

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.

IPR2021-00186
Patent 8,524,365 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 1–23 of U.S. Patent No. 8,524,365 B2 (Ex. 1001, “the ’365 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 38, 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. §§ 102 and 103, effective March 16, 2013. Because the ’365 patent application has an effective filing date prior to March 16, 2013, the pre-AIA versions of §§ 102 and 103 apply.

Claims Challenged	35 U.S.C. §	References
1, 7–12, 17, 22, 23	102	Banin ⁴
1, 7–12, 15–17, 22, 23	103(a)	Banin
2–6, 18–21	103(a)	Banin, Herron ⁵
13, 14	103(a)	Banin, Treadway ⁶
1–9, 17–23	103(a)	Zaban, ⁷ Farneth, ⁸ Yu ⁹
1, 2, 4, 7–12, 17, 18, 22, 23	103(a)	Lucey, ¹⁰ Ahrenkiel ¹¹

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

⁵ Herron et al., *Crystal Structure and Optical Properties of Cd₃₂S₁₄(SC₆H₅)₃₆·DMF₄, a Cluster with a 15 Angstrom CdS Core*, 259 SCIENCE 1426–1428 (1993) (“Herron,” Ex. 1016).

⁶ Treadway et al., U.S. Patent No. 6,815,064, issued Nov. 9, 2004 (“Treadway,” Ex. 1015).

⁷ Zaban et al., *Photosensitization of Nanoporous TiO₂ Electrodes with InP Quantum Dots*, 14 LANGMUIR 3153–3156 (1998) (“Zaban,” Ex. 1006).

⁸ Farneth et al., *Bulk Semiconductors from Molecular Solids: A Mechanistic Investigation*, 4 CHEM. MATER. 916–922 (1992) (“Farneth,” Ex. 1009).

⁹ 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).

¹⁰ Lucey et al., US 7,193,098 B1, issued Mar. 20, 2007 (“Lucey,” Ex. 1011).

¹¹ Ahrenkiel et al., *Synthesis and Characterization of Colloidal InP Quantum Rods*, 3 (6) NANO LETTERS 833–837 (2003) (“Ahrenkiel,” Ex. 1012).

Claims Challenged	35 U.S.C. §	References
13–16	103(a)	Lucey, Ahrenkiel, Treadway

After institution of trial, Patent Owner filed a Response (Paper 25,¹² “Resp.”), along with the Declaration of Brandi Cossairt, Ph.D. (Ex. 2030), Petitioner filed a Reply (Paper 32, “Reply”), along with the Second Declaration of Dr. Green (Ex. 1093), and Patent Owner filed a Sur-reply (Paper 39, “Sur-reply”).¹³ The parties presented oral arguments during a hearing held by video on February 23, 2022.¹⁴ Paper 46 (“Tr.”).

B. Related Matters

The parties identify litigation involving the ’365 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. 71; 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.

¹² Patent Owner filed Paper 25 (unredacted Response) under seal and Paper 26 (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 30, 1.

¹³ 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.

¹⁴ A consolidated hearing was conducted in IPR2021-00182, IPR2021-00183, IPR2021-00184, IPR2021-00185, and this proceeding, however, the cases are not consolidated. *See* Paper 43 (Order, setting oral argument).

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Patent No. 7,588,828 (“IPR183”), IPR2021-00184 for U.S. Patent No. 7,803,423, and IPR2021-00185 for U.S. Patent No. 7,867,557. Pet. 71; Paper 6, 1–2. Concurrently with this Decision, we enter final written decisions in those administrative proceedings.

C. The '365 Patent (Ex. 1001)

The '365 patent relates to “[a] nanoparticle comprising a molecular cluster compound and a core semiconductor material disposed on the molecular cluster compound.” Ex. 1001, 20:9–13. The semiconductor material, in turn, “comprises one or more elements not comprised within the molecular cluster compound.” *Id.* The nanoparticle may be prepared by a process that employs at least two precursor species in a nanoparticle precursor composition – “a first precursor species containing a first ion to be incorporated into the core semiconductor material and a separate second precursor species containing a second ion to be incorporated into the core semiconductor material.” *Id.* at 20:54–62.

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).” *Id.* at 1:21–25. 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 1:26–28. 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 1:29–31.

The written description discusses the preparation of two different molecular cluster compounds. *Id.* at 15:5–31. The description includes nine examples for preparing nanoparticles; eight involve a core that comprises cadmium and selenium, and one involves a core that comprises cadmium and tellurium. *Id.* at 15:33–19:4.

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 nanoparticle comprising a molecular cluster compound and a core semiconductor material disposed on the molecular cluster compound, wherein the semiconductor material comprises one or more elements not comprised within the molecular cluster compound.

Ex. 1001, 20:9–13. 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* 24–42, 49–54, 58–66. 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.¹⁵

¹⁵ 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 the

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 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

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.’” Paper 12, 20 (quoting Ex. 2005, 3). 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.

experience and vice-versa.” Pet. 20–21 (citing Ex. 1002 ¶¶ 76–75). 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:

While the full scope of the term “molecular cluster compound” is unclear—the ’365 patent states that the term “is widely understood in the relevant technical field” as relating to “clusters of 3 or more *metal or nonmetal atoms* and their associated ligands,” but related U.S. Patent No. 7,588,828 [at issue in related IPR183] “clusters of 3 or more *metal atoms* and their associated ligands”(compare Ex. 1001, 5:19–25, with Ex. 1054, 3:29–35)—this issue need not be resolved because the grounds relied on in this Petition disclose molecular cluster compounds with three or more metal atoms.

