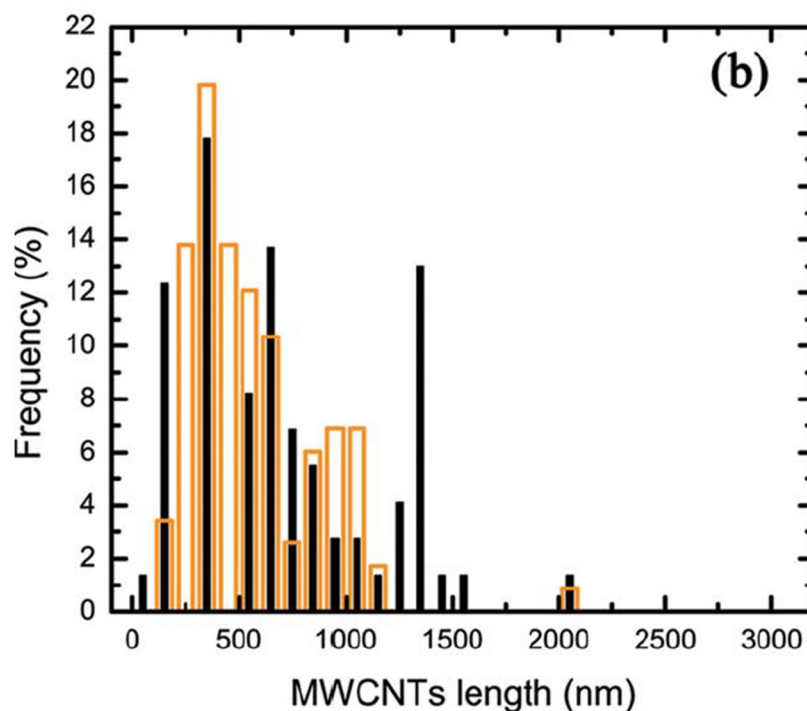
One of the techniques Albuerne relies on as part of its overall strategy to form nanotubes-polymer composites in which the nanotubes are well-dispersed in the polymer is to first oxidize the commercially available nanotubes. Specifically, Albuerne teaches an acid treatment step using nitric acid (HNO₃) followed by sonification that forms carboxylate groups on the sidewalls of commercially available multiwall carbon nanotubes from FutureCarbon GmbH having a mean diameter of 15 nm (denoted as “MWCNT_{FC}⁹⁹”). LGES-1009, 1036. Albuerne

illustrates the oxidation of carbon nanotubes (denoted as “ $\text{oxidMWCNT}_{\text{FC}}^{99}$ ”) as the following:



LGES-1009, Figure 1 (cropped); LGES-1003, ¶112.

Albuerne separated the dispersed nanotubes having the carboxylate groups from those that remain aggregated, and studied the length distribution of the discrete carbon nanotubes using scanning force microscopy (SFM). LGES-1009, 1039-1040. The length distribution for $\text{MWCNT}_{\text{FC}}^{99}$ is shown below in orange:



LGES-1009, Figure 5(b); LGES-1003, ¶113.

3. Combination of Bosnyak-129 and Albuerne

A POSITA would have been motivated to combine Bosnyak-129 with Albuerne for various reasons. For example, it would have been obvious to interchangeably use a nitric acid treatment step such as that discussed in Albuerne as one of the possible “acidic solution” discussed in Bosnyak-129 (LGES-1006, [0011]) to achieve the well-known recognized benefit of an improved preservation of the carbon nanotubes’ structures and lengths. LGES-1003, ¶¶114-115. The combination would have been a simple substitution of one known element (e.g., sulfuric and nitric acid solution in Bosnyak-129) for another (e.g., nitric acid solution taught by Albuerne) to obtain predictable results of obtaining discrete

oxidized carbon nanotubes having longer carbon nanotubes. *Id.* Indeed, Bosnyak-129 suggests that the electrical and mechanical properties of a nanotube composition can be improved by avoiding “carbon nanotube damage and shortened carbon nanotube lengths.” LGES-1006, [0130]. A POSITA would have been motivated to apply Bosnyak-129’s through Albuerne’s “chosen acid treatment” using nitric acid that “preserve[s] the carbon nanotubes ... without cutting the length of the carbon nanotubes or lo[]sing any of the walls.” LGES-1009, 1038. Thus, a POSITA would have turned to Albuerne and used its nitric acid treatment in obtaining Bosnyak-129’s discrete carbon nanotube fibers. LGES-1003, ¶115. And because the combination is a simple substitution between Bosnyak-129’s and Albuerne’s acid solution to achieve the same exfoliated carbon nanotubes that have carboxylic acid/carboxylate groups, a POSITA would have been able to make the modification. *Id.* Indeed, Bosnyak-129 itself notes that “one of ordinary skill in the art can easily ascertain the essential characteristics of this disclosure, and without departing from the spirit and scope thereof, can make various changes and modifications to adapt the disclosure to various usages and conditions.” LGES-1006, [0160]; LGES-1003, ¶116.

At a minimum, it would have been obvious to try to incorporate an acid treatment and discrete oxidized MWCNT_{FC}⁹⁹, such as those disclosed by Albuerne, into Bosnyak-129’s composition. As described above, a POSITA would have

recognized the need to use carbon nanotubes in a composition with improved dispersion, mechanical, or electrical properties, and would have appreciated the number of treatment methods identified in Bosnyak-129 and Albuerne. LGES-1003, ¶117.

A POSITA would further have had a reasonable expectation of success in applying Albuerne's teachings into Bosnyak-129's composition because (1) both references teach oxidizing carbon nanotubes using the similar acid solution and sonication techniques to disperse carbon nanotubes; and (2) Albuerne merely teaches specific steps for oxidation utilizing specific carbon nanotubes from particular manufacturers (e.g., MWCNT_{FC}⁹⁹ from FutureCarbon GmbH). LGES-1003, ¶118.

