

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

v.

MOLECULAR REBAR DESIGN, LLC,
Patent Owner.

IPR2024-01012¹
Patent 10,608,282 B2

Before GRACE KARAFFA OBERMANN, KRISTINA M. KALAN,
and AVELYN M. ROSS, *Administrative Patent Judges*.

KALAN, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
35 U.S.C. § 318(a)

¹ Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (“the Samsung Petitioners”) were joined as parties via a Motion for Joinder in IPR2025-00358 (“IPR358”). We designate this Decision as confidential because we cite information from a paper that the Samsung Petitioners identified as confidential in IPR358. *See infra* n.2 (citing IPR358, Paper 4).

I. INTRODUCTION

A. Background and Summary

LG Energy Solution, Ltd. (“Petitioner”)² filed a Petition to institute *inter partes* review of claims 1–16 of U.S. Patent No. 10,608,282 B2 (Ex. 1001, “the ’282 patent”). Paper 2 (“Petition” or “Pet.”). Molecular Rebar Design, LLC (“Patent Owner”)³ filed a Preliminary Response. Paper 5. With our authorization, Petitioner filed a Reply to the Preliminary Response directed only to our discretion under 35 U.S.C. § 314(a) (Paper 6), and Patent Owner filed a Sur-reply (Paper 7). We instituted *inter partes* review. Paper 8 (“Inst. Dec.”).

Thereafter, Patent Owner filed a Response (Paper 17, “Resp.”), Petitioner filed a Reply (Paper 22, “Reply”), and Patent Owner filed a Sur-reply (Paper 32, “Sur-reply”).

B. Related Matters

The parties identify the following litigation involving the ’282 patent: *Molecular Rebar Design, LLC v. LG Energy Solution, Ltd.*, Civil Action No. 2-24-cv-00107 (E.D. Tex.) filed Feb. 16, 2024; *Molecular Rebar Design, LLC v. Samsung Electronics Co., Ltd.*, Civil Action No. 2-24-cv-00108 (E.D. Tex.) filed Feb. 16, 2024; and *Molecular Rebar Design, LLC v. LG*

² The real parties-in-interest include LG Energy Solution, Ltd. (Pet. 78) and the Samsung Petitioners (IPR358, Paper 4, 73). With “caveats and reservations,” the Samsung Petitioners further identify [REDACTED]. *Id.*

³ The real party-in-interest is Molecular Rebar Design, LLC, which has granted Black Diamond Structures, LLC an exclusive license to the ’282 patent in certain enumerated “applications and uses related to electrical energy storage.” Paper 4, 2.

Chem, Ltd., Civil Action No. 1-22-cv-01130 (D. Del.) filed August 29, 2022 (dismissed). Pet. 78–79; Paper 4, 2.

Patent Owner also identifies as related matters these administrative proceedings, which involve the Samsung Petitioners: IPR2025-00355, IPR2025-00356, IPR2025-00357, IPR2025-00358, and IPR2025-00359. Paper 13, 3. Patent Owner further identifies as related matters these administrative proceedings, involving LG Energy Solution, Ltd. as the petitioner: IPR2024-01005, IPR2024-01006, IPR2024-01011, and IPR2024-01013. *Id.*

C. The '282 Patent (Ex. 1001)

The '282 patent, titled “Binders, Electrolytes and Separator Films for Energy Storage And Collection Devices Using Discrete Carbon Nanotubes,” issued March 31, 2020, and describes an improved binder composition, electrolyte composition, and a separator film composition using discrete carbon nanotubes,⁴ for energy storage and collection devices such as batteries, capacitors, and photovoltaics. Ex. 1001, codes (45), (54), (57).

The '282 patent explains that binders have conventionally been developed “to overcome the deficiencies of poor adhesion to current collectors and to prevent microcracking during expansion and contraction of rechargeable batteries.” Ex. 1001, 1:59–62. The '282 patent describes that “[i]mpurities . . . with the binder can . . . be highly deleterious to battery performance.” *Id.* at 3:4–6. For example, “[c]ommercially available carbon nanotubes such as Baytubes® (Bayer AG) or Graphistrength® (Arkema) can contain as much as ten percent or more by weight of residual metal catalysts

⁴ “CNT” is used herein as an acronym for “carbon nanotubes.”

and are not considered advantageous for batteries at these levels of impurity.” *Id.* at 3:13–17.

The ’282 patent further explains that the “low ionic conductivities of polymer and inorganic solid electrolytes are presently a limitation to their general use in energy storage and collection devices.” Ex. 1001, 3:43–46. The ’282 patent describes that “[r]eplacement of the presently used [liquid and corrosive] electrolytes is desirable, but candidate electrolytes have poor ion transport.” *Id.* at 4:1–3. According to the ’282 patent, “[i]mprovements desired” from typical electrolytic capacitors “include higher rates of charge and discharge which is limited by ion transport of the electrolyte.” *Id.* at 4:7–8.

The ’282 patent describes the conventional use of a separator film to provide “electrical insulation between the electrodes[,] yet allow[] ion transport.” Ex. 1001, 4:10–11. According to the ’282 patent, a “polymer separator film comprising discrete carbon nanotubes of this invention can improve ion transport yet still provide the necessary electrical insulation between the electrodes.” *Id.* at 4:18–21. The ’282 patent describes “a composition 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.” *Id.* at 4:30–34.

Figure 1 of the ’282 patent, reproduced below, depicts “discrete carbon nanotubes of this invention with 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.” Ex. 1001, 6:18–21.

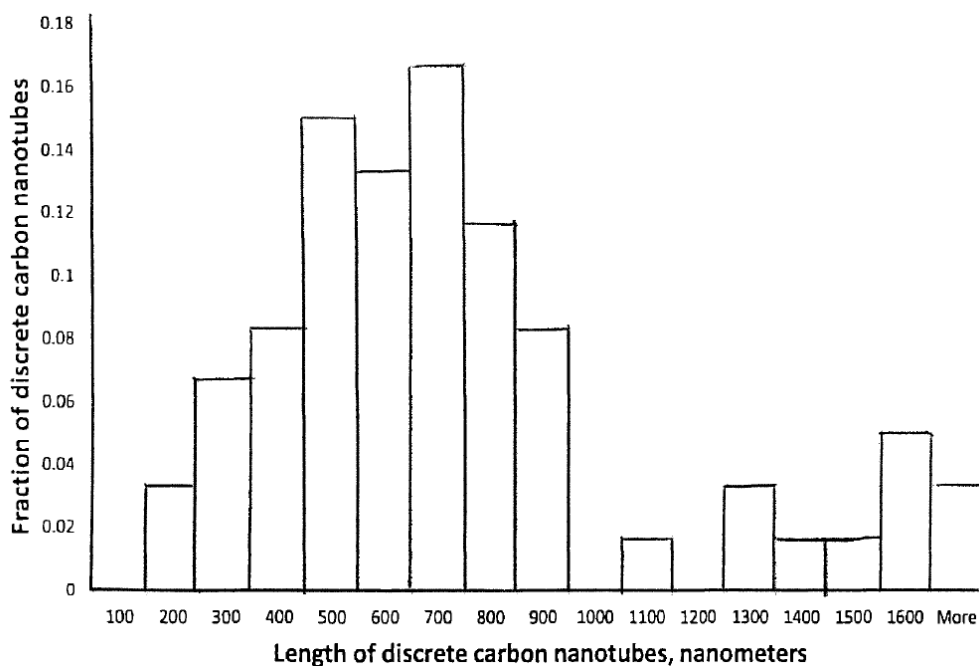


Figure 1 above shows a bimodal distribution of the length of discrete carbon nanotubes plotted on a graph. *Id.* at Fig. 1. The y-axis of Figure 1, labeled “Fraction of discrete carbon nanotubes,” ranges from 0 to 0.18. *Id.* at Fig. 1. The x-axis of Figure 1, labeled “Length of discrete carbon nanotubes, nanometers,” ranges from 100 nm to more than 1600 nm. *Id.* The ’282 patent explains that “[t]he lengths were determined by deposition of the discrete carbon nanotubes on a silicon wafer and by using scanning electron microscopy.” *Id.* at 6:21–24. According to the ’282 patent, a bimodal distribution of lengths of the discrete carbon nanotubes “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 . . . is useful in binders and electrolytes of the invention.” *Id.* at 5:63–67.

The ’282 patent describes examples in which the discrete oxidized nanotubes provide lower values of impedance and improved ion transport in binders and separator films, improvements in the conductivity of solid

electrolyte films, and higher strength in comparison to controls having no discrete oxidized nanotubes. Ex. 1001, 10:64, 11:1, 12:64–65, 13:1–2.

D. Illustrative Claim

Of the challenged claims, claim 1 is the sole independent claim, and is reproduced below.