Pet. 21 (footnote omitted) (Petitioner’s emphasis).

Patent Owner responds that the written description of the invention provided in the ’365 patent informs:

“Molecular cluster” is a term which is widely understood in the relevant technical field but for the sake of clarity should be understood herein to relate to clusters of 3 or more metal or nonmetal atoms and their associated ligands of sufficiently well defined chemical structure such that all molecules of the cluster compound possess the same relative molecular mass.

Resp. 24. Patent Owner contends that the parties’ dispute about the scope of the term “molecular cluster compound” was resolved in the parallel litigation and “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. 24–25 (quoting Dec. 16 (citing Ex. 1091, 18)).

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, 2:2–4.¹⁶ 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.

¹⁶ We refer to original page numbers in Exhibit 1005, not page numbers added by Petitioner.

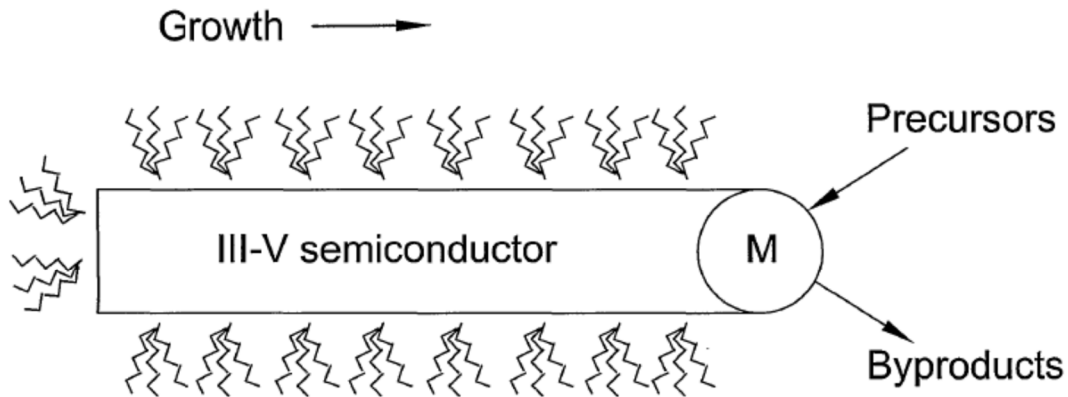


FIG. 1

Figure 1 illustrates the growth mechanism of indium-arsenic (“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. Herron

Herron is a journal article describing the formation of a $\text{Cd}_{32}\text{S}_{14}(\text{SC}_6\text{H}_5)_{36}\cdot\text{DMF}_4$ cluster from a solution of pyridine and *N,N*-dimethylformamide (DMF). Ex. 1016, 1426, Abstract. According to Herron, the cluster consists of an 82 atom CDS core that is approximately 12 angstroms in diameter. *Id.* Herron discloses that the “cluster dissolves intact in tetrahydrofuran.” *Id.*

Herron further describes the use of “very small molecular clusters as synthetic precursors to bulk, extended solids” as interesting for semiconductor materials and that the solubility of Herron’s cluster may be used in the production of polymer films having good photoconductor properties, “which points to a real utility for such soluble semiconductor clusters in the preparation of materials that go into electronic devices made for this and other thin-film applications.” *Id.* at 1426, 1428.

3. Zaban

Zaban is a paper titled “Photosensitization of Nanoporous TiO_2 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 Zn^{2+} ion per particle.” Ex. 1006, 3154.

4. Farneth

Farneth is a journal article regarding the mechanism of the solid-state conversion of II/VI precursors having the general formula

$(R_4N^+)_4[S_4M_{10}(SPh)_{16}]^{4-}$, where “(R = Me, Et; M = Cd, Zn).” Ex. 1009, 916, Abstract. Farneth describes heating the molecular cluster $[(CH_3)_4N^+]_4[S_4Cd_{10}(SPh)_{16}]^{4-}$ in an inert atmosphere to cause a first reaction in which $4(NMe_4SPh)$ is lost to produce the intermediate solid $Cd_{10}S_{16}Ph_{12}$. *Id.* at 918. A second reaction caused by the loss of S_6Ph_{12} leaves a solid residue of CdS. *Id.* Farneth discloses that “the structural integrity of the clusters appears to be maintained in the solid.” *Id.* at 920.

5. Yu

Yu is a journal article that is directed to heterogeneous seeded growth of monodisperse metallic nanoparticles, particularly the “growth of nearly monodisperse Bi [bismuth], Sn [tin], and In nanoparticles of various sizes upon 1.5-nm Au seeds.” Ex. 1010, 9198. Yu explains that growth can be accomplished by decomposing the precursors $Bi-[N(SiMe_3)_2]_3$, $Sn(NMe_2)_2$, or $In(C_5H_5)$ in solutions containing Au seeds and polymers that were added to stabilize the nanoparticles. *Id.* Yu discloses thermally decomposing the Bi and Sn precursors at 150 and 140°C, respectively, and decomposing the In precursor at room temperature by adding methanol in the presence of poly(vinylpyrrolidinone). *Id.* Yu proposes a mechanism for the formation of the monodisperse colloid or nanoparticles by describing the growth as “seeded growth” in which “preformed seeds provide the nuclei for subsequent growth of metallic nanoparticles.” *Id.*

6. Treadway, Lucey, and Ahrenkiel

Petitioner asserts Treadway, Lucey, and Ahrenkiel in one or more grounds advanced in the Petition. Pet. 14–15. We make no findings pertaining to these references because none is necessary to our analysis.

