

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD. and
SAMSUNG ELECTRONICS AMERICA, INC.,
Petitioner,

v.

NANOCO TECHNOLOGIES LTD.,
Patent Owner.

IPR2021-00185
Patent 7,867,557 B2

Before ERICA A. FRANKLIN, GRACE KARAFFA OBERMANN, and
CHRISTOPHER M. KAISER, *Administrative Patent Judges*.

OBERMANN, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining No Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

This is a Final Written Decision in an *inter partes* review of claims 1–6, 16, and 17 of U.S. Patent No. 7,867,557 B2 (Ex. 1001, “the ’557 patent”). We have jurisdiction under 35 U.S.C. § 6 and enter this Decision pursuant to 35 U.S.C. § 318(a). For the reasons that follow, we determine that Petitioner¹ does not establish by a preponderance of the evidence that any challenged claim is unpatentable.

A. Procedural History

Petitioner filed a Petition requesting review of the challenged claims. Paper 1 (“Pet.”). With the Petition, Petitioner filed the Declaration of Mark A. Green, Ph.D., in support of the challenges stated in the Petition. Ex. 1002. Patent Owner² filed a Preliminary Response to the Petition (Paper 12). Pursuant to our authorization, Petitioner filed a Reply (Paper 14) and Patent Owner filed a Sur-reply (Paper 15).

Based on that preliminary record, we instituted an *inter partes* review of all challenged claims based on all grounds of unpatentability asserted in the Petition. Paper 17 (“Dec.”). The following table sets forth the grounds.³

¹ “Petitioner” refers collectively to Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. *See* Paper 39, 1 (identification of Petitioner’s real parties-in-interest).

² “Patent Owner” refers to Nanoco Technologies Ltd. Paper 6, 1. *See* Paper 6, 1 (identification of Patent Owner’s real party-in-interest).

³ The Leahy-Smith America Invents Act (“AIA”), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. § 103, effective March 16, 2013. Because the ’557 patent application has an effective filing date prior to March 16, 2013, the pre-AIA version of § 103 applies.

Claims Challenged	35 U.S.C. §	References
1–6, 16, 17	103(a)	Banin, ⁴ Braun ⁵
1, 16, 17	103(a)	Zaban, ⁶ Ptatschek, ⁷ Braun
4–6	103(a)	Zaban, Ptatschek, Braun, Yu ⁸
1, 4, 16, 17	103(a)	Lucey, ⁹ Ahrenkiel, ¹⁰ Braun

After institution of trial, Patent Owner filed a Response (Paper 26,¹¹ “Resp.”), along with the Declaration of Brandi Cossairt, Ph.D. (Ex. 2030),

⁴ Banin et al., WO 03/097904 A1, published Nov. 27, 2003 (“Banin,” Ex. 1005).

⁵ Braun et al., *Variation of the Thickness and Number of Wells in the CdS/HgS/CdS Quantum Dot Quantum Well System*, 105 J. PHYS. CHEM. A. 5548–5551 (2001) (“Braun,” Ex. 1013).

⁶ Zaban et al., *Photosensitization of Nanoporous TiO₂ Electrodes with InP Quantum Dots*, 14 LANGMUIR 3153–3156 (1998) (“Zaban,” Ex. 1006).

⁷ Ptatschek et al., *Quantized Aggregation Phenomena in II-VI Semiconductor Colloids*, 102 PHYS. CHEM. 85–95 (1998) (“Ptatschek,” Ex. 1008).

⁸ Yu et al., *Heterogeneous Seeded Growth: A Potentially General Synthesis of Monodisperse Metallic Nanoparticles*, 123 J. AM. CHEM. SOC. 9198–9199 (2001) (“Yu,” Ex. 1010).

⁹ Lucey et al., US 7,193,098 B1, issued Mar. 20, 2007 (“Lucey,” Ex. 1011).

¹⁰ Ahrenkiel et al., *Synthesis and Characterization of Colloidal InP Quantum Rods*, 3 (6) NANO LETTERS 833–837 (2003) (“Ahrenkiel,” Ex. 1012).

¹¹ Patent Owner filed Paper 26 (unredacted Response) under seal and Paper 27 (redacted Response) in the public record. Thereafter, “the parties agreed that” the Response does “not contain confidential information and” does “not need to be sealed.” Paper 31, 1.

Petitioner filed a Reply (Paper 33, “Reply”), along with the Second Declaration of Dr. Green (Ex. 1093), and Patent Owner filed a Sur-reply (Paper 40, “Sur-reply”).¹² The parties presented oral arguments during a hearing held by video on February 23, 2022.¹³ Paper 47 (“Tr.”).

B. Related Matters

The parties identify litigation involving the ’557 patent as a related matter: *Nanoco Technologies Ltd. v. Samsung Electronics Co., Ltd.*, No. 2:20-cv-00038 (E.D. Tex.) (“District Court case”). Pet. 68; Paper 6, 1.

The parties also identify, as related matters, petitions for review filed in connection with four other patents asserted in the District Court case: IPR2021-00182 for U.S. Patent No. 9,680,068, IPR2021-00183 for U.S. Patent No. 7,588,828 (“IPR183”), IPR2021-00184 for U.S. Patent No. 7,803,423 (“IPR184”), and IPR2021-00186 for U.S. Patent No. 8,524,365. Pet. 68; Paper 6, 1–2. Concurrently with this Decision, we enter final written decisions in those administrative proceedings.

C. The ’557 Patent (Ex. 1001)

The ’557 patent relates to a method for producing nanoparticles having a core, a first layer, and a second layer. Ex. 1001, 3:24–29. Each comprises a semiconductor material, but the core material differs from that

¹² Based on their respective statements of qualifications and curricula vitae, which are not contested, we determine that both Dr. Green and Dr. Cossairt are qualified to provide opinions about the knowledge and understanding of a person of ordinary skill in the art at the time of the invention. Ex. 1002 ¶¶ 17–30; Ex. 1003; Ex. 2030 ¶¶ 5–21, Appendix A.

¹³ A consolidated hearing was conducted in IPR2021-00182, IPR2021-00183, IPR2021-00184, this proceeding, and IPR2021-00186, however, the cases are not consolidated. See Paper 44 (Order, setting oral argument).

of the first layer, and the first layer material differs from that of the second layer. *Id.* at 3:29–32, 30:65–31:17.

The written description states, “There has been substantial interest in the preparation and characterization of compound semiconductors” that include “particles with dimensions in the order of 2–100 [nanometers] (nm), often referred to as quantum dots and nanocrystals.” *Id.* at 1:16–19. That interest “mainly” may be “due to their size-tunable electronic, optical, and chemical properties and the need for the further miniaturization of both optical and electronic devices.” *Id.* at 1:21–23. The written description further indicates that such nanoparticles may be useful in a “range” of “commercial applications,” including “biological labelling, solar cells, catalysts, biological imaging, [and] light-emitting diodes.” *Id.* at 1:24–27.

The claimed method includes a step of “effecting conversion of a nanoparticle core precursor composition to the material of the nanoparticle core, depositing said first layer on said core and depositing said second layer on said first layer.” *Id.* at 3:33–36; *see id.* at 30:65–31:17 (claim 1). The “core precursor composition,” in turn, includes “a first precursor species containing a first ion to be incorporated into the growing nanoparticle core.” *Id.* at 3:35–38. The core precursor composition also includes “a separate second precursor species containing a second ion to be incorporated into the growing nanoparticle core.” *Id.* at 3:38–40. The “conversion” is “effected in the presence of a molecular cluster compound” (“MCC”) “under conditions permitting seeding and growth of the nanoparticle core.” *Id.* at 3:40–43.

The written description provides examples for preparing a nanoparticle core (*id.* at 15:60–17:57), a first layer (*id.* at 21:27–22:33), and a second layer (*id.* at 22:35–40). That description also provides examples for

preparing MCCs. *Id.* at 26:27–47. In addition, the '557 patent describes a preferred “three-step process” whereby “cores are synthesized and isolated from a growth solution,” then a first layer “is grown onto the cores in a separate reaction and isolated once again.” *Id.* at 23:45–51. An outer layer “is grown onto the core-shell structure,” thereby producing, for example, a “quantum dot-quantum well.” *Id.* at 23:51–53. The description further discusses experimental conditions for producing an exemplary nanoparticle represented by the formula $\text{ZnS/CdSe/Cd}_x\text{Zn}_{1-x}\text{S}$. *Id.* at 26:11–30:22.

D. Challenged Claims

We reproduce below claim 1, which is the sole independent challenged claim and illustrates the subject matter of the invention.

1. A method for producing a nanoparticle comprised of a core comprising a core semiconductor material, a first layer comprising a first semiconductor material provided on said core and a second layer comprising a second semiconductor material provided on said first layer, said core semiconductor material being different to said first semiconductor material and said first semiconductor material being different to said second semiconductor material, the method comprising:

 effecting conversion of a nanoparticle core precursor composition to the material of the nanoparticle core;

 depositing said first layer on said core; and

 depositing said second layer on said first layer, said core precursor composition comprising a first precursor species containing a first ion to be incorporated into the growing nanoparticle core and a separate second precursor species containing a second ion to be incorporated into the growing nanoparticle core,

 said conversion being effected in the presence of a molecular cluster compound different from the nanoparticle core precursor composition.