4. Analysis

(i) Claim 1

[1pre]

To the extent the preamble is limiting, Bosnyak-129 discloses the preamble. LGES-1003, ¶¶119-120. Bosnyak-129 describes a composition for “improved *energy storage devices [that] include* components such as, for example, current collectors, *electrodes*, insulators, *electrolytes and separators containing exfoliated carbon nanotubes.*” LGES-1006, [0131]. Bosnyak-129 explains “mix[ing], blend[ing], sonicat[ing], or a combination thereof” its carbon nanotube fibers “with

at least other material to form a **material/nanotube fiber composition.**” *Id.*,

Claim 33; *see also id.*, Abstract, [0002] (Bosnyak-129 “relates to the exfoliation and dispersion of carbon nanotubes resulting in high aspect ratio, surface-modified carbon nanotubes that are readily dispersed in various media”). Bosnyak-129 discloses a carbon nanotube containing composition for use as a binder, electrolyte material, or a separator film material of an energy storage or collection device. LGES-1006, [00131]; LGES-1003, ¶119.

For example, Bosnyak-129 teaches a composition for use as a binder material of an energy storage or collection device. LGES-1003, ¶120. At the outset, the ’282 Patent admits that electrodes are often made using binders. LGES-1001, 1:62-2:1 (“**Binder** such as polyacrylic acid (PAA), **for cathodes**, poly(styrene butadiene), carboxymethylcellulose (CMC), styrene-butadiene (SBR), **for anodes**, and particularly polyvinylidene fluoride (PVDF) **for cathodes and anodes**, are used in lithium based batteries to hold the active material particles together and to maintain contact with the current collectors i.e., the aluminum (Al) or the copper (Cu) foil.”), 2:6-11 (“A **cathode electrode** of a lithium ion battery is typically made by mixing active material powder, such as lithium iron phosphate, **binder** powder, i.e., high molecular weight PVDF, solvent such as NMP if using PVDF, and additives such as carbon black, into a slurry (paste) and pumping this slurry to a coating machine.”), 2:34-36 (“For a lead-acid battery the **anode** can be

made from carbon particles together with *a binder* to provide higher specific capacity (capacity per unit weight).”). Similarly, Bosnyak-129 explains that the carbon nanotubes may be “associated or functionalized with an electroactive material.” LGES-1006, [0092]. “[T]he electroactive material may be a conducting polymer such as, for example, polyaniline, polyvinylpyrrole or polyacetylene.” *Id.* Bosnyak-129 discloses using exfoliated carbon nanotubes for electrodes (e.g., LGES-1009, [0134]), which was well known to be made from a composition comprising a binder material (LGES-1001, 1:62-2:1, 2:6-14, 2:34-36 (Applicant Admitted Prior Art)). Accordingly, Bosnyak-129 teaches a composition with exfoliated carbon nanotubes for use as a binder material. LGES-1003, ¶120.

Bosnyak-129 also discloses a composition for use as an electrolyte material of an energy storage or collection device. LGES-1003, ¶121. Bosnyak-129 provides “improved energy storage devices includ[ing] *electrolytes* ... containing exfoliated carbon nanotubes.” LGES-1006, [0131] (“The improved energy storage devices also include a dielectric medium or *electrolyte*, each optionally including carbon nanotubes.”), [0159] (“Exfoliated carbon nanotube capacitor: The capacitor was prepared as for control 1, except oxidized multi-wall carbon nanotubes were used in place of as- received multi-wall carbon nanotubes [added to the electrolyte mixture].”). Accordingly, the electrolyte of the “improved energy storage device” is formed using a composition that includes “exfoliated carbon nanotubes.” *Id.*,

[0131], [0037] (“In various embodiments, compositions of fully and high aspect ratio exfoliated carbon nanotubes are disclosed herein.”), [0138]; LGES-1003, ¶121.

Finally, Bosnyak-129 also discloses a composition for use as a separator film material of an energy storage or collection device. LGES-1003, ¶122. Bosnyak-129 provides “improved energy storage devices includ[ing] ... *separators* containing exfoliated carbon nanotubes.” LGES-1006, [0131] (“The improved energy storage devices also include a *dielectric medium* or electrolyte, each optionally including carbon nanotubes. Accordingly, the separator film of the “improved energy storage device” is formed using a composition that includes “exfoliated carbon nanotubes.” *Id.*, [0131], [0037] (“In various embodiments, compositions of fully and high aspect ratio exfoliated carbon nanotubes are disclosed herein.”), [0138]; LGES-1003, ¶122.

[1a-i]

Bosnyak-129-Albuerne renders obvious this limitation. LGES-1003, ¶¶123-127. As an initial matter, during prosecution, the Examiner interpreted the term “discrete carbon nanotube fibers” to be synonymous with “exfoliated carbon nanotubes.” LGES-1002, 124. Applicant did not rebut that interpretation. Under that understanding, Bosnyak-129 discloses a plurality of exfoliated carbon nanotubes. *See, e.g.*, LGES-1006, [0037] (“In various embodiments, compositions

of fully and high aspect ratio exfoliated carbon nanotubes are disclosed herein.”), [0038], (“In other various embodiments, methods for preparing exfoliated carbon nanotubes are disclosed herein.”), [0043] (“In still other various embodiments, energy storage devices containing exfoliated carbon nanotubes are disclosed herein.”), [0092], [0131], [0134], [0138], [0140], Claim 33.

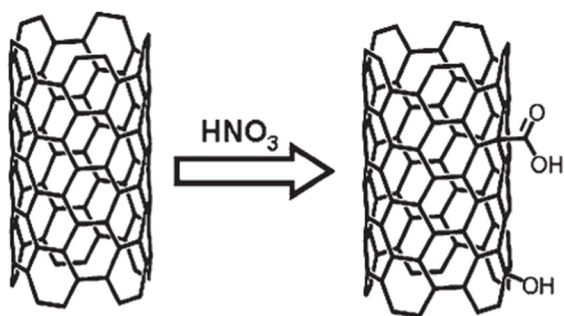
Indeed, Bosnyak-129 also appears to utilize the terms “carbon nanotube” and “carbon nanotube fibers” interchangeably. For example, Bosnyak-129 explains that “[i]n various embodiments, a plurality of *carbon nanotubes* is disclosed comprising single wall, double wall or multiwall *carbon nanotube fibers*” and that “[t]he fibers can have oxidation species comprising of carboxylic acid or derivative carboxylate groups and are essentially *discrete individual fibers*, not entangled as a mass.” LGES-1006, [0007]; *see also id.*, [0064]-[0065]; LGES-1003, ¶123.

At any rate, Bosnyak-129 explicitly teaches a plurality of “discrete carbon nanotube fibers.” *See* LGES-1006, [0011] (“In another embodiment, a method for preparing carbon nanotube fibers is disclosed, said method comprising suspending entangled non-discrete multi-wall carbon nanotube fibers in an acidic solution, optionally agitating said composition, sonically treating said suspended nanotube fiber composition to form *discrete carbon nanotube fibers*.”); LGES-1003, ¶124.