E. Grounds that Assert Banin

Petitioner asserts that the subject matter of claim 1, and claims depending directly or indirectly therefrom, would have been anticipated by or obvious over the disclosure of Banin alone. Pet. 14. In connection with other dependent claims, Petitioner asserts obviousness grounds based on Banin in combination with Herron or Treadway. *Id.* at 14–15.

We organize our analysis into five subparts, addressing, in turn, (1) whether Petitioner shows by a preponderance of the evidence that Banin’s small gold clusters are MCCs; (2) an alternative theory of unpatentability raised for the first time in the Reply, based on the disclosure of Banin alone, that an ordinarily skilled artisan would have replaced Banin’s gold clusters with known MCCs not identified with particularity by Petitioner; (3) the ground based on Banin and Herron; (4) the ground based on Banin and Treadway; and (5) our conclusions on the grounds that assert Banin.

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

Our analysis focuses on the claim 1 limitation that requires “[a] nanoparticle comprising a molecular cluster compound.” Ex. 1001, 20:9–13. Our analysis of independent claim 1 applies with equal force to each of the other challenged claims, because each depends directly or indirectly from claim 1 and, thereby, inherits the limitation requiring a molecular cluster compound (“MCC”). *Id.* at 20:9–21:18 (claims).

Petitioner asserts that Banin discloses small gold clusters that are MCCs. Pet. 22. 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. 22–23; Ex. 1002 ¶ 90. 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, 20:12–16) and the testimony of Dr. Green (Ex. 1002 ¶ 90). Pet. 22–23.

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 ¶ 90 (citing Ex. 1001, 5–25; Ex. 1005, 20:12–16). 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. 22–23.

Patent Owner counterargues that Banin “does not disclose [an] MCC.” Resp. 25; *see* Ex. 2030 ¶¶ 99–131 (Dr. Cossairt’s opinions, and citations to

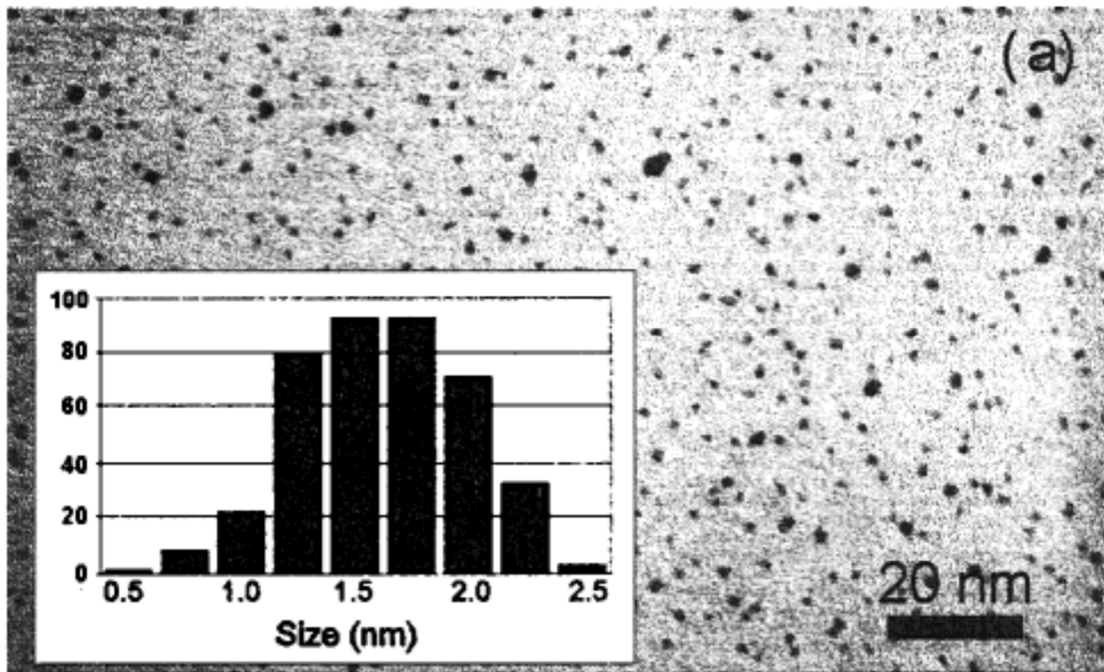
supporting evidence, explaining why Banin's gold clusters are not MCCs). According to Patent Owner, Banin's gold clusters "do not have a sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula," as required for MCCs. Resp. 25. 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 27 (citing Ex. 1005, 20:13–16; Ex. 2030 ¶¶ 101–102; Pet. 22). 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 28 (citing Ex. 2017, 12891; Ex. 2030 ¶¶ 107–108).

A preponderance of the evidence supports Patent Owner's position. *Compare* Ex. 1002 ¶ 90 (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.¹⁷ Resp. 27–28; Ex. 1005, 2:25–26, 20:13–16; Ex. 2030 ¶¶ 105–110. As Dr. Cossairt points out, the gold cluster catalysts in Banin's process are not well-defined and the molecular formula $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ is assigned based on a calculation that relies on the average of a range of particle sizes that result from the method of Hutchison. Ex. 2030 ¶¶ 106–108, 111 (citing Ex. 2017, 12891). Based on Dr. Cossairt's comprehensive

¹⁷ 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).