Ex. 1001, 30:65–31:17. The other challenged claims inherit the above limitations through direct or indirect dependence on claim 1. *See id.* at 31:18–56 (claims 2–6), 32:37–54 (claims 16 and 17).

II. ANALYSIS

Our analysis is centered on explaining why we determine that Petitioner does not carry its burden of proving the unpatentability of claim 1 based on any ground asserted in the Petition. Petitioner advances no information, in connection with any other challenged claim, that cures the deficiencies that we identify below in the context of claim 1. *See* Pet 33–38, 45–51, 59–62. Accordingly, the challenges asserted in the Petition rise and fall with the sufficiency of Petitioner’s showing made as to claim 1, and our analysis of claim 1 applies with equal force to each challenged claim.

A. Principles of Law

To prevail in this proceeding, Petitioner must demonstrate by a preponderance of the evidence that the challenged claims are unpatentable. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d) (2019). “In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.” *Harmonic Inc. v. Avid. Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016); *see also* 35 U.S.C. § 312(a)(3) (2012) (requiring *inter partes* review petitions to identify “with particularity . . . the evidence that supports the grounds for the challenge to each claim”). That burden of persuasion never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015); *see also In re Magnum Oil Tools Int’l, Ltd.*, 829 F.3d 1364, 1375–78 (Fed. Cir. 2016) (discussing the burden of proof in *inter partes* review proceedings).

A claim is unpatentable for obviousness if, to one of ordinary skill in the pertinent art, “the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made.” 35 U.S.C. § 103(a) (2006); *see also KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007).

The question of obviousness is resolved on the basis of underlying factual determinations including the scope and content of the prior art, any differences between the claimed subject matter and the prior art, the level of ordinary skill in the art, and objective evidence of nonobviousness.¹⁴

Graham v. John Deere Co., 383 U.S. 1, 17–18 (1966). “An obviousness determination requires finding both ‘that a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success in doing so.’” *CRFD Research, Inc. v. Matal*, 876

¹⁴ Although Patent Owner does not expressly argue that any objective evidence of nonobviousness undercuts Petitioner’s challenges in this case, Patent Owner does assert that Petitioner tried, without success, “to solve problems associated with producing cadmium-free quantum dots” and, further, that Petitioner’s “research lead” considered “developing cadmium-free quantum dot technology ‘to be quite a challenge.’” Resp. 9 (quoting Ex. 2005, 3). In addition, according to Patent Owner, Petitioner acknowledged that “the development of cadmium-free quantum dots was not as straightforward as optimizing existing synthesis methods.” *Id.* (citing Ex. 2006, 1316). To the extent Patent Owner asserts that these factual contentions are secondary indicia of non-obviousness, the contentions are not developed adequately. *Id.* In any event, even if we set aside those contentions, for reasons explained in our analysis of the challenges, we determine that Petitioner fails to show by a preponderance of the evidence that the prior art supports a finding of obviousness.

F.3d 1330, 1340 (Fed. Cir. 2017) (quoting *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1367–68 (Fed. Cir. 2016)).

We analyze Petitioner’s challenges according to the above-stated principles.

B. Person of Ordinary Skill in the Art

The level of 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 v. John Deere Co.*, 383 U.S. 1, 17–18 (1966); *Ryko Mfg. Co. v. Nu-Star, Inc.*, 950 F.2d 714, 718 (Fed. Cir. 1991)). In Petitioner’s view, an ordinarily skilled artisan would have had “at least a Ph.D. in chemistry, physics, chemical engineering, material science, or equivalent technical degree or equivalent work experience, with knowledge regarding nanoparticles and methods of synthesizing them” and “[a]dditional education might supplement practical experience and vice-versa.” Pet. 22 (citing Ex. 1002 ¶ 76). Patent Owner does not address Petitioner’s view or propose a counter definition.

We determine that the level of ordinary skill is reflected in the prior art of record. See *Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) (specific findings on the ordinary skill level are not required “where the prior art itself reflects an appropriate level and a need for testimony is not shown” (quoting *Litton Indus. Prods., Inc. v. Solid State Sys. Corp.*, 755 F.2d 158, 163 (Fed. Cir. 1985))). To the extent a more specific definition is required, we adopt Petitioner’s definition for purposes of this Decision, because that definition is unopposed and consistent with the disclosures of the asserted prior art references.

C. Claim Construction

The Board applies the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b). 37 C.F.R. § 42.100(b) (2020). Under that standard, claim terms “are generally given their ordinary and customary meaning” as understood by a person of ordinary skill in the art at the time of the invention. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc). “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). Extrinsic evidence is “less significant than the intrinsic record in determining ‘the legally operative meaning of claim language.’” *Phillips*, 415 F.3d at 1317.

Petitioner asserts that:

The '557 patent does not define the phrase “molecular cluster compound.” Two other patents assigned to [Patent Owner] and with overlapping inventors both describe the term as “widely understood,” but U.S. Patent No. 7,803,423 [at issue in related IPR184] states that the term relates to “clusters of three or more **metal or nonmetal atoms** and their associated ligands,” while U.S. Patent No. 7,588,828 [at issue in related IPR183] states it is limited to “clusters of 3 or more **metal atoms** and their associated ligands.” *Compare* Ex. 1055, 5:3–12, *with* Ex. 1054, 3:29–35. This issue need not be resolved, however, because the grounds relied on in this Petition disclose [molecular cluster compounds] with three or more metal atoms.

Pet. 23 (footnotes omitted) (Petitioner’s emphasis). Petitioner states that, according to the written description of the invention, the molecular clusters are “of sufficiently well-defined chemical structure such that all molecules

of the cluster compound possess the same relative molecular mass.” *Id.* at 23 n.6.

Patent Owner responds that “the District Court construed the term ‘molecular cluster compound’ to mean ‘clusters of three or more metal atoms and their associated ligands of sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula.’” Resp. 28 (quoting Ex. 1091, 18). As Patent Owner points out, “The parties dispute whether ‘sameness’ is measured in terms of ‘molecular formula’ or ‘molecular mass’ of the cluster compound—but this is a distinction without a difference for purposes of this IPR proceeding.” *Id.* at 29 n.2 (citing Pet. 22–23). On that point, Patent Owner observes, the District Court held that “the term ‘molecular formula’ as opposed to ‘molecular mass’ is most appropriate. By necessity, a compound with the same molecular formula will necessarily have the same molecular mass.” *Id.* (quoting Ex. 1091, 16). Petitioner does not contest that point effectively, if at all. *See* Reply 1 n.1 (Petitioner’s assertion that the challenged claims are unpatentable “under any possible construction”).

Based on our consideration of the record as a whole, we agree with the District Court that the molecular cluster compound of the claimed invention must have “sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula.” Ex. 1091, 18. To the extent that this or any other claim term requires further discussion, we provide it in our analysis of the challenges. No further express claim construction is necessary for purposes of this Decision. *See Wellman, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011) (“[C]laim terms need only be construed ‘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 the Asserted Prior Art References

1. Banin

Banin “relates to a method for synthesizing rod-shaped semiconductor nanocrystals, *inter alia* rod-shaped Group III-V semiconductor nanocrystals.” Ex. 1005, 2:2–4.¹⁵ Banin describes “introducing nanoparticles of a metal catalyst that serve as starting nanocrystals from which nanorods of inorganic semiconductors grow in solution while stopping the growth to obtain rods.” *Id.* at 7:3–6. Banin discloses that “[t]he metal catalyst can be made, for example, of a transition metal, e.g. Zn, Cd, Mn, etc., a Group IIIa metal, e.g. In, Ga, Al, alloys of such metals such as for example Au-In, or core/shell layered metal particle.” *Id.* at 7:9–11.

We reproduce below Banin’s Figure 1.

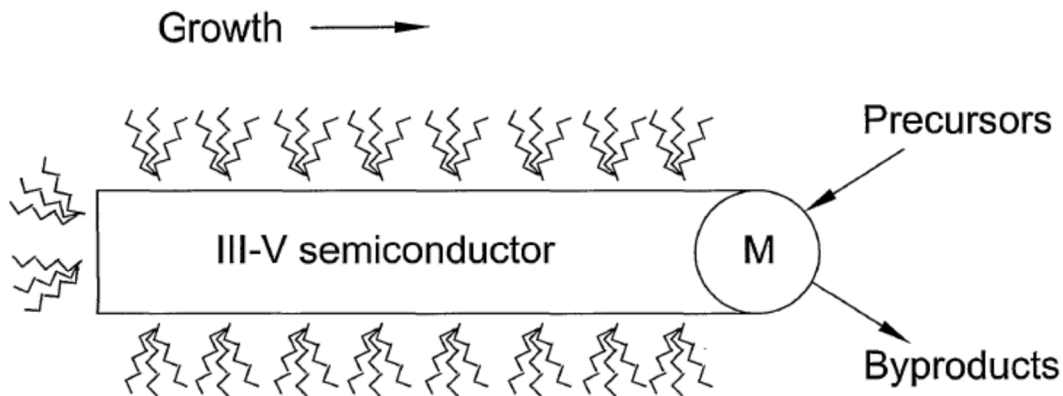


FIG. 1

¹⁵ We refer to original page numbers in Exhibit 1005, not page numbers added by Petitioner.