Bosnyak-129 further discloses that the discrete carbon nanotube fibers can be obtained by contacting the carbon nanotubes with an acid solution and sonicating them. LGES-1006, [0011] (“In another embodiment, a method for preparing carbon nanotube fibers is disclosed, said method comprising suspending entangled non-discrete multi-wall carbon nanotubes fibers in an acidic solution, optionally agitating said composition, sonically treating said suspended nanotube fiber composition to form discrete carbon nanotube fibers...”), [0012] (“In another embodiment, the method for preparing carbon nanotube fibers include an acidic solution which comprises a solution of sulfuric acid and nitric acid wherein the nitric acid is present in a dry basis of from about 10 wt% to about 50 wt%...”), [0071], [0076], [0154]-[0155]. Bosnyak-129 teaches that the acid treatment leads to oxidation of the nanotubes that have carboxylic acid/carboxylate groups. *Id.*, [0007] (“[T]he fibers can have oxidation species comprising of carboxylic acid or derivative carboxylate groups and are essentially discrete individual fibers, not entangled as a mass.”), [0065] (similar), Claim 3 (“wherein the oxidation species comprises carboxylic acid or derivative carboxylate groups”); LGES-1003, ¶124.

Like Bosnyak-129, Albuerne teaches oxidizing carbon nanotubes using an acid treatment to form carboxylic acid/carboxylate groups. Specifically, Albuerne teaches a “typical experiment” in which a nitric acid solution is used with an ultrasonication bath to form carboxylic acid groups on the carbon nanotubes.

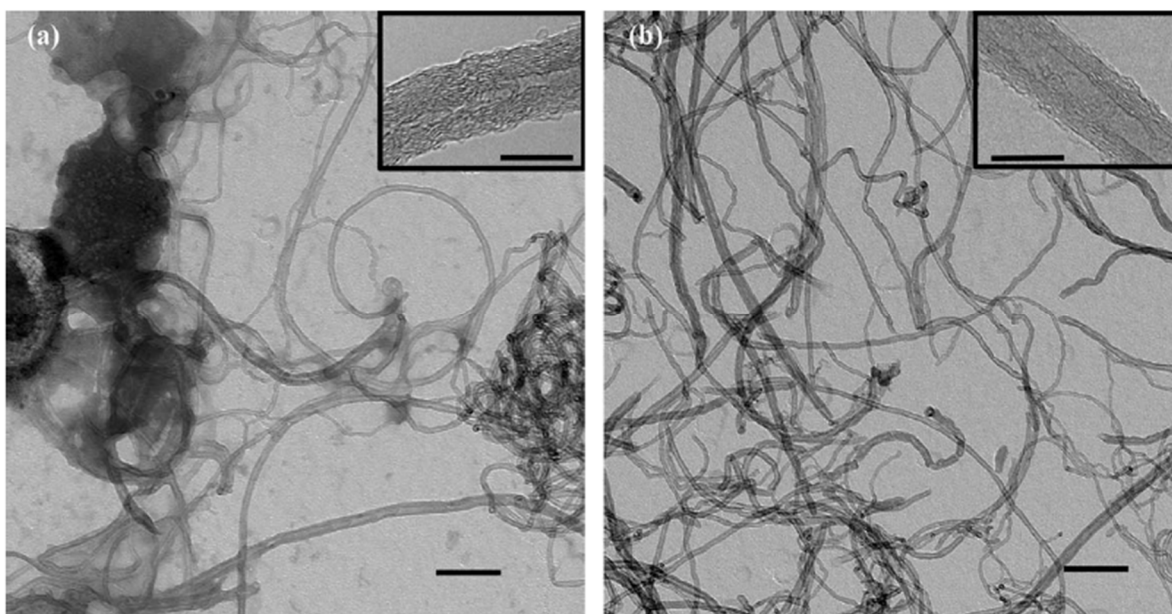
LGES-1009, 1036, 1040; LGES-1003, ¶125. This is schematically illustrated in Figure 1 of Albuerne (reproduced below).



LGES-1009, Figure 1 (cropped).

Indeed, Albuerne explains that such oxidation of carbon nanotubes can cause exfoliation and lead to improved dispersibility while preserving the carbon nanotube structure. *See* LGES-1009, 1040 (“After the acid treatment ... [t]he carbon nanotube length distribution is slightly shifted to higher values after the acid treatment, which could indicate that the reaction unbundles longer carbon nanotubes from the aggregates.”; *id.*, 1041 (“[T]he oxidation reaction using HNO₃ unbundles more efficiently the MWCNT_{FC}⁹....”). Albuerne compares using TEM images of the pristine (i.e., without acid treatment, below left) and oxidized (i.e., with acid treatment, below right) carbon nanotubes MWCNT_{BMS}⁹⁵ in Figure 1

(reproduced below).⁸ As shown below by the image on the right, the acid treatment is shown to debundle the nanotubes into individual exfoliated and dispersed state. In other words, Albuerne carried out acid treatment and sonication steps to obtain the carboxylate groups to obtain exfoliated carbon nanotubes, just as Bosnyak-129 similarly teaches. LGES-1003, ¶126.



LGES-1009, Figure 3.

Albuerne utilized a milder acidic treatment (using only nitric acid) than that described in Bosnyak-129 (using a mixture of sulfuric acid and nitric acid) because “stronger acids (like sulfuric acid) or air oxidation at high temperatures” can “lead

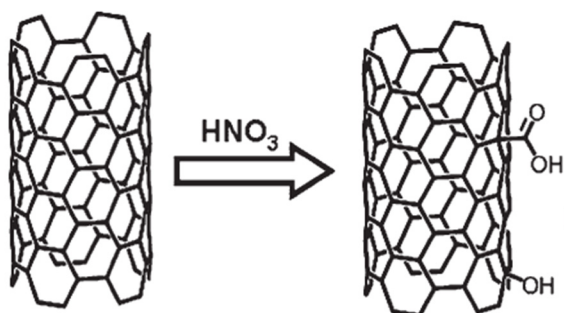
⁸ The TEM images for the corresponding MWCNT_{FC}⁹⁹ were “not shown.” LGES-1009, 1039.

to the destruction of the graphitic structure[and] reduction on the length” of the nanotubes. LGES-1009, 1038. And Albuerne teaches that the milder acid treatment was carried out “to preserve the carbon nanotubes ... without cutting the length of the carbon nanotubes or lo[osing any of the walls.” *Id*; LGES-1003, ¶127.