1. [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.

Ex. 1001, 14:2–13 (labels added to correspond with Petitioner’s designation of claim limitations); Pet. v. (Claim Listing).

E. Asserted Unpatentability Challenges

Petitioner asserts that claims 1–16 are unpatentable based on the following challenges:

Claim(s) Challenged	35 U.S.C. § ⁵	Reference(s)/Basis
1–16	§ 103	Bosnyak-392, ⁶ Son ⁷
4	§ 103	Bosnyak-392, Son, So ⁸
11	§ 103	Bosnyak-392, Son, Gu ⁹
1, 5–9, 12–16	§ 103	Bosnyak-129, ¹⁰ Albuerne ¹¹
2–4, 10, 11	§ 103	Bosnyak-129, Albuerne, Gu

Pet. 8. Petitioner relies on the Declarations of Dr. Samuel P. Gido.

Ex. 1003; Ex. 1030. Patent Owner relies on a Declaration of Dr. Deborah D.L. Chung. Ex. 2004.

⁵ The relevant sections of the Leahy-Smith America Invents Act (“AIA”), Pub. L. No. 112–29, took effect on March 16, 2013. As noted in the Institution Decision, Section I.E, we apply the AIA versions of the statutory bases for unpatentability. Neither party raised the priority date as an issue for trial, although we invited development of that issue when we instituted review. Inst. Dec. 6. Neither party argues that the ultimate result would change if we were to apply the pre-AIA version of § 103.

⁶ PCT Pub. No. WO 2010/117392 A1 to Bosnyak et al., published Oct. 14, 2010 (Ex. 1005).

⁷ KIPO Pub. No. KR 10-2010-0086854 to Son et al., published August 2, 2010 (Ex. 1007), relying on an uncontested certified English translation (Ex. 1008).

⁸ JPO Pub. No. JP 2005-262391 A to So, published Sept. 29, 2005 (Ex. 1013), relying on an uncontested certified English translation (Ex. 1014).

⁹ X. Gu et al. “Layered and interfacially blended polyelectrolyte multi-walled carbon nanotube composites for enhanced ionic conductivity,” *Thin Solid Films* 520, 1872–79 (2012) (Ex. 1016).

¹⁰ PCT Pub. No. WO 2011/163129 A2 to Bosnyak et al., published Dec. 29, 2011 (Ex. 1006).

¹¹ J. Albuerne, et al. “Modification of Multiwall Carbon Nanotubes by Grafting from Controlled Polymerization of Styrene: Effect of the Characteristics of the Nanotubes,” *Journal of Polymer Science: Part B: Polymer Physics*, Vol. 48, 1035–46 (2010) (Ex. 1009).

II. ANALYSIS

A. Legal Standard

A patent claim is unpatentable on that basis if the differences between the claimed subject matter and “the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007).

Obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when in evidence, objective evidence of nonobviousness.¹² *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

B. Level of Ordinary Skill in the Art

The level of ordinary skill in the art is a factual determination that provides a primary guarantee of objectivity in an obviousness analysis. *Al-Site Corp. v. VSI Int’l, Inc.*, 174 F.3d 1308, 1324 (Fed. Cir. 1999) (citing *Graham*, 383 U.S. at 17–18; *Ryko Mfg. Co. v. Nu-Star, Inc.*, 950 F.2d 714, 718 (Fed. Cir. 1991)). In determining the level of skill in the art, we consider the type of problems encountered in the art, the prior art solutions to those problems, the rapidity with which innovations are made, the sophistication of the technology, and the educational level of active workers in the field. *Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc.*, 807 F.2d 955, 962 (Fed. Cir. 1986); *Orthopedic Equip. Co. v. U.S.*, 702 F.2d 1005, 1011 (Fed. Cir. 1983).

¹² Neither party presents evidence as to objective indicia of nonobviousness.

Petitioner asserts that a person of ordinary skill in the art “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.” Pet. 7. Petitioner further argues that “[a]dditional work experience can compensate for less formal education, and vice versa.” *Id.* (citing Ex. 1003 ¶¶ 19–21).

“Patent Owner applies Petitioner’s definition of a POSITA [person of ordinary skill in the art] for purposes of this proceeding only.” Resp. 6. On this record, we adopt Petitioner’s unopposed definition because it appears consistent with the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (holding that the prior art itself can reflect the appropriate level of ordinary skill in the art).

C. Claim Construction

In an *inter partes* review, we construe claim terms according to the standard set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–17 (Fed. Cir. 2005) (en banc). 37 C.F.R. § 42.100(b). Under *Phillips*, claim terms are afforded “their ordinary and customary meaning.” *Phillips*, 415 F.3d at 1312. “[T]he ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention.” *Id.* at 1313. “Importantly, the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification.” *Id.* “In determining the meaning of the disputed claim limitation, we look principally to the intrinsic evidence of record, examining the claim language

itself, the written description, and the prosecution history, if in evidence.” *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 469 F.3d 1005, 1014 (Fed. Cir. 2006) (citing *Phillips*, 415 F.3d at 1312–17).

i. Parties’ Arguments

a. Petition

Petitioner argues that “no formal claim constructions are necessary in this proceeding.” Pet. 7.

b. Response

Patent Owner contends: “Because there is a controversy regarding the meaning of ‘discrete carbon nanotube fibers’ (Claim 1) and that controversy is material to whether Petitioner has carried its burden of showing unpatentability, claim construction is necessary.” Resp. 13. Patent Owner proposes that the “plain and ordinary meaning” of “discrete carbon nanotube fibers” is “carbon nanotubes that are separate and distinct from other nanotubes—not attached to other nanotubes.” *Id.* at 14 (citing Ex. 2004 ¶ 55). Patent Owner cites to Webster’s New World College Dictionary, 4th Edition, 1999 (Ex. 2008) and additional extrinsic evidence to support its construction. *Id.* at 14–18.

c. Reply

Petitioner replies that “because the Challenged Claims are obvious under any reasonable interpretation of ‘discrete carbon nanotube fibers,’ Petitioner maintains that no formal claim construction is necessary.” Reply 1–2. Petitioner argues that Patent Owner’s construction is unsupported by the ’282 patent Specification, relevant dictionary definitions, and other prior art. *Id.* at 2. More particularly, Petitioner states that the ’282 patent “describes that ‘discrete’ carbon nanotubes are ‘*alternatively termed*

exfoliated carbon nanotubes’ and that they can be ‘obtained from as-made bundled carbon nanotubes[.]’” *Id.* (Petitioner’s emphasis, quoting Ex. 1001, 6:50–54). Petitioner avers that the ’282 patent “says nothing about prohibiting discrete nanotubes from being attached to one another, or from touching one another.” *Id.*

Petitioner argues that Patent Owner is using the wrong dictionary, because the ’282 patent “instructs that to the extent a dictionary is needed, ‘Webster’s Dictionary, 3rd Edition, 2009’ should be used.” *Id.* at 3 (citing Ex. 1001, 6:43–46). Petitioner relies on Patent Owner’s declarant’s testimony that nanotubes should be touching one another. *Id.* at 4 (citing Ex. 1033, 36:18–37:5). Petitioner also relies on the use of the term “discrete” in Swogger (Ex. 1039), in that SEM images of “discrete” nanotubes show unbundled nanotubes that are nevertheless still touching. *Id.* at 5 (citing Ex. 1039, 3; Ex. 1030 ¶ 17). Petitioner also points to co-pending litigation in which Patent Owner acknowledges that “discrete” nanotubes need not be physically separated. *Id.* at 5 (citing Ex. 1027, 40; Ex. 1030 ¶ 18). Finally, Petitioner criticizes Patent Owner’s reliance on Dr. Zhu’s opinions from an “entirely different proceeding for an unrelated patent” as “misplaced and not supported by record evidence.” *Id.* at 7.

d. Sur-reply

Patent Owner responds that it understands Petitioner’s construction to be: “lacking direct association with other nanotubes along substantially the length of the nanotubes.” Sur-reply 3 (citing Resp. 16; Ex. 2005, 7:16–8:9). Patent Owner also characterizes the claim construction dispute as “whether ‘discrete’ precludes CNTs from being attached to one another (as proposed

by PO) or whether it only prohibits a vague and subjective degree of attachment (as proposed by Petitioner).” *Id.*

Patent Owner argues:

(1) Petitioner’s singular focus on one sentence from the Specification (“discrete oxidized carbon nanotubes, alternatively termed exfoliated carbon nanotubes,” Ex. 1001, 6:50–51) is misplaced (Sur-reply 3–5);

(2) Petitioner misunderstands the plain teachings of the Specification, namely, that the invention controls the degree of electrical conductivity by the amount of discrete carbon nanotubes (Ex. 1001, 9:16–21) and that electrical conductivity does not require physical contact between CNTs via, i.e., electron tunneling even if they do not touch one another (Ex. 1031, 114:19–115:20, 122:24–123:9) (Sur-reply 5–8);