Figure 1 illustrates the growth mechanism of InAs nanorods for Banin's invention. *Id.* at 11:11–12. Banin describes, for example, that “InAs nanorods were synthesized via the reaction of tris(trimethylsilyl)arsenine ((TMS)₃As) and InCl₃ in trioctylphosphine-oxide (TOPO), using metallic indium or gold as the catalyst.” *Id.* at 14:9–11. Metal catalyst M forms a starting nanocrystal from which a semiconductor nanorod grows, with the left end of the III-V semiconductor nanorod grown first and then moved away from the catalyst M during growth of the nanorod. *Id.* at 14:11–16.

Banin also uses “small Au clusters (1.4 nm in mean diameter) instead of Au particles (2 nm in mean diameter)” and describes an experiment that uses “triphenylphosphine coated Au clusters with a diameter of 1.4 nm and the suggested formula Au₁₀₁(PPh₃)₂₁Cl₅” to prepare InAs rods. *Id.* at 21:12–17. Banin further discloses that its metal catalyst can be “Fe, Zn, Pd, Pt, Ni, Co, Mn, Ag, Cd or alloys and layered particles thereof.” *Id.* at claim 30.

2. Zaban

Zaban is a paper titled “Photosensitization of Nanoporous TiO₂ Electrodes with InP Quantum Dots.” Ex. 1006, 3153. Zaban describes a method for synthesizing quantum dots from precursors in a solution that includes zinc acetate as a dopant. *Id.* at 3154; *see* Pet. 38; Reply 20 (acknowledging that Zaban relates to a “Zn-doped” nanoparticle synthesis). In Zaban's synthetic method, zinc acetate is employed as a dopant “in a ratio” to produced doped quantum dots of indium phosphide that “contain on average one Zn²⁺ ion per particle.” Ex. 1006, 3154.

3. Ptatschek

Ptatschek is a paper titled “Quantized Aggregation Phenomena in II-VI Semiconductor Colloids.” Ex. 1008, 85. The focus of the paper is “the

sol-gel chemistry of metal oxides” and, in particular, “metal ethoxy-acetate derived synthesis of II-VI chalcogenide quantum dots.” *Id.*

Ptatschek describes “semiconductor quantum dot solutions for coating applications” made using “cluster-like cadmium and zinc ethoxy-acetates.” *Id.* Ptatschek describes “[a] new route . . . for the preparation of concentrated” group “II–VI quantum dot coating solutions,” in which “initial nucleation in organic solvents produces several magic molecular clusters.” Ex. 1008, 95. A “starting procedure” results in “production of crystalline powders composed of well known pyramidal $\text{Zn}_4\text{O}(\text{OAC})_6$ -clusters” where “OAC” represents “acetate.” *Id.* at 86. Ptatschek employs those known crystalline powders in a chemical reaction to form a product that, upon study, “revealed the presence of $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters associated with 7 ethanol ligands and 1 water molecule. *Id.* Ptatschek reports, “The results of this detailed structural study will be published in the near future.” *Id.*

4. Braun, Yu, Lucey, and Ahrenkiel

Petitioner asserts Braun, Yu, Lucey, and Ahrenkiel in one or more grounds advanced in the Petition. Pet. 16–17. We make no findings pertaining to these references because none is necessary to our analysis.

E. Ground that Asserts Banin

Petitioner asserts that claims 1–6, 16, and 17 are unpatentable as obvious over Banin and Braun. Pet. 16. Our analysis of independent claim 1 applies with equal force to dependent claims 2–6, 16, and 17.

We organize this section into three subparts, addressing in turn (1) a dispositive issue whether Petitioner demonstrates, by a preponderance of the evidence, that Banin discloses MCCs; (2) an alternative theory of unpatentability, raised for the first time in the Reply, that an ordinarily

skilled artisan would have replaced “the small gold clusters” in Banin’s process with known MCCs not identified with particularity by Petitioner; and (3) our conclusions on this ground.

1. Whether Banin’s “small Au clusters” are MCCs

This challenge depends on Petitioner’s assertion that Banin discloses small gold clusters that are MCCs. Pet. 31. For reasons that follow, we find Petitioner does **not** show persuasively that Banin’s “small Au clusters” (also referred to herein as Banin’s “Au-based clusters,” “gold clusters,” “gold cluster catalysts,” and “metal catalysts”) are MCCs.

For reasons explained in our claim construction analysis, we apply the construction assigned by the District Court, under which MCCs are “clusters of three or more metal atoms and their associated ligands of sufficiently well-defined chemical structure such that all molecules of the cluster compound possess approximately the same relative molecular formula.” Ex. 1091, 18. According to Petitioner, Banin’s Au-based clusters are MCCs. Pet. 25; Ex. 1002 ¶ 103. To support that position, Petitioner directs us to Banin’s disclosure that the Au-based clusters have “the suggested formula $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ ” (Ex. 1005, 20:12–27) and the testimony of Dr. Green (Ex. 1002 ¶¶ 101–103). Pet. 31–32.

Dr. Green testifies, “It is my opinion that a [person of ordinary skill in the art] would have understood that the gold clusters $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ ” in Banin’s process “are ‘clusters of 3 or more metal’ atoms (*i.e.*, because the other atoms of the clusters, $(\text{PPh}_3)_{21}\text{Cl}_5$, are the ligands), and their associated ligands’ and that each cluster is ‘identical to one another.’” Ex. 1002 ¶ 102 (citing Ex. 1055, 4:61–5:12). Dr. Green continues, “That is supported by Banin’s disclosure that the Au clusters ‘provid[e] large seeds for rapid InAs

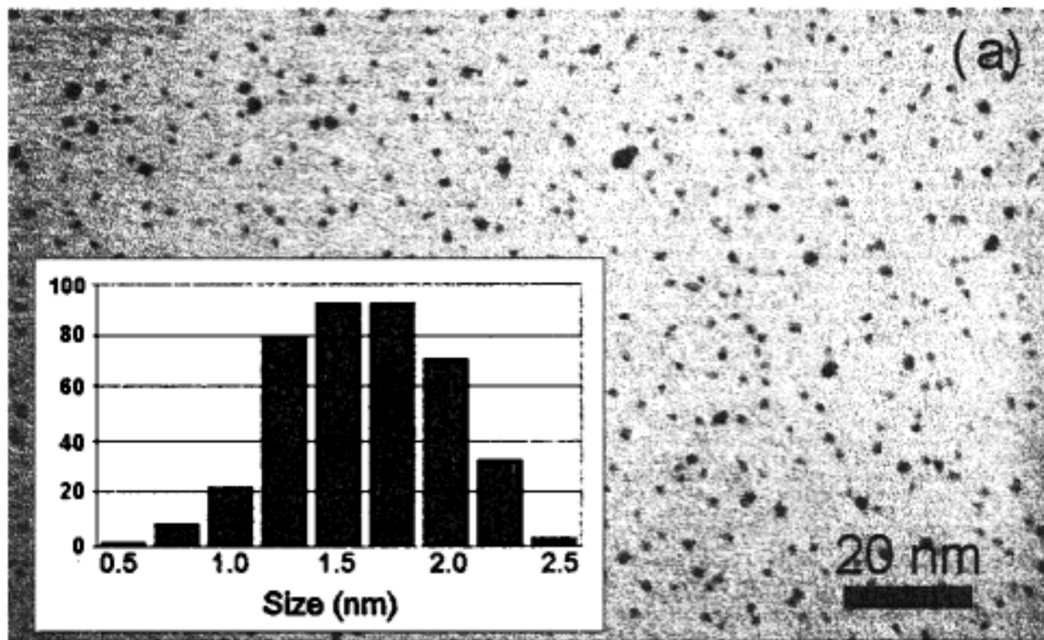
[nanoparticle] growth.” *Id.* (citing Ex. 1005, 23:24–27). Dr. Green considers the gold clusters to have a “sufficiently well-defined chemical structure such that all molecules of the cluster compound possess approximately the same relative molecular formula” because each cluster is identical and promotes Banin’s seeded synthetic reaction. At the petition stage, that is essentially the extent of Petitioner’s and Dr. Green’s explanation for their view that Banin’s gold clusters are MCCs. Pet. 31–32.

Patent Owner counterargues that “Banin does not disclose [an] MCC.” Resp. 30; *see* Ex. 2030 ¶¶ 99–131 (Dr. Cossairt’s opinions, and citations to supporting evidence, explaining why Banin’s gold clusters are not MCCs). According to Patent Owner, Banin’s gold clusters “do not have a sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula,” as required for MCCs. Resp. 30. On that point, Patent Owner states that Banin does *not* describe its gold clusters as “identical to one another,” as Petitioner contends and, further, “Petitioner points to the formula $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$,” which “Banin itself describes as “merely a ‘suggested formula.’” *Id.* at 32 (citing Ex. 1005, 20:13–16; Ex. 2030 ¶ 102; Pet. 31). In Patent Owner’s view, Banin’s clusters range in size, and “different sizes are averaged out” to estimate “that the average number of gold atoms is *approximately* 101.” *Id.* at 30 (Patent Owner’s emphasis) (citing Ex. 2030 ¶¶ 105–106); *see id.* at 33 (quoting Ex. 2017, 12891 for this same proposition).