Thus, for at least the reasons discussed *supra* in Section IV.D.3 a POSITA would have found it obvious to interchangeably use the nitric acid treatment step discussed in Albuerne as one of the possible “acidic solution” discussed in Bosnyak-129 (LGES-1006, [0011]) to achieve the well-known recognized benefit of an improved preservation of the carbon nanotubes’ structures and lengths. LGES-1003, ¶127.

[1a-iii]

Bosnyak-129-Albuerne renders obvious this limitation. LGES-1003, ¶¶128-129. For example, Bosnyak-129 discloses that “carbon nanotube fibers having an aspect ratio of from about 25 to about 500” can include “open ended carbon nanotube fibers.” LGES-1006, Claims 1, 9; *see also id.*, [0008] (“The fibers can be *open-ended*.”), [0067] (“In another embodiment, the fibers can be *open-ended* to allow transport or storage of small molecules such as ethane or propane.”). Moreover, Albuerne’s schematic representation of the carbon nanotubes show open-ended carbon nanotubes. LGES-1003, ¶128.



LGES-1009, Figure 1 (cropped).

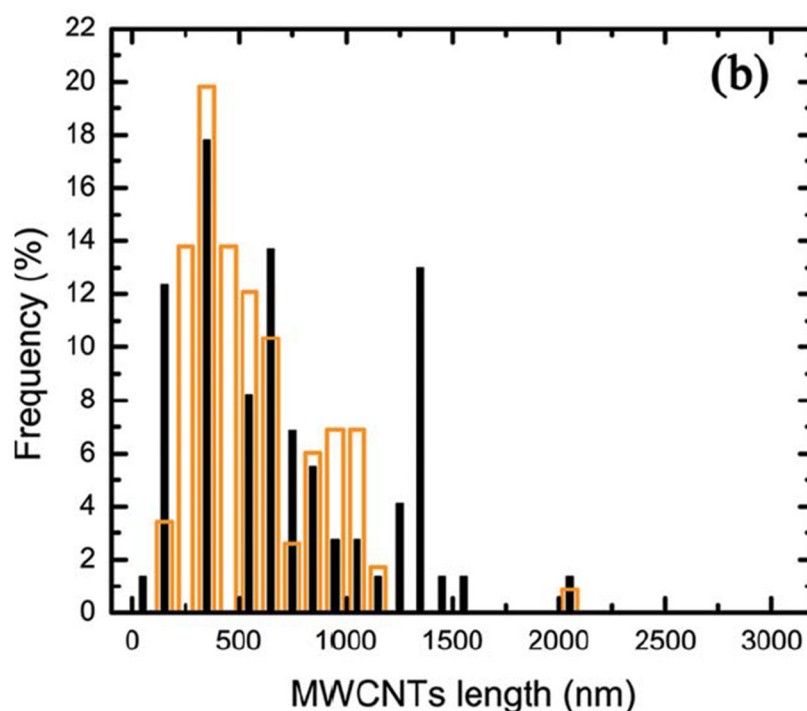
Moreover, it was well-known that a nitric acid treatment (as carried out by Albuerne) leads to opening the end of a nanotube. LGES-1026, [0044] (“The prepared carbon nanotube was refluxed in concentrated nitric acid, thereby opening an end of the nanotube.”). Accordingly, a POSITA would have understood that at least a portion of the discrete carbon nanotube fibers in Bosnyak-129/Albuerne’s composition are open-ended. LGES-1003, ¶129.

[1a-ii], [1b]

Bosnyak-129-Albuerne renders obvious these limitations. LGES-1003, ¶¶130-135. While Bosnyak-129 does not expressly disclose the specific percentage and aspect ratio ranges claimed, Albuerne teaches that discrete carbon nanotubes that were obtained by similar processing conditions would have had a distribution of aspect ratios that meet the claimed percentage ranges recited in these limitations. LGES-1003, ¶130.

As explained above, it would have been obvious to utilize the nitric acid and

sonication treatment steps taught by Albuerne to obtain the discrete carbon nanotube fibers discussed in Bosnyak-129. LGES-1003, ¶131. Taking the specific example of MWCNT_{FC}⁹⁹ taught by Albuerne, Albuerne shows, in orange outlines below, the length distribution of the oxidized MWCNT_{FC}⁹⁹ of the discrete nanotubes in Figure 5(b):