(3) Petitioner’s “dictionary” arguments are false and misleading, because the Specification requires that a term be “meaningless or essentially meaningless” before turning to a dictionary (Ex. 1001, 6:39–46), and Petitioner does not rely on the referenced dictionary either (Sur-reply 8–10);

(4) The notion that it is “simply not feasible” to create “discrete” CNTs is demonstrably false, because Petitioner improperly relies on incorporation by reference, and because Petitioner’s declarant agrees that the prior art was able to do so (citing Reply 11) (Sur-reply 10–14);

(5) Petitioner mischaracterizes the infringement contentions, which in the SEM images identify “discrete” CNTs (Sur-reply 14–18);

(6) Petitioner mischaracterizes Swogger (Ex. 1039) and “relies on the same optical illusion used to misrepresent the infringement contentions” (Sur-reply 18–21); and

(7) Dr. Zhu’s testimony is not irrelevant because it presents ample context for the testimony that “fully isolated” CNT are “discrete” and only identified fully isolated CNTs as “discrete.” Sur-reply 21–22.

ii. Analysis

a. Specification

The specification is “the single best guide to the meaning of a disputed term.” *Phillips*, 415 F.3d at 1315 (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)).

I. Claim Language

The language of claim 1 requires “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 then further specifies aspect ratios of the “discrete carbon nanotubes.” Other claims further specify that the carbon nanotubes are, i.e., “further functionalized” (claim 7), and “oriented” (claim 11).

We are directed to nothing in the claim language that expressly supports Patent Owner’s contention that discrete carbon nanotube fibers necessarily must be “not attached to other nanotubes.” We also are directed to nothing in the claim language that expressly supports Petitioner’s alleged position that the discrete carbon nanotubes must be “lacking direct association with other nanotubes along substantially the length of the nanotubes.”

II. Additional Specification Language

Patent Owner points to the Specification’s teaching that “discrete carbon nanotubes of this invention can improve ion transport yet still provide the necessary electrical insulation between the electrodes.” Resp. 13

(citing Ex. 1001, 4:18–21). Patent Owner argues that the “discrete CNTs can provide electrical insulation because they are not attached to one another, creating gaps that greatly increase the electrical resistance.” *Id.* at 13–14 (citing Ex. 2004 ¶ 54). Patent Owner agrees that the Specification “also teaches that ‘discrete oxidized carbon nanotubes’ are alternatively termed ‘exfoliated’” *Id.* at 14 (citing Ex. 1001, 6:50–54). Patent Owner further notes that the Specification “describes ‘discrete’ CNTs as having to be disentangled or de-bundled from other CNTs as part of achieving discrete status such that the CNTs do not form ‘discernable aggregates.’” *Id.* (citing Ex. 1001, 11:61–12:32).

Petitioner relies on the Specification’s description of “discrete oxidized carbon nanotubes, alternatively termed exfoliated carbon nanotubes.” Reply 2 (citing Ex. 1001, 6:50–54).

We note that this relied-upon portion of the Specification further describes that discrete oxidized carbon 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.” Ex 1001, 6:50–54. The end result of this process, at least according to one example in the Specification, is that there are “no discernible aggregates of carbon nanotubes” remaining, i.e., “the tubes are discrete and dispersed.” *Id.* at 11:61–12:32 (cited in Resp. 14). Therefore, although we do not agree with Patent Owner’s proffered construction that every “discrete” CNT is separate and not touching any other CNT, the discrete oxidized carbon nanotubes according to this example are at least “dispersed” and are no longer in the form of “discernible aggregates.”

The Specification directly supports Petitioner’s statements (and Patent Owner’s agreement) that “discrete oxidized carbon nanotubes,” are “alternatively termed exfoliated carbon nanotubes.” Ex. 1001, 6:50–54; *see also* Tr. 32:17–18 (Patent Owner stating that “our position is that discrete carbon nanotubes have to be exfoliated”). The Specification, however, does not support Patent Owner’s assertion that discrete CNTs are “not attached to other nanotubes.” Resp. 13–18; Reply 8.

Although we acknowledge Patent Owner’s assertion that discrete CNTs “can provide electrical insulation because they are not attached to one another, creating gaps that greatly increase the electrical resistance” (Resp. 13–14), we are not directed to any portion of the Specification supporting the assertion that electrical insulation can only be provided if every single CNT is “not attached to other nanotubes.” Rather, the portion of the Specification identified by Patent Owner as describing “disentangled or debundled” CNTs (Resp. 14) states only that the CNTs are “discrete and dispersed” and do not form “discernable aggregates.” Ex. 1001, 11:61–12:32 (“magnification revealed no discernible aggregates of carbon nanotubes, i.e. the tubes are discrete and dispersed”).

b. Dictionary Definitions

In construing claims, we “may rely on dictionary definitions, ‘so long as the dictionary definition does not contradict any definition found in or ascertained by a reading of the patent documents.’” *Grace Inst. Indus., LLC v. Chandler Inst. Co.*, 57 F.4th 1001 (2023) (quoting *Phillips*, 415 F.3d at 1317, 1322–23). The Specification provides:

While most of the terms used herein will be recognizable to those of ordinary skill in the art, it should be understood, that when not explicitly defined, terms should be interpreted as

adopting a meaning presently accepted by those of ordinary skill in the art. In cases where the construction of a term would render it meaningless or essentially meaningless, the definition should be taken from Webster's Dictionary, 3rd Edition, 2009. Definitions and/or interpretations should not be incorporated from other patent applications, related or not, unless specifically stated in this specification.

Ex. 1001, 6:39–49.

Patent Owner relies on Webster's New World College Dictionary, 4th Edition, 1999 to support its construction, arguing that this dictionary defines "discrete" as "separate and distinct; not attached to others; unrelated." Resp. 14 (citing Ex. 2008, 4).

Petitioner provides a definition from Webster's Dictionary, 2009 (no edition number provided), defining "discrete" as "individually distinct." Reply 3 (citing Ex. 1034, 3). Petitioner states that this "prescribed dictionary" does not include the "'not attached to others' (MRD-2008, 4) phrase that PO was able to find only in its single dictionary from 1999." *Id.* Petitioner further relies on another Merriam-Webster dictionary from 2009, which "likewise does not mention 'not attached to others.' LGES-1035, 3." *Id.* (Merriam-Webster's Collegiate Dictionary, Eleventh Edition, defining "discrete" as "constituting a separate entity : individually distinct" and "consisting of distinct or unconnected elements : NONCONTINUOUS").

We agree with Patent Owner that "neither party proposes a construction that would render the term discrete 'meaningless or essentially meaningless,'" and, accordingly, we are not necessarily bound to use the dictionary identified in the Specification. Sur-reply 9. Nevertheless, because dictionaries can be instructive so long as they do not contradict any definition found in or ascertained by a reading of the patent documents

(*Phillips*, 415 F.3d at 1322–23), we do not disregard the Specification’s affirmative designation of this particular dictionary. We note that none of the dictionaries relied upon by either party are definitively shown to be the exact dictionary identified in the Specification, but Petitioner’s Exhibit 1034 is the closest, missing only the identification of whether it is the third edition.

We also find that none of the dictionary definitions cited definitively require that the word “discrete” mean “not attached” or “not touching.” Petitioner’s cited dictionary (Ex. 1034), as perhaps the closest to the dictionary identified in the Specification, defines “discrete” as “individually distinct”; a discrete CNT, however, could be individually distinct and still be touching another CNT. Although Patent Owner’s dictionary definition includes the term “not attached to others,” this is one possible definition in a serial list of definitions along with “separate and distinct” and “unrelated.” Ex. 2008, 4 (defining “discrete” as “**1** separate and distinct; not attached to others; unrelated **2** made up of distinct parts; discontinuous **3** designating or of an electronic circuit having separate transistors, resistors, etc.”). Patent Owner does not persuasively explain why this “not attached to others” portion of the definition must be adopted in view of the totality of possible alternate definitions provided, and in view of the totality of definitions provided that allow for “discrete” to mean “individually distinct” or “separate and distinct,” none of which prohibit an attachment or a touching.

We are directed to nothing in the dictionary definitions that expressly supports Patent Owner’s contention that each discrete oxidized carbon nanotube must necessarily be “not attached to other nanotubes.” We also are directed to nothing in the claim language that expressly supports Petitioner’s

alleged position that the discrete nanotubes must be “lacking direct association with other nanotubes along substantially the length of the nanotubes.”

c. Additional Extrinsic Evidence

Both parties rely on additional extrinsic evidence as discussed below to support their claim construction positions. Although we consider and assess the additional extrinsic evidence relied upon by the parties, this extrinsic evidence is accorded less weight than the intrinsic record.