A preponderance of the evidence supports Patent Owner’s position. *Compare* Ex. 1002 ¶¶ 101–103 (Dr. Green’s testimony and cited evidence), *with* Ex. 2030 ¶¶ 99–131 (Dr. Cossairt’s testimony and cited evidence). Banin discloses that the Au clusters are “synthesized by the published

procedures” in Hutchison.¹⁶ Resp. 32 (citing Ex. 1005, 2:25–26, 20:13–16; Ex. 2030 ¶ 104). As Dr. Cossairt points out, the gold cluster catalysts in Banin’s process are not well-defined and are assigned the molecular formula $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ based on a calculation that relies on the average of a range of particle sizes that result from the method of Hutchison. Ex. 2030 ¶¶ 103–105 (citing Ex. 2017, 12891). Based on Dr. Cossairt’s comprehensive examination of Hutchison’s disclosure and other supporting evidence, Patent Owner provides detailed reasons why the clusters that Banin prepares according to Hutchison’s process do **not** qualify as MCCs within the scope of claim 1. Ex. 2030 ¶¶ 99–131; Resp. 32–44.

Specifically, referring to Hutchison Figure 1(a), reproduced below, Dr. Cossairt testifies, “The Hutchison process creates gold particle agglomerations of many different sizes.” Ex. 2030 ¶ 104.



¹⁶ Weare et al., *Improved Synthesis of Small ($d_{\text{CORE}} \approx 1.5\text{nm}$) Phosphine-Stabilized Gold Nanoparticles*, 122 J. A J. AM. CHEM. SOC. 12890–12891 (2000) (“Hutchison,” Ex. 2017).

Ex. 2017, 12891, Fig. 1(a). Dr. Cossairt testifies that Hutchison's Figure 1(a) "is a transmission electron microscopy [TEM] image along with an imbedded histogram that shows the size distribution of the gold particles." Ex. 2030 ¶ 104. She also testifies that this figure shows, and the histogram confirms with its variety of differently sized black dots, that the sizes of the gold clusters prepared by Hutchison's process vary by "a size difference ranging from 0.75 nm to 2.25 nm." *Id.*

Dr. Cossairt further testifies that, in Hutchison's process, "[t]hese different sizes [of gold clusters] are averaged out, and then using the *average size* of the particle[s], it is estimated that the average number of gold atoms [in the metal core] is approximately 101." *Id.* ¶ 105 (citing Ex. 2017, 12891). Additionally, as Dr. Cossairt observes, Hutchison uses the tilde symbol, "~", when referring to the estimated particle size, i.e., "~101," which indicates that the disclosed particle size of 101 is "only an approximate formula for an average-sized particle, not a well-defined formula." *Id.* In other words, both Banin and Hutchison assign a "suggested" value of 101 to the gold in the clusters. *Compare* Ex. 1005, 2:25–26, 20:13–16 (Banin, assigning a "suggested" formula to the gold clusters), *with* Ex. 2017, 12891 (Hutchison, assigning the same "estimated" formula as Banin to the gold clusters).

Dr. Cossairt asserts that Hutchison's Figure 1(a) provides "[d]irect evidence of nanoparticle size and dispersity." Ex. 2030 ¶ 106 (quoting Ex. 2017, 12890). According to Dr. Cossairt, the histogram of Figure 1(a) shows that the overall size variation, or dispersity, for the gold clusters resulting from Hutchison's process is over 25%, which "is not considered monodisperse in the art." *Id.* ¶ 107 (citing Ex. 2017, 12890).

Dr. Cossairt further testifies that an ordinarily skilled artisan “would understand that the claimed [MCC] would, at the very least, need to be able to be chemically characterized,” Petitioner acknowledges that Banin does not “actually chemically characterize the gold clusters produced by the Hutchison process,” and that both Banin and Hutchison “rely upon an average gold droplet size” and “theoretical assumptions that provide only a potential estimated average formula.” *Id.* ¶ 108 (citing Ex. 1005, 20:12–15; Ex. 1010, 9198; Ex. 2017, 12891). Dr. Cossairt continues, “By its nature, an uncharacterized particle that has only an average value assigned to a broad distribution of particle sizes cannot be a ‘sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula.’” *Id.*

In addition, Dr. Cossairt testifies, “By using particles that are not sufficiently well-defined,” Banin’s process cannot achieve the stated “goal of the ’557 patent, which is to make a population of semiconductor nanoparticles that is essentially monodisperse.” *Id.* ¶ 110 (citing Ex. 1001, 19:16–21). Dr. Cossairt directs us to disclosures within the four corners of Banin, which indicate that “the diameter of the nanorods is dictated by the size of the gold particle” and that “the diameter of Banin’s nanorods vary by up to 25%, just like the gold particles do.” *Id.* (citing Ex. 1005, 7:6–8, 15:2–4, 23:17–18). Dr. Cossairt also explains, “This size distribution reflects the same size distribution of the gold particles taught by Hutchison” in Figure 1(a), “showing particles of 1.5 nm $\pm$ 0.4 nm [a 25% difference]” *Id.* ¶ 111 (citing Ex. 2017, Fig. 1(a)); *see* Ex. 1005, 23:17–18 (Banin, describing “nanorod fractions” produced using gold particles prepared by Hutchison’s process, in which “[t]he width of the diameter distribution is 20–25%”).

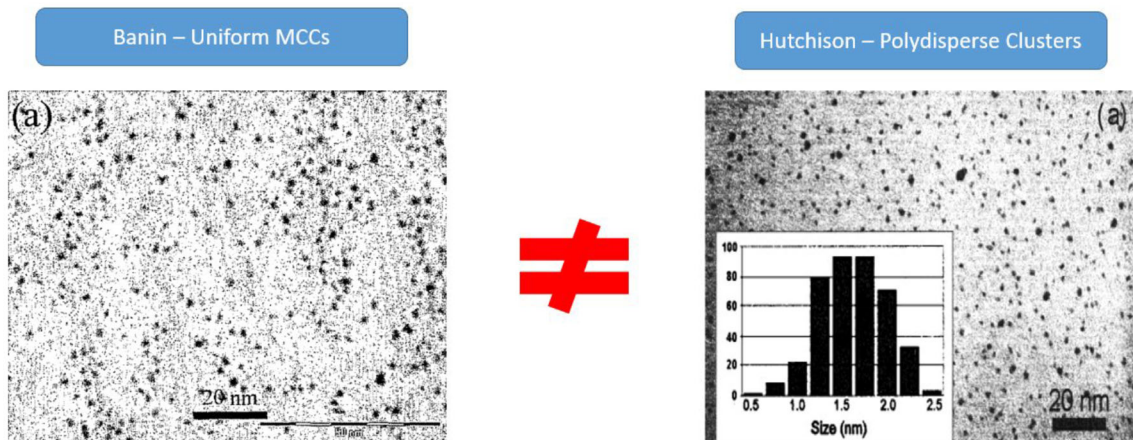
Against that backdrop, Dr. Cossairt testifies, “These uncharacterized gold particles” in Banin have “a large size distribution,” and “do not have ‘sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula.’” Ex. 2030 ¶ 111 (quoting Ex. 1091, 18). Therefore, according to Dr. Cossairt, Banin’s gold cluster catalysts “are not molecular cluster compounds at all.” *Id.*

Patent Owner argues that Petitioner’s own witness, Dr. Green, agreed, during his deposition, that a mixture of clusters is not an MCC “because they wouldn’t have the same relative molecular formula,” and would not be identical. Resp. 38 (citing Ex. 2031, 68:6–14). Patent Owner emphasizes that Banin prepares its gold clusters according to Hutchison’s process, and that Hutchison makes plain that its process produces clusters having a *range* of sizes, and that the suggested molecular formula, upon which Petitioner’s relies, is an *estimate* based on an *average* of that *range* of sizes. *Id.* at 41.

Petitioner, in the Reply, reiterates its opposing position, that “Banin discloses clusters with a single molecular formula ($\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$) and size (1.4 nm), which is sufficient to inform” an ordinarily skilled artisan “that those clusters are MCCs.” Reply 6–7. In Petitioner’s view, Patent Owner’s assertion that Banin’s gold clusters are not MCCs “is incorrect.” *Id.* at 2. Petitioner emphasizes, again, its position that an ordinarily skilled artisan would “recognize that Banin identifies only one specific cluster—having a single molecular formula (i.e., $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$) and size (1.4 nm) with more than three metal atoms.” *Id.* at 2–3.

Petitioner further argues that Patent Owner “ignores that Banin provides its own TEM image that shows that Banin’s ‘ Au_{101} clusters,’” in fact, “do not have the size distribution that the clusters in Hutchison do.” *Id.*

at 3 (*comparing* Ex. 1005, 11:15, Fig. 10(a), *with* Ex. 2017, Fig. 1(a)). By way of support, however, Petitioner directs us to the following side-by-side comparison of Banin's and Hutchison's TEM images.