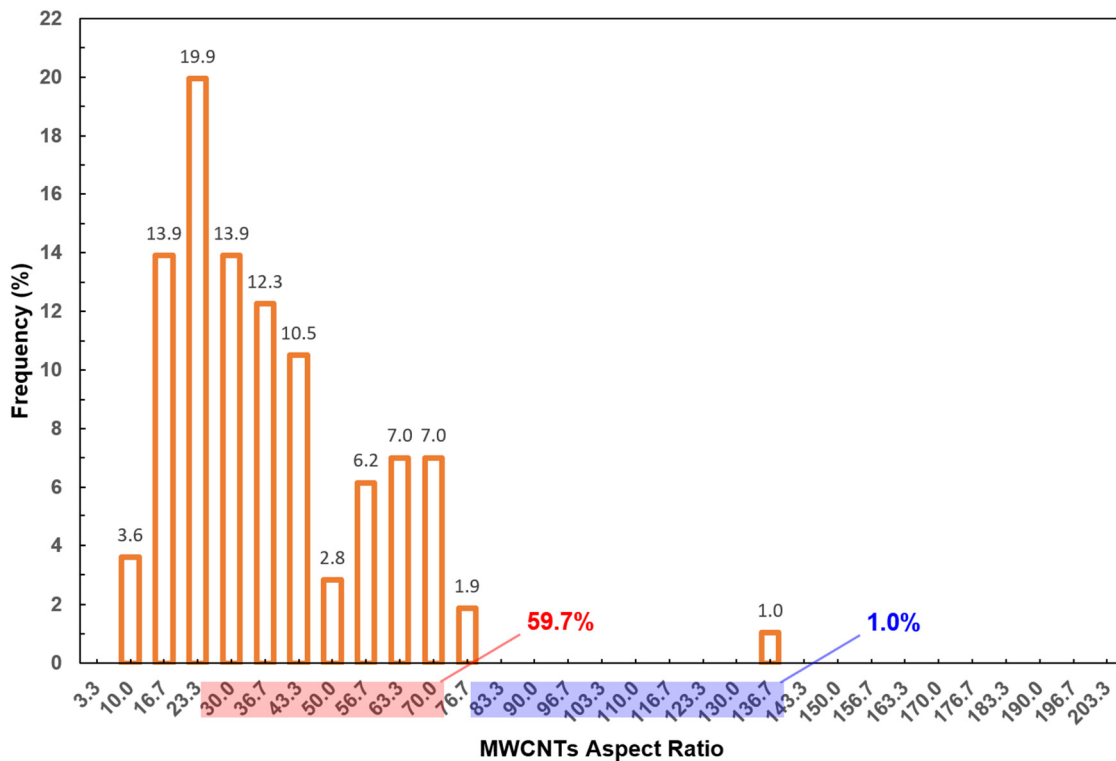


LGES-1009, Figure 5(b).

The length distribution was measured by scanning force microscopy (SFM) based on approximately 100 independent length measurements from different positions on silicon wafer that the nanotubes were deposited on. LGES-1009, 1039-1040. In other words, these lengths were measured only on those nanotubes

that were dispersed into solution as discrete nanotubes (and subsequently deposited onto the silicon wafer). The measurement did not count the ones that remain aggregated. LGES-1003, ¶132.

Given Bosnyak-129’s teaching that the aspect ratio is “the ratio of length of the nanotube to the diameter of the nanotube,” LGES-1006, [0007], a POSITA would have been able to readily calculate the aspect ratio distribution of the oxidized MWCNT_{FC}⁹⁹ utilizing Figure 5(b) by dividing the observed length with the external mean diameter of 15 nm disclosed by Albuerne (LGES-1009, 47). Specifically, a POSITA would have found that Albuerne’s oxidized MWCNT_{FC}⁹⁹ has the following aspect ratio distribution:



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

LGES-1003, ¶133.

Bosnyak-129 similarly discloses that “[i]n various embodiments, a plurality of carbon nanotubes is disclosed comprising single wall, double wall or multiwall *carbon nanotube fibers having an aspect ratio* (the ratio of length of the nanotube to the diameter of the nanotube) of from *about 25 to about 500*[]” LGES-1006, [0007], [0064], Claim 1 (“A plurality of carbon nanotubes comprising carbon nanotube fibers having an aspect ratio of from about 25 to about 500.”). Albuerne’s “disclosed range between 10 to 137” and Bosnyak-129’s “disclosed range of ‘about 25 to about 500’” overlap with the claimed range of “about 10 to about 500.” LGES-1003, ¶134. By disclosing an aspect ratio range that falls within the claimed range, both Bosnyak-129 and Albuerne disclose limitation [1b]. *See Titanium Metals Corp. v. Banner*, 778 F.2d 775, (Fed. Cir. 1985) (*citing In re Petering*, 301 F.2d 676, 682, (CCPA 1962) (“[W]hen, as by a recitation of ranges or otherwise, a claim covers several compositions, the claim is ‘anticipated’ if one of them is in the prior art.”); LGES-1003, ¶134.

Moreover, Albuerne's distribution teaches the specific percentages of the aspect ratio ranges claimed in limitations [1b].⁹ **First**, as shown in the above figure, the relative number (i.e., frequency) of discrete carbon nanotubes with an aspect ratio of 30-70 is 59.7%, which falls within the claimed range of "40% to 90% by number of the discrete carbon nanotubes have an aspect ratio of 30-70." LGES-1003, ¶135. **Second**, as shown in the above figure, the relative number of discrete carbon nanotubes with an aspect ratio of 80-140 is 1.0%, which falls within the claimed range of from "1% to 30% by number of discrete carbon nanotubes have an average aspect ratio 80-140." *Id.*

(ii) **Claims 5 and 6**

Bosnyak-129-Albuerne renders obvious [5] and [6]. For example, Bosnyak-129 teaches that the exfoliated carbon nanotubes are modified with electroactive materials that include a conductive polymer. LGES-1003, ¶136. Specifically, Bosnyak-129 teaches that "the exfoliated carbon nanotubes are modified with an electroactive material ... [that] that may be a conducting polymer such as, for example, polyaniline, polyvinylpyrrole or polyacetylene." LGES-1006, [0092],

⁹ Petitioner interprets "average aspect ratio" to mean "aspect ratio," which is consistent with how this term was interpreted during prosecution of the '282 Patent.

[0139]. As Bosnyak-129 notes, “[c]arbon nanotubes associated or functionalized with an electroactive material may be particularly advantageous for applications involving electrical conductivity,” *id.*, [0092], which is one of the properties a POSITA would have been concerned with in a lithium-ion battery application. LGES-1003, ¶136.

(iii) **Claim 7**

Bosnyak-129-Albuerne renders obvious [7]. For example, Bosnyak-129 discloses that “[i]n various embodiments, the bundled and/or exfoliated carbon nanotubes may include, for example, ... functionalized carbon nanotubes.” *See, e.g.*, LGES-1006, [0090], [0091], [0092] (“[T]he carbon nanotubes may be further associated or functionalized with an electroactive material.... Carbon nanotubes associated or *functionalized with an electroactive material* may be particularly advantageous for applications involving electrical conductivity.”), [00102], [00121]. LGES-1003, ¶137.

(iv) **Claim 8**

Bosnyak-129-Albuerne renders obvious [8]. For example, Bosnyak-129 discloses dispersion aids including surfactants “for resuspension include, for example, both ionic and non-ionic surfactants, such as, for example, polyvinyl pyrrolidone, sodium dodecyl sulfate and PLURONICS.” *See, e.g.*, LGES-1006, [00107], [00109] (“Surfactants are well known in the carbon nanotube art to aid in

solubilization.... In various embodiments of the present disclosure, the surfactant may include, for example, sodium dodecyl sulfate, sodium dodecylbenzene sulfonate, or tetralkylammonium hydroxide.”), [00138] (“Electrolyte salts may also be used for dispersing the carbon nanotubes or maintaining exfoliated carbon nanotubes in an exfoliated state.”). LGES-1003, ¶138.