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. 27–37.

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 ¶ 106.



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 ¶ 106. 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 at least 1.0–2.25 nm.” *Id.*

Dr. Cossairt further testifies that “Hutchison describes the gold clusters as ‘narrowly disperse’ nanoparticles 1.5 nm \pm 0.4 nm in diameter.” *Id.* ¶ 107 (citing Ex. 2017, 12890). In Dr. Cossairt’s view, “What this really means is that on average, there is a distribution of sizes from around 1.1–1.9 nm, but as the histogram of” Hutchison’s Figure 1(a), reproduced above, “shows, the overall size variation is much broader.” *Id.* “Despite that broad mix of sizes,” Dr. Cossairt explains, “Hutchison attempted to assign a molecular weight formula to the synthesized gold clusters.” *Id.*

Dr. Cossairt points out, “As Hutchison explains, Au₁₀₁(PPh₃)₂₁Cl₃ is ‘an *average* molecular formula’ that was ‘estimated’ in order to assign a formula based off of the average 1.5 nm particle size” observed in Hutchison’s synthesized clusters. *Id.* (quoting Ex. 2017, 12891) (Dr. Cossairt’s emphasis). Additionally, as Dr. Cossairt observes, Hutchison uses the tilde symbol, “~”, when referring to the estimated particle size, namely, “~101,” which indicates that the disclosed particle size of 101 is only an “approximate formula for an average-sized particle.” *Id.* ¶ 113. 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). In Dr. Cossairt’s view, an ordinarily skilled artisan “would not confuse assumptions and estimates with a well-defined chemical structure, particularly where the data points used to generate that assumption are so widely varied.” Ex. 2030 ¶ 109.

Dr. Cossairt asserts that Hutchison’s Figure 1(a) shows that gold clusters prepared according to its process do not “have the same molecular

mass.” *Id.* ¶ 106 (quoting Ex. 2017, 12890). Dr. Cossairt states, “A dispersity that varies by 25% is not considered monodisperse in the art.” *Id.* ¶ 118 (citing Ex. 1001, 5:28–29). Dr. Cossairt 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,” that Banin does not “actually chemically characterize the gold clusters produced by the Hutchison process,” and that both “references cite and rely upon an average gold droplet size that is then itself used to generate a suggested formula without actually characterizing any observed particles.” *Id.* ¶ 111.

Dr. Cossairt testifies further, by using “gold particles that are not sufficiently well-defined,” Banin’s process cannot achieve the stated goal of the ’365 patent, which is to make “a population of nanoparticles that is essentially monodisperse.” *Id.* ¶ 118 (citing Ex. 1001, 5:28–29). 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 can vary by up to 25%,” just like the gold particles do. *Id.*; Ex. 1005, 15:2–4, 23:17–18; Ex. 2017, 12890.

Dr. Cossairt explains, “[T]he wide size distribution seen in Banin reflects the wide size distribution of the gold particles taught by Hutchison” in Figure 1(a), “showing particles of 1.5 nm ± 0.4nm [a 25% difference].” Ex. 2030 ¶ 118 (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%”).

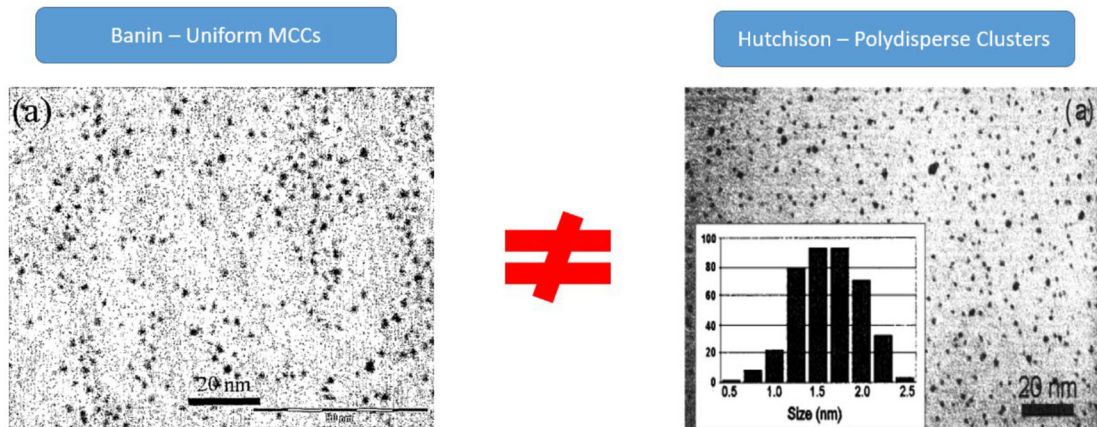
Against that backdrop, Dr. Cossairt testifies, Banin’s clusters are not “of sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula” as

required under the construction assigned by the District Court and adopted in this proceeding. Ex. 2030 ¶¶ 100–101 (quoting Ex. 1091, 18). Therefore, according to Dr. Cossairt, Banin’s gold clusters are not MCCs at all. *See 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. 33–34 (citing Ex. 2031, 68:6–14). Patent Owner emphasizes that Banin prepares its 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 34–36.