I. Infringement Contentions and Co-Pending Litigation

SEM images from co-pending litigation illustrate that the “discrete” carbon nanotubes are touching each other, according to Petitioner. Reply 5–6 (citing Ex. 1027, 35–42; Ex. 1030 ¶ 18). Petitioner also asserts that Swogger (Ex. 1039, Figs. 1A, 1B), which depicts “bundled carbon nanotubes” side by side with “discrete, untangled carbon nanotubes,” illustrates that “common usage of this term [discrete] encompasses non-bundled nanotubes that nevertheless can still cross and contact one another.” Reply 5. Patent Owner argues that Swogger’s “discrete, untangled carbon nanotubes” appearing as “a thin mat due to an artifact of sample preparation” is “misleading” and undercuts Petitioner’s arguments. Sur-reply 18–19. Our review of the SEM depictions and text of Swogger indicate that the “discrete” CNTs are both touching and not touching, which supports Petitioner’s assertion that “discrete” CNTs may be touching.

II. Declarant Opinions

A. Gido

Dr. Gido’s testimony regarding CNTs lacking “direct association with one another along substantially the length of the nanotube” is not fatally

flawed, as alleged by Patent Owner. Resp. 17 (citing Ex. 2005, 8:11–19, 9:1–11). Dr. Guido testified that he “would say that 50 percent is a fair amount of association.” Ex. 2005, 9:1–11. On this record, Dr. Guido’s testimony and fifty percent figure is reasonably persuasive and illustrative of how a CNT could be “discrete” yet still be touching or attached to other nanotubes, and not fully isolated from other CNTs. We are presented with no persuasive reason, however, to incorporate this fifty percent figure into a claim construction.

Dr. Guido further testifies that “because of the high aspect ratio of carbon nanotubes, it is simply not feasible to have even a very small concentration of nanotubes without them crossing and contacting one another in the context of the ’282 Patent.” Reply 4 (citing Ex. 1030 ¶¶ 7–16). Patent Owner argues that this testimony is improper incorporation by reference, and inconsistent with Dr. Guido’s position elsewhere that certain CNTs could be entirely not touching. Sur-reply 10–14. Patent Owner points to countervailing sources that show, according to Patent Owner, that discrete CNTs may be present on different planes and thus not in contact at all. *Id.* at 13 (citing Pet. 9–10; Reply 11). Dr. Guido’s testimony appears internally consistent in that it supports that a composition made up of entirely isolated and non-touching CNTs is “not feasible” in the context of the ’282 patent, although it could happen in another context. *See, e.g.*, Ex. 1030 ¶ 13. This is consistent with Petitioner’s position that the “discrete” CNTs of the ’282 patent may be touching.

B. Zhu

Dr. Zhu testified, according to Patent Owner, that “discrete CNTs are CNTs that are fully isolated and separate from one another.” Resp. 16

(citing Ex. 2004 ¶ 58). We are less persuaded by this testimony in view of Petitioner's assertion that Dr. Zhu "has not provided any opinions regarding the '282 patent" (Reply 7) and Petitioner's interpretation of Dr. Zhu's testimony as acknowledging that a fully isolated CNT can be discrete, but that a CNT need not "necessarily be fully isolated to be considered discrete" (*id.*).

C. Chung

Dr. Chung testified, according to Petitioner, that "having an exfoliated carbon nanotube 'does not imply that the nanotubes are not touching at all.'" Reply 2–3 (citing Ex. 1031, 103:13–25). Dr. Chung further testified, according to Petitioner, that "fully exfoliated" nanotubes are necessarily "discrete." *Id.* at 8 (citing Ex. 1029, 80:12–22). Petitioner further points to Dr. Chung's testimony that the three-dimensional diagrams of Son show that the CNTs "might not be" in physical contact, whereas the two-dimensional diagrams of Son show that the CNTs "are in physical contact." *Id.* at 11–12 (citing Ex. 1031, 127:16–128:1). This testimony also supports Petitioner's assertion that "discrete" CNTs may be touching.

iii. Summary

As we understand the parties' positions, Patent Owner appears to argue that the only CNTs that can be considered "discrete" are the ones that are not touching any other CNTs, i.e., "not attached to other nanotubes." Petitioner appears to argue that CNTs that have been through exfoliation, such that they are less tangled and more dispersed than before exfoliation, can be considered "discrete." It appears that, under Petitioner's construction, these "discrete" CNTs can still be touching each other, although to a lesser degree than before exfoliation.

Patent Owner avers that the “sole claim construction issue remaining is whether ‘discrete’ precludes CNTs from being attached to one another (as proposed by PO) or whether it only prohibits a vague and subjective degree of attachment (as proposed by Petitioner).” Sur-reply 3. We find that the descriptor “discrete” does not preclude CNTs from touching or from being attached to one another. We, thus, decline to adopt Patent Owner’s proposed construction that the plain and ordinary meaning of “discrete carbon nanotube fibers” is “carbon nanotube fibers that are separate and distinct from other nanotube fibers—not attached to other nanotubes.” Resp. 14. As discussed above, the record does not support that the term “discrete” as applied to carbon nanotube fibers means that *every last* CNT must not be or cannot be attached to or touching another CNT.

According to the Specification, “discrete oxidized carbon nanotubes” are “alternatively termed exfoliated carbon nanotubes” (Ex. 1001, 6:50–54) and in at least one embodiment there are “no discernible aggregates of carbon nanotubes” remaining after processing, i.e., “the tubes are discrete and dispersed” (*id.* at 11:61–12:32). However, neither the Specification nor the additional evidence persuasively supports a construction that calls for any particular metric or type of attachment, touching, or dispersion of CNTs. There is no identified requirement for a particular percentage of attachment (i.e. 50%) or a particular configuration of attachment (i.e. “along the length of”), and we decline to import any such restrictions as part of a formal claim construction. We do, however, disagree that “discrete” must mean “not attached to other nanotubes.”

The Specification and other evidence support that “discrete oxidized carbon nanotubes” are “alternatively termed exfoliated carbon nanotubes.”

Ex. 1001, 6:50–54. Petitioner proffers, and Patent Owner agrees with, this statement. Reply 1, Resp. 14. We, therefore, adopt this construction.

iv. Other Claim Terms

Upon review of the record, we determine that no other claim terms require express construction for purposes of this Decision. *See Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1375 (Fed. Cir. 2019) (“The Board is required to construe ‘only those terms . . . that are in controversy, and only to the extent necessary to resolve the controversy.’”) (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

D. Overview of Certain Asserted Prior Art

i. Bosnyak-392 (Ex. 1005)

Bosnyak-392 is a PCT patent publication titled “Exfoliated Carbon Nanotubes, Methods for Production Thereof and Products Obtained Therefrom” and describes the nanotubes’ utility for energy storage devices and in polymer composites. Ex. 1005, codes (54), (57).

According to Bosnyak-392, “inability to reliably produce individualized carbon nanotubes” has hampered their use in energy storage devices and polymer composites. *Id.* ¶ 5. Bosnyak-392 describes that “current methods for producing exfoliated carbon nanotubes usually results in shortening or functionalization of the nanotubes,” which “generally results in reduced conductivity.” *Id.* ¶ 6. Bosnyak-392 further describes that “solid exfoliated carbon nanotubes and methods for efficiently exfoliating carbon nanotubes without nanotube damage are” desirable. *Id.* ¶ 7.

Bosnyak-392 explains that 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.”

Id. ¶ 37. Bosnyak-392 describes embodiments having exfoliated carbon nanotubes having a narrower distribution of lengths and diameters than bundled carbon nanotubes (*id.* ¶¶ 41, 42) and “full-length carbon nanotubes that have open ends” (*id.* ¶ 38). Bosnyak-392 describes carbon nanotubes having an aspect ratio of least about 100 in some embodiments and at least about 1000 in other embodiments. *Id.* ¶ 42.

*ii. Son (Ex. 1008)*¹³

Son is a Korean patent publication titled “Polymer composite and manufacturing method thereof.” Ex. 1008, code (54). Son describes a polymer composite comprising carbon nanotubes, “characterized in that a distribution graph of weight ratio to aspect ratio has at least two peak shapes.” *Id.* at code (57).

Son explains that it is advantageous to use carbon nanotubes with a high aspect ratio, but “when the aspect ratio is high, the dispersibility of the carbon nanotubes deteriorates due to the van der Waals bonding force between the carbon nanotubes.” Ex. 1008 ¶ 3. Son further describes that

[c]arbon nanotubes with a small aspect ratio are problematic in that it is difficult to form an electrical network because it is difficult to connect contacts between nanotubes. On the other hand, when carbon nanotubes with short lengths are used, their compatibility with polymers increases and mechanical properties of polymer composites are improved.