(v) **Claim 9**

Bosnyak-129-Albuerne renders obvious [9]. For example, Bosnyak-129 teaches that the discrete carbon nanotube fibers are interspersed between graphene. LGES-1006, [0088] (“In another embodiment the nanotube fibers are further mixed or blended and/or sonicated with at least one material and an inorganic nanoplate to form a material nanotube fiber and nanoplate composition. The materials can be elastomers, thermoplastics and thermosets. *The nanoplates can be*, for example, clays, transition metal containing phosphates or *graphene* structures. The nanoplates have an individual plate thickness less than 20nm. *The nanotube fibers of this invention can disperse between the individual nanoplates.*”). LGES-1003, ¶139.

(vi) **Claims 12-14**

Bosnyak-129-Albuerne renders obvious [12]-[14]. For example, Bosnyak-129 discloses that “the carbon nanotubes may be further oriented in an alignment step after isolating the exfoliated carbon nanotubes.” LGES-1006, [00106]; *see*

also id., [00125] (“[T]he carbon nanotubes in polymers ***can be oriented to be aligned*** by various methods known to those of ordinary skill in the art.”), [00140], [00142]; LGES-1003, ¶140.

Bosnyak-129 further discloses that “the alignment may occur through ***melt extrusion***.” LGES-1006, [00142]; *see also id.*, [00141] (“[C]o-extrusion of liquids or melts containing exfoliated carbon nanotubes through multilayer dies or multilayer generators may be used in making the energy storage devices of the present disclosure.”); LGES-1003, ¶141.

Moreover, Bosnyak-129 discloses that numerous different fabrication and assembly techniques (i.e., post fabrication methods) may be used, one of which includes thermoforming. *See* LGES-1006, [0089] (“[T]he oxidized and exfoliated carbon nanotubes may also be used in ***fabrication and assembly techniques*** including, for example, ink-jet printing, spraying, coating, melt extruding, ***thermoforming***, blow-molding, film blowing, foaming and injection molding.”), [0095]; LGES-1003, ¶142.

(vii) **Claims 15-16**

Bosnyak-129-Albuerne renders obvious [15]-[16]. For example, Bosnyak-129 discloses that, in relation to Figure 2, “electrolytes 13 and 15 can contain exfoliated carbon nanotubes, which may be exfoliated conductive carbon nanotubes in some embodiments.” LGES-1006, [00133], [00134], [00138],

[00143], [00159]; LGES-1003, ¶143.

Moreover, “the electrolyte of the energy storage devices can be a ... fluid” or “a polymer-gel type such as, for example, polyurethane-lithium perchlorate, polyvinyl alcohol-KOH-H₂O.” LGES-1006, [00138], [00159]; LGES-1003, ¶143.

**E. [GROUND 2B] – CLAIMS 2-4 AND 10-11 ARE OBVIOUS
OVER BOSNYAK-129 IN VIEW OF ALBUERNE AND GU**

1. Overview of Gu

Gu teaches utilizing carbon nanotubes to enhance the ionic conductivity for electrolytes in lithium ion batteries. *See* LGES-1016, Abstract (“To enhance the ionic conductivity in solid phase polyelectrolyte systems for lithium ion battery applications.... The improvement of ionic conductivity was attributed to ... (ii) the MWNT contribution in the interfacial region, and (iii) the preferential adsorption of lithium-ions along the carbon nanotubes.”); LGES-1003, ¶¶144-145. More specifically, Gu teaches that the improvement is likely attributable to the “improved ionic transport due to the MWNTs themselves.” *Id.*, 1878. Gu also discloses specific examples of electrolyte materials made with carbon nanotubes where the resulting conductivity ranges from approximately 10⁻⁶ Siemens/cm to 10⁻⁵ Siemens/cm. LGES-1016, 1875, FIG. 2.

2. Combination of Bosnyak-129, Albuerne, and Gu

A POSITA would have been motivated to further combine Bosnyak-129-Albuerne with Gu for various reasons. LGES-1003, ¶¶146-147. For example,

similar to Bosnyak-129, Gu is similarly directed to improving the performance of lithium ion batteries. Gu does so by incorporating carbon nanotubes in electrolytes, which is precisely one of the application Bosnyak-129 teaches.

LGES-1016, Abstract; LGES-1006, [00134]); LGES-1003, ¶146. Indeed, each of Bosnyak-129, Albuerne, and Gu contemplate utilizing carbon nanotubes that have been functionalized with carboxylic acid groups. *See* LGES-1006, [0007]; LGES-1009, Figure 1 (showing carbon nanotubes functionalized with carboxylic acid groups after nitric acid treatment); LGES-1016; LGES-1003, ¶146. The combination merely results in combining well-known components often found in lithium ion batteries in a known and predictable manner. LGES-1003, ¶147.

Hence, a POSITA would have had a reasonable expectation of success in incorporating Albuerne's exfoliated carbon nanotubes that were treated using nitric acid to include carboxylic acid groups as a component in an electrolyte (as per Gu and Bosnyak-129) to increase the ionic conductivity (as per Gu). *Id.*

3. Analysis

(i) Claim 2

Bosnyak-129-Albuerne-Gu renders obvious [2]. LGES-1003, ¶148. For example, Bosnyak-129 teaches that any of the energy storage device components, such as “current collectors, electrodes, insulators, electrolytes and separators contain[] exfoliated carbon nanotubes.” LGES-1006, [00131]. For example,

“electrolytes 13 and 15 can contain exfoliated carbon nanotubes, which may be exfoliated conductive carbon nanotubes.” *Id.*, [00133]. Bosnyak-129 further teaches that open-ended carbon nanotubes allow transport of small molecules. *See Id.*, [0067] (“In another embodiment, the fibers can be open-ended to allow transport or storage of small molecules such as ethane or propane.”). Bosnyak-129 does not explicitly teach that the open ended carbon nanotubes are ion conducting. LGES-1003, ¶148.

However, the fact that open-ended carbon nanotubes are ion conducting was well-known to a POSITA. LGES-1003, ¶149. For example, Gu teaches utilizing carbon nanotubes to enhance the ionic conductivity for electrolytes in lithium ion batteries. *See* LGES-1016, Abstract; LGES-1003, ¶149. Specifically, Gu teaches that the improvement is likely attributable to the “improved ionic transport due to the MWNTs themselves.” LGES-1016, 1878. And Gu attributed this to the increased adsorption and diffusion of the lithium ions through the open ends of the carbon nanotubes. *See id.* (“...diffusion to the interior of SWNTs occurred through open ends....”); LGES-1003, ¶149.