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. 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.*

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 2–3 (*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 3–4 (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." *Id.* at 5 (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.* (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), 4–5 (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. 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 $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ characterized by mean diameters. *Id.* at 6–9; Ex. 1005, 20:12–16; *see* Ex. 2030 ¶¶ 104–116 (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 3–4 and n.3. Patent Owner asserts that this new argument is untimely. Sur-reply 5. 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 6 (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 the “gold catalysts” are size-selected after being made by Hutchison’s process. *Id.* at 8. Banin describes size-selection only with regard to its nanorod end-products, not its gold cluster catalysts. *Id.* at 8, 10 (and citations therein to Ex. 1005). Petitioner directs us to Banin’s disclosure of centrifugation as a further size-selection process (Reply 3–4 n.3), but as Patent Owner points out, “Banin reports that even after centrifugation, its nanorods have a ‘diameter distribution [of] 20–25%, while the length distribution is 15–20%.’” Sur-reply 8 (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 7 (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 3–4 (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), 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 10 (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 [solution-liquid-solid] and [vapor-liquid-solid] 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, ¶118; Ex. 1005, 23:17–18 (20–25% distribution); Ex. 2017, Fig.1(a) (25% distribution).

Sur-reply 11–12 (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 ¶ 90; Pet. 22. 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 citations to supporting 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 ¶¶ 101–127; 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 Au₁₀₁(PPh₃)₂₁Cl₅.

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 ¶¶ 105–107. 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.* ¶¶ 101–127.

To the extent Petitioner seeks to distinguish Banin’s and Hutchison’s gold particles at the Reply stage, we are not persuaded. Reply 2–11.

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,¹⁸ 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 the “gold catalysts” are size-selected after being made by Hutchison’s process. Sur-reply 8. 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 — “Fig. 10A presents a TEM image of the Au₁₀₁ clusters without further size selection” (Ex. 1005, 22:26–27) — to mean that

¹⁸ Patent Trial and Appeal Board Consolidated Trial Practice Guide (November 2019), available at <https://www.uspto.gov/sites/default/files/documents/tpgnov.pdf> (“CTPG”).

Hutchison's process *itself* serves as the sole form of size selection and no further size selection is performed on the clusters shown in 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 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 based on anticipation by Banin. Pet. 22–23. That finding also disposes of the obviousness ground, based on Banin alone, which, like the ground based on anticipation, rests on Petitioner's view that Banin's gold clusters are MCCs. *Id.* at 31.

2. Alternative Theory of Unpatentability Raised in the Reply

The anticipation and obviousness grounds, based on Banin alone and as set forth in the Petition, rest on Petitioner's contention that Banin discloses an MCC. *Id.* at 22–23, 31. For the first time in the Reply, Petitioner presents an alternative theory of unpatentability, based on the

disclosure of Banin alone, 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 11 (arguments presented in connection with Ground 2). 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 11 (arguments presented in connection with Ground 2). Petitioner does not identify any

particular MCC as a proposed substitute for Banin's gold cluster, much less explain why any "known" 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.*

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.*

3. Obviousness Ground Based on Banin and Herron

Petitioner argues that some of the subject matter of some of the dependent challenged claims would have been obvious over the combined

disclosures of Banin and Herron. Pet. 14, 33. This ground is based on the theory that Banin discloses an MCC. *Id.* at 33. Our reasoning above, and our determination that Banin does not disclose an MCC, disposes of this ground.

An independent, alternative reason supports our decision that Petitioner fails to show by a preponderance of the evidence that that an ordinarily skilled artisan would have combined the disclosures of Banin and Herron in the manner claimed. *Id.* at 33–36. In that regard, Petitioner acknowledges that Banin does not disclose an MCC that includes elements required by the limitations of some of the dependent claims. *Id.* at 36–39. For those limitations, Petitioner turns to Herron. *Id.*

Specifically, Petitioner contends that an ordinarily skilled artisan would have been prompted to exchange Banin’s gold clusters, having a suggested molecular formula of $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$, with Herron’s “‘large, well-characterized semiconductor molecular cluster’ having the formula ‘ $\text{Cd}_{32}\text{S}_{14}(\text{SC}_6\text{H}_5)_{36}\cdot\text{DMF}_4$.’” *Id.* at 34 (quoting Ex. 1016, Abstract, 1426, 1428). Petitioner alleges that an ordinarily skilled artisan “would have been motivated to replace Banin’s Au-based MCC with Herron’s Cd-Based MCC because Banin teaches using Cd-based compounds, Cd-based MCCs were known and widely used in the field, and Cd-based MCCs are less expensive to obtain than Au-based MCCs.” *Id.* (citing Ex. 1002 ¶ 127).

Petitioner further alleges that an ordinarily skilled artisan “would have understood that using a Cd-based MCC was preferable to using a non-MCC Cd-based compound because MCCs were know[n] to provide desirable benefits during nanoparticle synthesis,” such as “high nanoparticle yield,” “[l]ow temperature deposition routes,” “rational size control,” and “narrow size distributions.” *Id.* at 34–35. Petitioner also asserts that Herron’s MCC

would have been “compatible” with Banin’s “nanoparticle cores,” therefore, replacing Banin’s MCC with Herron’s MCC would have been “a matter of routine” substitution that would have been “reasonably expected . . . to succeed in growing an InAs core containing a Cd-based MCC through a seeded growth reaction.” *Id.* at 35 (citing Ex. 1002 ¶¶ 129, 130).