Reply 3; Ex. 1093 ¶ 17. Petitioner's side-by-side comparison of Banin's Figure 10A ("a TEM image of the Au₁₀₁ clusters without further size selection," Ex. 1005, 22:26–27) and Hutchison's Figure 1(a) (a "representative TEM" image of Hutchison's "disperse nanoparticles," Ex. 2017, 12890) includes annotations by Petitioner labeling Banin's figure as showing "Uniform MCCs" and Hutchison's figure as showing "Polydisperse Clusters" and, further, Petitioner's annotations include a red "≠" (not equal to) sign between the TEM images.

Petitioner's witness, Dr. Green, states that "Banin's TEM is consistent with uniform Au₁₀₁(PPh₃)₂₁Cl₅ MCCs, while the gold particles illustrated in Hutchison are consistent with a size distribution of clusters." Ex. 1093 ¶ 18. According to Dr. Green, based on the above side-by-side comparison of the TEM images, an ordinarily skilled artisan would have recognized "that the MCCs in Banin are purified and size-selected, even if those MCCs in Banin

were made starting with the production method disclosed in Hutchison.” *Id.*; *see* Reply 3 (Petitioner’s reliance on that testimony).

Dr. Green allows that the image of Banin’s gold clusters may appear varied in size, in the TEM image, but testifies that the apparent variance in cluster sizes may be attributed to the following circumstances: (a) the clusters in Banin’s TEM image are non-spherical and will be oriented differently; and (b) the clusters in Banin’s TEM image can aggregate next to one another, “mak[ing] two MCCs appear as one.” Ex. 1093 ¶ 19. Dr. Green also directs us to Banin’s disclosure that the MCCs are depicted “without *further* size selection,” which he interprets as proof that Banin employs a further size selection to obtain *uniformly* sized particles. *Id.* ¶ 22 (quoting Ex. 1005, 22:26–28) (Dr. Green’s emphasis); *see* Reply 4 (Petitioner’s reliance on that testimony).

Petitioner also contends that Patent Owner improperly correlates the 25% width in the size distribution in Banin’s gold nanorod products with the 25% size distribution in Hutchison’s gold cluster catalysts. Reply 5–6. Petitioner contends that “there is *no such size distribution shown in Banin’s MCCs* as depicted in Banin Fig. 10A.” Reply 4 (citing Ex. 1093 ¶ 24; Ex. 1005, Fig. 10A) (Petitioner’s emphasis). Petitioner also argues that “there could be a number of reasons for a size distribution of nanorods that are unrelated to the size of the” gold clusters. *Id.* at 6 (citing Ex. 1005, 7:9–12; Ex. 1099, 64:6–65:9).

Patent Owner, in the Sur-reply, points out that Petitioner does *not* contest that “Hutchison’s process” is “used by Banin” to prepare the gold clusters and, further, does *not* contest that Hutchison “produces differently sized gold clusters which are averaged to assign a ‘suggested’ formula of

Au₁₀₁.” Sur-reply 3 (citing Reply 5), 5 (quoting Reply 3). Patent Owner directs us to evidence that Hutchison’s process does *not* make MCCs because the particles “span a distribution of masses” and “do not have the sufficiently well-defined structure of [an] MCC.” *Id.* at 3–4 (citing Ex. 2030 ¶¶ 106, 114; Ex. 2034, 120:3–13, 123:1–7). Because Banin uses the *same* Hutchison process to make its gold clusters, Patent Owner contends, Banin’s gold clusters also are not MCCs. *Id.* at 3–5. In Patent Owner’s view, Petitioner’s own TEM comparison confirms that proposition and, further, Petitioner’s view that Banin somehow produces identical gold particles is refuted by Banin’s express description of them as having a suggested formula Au₁₀₁(PPh₃)₂₁Cl₅ characterized by mean diameters. *Id.* at 6–10; Ex. 1005, 20:12–16; *see* Ex. 2030 ¶¶ 104–119 (Dr. Cossairt’s testimony).

Petitioner asserts for the first time in the Reply that Banin further size selects its gold catalyst particles, to obtain a population of particles of the same size and molecular formula. Reply 4 and n.3. Patent Owner asserts that this new argument is untimely. Sur-reply 6–7. Alternatively, Patent Owner asserts, “Petitioner resorts to comparing two curiously similar TEM images, one from Banin and one from Hutchison,” that “are practically indistinguishable.” Sur-reply 7 (illustrating “anonymized images” taken from Petitioner’s side-by-side TEM images).

Patent Owner argues, and we agree on this record, that “[n]othing in Banin suggests that gold catalysts are size-selected after being made by Hutchison’s process.” *Id.* at 7. Banin describes size-selection only with regard to its nanorod end-products, not its gold cluster catalysts. *Id.* at 9 (and citations therein to Ex. 1005). Petitioner directs us to Banin’s disclosure of centrifugation as a further size-selection process (Reply 4 n.3), but as Patent

Owner points out, “Banin reports that even after centrifugation, its nanorods have a ‘diameter distribution [of] 25%, while the length distribution is 15–20%.” Sur-reply 9–10 (quoting Ex. 1005, 24:15–23).

We agree with Patent Owner that Hutchison’s process *itself* is “a form of size selection,” because as Hutchison explains, its “synthesis allows size control.” *Id.* at 8 (quoting Ex. 2017, 12891). That casts significant doubt on Petitioner’s assertion that Banin’s disclosure, indicating that its TEM image reflects the gold clusters “without **further** size selection,” necessarily refers to some additional size selection process conducted only by Banin, rather than the size selection process of Hutchison. Reply 4 (Petitioner’s emphasis), 4 n.3.

As for Petitioner’s position that Banin’s gold catalyst particles have a uniform and identical size of 1.4 nm (Reply 6–7), Patent Owner argues that this position is inconsistent with Banin’s express description of the clusters as “1.4 nm in **mean** diameter,” which indicates a size dispersion (Sur-reply 11 (citing Ex. 1005, 20:12–16) (Patent Owner’s emphasis)). And regarding Petitioner’s further assertion that “[t]here is no evidence that the size distribution in the width of nanorods is due to an alleged size distribution of Banin’s clusters” (Reply 5), Patent Owner responds:

On the contrary, there is overwhelming evidence that nanorod diameter is dictated by gold catalyst size. Ex. 1005, 7 (“The rod-shaped nanocrystals prepared by the method of the invention possess **diameters that depend on the diameter of the catalyst nanoparticles** used in their growth”); *id.*, 4 (“the diameters of the nanowires could be tuned by changing the size of the catalyst clusters”); *Id.*, 20 (“changing the diameter of the rod, which can easily be controlled ... by **defining a desired diameter of the metallic catalyst**”) (emphasis added). Petitioner’s other references confirm that catalyst size dictates nanorod diameter in SLS and

VLS reactions. *See* Ex. 1098 (“...metal-catalyzed nanowire growth, in which ***the diameter of the nanowires is mainly determined by the size of the catalyst particles...***”); Ex. 2008 (“...the ***diameters of the wires should depend on the diameters of the catalyst*** particles from which they grew...” (emphasis added)). Because the diameter of the nanowire depends on the diameter of the catalyst, it is no coincidence that the diameters of Banin’s nanorods show the same size distribution as Hutchison’s gold particles. Ex. 2030, ¶110; Ex. 1005, 23:17–18 (20–25% distribution); Ex. 2017, Fig.1(a) (25% distribution).

Sur-reply 12–13 (Patent Owner’s emphasis). We find these arguments persuasive and well-supported by citations to evidence. *Id.*

Having considered the record as a whole, we agree with Patent Owner that Petitioner does not show by a preponderance of the evidence that Banin’s gold clusters are MCCs. According to Petitioner and Dr. Green, Banin’s gold clusters are MCCs because they “are ‘clusters of 3 or more metal’ atoms with ‘associated ligands’ that ‘are *identical to one another.*’” Ex. 1002 ¶ 102; Pet. 31. But Petitioner and Dr. Green do not identify any disclosure in Banin that describes the clusters as identical. Instead, they refer to Banin’s disclosure that the Au clusters have “the suggested formula $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ ” and are “1.4 nm in mean diameter.” Ex. 1005, 20:12–16. In doing so, Petitioner and Dr. Green do not meaningfully address, much less adequately explain, how Banin derives its “suggested” molecular formula for the gold clusters or why Banin reports a “mean” diameter for the clusters. *Id.* In a nutshell, Petitioner and Dr. Green provide *no* persuasive reason why an ordinarily skilled artisan would have understood Banin’s disclosures of a “suggested formula” and a “mean diameter” to convey that the Au clusters are identical.

By contrast, Patent Owner's witness, Dr. Cossairt, explains her opinion, with supporting citations to evidence, that Banin describes gold clusters that range in size and, further, why the reference indicates that the *suggested* formula assigned to those clusters is based on a calculation that relies on the *average* of a wide distribution of particle sizes reported in the literature by Hutchison. Ex. 2030 ¶¶ 102–125; Ex. 2017, 12891. We assign persuasive weight to her testimony because it is supported by clear disclosures in Hutchison, which Banin explicitly identifies as the source of the procedures by which Banin synthesizes its gold clusters. In particular, Dr. Cossairt's testimony comports with this discussion in Hutchison:

To calculate an average molecular formula for [gold nanoparticle] 1 it is necessary to know the number of gold atoms in the metal core. Given the average particle size (1.5 nm) this number is estimated to be ~101 by the method of Whetten et al. and leads to an estimated formula of $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$.