Moreover, when Examiner noted that this limitation was well-known (citing to Gu), Applicant did not rebut that rejection, and merely acquiesced. LGES-1002, 126 (“In the battery art, Gu teaches an electrolyte material comprising carbon nanotubes.... Gu further teaches that the nanotubes themselves may be ion

conducting (Section 3.3.3, 3rd paragraph).”), *id.*, *110* (amending claim 1 to incorporate subject matter indicated as having allowable subject matter without rebutting any of the other rejections).

(ii) **Claim 3**

Bosnyak-129-Albuerne-Gu renders obvious [3]. LGES-1003, ¶150. For example, Bosnyak-129 teaches that the exfoliated carbon nanotubes are modified with electroactive materials that include elements found in Groups 2 through 14 of the Periodic Table. Specifically, Bosnyak-129 teaches that “the exfoliated carbon nanotubes are modified with an electroactive material ...[of] a transition metal or transition metal oxide ... [that] include, for example, Ru, Ir, W, Mo, Mn, Ni, and Co.” LGES-1006, [00139]. These electroactive materials can be a “nanomaterial bound to the exfoliated nanotubes..., for example, SnO₂, Li₄Ti₅O₁₂, silicon nanotubes, silicon nanoparticles, and various combinations thereof.” *Id.*, [00139], [0092]. As Bosnyak-129 notes, “[c]arbon nanotubes associated or functionalized with an electroactive material may be particularly advantageous for applications involving electrical conductivity,” *id.*, [0092], which is one of the properties a POSITA would have been concerned with in a lithium-ion battery application. LGES-1003, ¶150.

(iii) **Claim 4**

Bosnyak-129-Albuerne-Gu renders obvious [4]. LGES-1003, ¶151. For example, Bosnyak-129 teaches that the carbon nanotube fibers are further mixed with graphene. LGES-1006, [0088] (“In another embodiment the nanotube fibers are further mixed or blended and/or sonicated with at least one material and an inorganic nanoplate to form a material nanotube fiber and nanoplate composition. The materials can be elastomers, thermoplastics and thermosets. *The nanoplates can be*, for example, clays, transition metal containing phosphates or *graphene* structures. The nanoplates have an individual plate thickness less than 20nm. *The nanotube fibers of this invention can disperse between the individual nanoplates.*”). LGES-1003, ¶151.

(iv) **Claims 10-11¹⁰**

Bosnyak-129-Albuerne-Gu renders obvious [10]-[11]. LGES-1003, ¶¶151-154. For example, regarding [10], a POSITA would have recognized that the recited “impedance of less than or equal to about one billion ohm-m” is an extremely broad range that is likely to be satisfied by any material where, as in

¹⁰ For the reasons discussed *supra* for Ground 1A, Petitioner maintains that claims 10 and 11 do not further narrow independent claim 1 and are thus rendered obvious by Bosnyak-129-Albuerne for reasons discussed for claim 1.

Bosnyak-129-Albuerne, improved conductivity is desired. LGES-1003, ¶152.

Indeed, Bosnyak-129 describes that a matt made of nanotubes can have a conductivity of “at least 0.1 Siemens/cm and as high as 100 Siemens/cm.” LGES-1006, [0008]. Such levels of conductivity corresponds to an impedance of 0.0001 ohm-m to 0.1 ohm-m, which is far less than the claims value of one billion ohm-m. LGES-1003, ¶152.

Similarly, with regard to [11], a POSITA would have recognized that the recited “charge transfer resistance of less than or equal to about 10 million ohm-m” is also an extremely broad range that is likely to be satisfied by any material where, as in Bosnyak-129-Albuerne, improved conductivity (*i.e.*, reduced resistivity) is desired. LGES-1003, ¶153. Again, Gu describes the use of carbon nanotubes in an electrolyte for improved conductivity. LGES-1016, 1872; LGES-1003, ¶153. Additionally, Gu discloses specific examples of electrolyte materials made with carbon nanotubes where the resulting conductivity ranges from approximately 10^{-6} Siemens/cm to 10^{-5} Siemens/cm. LGES-1016, 1875, FIG. 2; LGES-1003, ¶85. Given the inverse relationship between conductivity and resistance, these conductivity values correspond to a charge transfer resistance of 1000 to 10000 ohm-m, which is far less than 10 million ohm-m and thus fall within the claimed limitation. LGES-1003, ¶¶153.

Thus, at a minimum, it would have been obvious to modify the Bosnyak-129/Albuerne composition to have the conductivity values taught by Gu. *See* LGES-1016, 1875 (“[PEO/PAA/PEO/(PAA + MWNT)]_m LBL films provide thickness-normalized ionic conductivity values of 10^{-5} S cm⁻¹ for ultrathin films and 10^{-6} S cm⁻⁸ for undoped bulk films, while the corresponding values for [PEO/PAA]_n films are 10^{-7} S cm⁻¹ and 10^{-9} S cm⁻¹...[I]_n the presence of lithium triflate dopant, the tri-component (MWNT) system shows relatively stable ionic conductivity on the order of 10^{-5} S cm⁻¹ over a broad range of thicknesses.”). Among other things, a POSITA would have understood to use the “the presence of the MWNTS[with] ... their *carboxylic acid moieties*” to obtain conductivity values that would have provided a composition that met limitations [10] and [11]. *See id.*, 1878; LGES-1003, ¶¶154.

V. PTAB DISCRETION SHOULD NOT PRECLUDE INSTITUTION

A. The *Fintiv* Factors Favor Institution—§314(a)

The Board should not discretionarily deny based on the *Fintiv* factors.

Factor 1 is neutral; neither party has requested a stay in co-pending litigation.

Factor 2 is neutral based on an expected Final Written Decision date in December 2025, which is within a few weeks of the likely trial date. In particular, the median time-to-trial date for EDTX is currently 21.4 months, which would

suggest a likely trial date in November 2025. *See*

https://www.uscourts.gov/sites/default/files/fcms_na_distprofile1231.2023_0.pdf,

35. Moreover, the Court set the trial date for December 2025. *See generally* LGES-1028.

Factor 3 favors institution; Petitioner has diligently filed this Petition months ahead of the one-year time bar, while the EDTX litigation is still in its early stages and investment minimal.