Id. ¶ 5 According to Son, the “object of the present invention is achieved by having at least two peaks in a distribution graph of a weight ratio to an

¹³ In this Decision, citations to Son refer to its certified English translation, Exhibit 1008.

aspect ratio of the carbon nanotubes in a polymer composite material comprising carbon nanotubes.” *Id.* ¶ 8.

Figure 1 of Son, reproduced below, depicts conceptually a polymer composite using carbon nanotubes.

Drawings
FIG. 1

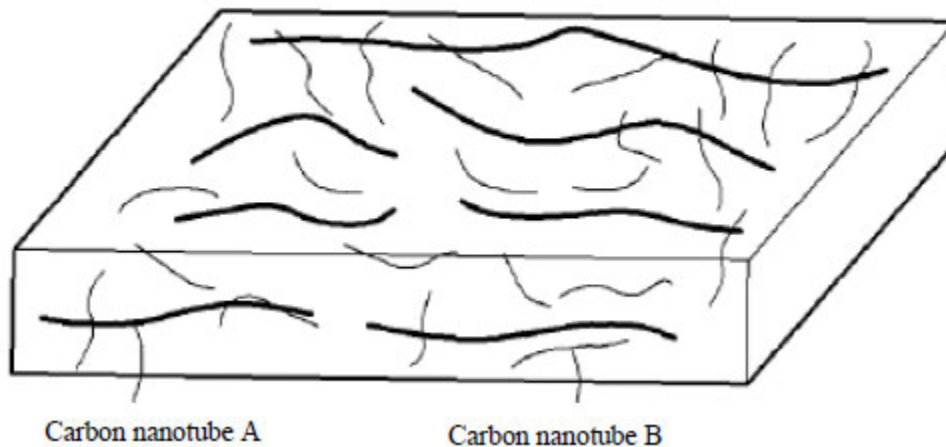


Figure 1 above shows carbon nanotubes A having a large aspect ratio and carbon nanotubes B having a small aspect ratio together in a block of polymer composite. *Id.* ¶ 20. According to Son, “the excellent dispersibility of the carbon nanotube B with a small aspect ratio and the electrical properties of the carbon nanotube A with a large aspect ratio are simultaneously expressed.” *Id.* ¶ 21.

Figure 4 of Son, reproduced below, is a distribution graph showing the aspect ratio-weight ratio of carbon nanotubes in a polymer composite. Son ¶ 63.

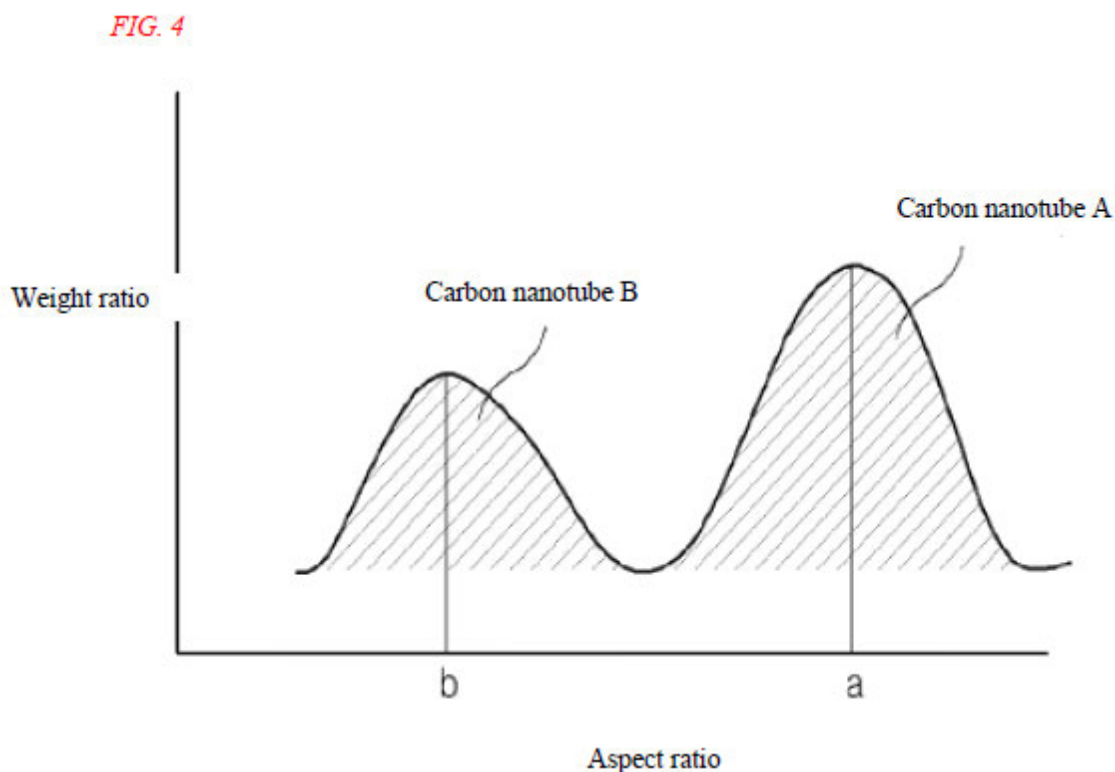


Figure 4 above shows “carbon nanotubes comprised in the polymer composite ... expressed as a weight ratio according to an aspect ratio.” *Id.* ¶ 25. Son explains that a “peak having a relatively high aspect ratio and having a vertex at the aspect ratio a corresponds to carbon nanotube A,” whereas a “peak having a relatively low aspect ratio and having a vertex at the aspect ratio b corresponds to carbon nanotube B.” *Id.* ¶ 27. According to Son, if “the carbon nanotube A is too long, mechanical properties may deteriorate due to non-uniform dispersion,” but “if the carbon nanotube B is too short, a problem arises in that the total content of the carbon nanotube must be excessively increased to form an electrical network.” *Id.* ¶ 30. Son describes that the weight ratio of each type of carbon nanotube “can be easily determined by a person skilled in the art according to the inherent properties of carbon nanotubes and which of mechanical properties and electrical properties to give priority to.” *Id.* ¶ 33.

iii. Bosnyak-129 (Ex. 1006)

Bosnyak-129 is a PCT patent publication titled “Modified Carbon Nanotubes, Methods for Production Thereof and Products Obtained Therefrom.” Ex. 1006, code (54). Bosnyak-129 relates to exfoliation and dispersion of carbon nanotubes resulting in high aspect ratio, surface-modified carbon nanotubes that are readily dispersed in various media. *Id.* at code (57).

Bosnyak-129 explains that the “fibers can be open-ended.” Ex. 1006 ¶ 8. Bosnyak-129 further explains that the “fibers have an average diameter of from about 0.6 nanometers to about 30 nanometers” and “have an average distribution length of from about 50 nanometers to about 10000 nanometers.” *Id.* ¶ 10. Bosnyak-129 discloses carbon nanotube fibers having an aspect ratio of from about 25 to about 500 (*id.* ¶ 7) and also discloses aspect ratios of at least about 60 in some embodiments and at least about 100 in other embodiments. *Id.* ¶ 100. Bosnyak-129 describes that in some embodiments, “the exfoliated carbon nanotubes have a narrower distribution of lengths [and diameters] than do the bundled carbon nanotubes.” *Id.* ¶¶ 99–100. Bosnyak-129 further describes that exfoliated carbon nanotubes prepared by its techniques are typically longer than are carbon nanotubes exfoliated using existing technology. *Id.* ¶ 130.

According to Bosnyak-129, ultracapacitors and batteries having components containing exfoliated carbon nanotubes have high energy density and power density and better discharge and charge capabilities. Ex. 1006 ¶ 131.

iv. *Albuerne (Ex. 1009)*

Albuerne is a journal article titled “Modification of Multiwall Carbon Nanotubes by *Grafting from* Controlled Polymerization of Styrene: Effect of the Characteristics of the Nanotubes.” Ex. 1009, 1035.¹⁴ Albuerne describes that “[d]ifferent strategies have been used to reduce the size of the aggregates or to improve the dispersion of individual carbon nanotubes.” *Id.*

Figure 1 of Albuerne, reproduced below, depicts a schematic representation of surface modification reactions carried out on multiwall carbon nanotubes (MWCNTs). Ex. 1009, 1038.