Patent Owner asserts that Petitioner relies on improper hindsight by combining the references merely as a means to satisfy the claim limitations that require the MCC to incorporate specific ions from groups not provided by Banin’s gold clusters. Resp. 49–51. According to Patent Owner, Petitioner otherwise fails to articulate a logical motivation to combine. *Id.* at 45–49. In particular, Patent Owner asserts, the catalyst used in Banin must be a metal, whereas the cadmium sulfide in Herron is a semiconductor material. *Id.* at 45–46. Patent Owner contends that an ordinarily skilled artisan “would not have been motivated to replace the metal catalysts disclosed in Banin with a semiconductor material disclosed in Herron.” *Id.* at 46 (citing Ex. 2030 ¶ 137).

Further, according to Patent Owner and Dr. Cossairt, there is no indication on the record that anyone has ever tried or succeeded in using a semiconductor as a catalyst in solution-liquid-solid (“SLS”) nanorod synthesis. *Id.* at 50–51 (citing Ex. 2030 ¶ 152). In addition, Patent Owner contends, Petitioner and Dr. Green fail to address key considerations that would have guided the selection of a metal catalyst for use in an SLS reaction, such as Banin’s, including the melting point, solvating ability, and reactivity of the metal. *Id.* at 47 (citing Ex. 2030 ¶ 139; Ex. 2008, 7514).

Regarding Patent Owner’s assertion that an ordinarily skilled artisan would not have been led to replace Banin’s metal catalyst with Herron’s

semi-conductor MCC, Petitioner asserts that “semiconductor MCCs had been used to seed growth of nanoparticles before the alleged invention.” Reply 14–15. Therefore, according to Petitioner, an ordinarily skilled artisan “would have had a reasonable expectation that Herron’s . . . MCCs would have seeded growth of Banin’s InAs nanoparticles regardless of alleged ‘differences’ between semiconductors and metals.” *Id.* at 15 (citing Ex. 1093 ¶¶ 44). Petitioner asserts that it is irrelevant that Herron does not disclose forming its semiconductor MCCs in solution because the challenged claims do not require a nanoparticle semiconductor material that is formed “in solution.” *Id.* Petitioner also asserts that “the prior art taught the use of MCCs to make semiconductor nanoparticles in solution.” *Id.* (citing Ex. 1002 ¶¶ 54–55).

In the Sur-reply, Patent Owner maintains its position that Petitioner does not meet its burden of demonstrating how or why an ordinarily skilled artisan would have been prompted to combine Banin and Herron in the manner claimed, because Banin uses metals and not Zn- or Cd-based semiconductor compounds and, further, Petitioner fails to show that a semiconductor material would have been recognized as an interchangeable replacement for the metal catalyst used in Banin’s SLS process. Sur-reply 20. Patent Owner further emphasizes that Petitioner fails to show any “expectation of success for the proposed substitution.” *Id.* at 18.

Based on our consideration of the arguments and the evidence, we determine that Petitioner fails to demonstrate that a person of ordinary skill in the art would have been led to substitute Banin’s gold metal catalyst with Herron’s semiconductor compounds. In the Petition, Petitioner articulated an asserted motivation to modify Banin with Herron’s compounds. That

motivation was premised upon Banin disclosing an MCC. Indeed, Petitioner repeatedly asserts in the Petition that basis for the proposed combination. *See* Pet. 34 (an ordinarily skilled artisan “would have been motivated to replace Banin’s Au-based MCC with Herron’s Cd-based MCC”); *id.* at 35 (an ordinarily skilled artisan “would have understood that it would have been a matter of routine to substitute a Cd-based MCC in place of the Au-based MCC expressly identified in Banin”); *id.* at 36, 38 (twice asserting that an ordinarily skilled artisan “would have been motivated to replace Banin’s Au-based MCC with Herron’s MCC”).

Because we determine that Petitioner does not demonstrate persuasively that Banin’s Au-based clusters are MCCs, Petitioner’s rationale for substituting one MCC for another fails. Moreover, we agree with Patent Owner that Petitioner fails to demonstrate persuasively that a skilled artisan would have been prompted to replace Banin’s gold clusters with Herron’s cadmium-based MCCs with a reasonable expectation of success. Resp. 45–51; Sur-reply 18–20.

For example, Petitioner’s witness, Dr. Green, does not dispute that Banin’s SLS process requires the use of a *metal* catalyst. Ex. 1002 ¶ 79; Ex. 1005, 4:3–9, 6:9–16. Nor does Dr. Green dispute that Herron’s $\text{Cd}_{32}\text{S}_{14}(\text{SC}_6\text{H}_5)_{36}$ cluster is not a metal, but rather is a cadmium sulfide *semiconductor*. Ex. 1002 ¶ 86; Ex. 1016, 1426. According to Patent Owner and Dr. Cossairt, there is no indication on the record that anyone has ever tried or succeeded in using a semiconductor as a catalyst in SLS nanorod synthesis. Resp. 50–51; Ex. 2030 ¶ 152. We agree and determine that Petitioner does not show otherwise by referring to the use of a

semiconductor in a different type of nanoparticle synthesis, i.e., a vapor-liquid-solid nanoparticle synthesis. *See* Reply 12–13.