Ex. 2017, 12891. In other words, as this disclosure makes plain, Hutchison calculates an *average molecular formula* for its gold clusters by *estimating the number of gold atoms* in the metal core based upon the *average particle size* of 1.5 nm. *Id.* Indeed, as Dr. Cossairt recognizes, Banin's suggested molecular formula is *exactly the same* formula that Hutchison calculates based on the *average* molecular formula for the variably-sized gold clusters produced according to its process. Ex. 2030 ¶¶ 102–105. Dr. Cossairt provides persuasive reasons why a person of ordinary skill in the art would have understood that Banin's suggested formula represents an average molecular formula for a disperse mixture of gold clusters that are not identical in size and do not have sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula, as required for MCCs. *Id.* ¶¶ 102–125.

To the extent Petitioner seeks to distinguish Banin’s and Hutchison’s gold particles at the Reply stage, we are not persuaded. Reply 2–10. Petitioner and Dr. Green both acknowledge that Hutchison’s TEM image is “consistent with a size distribution of clusters.” *Id.* at 3; Ex. 1093 ¶ 18. Although produced by Hutchison’s method, Petitioner nevertheless asserts, and Dr. Green testifies, that Banin’s TEM image shows that its clusters, although prepared according to Hutchison’s process, do not have the size distribution exhibited by Hutchison’s clusters. Reply 3; Ex. 1093 ¶ 18. According to Dr. Green, a skilled artisan would have recognized, from Banin’s TEM image, that Banin’s gold clusters represent “purified and size-selected” MCCs, “even if those MCCs in Banin were made starting with the production method disclosed in Hutchison.” Ex. 1093 ¶ 18.

Based on our review of the record, including Petitioner’s and Dr. Green’s annotated side-by-side comparison of the TEM images in Banin and Hutchison (Reply 3; Ex. 1093 ¶ 17), we are unable to discern any meaningful distinction between the images. We do not assign Dr. Green’s testimony on that point persuasive weight, as he does not supply sufficient facts and data to support his opinion that a skilled artisan would have understood that the differences in the appearances of the clusters in Banin’s TEM images are attributable to a different orientation of the non-spherical clusters and/or the aggregation of the clusters next to one another, as opposed to a size distribution among the clusters. *See* Ex. 1093 ¶¶ 19–20. As discussed in the Patent Trial and Appeal Board Consolidated Trial Practice

Guide,¹⁷ expert testimony must be based on sufficient facts and data. *See* CTPG 35 (citing Fed. R. Evid. 702; 37 C.F.R. §42.65(a)).

Although Dr. Green testifies that Banin’s gold clusters, as depicted in the TEM image, reflect “purified and size-selected” MCCs (Ex. 1093 ¶ 18), we remain unpersuaded by that testimony, because Dr. Green does not direct us to any disclosure in Banin reporting a size selection of the gold clusters, after being synthesized by Hutchison’s process, or prior to the TEM imaging (Ex. 1093 ¶¶ 17–21). Here again, we observe, a centrifugation step in Banin, to which Dr. Green refers as supporting his opinion in that regard, relates to the purification of the size-selected *nanorods*, not the *gold metal clusters*. *See* Ex. 1005, 7:4–5 (“The purification is carried out by centrifugation that affords purified nanorods having selected size.”); *id.* at 20:24–25 (“The rods were purified and size-selected by centrifugation.”); *id.* at 22:29–30 (“The rods were purified and size-selected by centrifugation.”).

As Patent Owner points out, “Nothing in Banin suggests that gold catalysts are size-selected after being made by Hutchison’s process.” Sur-reply 7. Patent Owner directs us to persuasive evidence that Hutchison’s process is a form of size selection (*id.* at 7–8), as Hutchison explains that its “synthesis allows size control” (Ex. 2017, 12891). Based on that disclosure, we find that an ordinarily skilled artisan would have understood Banin’s explanation — that “Fig. 10A presents a TEM image of the Au₁₀₁ clusters without further size selection” (Ex. 1005, 22:26–27) — to mean that Hutchison’s process *itself* serves as the sole form of size selection and no

¹⁷ Patent Trial and Appeal Board Consolidated Trial Practice Guide (November 2019), available at <https://www.uspto.gov/sites/default/files/documents/tpgnov.pdf> (“CTPG”).

further size selection is performed on the clusters shown Banin's TEM image (*see* Sur-reply 7–8).

That finding is consistent with Banin's disclosure that the gold clusters have a "mean diameter" of 1.4 nm (Ex. 1005, 20:12), that is, an average of a number of diameters, as well as a "suggested formula" (*id.* at 20:15), which, as explained above, represents an *estimated* molecular formula based upon a calculated average of gold cluster sizes. We are not persuaded that Banin's clusters are purified and size-selected to provide a population of identically-sized particles, where neither Petitioner nor Dr. Green identifies disclosure in Banin of a method by which such selection is accomplished, or explains why Banin assigns only a "mean" diameter and a "suggested" molecular formula to the allegedly identical clusters. *Id.* at 20:12, 20:15.

For all of these reasons, we determine that Petitioner fails to carry its burden of demonstrating by a preponderance of the evidence that Banin's gold cluster catalysts are MCCs within the scope of claim 1. That finding disposes of the ground that asserts Banin, which rests on Petitioner's view that Banin's gold clusters are MCCs. *See* Pet. 31–32.

2. Alternative Theory of Unpatentability Raised in the Reply

The ground based on Banin, as set forth in the Petition, rests on Petitioner's contention that Banin discloses an MCC. *Id.* For the first time in the Reply, Petitioner presents an alternative theory of unpatentability that it would have been obvious to replace the gold clusters in Banin's process with "known" MCCs that are not identified by Petitioner with any particularity. Reply 10. We reject that theory for two independent reasons: It comes too late in the Reply and is unpersuasive.

Our rules require a petitioner to explain with particularity, at the outset in the petition, why the patent it challenges is unpatentable. *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016). “Unlike district court litigation — where parties have greater freedom to revise and develop their arguments over time and in response to newly discovered material — the expedited nature of” *inter partes* review proceedings “bring with it an obligation for petitioners to make their case in their petition to institute.” *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1369 (Fed. Cir. 2016). Accordingly, Petitioner carries a burden to “identify with particularity” at the outset, in the Petition, “the grounds on which the challenged to each claim is based, and the evidence that supports the grounds for the challenge to each claim.” 35 U.S.C. § 312(a)(3). Although “the introduction of new evidence in the course of the trial is to be expected in *inter partes* review trial proceedings,” *Genzyme Therapeutic Prods. LP v. Biomarin Pharm. Inc.*, 825 F.3d 1360, 1366 (Fed. Cir. 2016), the shifting of arguments is not, *Wasica Fin. GmbH v. Cont’l Auto. Sys., Inc.*, 853 F.3d 1272, 1286 (Fed. Cir. 2017).

Alternatively, Petitioner’s new theory of unpatentability rests on conclusory and undeveloped assertions about a proposed substitution that involves an allegedly “known,” but unnamed, MCC. Reply 9–10. Petitioner does not identify any particular MCC as a proposed substitute for Banin’s gold cluster, much less explain why that MCC would have been recognized as a suitable alternative that serves the same function as the gold cluster in Banin’s method of nanoparticle synthesis. *Id.*

To the extent that Petitioner means to argue that an ordinarily skilled artisan would have size-selected Banin’s gold clusters to produce identical

clusters that uniformly meet the suggested formula assigned by Banin and Hutchison, Petitioner makes no attempt to show that such an endeavor would have been within the technical grasp of a person exercising no more than ordinary skill in the art, or undertaken with a reasonable expectation of success. *Id.*

Petitioner expounds this new theory of unpatentability without directing the Board to a prior art patent or printed publication that discloses an MCC, or indicates that size selecting Banin's gold clusters to obtain identically-sized particles would have been feasible. *Id.* Instead, Petitioner asserts, Patent Owner "never argued to the contrary," which is ineffective to discharge Petitioner's burden of proof on these issues or shift the burden to Patent Owner. *Id.* at 10.

For these reasons, we determine that Petitioner's argument that an ordinarily skilled artisan would have been led to modify Banin's synthetic method by replacing its gold clusters with a "known," but unnamed, MCC comes too late for the first time in the Reply and, in any event, is not persuasive. *Id.* at 9–10.

3. Conclusions on the Ground that Asserts Banin

We determine that Petitioner does not show by a preponderance of the evidence that the subject matter of any challenged claim would have been obvious based on the ground that asserts Banin. In particular, for the reasons discussed above, we find that Petitioner fails to demonstrate persuasively that Banin's gold clusters are MCCs or that an ordinarily skilled artisan would have been led to substitute Banin's gold clusters with MCCs.

F. Grounds that Assert Zaban and Ptatschek

Petitioner advances two obviousness grounds that assert Zaban and Ptatschek; one against claims 1, 16, and 17 based on Zaban, Ptatschek, and Braun, and a second against claims 4–6 based on Zaban, Ptatschek, Braun, and Yu. Pet. 16–17. In the Institution Decision, based on the preliminary record, we found Petitioner does **not** satisfy the threshold showing necessary to support review of any claim based on either ground that asserts Zaban. Dec. 27. Nevertheless, both parties address these grounds in their trial briefs. Resp. 47–52; Reply 13–21; Sur-reply 16–19. The following analysis applies with equal force to each of the challenged claims and both grounds.