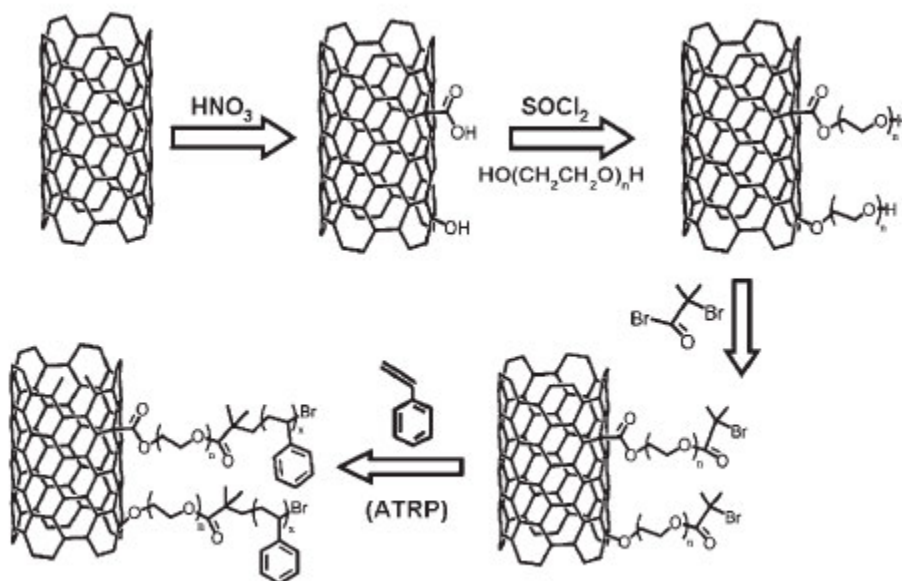


FIGURE 1 Schematic representation of the surface modification reactions carried out on MWCNTs.

Figure 1 above shows the surface modifications carried out on MWCNTs of Albuerne. *Id.* Albuerne describes oxidizing “two commercially available multiwall carbon nanotubes (MWCNTs) . . . with nitric acid, consecutively reacted with thionyl chloride, glycol or poly(ethylene glycol), 2-bromo-2-methylpropionyl bromide and finally with styrene under atom transfer

¹⁴ We cite to the original page numbering of Albuerne.

radical polymerization (ATRP) conditions.” *Id.* at Abstract. Albuerne describes separating the dispersed nanotubes having the carboxylate groups from those that remain aggregated, and studying the length distribution of the discrete carbon nanotubes using scanning force microscopy (SFM). *Id.* at 1039–1040.

Figure 5(b) from Albuerne, reproduced below, depicts the multiwall carbon nanotube length distribution (nm) of two commercially available MWCNTs that have been oxidized. *Id.* at 1040.

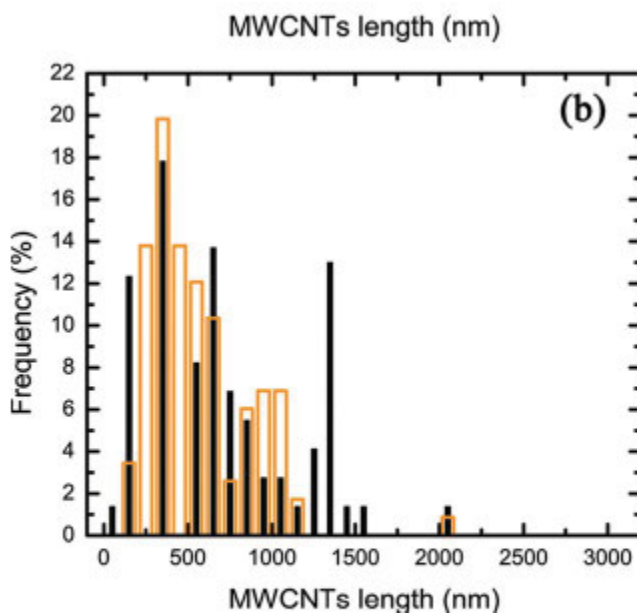


FIGURE 5 Carbon nanotube length distribution (nm) of (a) pristine MWCNTs and (b) oxidized MWCNTs, calculated from SFM phase images. Filled bars (black) correspond to MWCNT_{BMS}⁹⁵ and contour bars (orange) correspond to MWCNT_{FC}⁹⁹.

As shown in Figure 5(b) above, filled black bars correspond to MWCNT_{BMS} and orange contour bars correspond to MWCNT_{FC}.¹⁵ *Id.* Albuerne describes that the “distribution of the MWCNTs contour lengths

¹⁵ MWCNT_{BMS} denotes carbon nanotubes obtained from Bayer MaterialScience. MWCNT_{FC} denotes carbon nanotubes obtained from FutureCarbon GmbH. Ex. 1009, 1036.

can be appreciated in Figure 5.” *Id.* at 1039–1040. Albuerne explains: “After the acid treatment, the population of carbon nanotubes with shorter lengths decreases . . . , which evidences that the HNO₃ is also able to disrupt the carbon nanotubes.” *Id.* at 1040. “The 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.*

E. Obviousness Challenges Based on Bosnyak-392

Petitioner contends the combination of Bosnyak-392 and Son renders claims 1–16 obvious. Pet. 8–39. In support, Petitioner and Dr. Guido explain where they believe each limitation of the challenged claims is disclosed in the references, and the reasons a person of ordinary skill would have been motivated to combine the disclosures of the references. *See, e.g., id.* at 11–39; Ex. 1003 ¶¶ 33–101. Patent Owner opposes. Resp. 19–49.

i. Petition - Claim 1

Petitioner argues Bosnyak-392 discloses electrolytes and separators as components of energy storage devices, and compositions of exfoliated carbon nanotubes for those components. Pet. 13–14 (citing Ex. 1005 ¶¶ 8, 14, 74, claim 37). Petitioner argues Bosnyak-392 discloses discrete carbon nanotubes because it describes providing “individual carbon nanotubes” as opposed to nanotubes aggregated into bundles. *Id.* at 15 (citing Ex. 1008 ¶¶ 6, 8, 36, 37, 54). Further, Petitioner argues the ’282 patent recognizes exfoliated carbon nanotubes are discrete, because it refers to “discrete oxidized carbon nanotubes, alternatively termed exfoliated carbon nanotubes.” *Id.* (citing Ex. 1001, 6:50–54) (emphasis omitted).

Petitioner argues Bosnyak-392 discloses its carbon nanotubes have an aspect ratio of at least about 100 (*id.* at 14, citing Ex. 1005 ¶ 42), and that Son discloses using two different groups of carbon nanotubes, the first group having an aspect ratio between 10–65 and the second group having an aspect ratio between 130–1000. *Id.* (citing Ex. 1008 ¶¶ 9, 14, 16, 28, 29, Fig. 4, claims 2, 7, 9). Petitioner further argues Son discloses a bimodal aspect ratio distribution of its two nanotube groups, with “more of the lower aspect ratio nanotubes compared to the higher aspect ratio nanotubes.” *Id.* at 18–19 (citing Ex. 1008, Fig. 6). Petitioner and Dr. Guido explain, using three different approaches, that a person of ordinary skill would have understood how to approximate or calculate a distribution of aspect ratios by number percentage (as recited in claim 1 of the ’282 patent) from Son’s disclosure of distribution of aspect ratios by weight percentage. *Id.* at 19–28 (citing Ex. 1003 ¶¶ 52–80).

Petitioner argues a person of ordinary skill in the art would have been motivated by Son’s teachings to use Son’s aspect ratio distribution in Bosnyak-392’s composition of carbon nanotubes. Pet. 11–13. Petitioner explains that Son, like Bosnyak-392, teaches a polymer composite material using carbon nanotubes, and Son additionally recognizes that using discrete carbon nanotubes with two different aspect ratios within the composite material can yield improved mechanical and electrical properties, using a “routine/conventional process that can be ‘easily determined by a person skilled in the art.’” *Id.* at 12 (citing Ex. 1008 ¶¶ 4, 20, 33). Petitioner further argues Bosnyak-392 similarly recognizes the desire to use a bimodal aspect ratio distribution of both shorter and longer nanotubes. *Id.* at 17 (citing Ex. 1005 ¶ 73). Petitioner thus argues a person of ordinary skill in

the art would have recognized the mechanical and electrical properties of Bosnyak-392's nanocomposite material can be further improved through the specific bimodal distribution teachings of Son. *Id.* at 12–13 (citing Ex. 1008 ¶¶ 8, 21). Petitioner argues using Son's teachings in Bosnyak-392's composition would merely have involved application of a known technique to a known structure to yield predictable results, and a person of ordinary skill in the art would have had a reasonable expectation of success in doing so. *Id.* at 13 (citing Ex. 1003 ¶¶ 38, 52; Ex. 1005 ¶ 58; Ex. 1014 ¶ 18).

ii. Patent Owner Response

Patent Owner contends:

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

Resp. 5.

iii. Petitioner's Reply

Petitioner replies, first, that the CNTs in the Bosnyak-392 and Son combination are discrete, based in large part on Petitioner's claim construction arguments and Patent Owner's "fundamentally flawed" interpretation of Son's Figures. Reply 8–12.