In any event, we find that Petitioner fails to support a motivation to employ Herron’s cadmium sulfide semiconductor as a replacement for the gold clusters in Banin’s process, with a reasonable expectation of success, where Petitioner fails to address sufficiently (or at all) the differences between metal catalysts and Herron’s semiconductor material, or otherwise explain why a person of ordinary skill in the art would have used such a semiconductor material in place of the metal as the catalyst in Banin’s process, despite Banin’s teachings that the catalyst must be a metal. *See* Pet. 33–39; Reply 11–16 (sum total of Petitioner’s information on point).

Accordingly, for the foregoing reasons, we determine that Petitioner has failed to establish persuasively that a person of ordinary skill in the art would have been led to modify Banin’s nanoparticle synthesis by replacing its gold metal catalyst with Herron’s cadmium-based semiconductor.

4. Obviousness Ground Based on Banin and Treadway

Petitioner asserts that claims 13 and 14 are unpatentable as obvious over Banin in view of Treadway. Pet. 39–42. Both of these dependent claims inherit the limitation of claim 1 that requires a nanoparticle that includes “a molecular cluster compound.” Ex. 1001, 20:9–10 (claim 1); *see id.* at 20:46–49 (claims 13 and 14). We agree with Patent Owner that “Petitioner does not contend that Treadway discloses” an MCC. Resp. 51. Therefore, “the shortcomings” identified above, in connections with the other grounds that assert Banin, apply with equal force to this ground. *Id.* In particular, Banin neither discloses nor suggests an MCC.

5. Conclusions on the Grounds that Assert Banin

Having considered the record as a whole, we determine that Petitioner fails to show by a preponderance of the evidence that any challenged claim is unpatentable based on any ground that asserts Banin. In particular, for the reasons discussed above, we find that Petitioner does not show 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. Ground that Asserts Zaban and Farneth

Petitioner asserts that "Zaban discloses InP" quantum dots that are "synthesized in solution from In-based and P-based precursors in the presence of a Zn-based precursor." Pet. 42 (citing Ex. 1006, 3154). Petitioner further asserts that Farneth discloses a Zn-based and Cd-based MCC designated by the molecular formula $M_{10}S_{16}Ph_{12}$, where $M = Zn$ or Cd . *Id.* (citing Ex. 1009, Abstract, 917–918, 920). According to Petitioner, a person of ordinary skill in the art would have been prompted to replace Zaban's Zn-based precursor (namely, Zaban's zinc acetate, which serves a doping function in Zaban's process (Ex. 1006, 3155; Pet. 18)) with Farneth's Cd-based or Zn-based MCC because the skilled artisan "would have known that using MCCs to grow nanoparticles would result in significant production cost savings by lowering energy inputs while simultaneously increasing process efficiencies." Pet. 44 (citing Ex. 1002 ¶ 158).

Petitioner acknowledges that a skilled artisan would not have expected Farneth's MCCs to remain as crystalline solids or act as seeds at the temperatures disclosed for Zaban's process. *Id.* at 45 (citing Ex. 1002 ¶ 161; Ex. 1006, 3154 n.14; Ex. 1007, 4966). To address that issue, Petitioner relies on Yu's disclosure of heterogeneous seeded growth of

metallic nanoparticles on gold seeds at temperatures ranging from room temperature to 150 °C. *Id.* at 44–45 (citing Ex. 1010, 9198). Against that backdrop, Petitioner argues, an ordinarily skilled artisan “would have been motivated to perform Zaban’s InP [quantum dot] synthesis using Farneth’s MCC and Yu’s reaction temperatures.” *Id.* at 46 (citing Ex. 1002 ¶ 162).

Specifically, Petitioner asserts that Yu teaches that using an MCC in solution at temperatures in that range improves the stability of the MCC, helps ensure monodispersity of the resulting nanoparticle, and allows seed growth of a nanoparticle from a precursor composition. *Id.* at 44–45. Based on those teachings, Petitioner contends that a person of ordinary skill in the art would have been motivated to perform Zaban’s reaction at a lower temperature, as disclosed in Yu, to accommodate the use of Farneth’s Zn-based MCC. *Id.* at 45–46 (citing Ex. 1002 ¶¶ 161–162).

According to Petitioner, an ordinarily skilled artisan would have reasonably expected such a combination to successfully improve nanoparticle growth because “the prior art discloses the successful use of MCCs like the one disclosed in Farneth to grow nanoparticles at the temperatures disclosed in Yu,” for example, Banin uses Au clusters to grow InAs nanoparticles, and Yu uses MCCs as seed nuclei to grow nanoparticles from ions of a separate precursor at temperatures ranging from room temperature to 150 °C. *Id.* at 46 (citing Ex. 1002 ¶ 163; Ex. 1005, 17:22–30, 20:12–27; Ex. 1010, 9189–9199). Additionally, Petitioner asserts, such motivation is supplied by the fact that Zaban, Farneth, and Yu occupy the same field of art as the ’365 patent, that is, nanoparticles and their formation, and address a problem alleged to have been solved by the ’365 patent,

namely, providing an MCC capable of maintaining its structural integrity during a reaction. *Id.* (citing Ex. 1002 ¶ 163); Ex. 1001, 3:20–48; 5:53–6:11.

Patent Owner responds that a person of ordinary skill in the art would not have been led to combine the teachings of Zaban, which describe a process of making InP (group III-V) quantum dots using a heat-up method, with Farneth, which investigates a mechanism of solid-state (that is, solvent-free) conversion of a particular series of II-VI precursors to a bulk metal sulfide structure and “has nothing to do with group III-V quantum dots.” Resp. 52–63. 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. 42–54.