We organize this section into six subparts, addressing (1) known zinc dopants and pyramidal zinc cluster compounds; (2) Petitioner’s view that Zaban’s zinc dopant and Ptatschek’s pyramidal zinc cluster compound would have been interchangeable substitutes that serve a common function in Zaban’s reaction; (3) the sufficiency of Petitioner’s alternative reason to combine based on a desire to increase the speed of nanoparticle synthesis; (4) new reasons to combine raised by Petitioner in the Reply; (5) indications that these grounds are based on an exercise of impermissible hindsight reconstruction; and (6) our conclusions on these grounds.

1. Known Zinc Dopants and Pyramidal Zinc Cluster Compounds

Zaban is concerned with synthesis of an electrode using a titanium dioxide film embedded with indium phosphide quantum dots. Ex. 1006, 3153. Indium phosphide quantum dots are group III–IV nanoparticles. *Id.* In Zaban’s reaction, indium phosphide quantum dots “are homogenously distributed on” a titanium dioxide surface in the presence of a zinc acetate dopant under conditions that ensure that the quantum dots “contain on

average one Zn^{2+} ion per particle.” *Id.* at 3154–3155. Petitioner directs us to no disclosure in Zaban that suggests its synthetic method would have been adaptable for use in producing group II–VI quantum dots. Pet. 38–45.

Ptatschek, by contrast, is concerned with synthesis of group II–VI quantum dots, such as cadmium sulfide or zinc selenide. Ex. 1008, 87. Ptatschek describes “semiconductor quantum dot solutions for coating applications” made using “cluster-like cadmium and zinc ethoxy-acetates.” *Id.* at 85. Ptatschek describes “[a] new route” for synthesis of group II–VI quantum dots, such as cadmium- and zinc-based quantum dots, in which “initial nucleation in organic solvents produces several magic molecular clusters.” *Id.* at 95. In a reaction product, Ptatschek detects the presence of pyramidal “ $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters associated with 7 ethanol ligands and 1 water molecule.” *Id.* According to Petitioner, Ptatschek dissolves pyramidal $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters “in a reaction solvent to create a solution of Zn-based” quantum dots. Pet. 20 (citing Ex. 1008, 86).

2. Interchangeability as a Reason to Combine

Petitioner first argues that Ptatschek’s “pyramidal $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters” would have been recognized as an interchangeable alternative for the zinc acetate dopant employed in Zaban’s process. Pet. 20, 38–40, 47–48. Where an ordinarily skilled artisan would have recognized two compounds as interchangeable substitutes that serve a common function in a chemical reaction, an express suggestion to replace one with the other may not be needed to show the obviousness of the substitution. *See, e.g., In re Fout*, 675 F.2d 297, 301 (CCPA 1982); *In re Siebentritt*, 372 F.2d 566, 568 (CCPA 1967). Petitioner directs us to no persuasive evidence that the pyramidal $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters in Ptatschek’s reaction would have been recognized

as an interchangeable alternative serving a common function with the zinc acetate dopant in Zaban's process. Pet. 20, 38–40, 47–48.

As Patent Owner points out, Zaban is concerned with “an improved way to create an electrode using titanium dioxide film embedded with indium phosphide” nanoparticles, which, on this record, appears to have little in common with Ptatschek's method for synthesizing cadmium-based and zinc-based nanoparticles. Resp. 48; Ex. 1006, 3153 (Zaban); Ex. 1008, 86 (Ptatschek). Petitioner does not address adequately the disparate conditions, reagents, and reaction products that distinguish Zaban's method from Ptatschek's. Pet. 38–40, 47–48. Patent Owner argues that, where “Zaban is synthesizing indium phosphide” nanoparticles, there would have been “little need to look for zinc-based precursors” to improve Zaban's method. Resp. 48. That argument casts doubt on the proposed substitution.

In addition, Petitioner acknowledges that zinc acetate serves a doping function in Zaban's method. *See* Pet. 19 (arguing that Zaban's method includes a “Zn-based precursor that dopes zinc into the nanoparticles”). “A dopant is not the core semiconductor material itself, but rather it is a small impurity intentionally added to change the core semiconductor's electrical properties.” Resp. 49 (citing Ex. 1049, 42–44; Ex. 2030 ¶ 140). Where the zinc acetate in Zaban's process contributes no indium or phosphide for growing “Zn-doped InP nanoparticle” (Pet. 38), it is not clear, and Petitioner does not explain adequately, why an ordinarily skilled artisan would have viewed the zinc acetate dopant in Zaban as a “Zn-based precursor” (*id.* at 19). Nor does Petitioner establish that Ptatschek's “pyramidal $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters” would have been viewed as an interchangeable

substitute that would serve the same doping function as the zinc acetate in Zaban's process. *Id.* at 19.

Zaban uses zinc acetate "in a ratio" selected to produce nanoparticles that contain "on average one Zn^{2+} ion per particle" to control the electrical properties of the resulting indium phosphide quantum dot core. Ex. 1006, 3154. Zaban uses only "one zinc ion for every 1000 indium ions." Resp. 51; Ex. 1006, 3154 ("the ratio In:Zn is $10^3:1$ "). "Here, there has been no showing as to why" an ordinarily skilled artisan "would think to combine Ptatschek's zinc precursor with Zaban's process." Resp. 50. Replacing Zaban's zinc acetate with Ptatschek's $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters "would result in many times the amount of zinc" in Zaban's process. *Id.* ("Ptatschek's zinc precursor has *ten* zinc atoms.") (emphasis supplied by Patent Owner).

Petitioner, in the Petition, fails to address Zaban's "ratio of zinc to indium while suggesting that Ptatschek's zinc-based 'precursor' could be used in place of zinc in Zaban's method." Resp. 51 (citing Pet. 38; Ex. 2030 ¶ 145). Patent Owner, by contrast, directs us to evidence that excessive amounts of dopants may "be undesirable" additions in reactions for synthesizing "semiconductor nanoparticles," because dopants would have been understood to "reduce conductivity and mechanical integrity of the crystalline material." Resp. 50 (citing Ex. 2029, 22105; Ex. 2030 ¶ 143). Patent Owner also directs us to evidence that "defects" resulting from over-doping would "potentially lower" the "photoluminescent efficiency" of the resulting nanoparticles "by creating states that do not result in light emission at the desired wavelength." *Id.* (citing Ex. 2025, 5; Ex. 2030 ¶ 143). Petitioner does not respond to those factual assertions effectively, if at all. *See* Reply 13–21. Patent Owner's evidence, on these issues, casts doubt on

the sufficiency of Petitioner's reasons as to why an ordinarily skilled artisan would have been prompted to undertake the proposed substitution.

Petitioner does not contest, moreover, Patent Owner's evidence that a semiconductor material can "be doped to such high levels that it acts more like a conductor than a semiconductor." Resp. 50 (citing Ex. 2030 ¶ 143). "This is referred to as a degenerate semiconductor." *Id.* (citing Ex. 2015; Ex. 2030 ¶ 143). We agree with Patent Owner that "a change in the amount of zinc dopant" employed in reactions for semiconductor nanoparticle synthesis would have been understood to change the properties of the resulting nanoparticles. *Id.* (citing Ex. 2025, 3; Ex. 2030 ¶ 144); *see* Reply 13–21 (failing to respond effectively to that factual assertion).

Petitioner, in the Reply, for the first time argues that "additional zinc would have encouraged, not discouraged" the proposed substitution, but stops short of providing a rational reason why that would have been the case, and no explanation is self-evident from review of the evidence cited in support of that contention. Reply 18 (citing Ex. 1006, 3156). In that regard, Petitioner directs us to "behavior" in Zaban's chemical reaction that "is not understood" (*id.*), but the behavior at hand is the relative photo-stability, during illumination, of "p-type InP/TiO₂ electrodes" as compared to "n-type InP/TiO₂ electrodes" (Ex. 1006, 3156). It is not clear on this record, and Petitioner does not explain adequately, why that disclosure supports Petitioner's view that "additional zinc would have been encouraged" in Zaban's process. Reply 18.

In any event, as Patent Owner points out, Zaban teaches that "large InP particles adsorb better onto TiO₂ nanoparticles than small ones." Resp. 47 (quoting Ex. 1006, 3154). Patent Owner directs us to evidence,

which Petitioner does not dispute, that doping with too much zinc would make smaller quantum dots. Resp. 44–45, 47; Ex. 1006, 3154; Ex. 2025, 3; Ex. 2030 ¶ 144; *see generally* Reply (nowhere disputing that contention). That undisputed fact casts further doubt on Petitioner’s stated rationale for the proposed substitution. We view Petitioner’s failure to address the increased zinc content that would attend the proposed substitution as an evidentiary deficiency in the Petition. Pet. 38–40, 47–48; Dec. 24–27; *see* Resp. 44–46 (Patent Owner’s argument that Petitioner’s failure to address that issue in the Petition suggests an exercise of hindsight reconstruction).