Regarding Patent Owner's third argument, Petitioner replies that the CNTs in the Bosnyak-392 and Son combination satisfy the claimed concentrations, referring to Dr. Gido's three different conversion approaches. *Id.* at 12–17.

iv. Patent Owner's Sur-Reply

Patent Owner responds that the combination of Bosnyak-392 and Son does not teach or enable the generation of a bimodal distribution of discrete CNTs. Sur-reply 23–26.

Patent Owner further responds that the combination of Bosnyak-392 and Son does not teach discrete CNTs in the claimed concentrations. *Id.* at 26. Patent Owner criticizes the alleged assumptions Petitioner makes to justify its conversions, and maintains that Bosnyak-392 and Son do not teach discrete CNTs in the specific claimed range. *Id.* at 26–30.

v. Analysis

Regarding Patent Owner's first argument, as noted in our discussion above, we do not adopt Patent Owner's proposed claim construction. Patent Owner's arguments are premised on the proposal that "discrete" CNTs are CNTs that are "not attached to other nanotubes." Applying our claim construction above that "discrete oxidized carbon nanotubes" are "alternatively termed exfoliated carbon nanotubes," we are persuaded that Petitioner has established by a preponderance of the evidence that the

combination of Bosnyak-392 and Son teaches the limitations of claim 1, particularly the “discrete” CNTs limitation. Bosnyak-392 describes exfoliated and fully exfoliated CNTs. Reply 8–9 (citing Ex. 1005 ¶ 56); *see also* Ex. 1005 ¶¶ 6–8, 41, 42; Tr. 20:19–21 (Petitioner stating “it’s the nanotubes in the Bosnyak-392, which we believe very clearly provide these fully exfoliated discrete carbon nanotubes, that form the basis of this combination”). Even though we disagree with Patent Owner that “discrete” CNTs are CNTs that are “not attached to other nanotubes,” we address and acknowledge Petitioner’s arguments that the depiction of CNTs found in Son’s three-dimensional Figure 1, showing that the CNTs are not necessarily touching, is more accurate than Patent Owner’s annotated two-dimensional depiction in Son’s Figure 3, which purports to show every larger aspect CNT touching. Reply 9–10. We agree that Patent Owner’s reliance on Figure 3 “for the notion that every single one of Son’s larger aspect ratio CNTs are touching each other is fundamentally flawed.” *Id.* at 12 (citing Ex. 2005, 36:9–37:5).

Regarding Patent Owner’s second argument having to do with motivation to combine, we are persuaded that Petitioner has established by a preponderance of the evidence that one of ordinary skill in the art would have been motivated to combine Bosnyak-392 and Son with a reasonable expectation of success. This second argument is also tied to Patent Owner’s proposed claim construction, which we have not adopted. Applying the meaning of “discrete” discussed above, we are persuaded by Petitioner’s showing that Bosnyak-392 teaches exfoliated carbon nanotubes. Pet. 8; *see also id.* at 15 (“Son similarly relies on the use of such discrete nanotubes having ‘excellent dispersibility.’ LGES-1008, [0021].”). Son recognizes

that “concurrently using discrete carbon nanotubes with two different aspect ratios within a composite material can yield improved mechanical and electrical properties,” using a “routine/conventional process that can be ‘easily determined by a person skilled in the art.’” Pet. 12 (citing Ex. 1008 ¶¶ 4, 20, 33). For this and the further reasons given in the Petition and Reply regarding motivation to combine with a reasonable expectation of success, we are persuaded that Petitioner has met its burden in this regard. *See* Pet. 11–19; Reply 8–12.

Regarding Patent Owner’s third argument that Petitioner’s conversions of Son’s concentrations given in weight percentages to the claims’ concentrations given in number percentages are impossible, we disagree. As explained by Petitioner and Dr. Gido, Son’s broad disclosure of its aspect ratio distribution (given as a weight distribution) covers the claimed aspect ratio distribution in the ’282 Patent (given as a number distribution). Pet. 19–20; Ex. 1003 ¶¶ 51–80; Reply 12–17. Petitioner’s declarant provided three approaches to converting Son’s concentrations. Ex. 1003 ¶¶ 52–80. Because the third approach was the most rigorous, and the most thoroughly discussed in the briefing and at oral hearing (*see, e.g.*, Tr. 24:11–22), we focus on Dr. Gido’s third approach. Ex. 1003 ¶¶ 58–80. We note that Patent Owner’s declarant did not dispute the mathematics of the third approach, but disagreed with the assumption that each aspect ratio for certain carbon nanotubes has an average diameter. *Id.* at 24:17–22 (“the only assumption that Dr. Gido made is that each aspect ratio for certain carbon nanotube has an average diameter. That’s all that he assumed. That’s something that Dr. Chung, I think, agreed to as well, that, you know, when you buy a nanotube, you buy it or you specify it in terms of average

diameters. But if you actually follow the math . . . even the average diameter drops off.”); Reply 15. Although we acknowledge Patent Owner’s concern with the third approach and with Dr. Gido’s assumption “that the distribution of carbon nanotube diameters is similar across the range of aspect ratios (range of lengths),” (Sur-reply 29 (citing Ex. 1003 ¶ 53)), we disagree that this assumption is incorrect. Petitioner’s explanation of the third approach “in which the nanotube diameters, instead of being assumed to be constant as per the ’282 Patent, were taken to have a distribution of diameters characterized by an average diameter $\langle d \rangle$ ” (citing Pet. 26–27 (citing Ex. 1003, ¶ 63)) addresses the approach taken by Dr. Gido to “more precisely go from Son’s weight distribution domain to the number distribution domain of the ’282 Patent.” Reply 14–15 (citing Ex. 1003 ¶¶ 58–60). Importantly, Petitioner notes that the disputed “nanotube diameters $\langle d \rangle$ ultimately drop out of the conversion calculation” to yield the two formulas used by Dr. Gido to convert “a known number distribution (n/N) into the corresponding weight distribution (m/M), or a known weight distribution into a number distribution.” *Id.* at 15 (citing Pet. 27; Ex. 1003 ¶¶ 64–67). Thus, the third approach taken by Dr. Gido satisfactorily provides the conversion relied upon by Petitioner in its argument that Son’s weight distribution may be converted to the number distribution of the ’282 patent, and satisfy the relevant limitations of claim 1.

Regarding Patent Owner’s fourth argument that Petitioner fails to demonstrate that finding an optimum range in Son’s disclosure would be a routine matter, we are persuaded by Petitioner’s arguments on this point. Petitioner argues that the “sole difference between Son and the ’282 Patent relate to numerical optimization within an overlapping numeric range for a

single structural parameter (*i.e.*, aspect ratio),” thus distinguishing the present case from the case relied upon by Patent Owner. Reply 16; Resp. 45; *Genetics Inst., LLC v. Novartis Vaccines & Diagnostics, Inc.*, 655 F.3d 1291, 1304–07 (Fed. Cir. 2011). Petitioner provides further, credible support for its assertion that “adjustment of aspect ratios of CNTs was a well-known and exceedingly common technique with predictable results.” Reply 16 (citing Ex. 1003 ¶ 38; Ex. 2004 ¶ 70).

vi. Conclusion on Claim 1

For the above reasons, Petitioner demonstrates that claim 1 would have been obvious in view of the combined teachings of Bosnyak-392 and Son.

vii. Claims 2–16

Claims 2–16 depend, directly or indirectly, from claim 1. These claims inherit the all the claim limitations of claim 1, including the disputed “discrete carbon nanotube fibers” limitation. Our reasoning above, provided in the context of claim 1, applies with equal force to these dependent claims.

Petitioner identifies where it believes every limitation of challenged dependent claims 2–16 is found in the combination of Bosnyak-392 and Son. Pet. 28–39. Patent Owner does not present separate arguments as to these dependent claims. *See generally* Resp. We have reviewed Petitioner’s evidence and arguments, and are persuaded on this complete record that Petitioner has shown by a preponderance of the evidence that claims 2–16 would have been obvious over the combination of Bosnyak-392 and Son.

viii. Claims 4 and 11

In its second and third Grounds, Petitioner identifies where it believes every limitation of challenged dependent claim 4 is found in the combination

of Bosnyak-392, Son and So (Pet. 40–42), and where it believes every limitation of challenged dependent claim 11 is found in the combination of Bosnyak-392, Son and Gu (Pet. 42–43). Patent Owner does not present separate arguments as to these dependent claims. *See generally* Resp. We have reviewed Petitioner’s arguments for its second and third Grounds, including Petitioner’s reasoning and evidence in support of its arguments, and adopt them as our own. We are persuaded on this complete record that Petitioner has shown by a preponderance of the evidence that claim 4 would have been obvious over the combination of Bosnyak-392, Son, and So, and that claim 11 would have been obvious over the combination of Bosnyak-392, Son and Gu.

ix. Conclusion on Obviousness Challenges Based on Bosnyak-392

Petitioner establishes that all of the challenged claims are obvious in view of the combined teachings of Bosnyak-392 and the secondary references.