Factor 4 favors institution; if the Board institutes trial, Petitioner stipulates not to seek resolution in the district court of the same grounds presented in this Petition.

Factor 5 is neutral; parties in the parallel litigation are the same.

Factor 6 favors institution; the Petition presents a compelling case of invalidity.

B. The *Advanced Bionics* Test Favors Institution—§ 325(d)

The grounds advanced in this Petition are based on six prior art references: Bosnyak-392, Bosnyak-129, Son, So, Albuerne, and Gu. Four of the six—namely, Bosnyak-129, Son, So, and Albuerne—were neither cited nor relied upon during prosecution of the '282 Patent. *See* LGES-1002, 118-131. Although Gu and CA2747728, which corresponds to Bosnyak-392, were relied upon during

prosecution for some of the rejections, discretionary denial based on this fact is improper under *Advanced Bionics*.

Indeed, under 35 U.S.C. § 325(d), the Board uses a two-part framework in determining whether to exercise its discretion to institute. *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6, 8 (PTAB Feb. 13, 2020) (precedential) (“*Advanced Bionics*”). First, the Board considers “whether the same or substantially the same art previously was presented to the Office or whether the same or substantially the same arguments previously were presented to the Office.” *Id.* When either condition of the first part of the framework is satisfied, the Board next considers “whether the petitioner has demonstrated that the Office erred in a manner material to the patentability of challenged claims.” *Id.*

In applying this framework, the Board evaluates six factors (“the *Becton* factors”). *Id.*, 8-10 (citing *Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 (PTAB Dec. 15, 2017) (precedential as to § III.C.5, first paragraph) (“*Becton*”); see Trial Practice Guide July 2019 Update, 28-31, Fed. Reg. 33,925 (July 16, 2019). These factors are known as the Becton factors (a) through (f). *Advanced Bionics* at 9, n.10 (citing *Becton*). As discussed below, the *Becton* factors favor institution.

1. Grounds and Obviousness Rationale Advanced in This Petition Were Not Previously Considered by the Office

Becton factors (a), (b), and (d) support institution because this Petition does not present substantially the same prior art combinations or arguments that were before the Office during examination of the '282 Patent. Though Bosnyak-392 (through consideration of CA2747728) was addressed in the one and only office action during prosecution, the secondary reference of Son combined with Bosnyak-392 was not considered. *See* LGES-1002, 118-131. Albuerne and Bosnyak-129, nor combinations involving the same, were also not considered. *Id.* In short, the Office did not consider any of the prior art combinations of (i) Bosnyak-392-Son or (ii) Bosnyak-129-Albuerne that are being advanced in this Petition, and therefore, these combinations are not cumulative of the prior art evaluated during examination.

Patent Owner thus cannot argue, and the Board should not find, that “the same or substantially the same art previously was presented to the Office” or that “the same or substantially the same arguments previously were presented to the Office,” as required under part 1 of the *Advanced Bionics* framework. The *Advanced Bionics* analysis should therefore end with part 1, and the Board should not exercise its discretion to deny institution.

2. The Office Erred in Granting the '282 Patent

Because this Petition uses art and arguments that are materially different from those considered during prosecution, the Board need not reach part 2 of the *Advanced Bionics* framework (since part 1 is not satisfied). Nonetheless, each of *Becton* factors (c), (e), and (f) favors Petitioner. The analysis of factor (c) is straightforward. The Office was not made aware of at least Son and Albuerne, which are relied upon in the grounds advanced in the Petition. As such, the Office did not evaluate these references or use these references as a basis for any rejection during examination.

Moreover, in stating the reason for allowance, the Examiner indicated that the art relied upon in the Office Action of October 17, 2019 (which did not include Son and Albuerne) “does not appear to teach or fairly suggest the limitations of ... a distribution of carbon nanotube aspect ratios, wherein 40 to 90% of the nanotubes have an aspect ratio of 30 to 70, and wherein 1 to 30% of the carbon nanotubes have an aspect ratio of 80 to 140....” LGES-1002, 129-130. But as carefully laid out in the Petition, each of the Bosnyak-392-Son and the Bosnyak-129-Albuerne combinations render obvious such a feature.

In short, by not considering these references—and combinations based on the same—as potentially teaching the features that ultimately led to allowance, the examiner erred in the evaluation of the prior art, thus warranting reconsideration.

Advanced Bionics, Paper 6, 10 (clarifying that a petitioner need not prove material error through any affirmative act of the Patent Office; instead “if the record of the Office’s previous consideration of the art is not well developed or silent, then a petitioner may show the Office erred by overlooking something persuasive under factors (e) and (f).”).

Thus, *Becton* factors (c), (e), and (f) weigh in favor of institution.

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

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

VII. CONCLUSION

For at least the reasons above, the Challenged Claims are unpatentable. Petitioner authorizes charge of fees to Deposit Account 06-1050.

VIII. MANDATORY NOTICES UNDER 37 C.F.R § 42.8(a)(1)

A. Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1)

Petitioner, LG Energy Solution, Ltd., is the real party-in-interest.

B. Related Matters Under 37 C.F.R. § 42.8(b)(2)

Petitioner is not aware of any disclaimers, reexamination certificates or petitions for *inter partes* review for the '282 Patent. The '282 Patent is the subject of a number of civil actions including: *Molecular Rebar Design, LLC et al v. LG*

Energy Solution, Ltd., 2-24-cv-00107 (EDTX) filed Feb. 16, 2024 (Pending);
Molecular Rebar Design, LLC et al v. Samsung Electronics Co., Ltd. et al, 2-24-cv-00108 (EDTX) filed Feb. 16, 2024; and *Molecular Rebar Design, LLC et al v. LG Chem, Ltd. et al*, 1-22-cv-01130 (DDE) filed August 29, 2022 (Dismissed prior to service of complaint).

C. Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)

Petitioner provides the following designation of counsel.

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D. Service Information

Please address all correspondence and service to the address listed above.

Petitioner consents to electronic service by email at IPR18768-0210IP8@fr.com
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Respectfully submitted,

Dated: 6/12/2024

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CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter Partes* Review totals 13,912 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

Dated: 6/12/2024

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on June 12, 2024, a complete and entire copy of this Petition for *Inter Partes* Review and all supporting exhibits were provided by Federal Express, to the Patent Owner by serving the correspondence address of record as follows:

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