3. Faster Nanoparticle Growth as a Reason to Combine

Petitioner advances a second reason for the proposed modification in the Petition. Specifically, Petitioner argues that molecular cluster compounds would have been understood to afford “faster nanoparticle growth at lower temperatures while maintaining the quality of the final nanoparticle.” Pet. 39 (citing Ex. 1002 ¶ 128). But Petitioner does not identify—in the unmodified method of Zaban—any compound that would have been understood to afford relatively slower nanoparticle growth, much less demonstrate that Zaban’s zinc acetate dopant would have been targeted for substitution with Ptatschek’s $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters based on any path suggested by the prior art. *Id.* at 39–40.

Petitioner simply asserts, without adequate analysis, that Ptatschek’s $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters would maintain “the quality of” Zaban’s “final nanoparticle product.” *Id.* at 38–39 (citing Ex. 1002 ¶ 128). By way of support, Petitioner directs us to Dr. Green’s opinion testimony, which parrots the same conclusion without citation to evidence. *See* Ex. 1002 ¶ 128. One’s expertise, even draped with a skilled-artisan veil, does not

entitle a naked opinion to much weight. *See Ashland Oil, Inc. v. Delta Resins & Refractories, Inc.*, 776 F.2d 281, 294 (Fed. Cir. 1985) (“Lack of factual support for expert opinion going to factual determinations” pertaining to validity “may render the testimony of little probative value”).

4. Other New Arguments Raised in the Reply

To the extent that Petitioner seeks to cure the deficiencies in the Petition by advancing, for the first time in the Reply, new rationales for the proposed substitution, that exercise violates our authorizing statute, our rules, and principles of fairness and due process. *See* Reply 15–21; 35 U.S.C. § 312(a)(3) (a petition must identify “with particularity” the evidence supporting the grounds); 37 C.F.R. § 104(b)(5) (a petition must identify with particularity the evidence that supports the challenge). Here again, we observe, “Unlike district court litigation—where parties have greater freedom to revise and develop their arguments over time and in response to newly discovered material—the expedited nature of IPRs bring with it an obligation for petitioners to make their case in their petition to institute.” *Intelligent Bio-Sys., Inc.*, 821 F.3d at 1369.

For the first time in the Reply, Petitioner proposes that an ordinarily skilled artisan would have possessed the technical acumen to adjust the concentration of Ptatschek’s $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters to serve as an interchangeable replacement for the zinc acetate dopant in Zaban’s method. Reply 19. That argument comes too late in the Reply. In any event, alternatively, that argument is ineffective to establish that an ordinarily skilled artisan would have known how to employ Ptatschek’s pyramidal zinc clusters in Zaban’s process to serve as a *molecular cluster compound* as opposed to the zinc acetate *dopant* it replaces in Zaban’s process. Petitioner

does not establish why an ordinarily skilled artisan would swap in Ptatschek's pyramidal cluster as a replacement for a dopant, then reasonably expect the cluster to serve an entirely different function to "act as a nucleation point upon which Zaban's [indium phosphide quantum dot] core forms." We agree with Patent Owner that this argument is flawed, at least because Petitioner disregards the requirement in Zaban that the indium and zinc ratio is balanced "such that the resulting" quantum dot products "contain on average one Zn^{2+} ion per particle." Ex. 1006, 3154.; *see* Sur-reply 16–19 (Patent Owner's counterarguments).

Petitioner also asserts, for the first time in the Reply, that an ordinarily skilled artisan would have understood that Ptatschek's pyramidal $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -cluster "improves the electrical properties of the core" in a manner "similar to a dopant." Reply 20. We reject that new rationale because it comes too late in the Reply. In any event, Petitioner presents that new rationale in a single sentence without further analysis, and the evidence cited by Petitioner in support of that rationale falls short of establishing that an ordinarily skilled artisan would have recognized that Ptatschek's cluster and Zaban's dopant are interchangeable substitutes serving any common purpose in Zaban's process. *Id.* (citing Ex. 1002 ¶¶ 56–57, 129–30; Ex. 1008, Abstract, 85–86; Ex. 1010, 9198; Ex. 1093 ¶ 47; Ex. 1096, Abstract, 7843).

There is no genuine dispute that Zaban uses zinc acetate as a dopant in a method for synthesizing indium phosphide nanoparticles, whereas Ptatschek uses pyramidal $\text{Zn}_{10}\text{O}_4(\text{OAC})_{12}$ -clusters as a zinc-based precursor in a method for synthesizing zinc-based nanoparticles. Petitioner does not establish that the "mere presence of zinc in some molecule is sufficient

motivation to use it in place of another zinc-containing molecule” in a chemical reaction, such as Zaban’s, where no showing is made that the zinc compounds would have been understood to serve a common function.

Resp. 49 (citing Pet. 38–39; Ex. 1002 ¶ 128).

5. Indications of Impermissible Hindsight Reconstruction

“Chemistry is specific” and “reagents, precursors, catalysts and other materials must be precisely chosen to obtain the specific result sought.”

Resp. 49. Given that unpredictability in the field of the invention, we find that Petitioner fails to come forward with persuasive art-based reasons for the proposed modification, in which the zinc dopant in Zaban’s process is replaced with Ptatschek’s pyramidal zinc cluster-like compound in a manner that would “succeed in producing” indium phosphide quantum dots. Pet. 45. These grounds are based on bare assertions of a reasonable expectation of success, without adequate analysis or supporting evidence. *Id.*

That circumstance favors Patent Owner’s view that the weaknesses in Petitioner’s reasons for the proposed substitution indicate an exercise of impermissible “hindsight” reconstruction. Resp. 51. Although Petitioner argues in the Reply that an ordinarily skilled artisan would have known about “heterogeneous seeded growth” of nanoparticles, and that this knowledge would have suggested the proposed modification, Petitioner does not direct us to evidence adequate to show that a person, exercising no more than ordinary skill in the art at the time of the invention, would have had the technical acumen or understanding to modify Zaban’s method to use Ptatschek’s pyramidal cluster-like compound successfully to attain a synthetic method that meets the limitations of a challenged claim. Reply 17. Petitioner directs us to opinion testimony that molecular cluster compounds

would have been known to result in “significant production cost savings,” but identifies no art-based reason how or why an ordinarily skilled artisan would have been led to replace Zaban’s dopant to achieve a nanoparticle in the manner claimed. Pet. 40 (citing Ex. 1002 ¶ 130 (Dr. Green, parroting those conclusions without directing us to supporting evidence on point)).

These circumstances support Patent Owner’s view that the proposed substitution is driven, not by any path illuminated by the prior art, but by an impermissible exercise of hindsight reconstruction of the claimed invention. Resp. 47–48 (citing Ex. 1006, 3143; Ex. 1008, Title, 87; Ex. 2030 ¶¶ 138–139); *see* Sur-reply 16–19 (Patent Owner contesting the new arguments raised by Petitioner for the first time in the Reply).

6. Conclusions on the Grounds that Assert Zaban and Ptatschek

None of the information developed during the trial persuades us to change the initial determination in our Institution Decision that Petitioner failed from the outset to establish a reasonable likelihood of prevailing at trial in showing the unpatentability of any claim based on either ground that asserts Zaban and Ptatschek. Dec. 25–27.

For reasons discussed above, we determine that Petitioner does not demonstrate by a preponderance of the evidence that an ordinarily skilled artisan would have combined the disclosures of Zaban and Ptatschek in the manner claimed. Pet. 20, 39–41, 47–48. Petitioner directs us to no disclosure in Braun or Yu that cures the above-discussed deficiencies in the challenges. Accordingly, we determine that Petitioner does not establish, by a preponderance of the evidence, the unpatentability of any challenged claim based on either ground that asserts Zaban and Ptatschek.

G. Ground that Asserts Lucey

Petitioner asserts that claims 1, 6, 16, and 17 are unpatentable as obvious over Lucey, Ahrenkiel, and Braun. Pet. 17, 51–62. Based on the preliminary record, in the Institution Decision, we determined that Petitioner did not show a reasonable likelihood of prevailing at trial with respect to any claim based on this ground. Dec. 27–29. The parties nevertheless addressed this ground in the trial phase. Resp. 52–57; Reply 22–24; Sur-Reply 19–21.

At the final hearing, Petitioner withdrew this ground from contention. Tr. 49–50. Because Petitioner has withdrawn this ground, we do not address it in this Final Written Decision.

III. CONCLUSION

For the above reasons, Petitioner does not demonstrate by a preponderance of the evidence that any challenged claim is unpatentable based on any challenge stated in the Petition.

Claims	35 U.S.C. §	References	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1–6, 16, 17	103	Banin, Braun		1–6, 16, 17
1, 16, 17	103	Zaban, Ptatschek, Braun		1, 16, 17
4–6	103	Zaban, Ptatschek, Braun, Yu		4–6
1, 4, 16, 17	103	Lucey, Ahrenkiel, Braun ¹⁸		
Overall Outcome				1–6, 16, 17

¹⁸ This Final Written Decision does not address this ground because it was withdrawn by Petitioner’s counsel at the final hearing. Tr. 49–50.

VI. ORDER

It is

ORDERED that claims 1–6, 16, and 17 of the '557 patent have not been proven unpatentable on this record; and

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

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