F. Obviousness Challenges Based on Bosnyak-129

Petitioner contends the combination of Bosnyak-129 and Albuerne renders claims 1, 5–9, and 12–16 obvious. Pet. 43–67. In support, Petitioner and Dr. Guido explain where they believe each limitation of the challenged claims is disclosed in the references, and the reasons a person of ordinary skill would have been motivated to combine the disclosures of the references. *Id.* at 48–67; Ex. 1003 ¶¶ 114–143. Petitioner also contends the

combination of Bosnyak-129, Albuerne, and Gu renders claims 2–4, 10, and 11 obvious. Pet. 67–73; Ex. 1003 ¶¶ 144–154.

i. Arguments

Petitioner argues Bosnyak-129 discloses electrolytes and separators as components of energy storage devices, and compositions of exfoliated carbon nanotubes for those components. Pet. 50–53 (citing Ex. 1006 ¶¶ 2, 37, 92, 131, 134, 138, 159, code (57), claim 33). Petitioner further argues Bosnyak-129 discloses discrete carbon nanotube fibers that can be obtained by contacting entangled nanotubes with an acid solution such as sulfuric and nitric acids, and sonicating them. *Id.* at 53–55 (citing Ex. 1006 ¶¶ 11–12).

Petitioner argues Bosnyak-129 discloses its carbon nanotubes have an aspect ratio of from about 10 to about 500 and at least a portion of the nanotubes are open-ended. Pet. 46 (citing Ex. 1025, 28; Ex. 1006 ¶ 17). Petitioner notes that Bosnyak-129 does not disclose the specific percentage and aspect ratios of claim 1. *Id.* at 59.

Petitioner argues Albuerne discloses using a nitric acid treatment step followed by sonication to disentangle aggregated nanotubes into discrete nanotubes, in a process for making polymer matrix composites. Pet. 46–47 (citing Ex. 1009, 1035–36). Petitioner further argues Albuerne discloses that its discrete nanotubes have mean diameter of 15 nm and length distribution as shown in Figure 5(b), and that the aspect ratio distribution, which a person of ordinary skill in the art would have been able to calculate from the lengths and mean diameter, overlaps with the specific percentages of aspect ratio ranges in claim 1. *Id.* at 60–63 (citing Ex. 1009, 1039–40).

Petitioner argues a person of ordinary skill in the art would have been motivated to combine Albuerne with Bosnyak-129 because both references

teach oxidizing aggregated carbon nanotubes using similar acid solutions and sonication techniques to disperse the nanotubes. Pet. 48–50. Petitioner further argues it would have been a simple substitution for a person of ordinary skill in the art to have used Albuerne’s nitric acid treatment in Bosnyak-129’s process, in view of Albuerne’s teaching that its acid treatment preserves the discrete nanotubes “without cutting the length of the carbon nanotubes or lo[]sing any of the walls” (*id.* at 49 (citing Ex. 1009, 1038)), and Albuerne’s teaching that nitric acid treatment provides the predictable result “of obtaining discrete oxidized carbon nanotubes having longer carbon nanotubes.” *Id.* at 48–49 (citing Ex. 1003 ¶¶ 114–15).

Patent Owner argues that the grounds based on Bosnyak-129 are “deeply flawed”:

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

Resp. 6.

Petitioner replies, regarding Albuerne’s alleged “single data point,” that “regardless of whether the relevant disclosure from Albuerne comes from a ‘blip,’ a clump, a blob, or something else, it nevertheless remains that

a reference is prior art for all that it discloses: Albuerne discloses the claimed aspect ratio ranges.” Reply 17.

Patent Owner responds: “**One** CNT was measured with the length 2000 nm, and Petitioner extrapolates this to contend that this provides some meaningful understanding of the aspect ratio ranges found in the *sample as a whole*.” Sur-reply 32 (citing Ex. 2004 ¶ 131 (citing Pet. 59)). Patent Owner criticizes this as extrapolation as “hyper-technical nonsense that no POSITA would reasonably make.” *Id.*

ii. Analysis

Having considered the evidence and arguments presented by both parties on the complete record, we are persuaded by Patent Owner’s arguments regarding Petitioner’s proposed combination of Albuerne with Bosnyak-129.

We agree that Petitioner appears to rely on Albuerne for a “bimodal aspect ratio distribution” purportedly shown in Albuerne’s Figure 5(b). Resp. 50; Pet. 46, 48, 49, 56–58. We are not persuaded, however, that a POSITA would consider Albuerne “for providing a bimodal mechanism to Bosnyak’s aspect ratio ranges.” Resp. 55 (citing Ex. 2004 ¶ 134). As Patent Owner notes, the “CNTs measured and displayed in the graph of Figure 5(b) are 100 CNTs out of the many billions of CNTs contained in Albuerne’s sample.” Sur-reply 31–32. Of these, only “[o]ne CNT was measured with the length 2000 nm.” *Id.* at 32. From this sample, Petitioner “extrapolates this to contend that this provides some meaningful understanding of the aspect ratio ranges found in the *sample as a whole*.” *Id.* (citing Ex. 2004 ¶ 131 (citing Pet. 59)). We agree with Patent Owner that it does not. *See* Ex. 2004 ¶ 133. As Petitioner noted, the term bimodal “is not a term that

appears in the claims” but “is in the spec.” Tr. 27:16–27; Ex. 1001, 5:50–52 (“In statistics, a bimodal distribution is a continuous probability distribution with two different modes.”); *see also* Tr. 60:23–61:6 (citing Ex. 1003 ¶¶ 47, 74–81, discussing Son’s bimodal distribution). In view of this, we credit Patent Owner’s declarant’s testimony that a “POSITA would have no reason to consider Albuerne for providing a bimodal mechanism to Bosnyak’s aspect ratio ranges” because a “POSITA would never see Albuerne as teaching any bimodal distribution, as the 1% indication of 2,000 nm length CNTs is statistically insignificant.” Ex. 2004 ¶ 134. We agree that this “statistical insignificance” would not lead a POSITA to view Albuerne’s histogram as displaying a “bimodal distribution,” which undermines Petitioner’s arguments regarding the proposed combination of Albuerne with Bosnyak-129 to meet the limitations of claim 1.

For the above reasons, Petitioner does not demonstrate by a preponderance of the evidence that claim 1 would have been obvious in view of the combined teachings of Bosnyak-129 and Albuerne.

Claims 5–9 and 12–16 depend, directly or indirectly, from claim 1. These claims inherit the limitations of claim 1 and, therefore, our reasoning with respect to claim 1 applies with equal force to claims 5–9 and 12–16. Accordingly, we determine that Petitioner fails to demonstrate that any of the dependent claims would have been obvious in view of the combined teachings of Bosnyak-129 and Albuerne.

Petitioner additionally challenges claims 2–4, 10, and 11 as allegedly obvious over the combination of Bosnyak-129, Albuerne, and Gu. These claims also inherit the limitations of claim 1 and, therefore, our reasoning with respect to claim 1 applies with equal force to claims 2–4, 10, and 11.

Accordingly, we determine that Petitioner fails to demonstrate that any of the dependent claims would have been obvious in view of the combined teachings of Bosnyak-129, Albuerne, and Gu.

For the reasons stated by Patent Owner, we determine that Petitioner fails to prove by a preponderance of the evidence that any claim is unpatentable as obvious based on the challenges that assert Bosnyak-129 and Albuerne.

III. CONCLUSION

Petitioner establishes by a preponderance of the evidence that claims 1–16 of the '282 patent are unpatentable. We summarize our decision in the following chart.

Claim(s)	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1–16	§ 103	Bosnyak-392, Son	1–16	
4	§ 103	Bosnyak-392, Son, So	4	
11	§ 103	Bosnyak-392, Son, Gu	11	
1, 5–9, 12–16	§ 103	Bosnyak-129, Albuerne		1, 5–9, 12–16
2–4, 10, 11	§ 103	Bosnyak-129, Albuerne, Gu		2–4, 10, 11
Overall Outcome			1–16	

IV. ORDER

It is

ORDERED that Petitioner has proven by a preponderance of the evidence that claims 1–16 of the '282 patent are unpatentable;

FURTHER ORDERED that *within one week of this Decision*, the Samsung Petitioners shall submit to the Board, via email to Trials@uspto.gov, a version of this Decision to be filed in the public record, with proposed any redactions; and

FURTHER ORDERED that, because this is a Final Written Decision, any party to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Patent 10,608,282 B2

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