Further, Patent Owner argues, Petitioner identifies no persuasive reasons why an ordinarily skilled artisan would replace Zaban’s zinc acetate, which serves a doping function in Zaban’s process, for Farneth’s $Zn_{10}S_6Ph_{12}$ bulk-metal intermediate, which is not shown on this record to serve any comparable function. Resp. 53–54. Patent Owner points out that Zaban’s process uses zinc acetate as a dopant, i.e., “a small impurity intentionally added to change the core semiconductor’s electrical properties.” *Id.* at 54; Ex. 2030 ¶ 160; Ex. 1049, 42–44. According to Patent Owner and Dr. Cossairt, Zaban carefully dopes the quantum dots with a very low and precise amount of zinc, specifically, one Zn^{2+} ion per quantum dot, which results in an indium to zinc ratio of 1000 to 1. Resp. 54; Ex. 2030 ¶ 161; Ex. 1023, 3154.

Patent Owner asserts that such precision is necessary because “changing the amount of zinc dopant changes the properties of the resultant quantum dot.” Resp. 55; Ex. 2030 ¶ 164; Ex. 2023, 3. On that point, Patent

Owner argues, Petitioner does not explain adequately why one would have added Farneth's zinc intermediate, which has ten zinc atoms, into Zaban's synthetic reaction process. Patent Owner asserts that an ordinarily skilled artisan would not have been led to use Farneth's zinc intermediate because, for example, its increased quantity of zinc would result in smaller quantum dot products and drastically increase the zinc content zinc in Zaban's process, notwithstanding that Zaban's reaction depends on a "careful ratio of zinc to indium." Resp. 55–56 (citing Ex. 1006, 3154; Ex. 2030 ¶¶ 164–166). Patent Owner emphasizes, "Chemistry is specific," and "reagents, precursors, catalysts and other materials must be precisely chosen to obtain the specific result sought." *Id.* at 54–55 (citing Ex. 2030 ¶ 162).

In Patent Owner's view, nothing in the prior art would have guided the ordinarily skilled artisan to replace Zaban's zinc precursor with Farneth's MCC then perform Zaban's method, so modified, at the temperatures disclosed in Yu and, further, this proposed combination is driven by hindsight reconstruction of the claimed invention. *Id.* at 52–58. Patent Owner submits that Petitioner falls short of identifying persuasive evidence that an ordinarily skilled artisan would have upset Zaban's careful ratio of zinc to indium by replacing Zaban's zinc precursor with Farneth's intermediate. *Id.*; Sur-reply 21–24 (evidence cited by Patent Owner); *see* Pet. 42–46; Reply 17–23 (and cited by Petitioner).

Patent Owner refers to Zaban's disclosure that "[f]or synthesis of p-type InP [quantum dots], indium oxalate was mixed with zinc acetate in a ratio such that the resulting [quantum dots] contain on average one Zn²⁺ ion per particle. For example, for 40-A QDs, the ratio In:Zn is 103:1." Resp. 54 (quoting Ex. 1006, 3154); *see* Ex. 2030 ¶¶ 160–161 (Dr. Cossairt's

declaration testimony). According to Patent Owner, because Farneth's intermediate has no indium ions, Petitioner's proposed use of it in place of Zaban's zinc acetate would "eviscerate the delicately balanced doping ratio and change the nature of Zaban's quantum dots," as well as introduce unknown effects due to the presence of sulfur in Farneth's intermediate. Resp. 56 (citing Ex. 2030 ¶ 166).

In Patent Owner's further view, Petitioner's suggestion that one would have been led to replace Zaban's zinc precursor with Farneth's intermediate involves a hindsight-driven exercise of picking and choosing the precise component from the prior art required to reconstruct the claimed invention. *See id.* at 56–57 (arguing that Petitioner's "far-fetched rationales" for the proposed combination of elements from disparate prior art references is a "backwards looking effort by Petitioner to pick and choose the elements necessary to reconstruct the patented invention from the prior art").

In addition, Patent Owner contends, Yu fails to assist the combination of Zaban and Farneth, as Yu "uses an entirely different method" for "utilizing gold" and does not align "with Zaban's heat-up colloidal process or Farneth's solid state method." *Id.* at 57 (citing Ex. 2030 ¶ 169). Patent Owner asserts, "If anything, Yu promotes the use of gold clusters as 'potent heterogenous nucleants' and would have directed a [person of ordinary skill in the art] away from using Farneth's solid state method." *Id.* (citing Ex. 1010, 9199).

1. Whether a Motivation to Combine Exists

Based on our consideration of the record as a whole, we find that Patent Owner has identified deficiencies in the Petition regarding Petitioner's asserted motivation to substitute Zaban's zinc acetate dopant

with Farneth's zinc-based compound and then conduct the modified chemical reaction at the temperatures disclosed in Yu.¹⁹ In particular, we find that Petitioner does not address sufficiently the differences between the allegedly interchangeable components or demonstrate that a skilled artisan would have seen fit to exchange them in Zaban's process for any reason.

For example, Petitioner recognizes that Zaban's zinc acetate "dopes zinc into the nanoparticles." Pet. 33. However, in the Petition, Petitioner does not address how Zaban performs that function. Zaban discloses, "For synthesis of p-type InP QDs, indium oxalate was mixed with zinc acetate in a ratio such that the resulting QDs contain on average one Zn^{2+} ion per particle. For example, for 40-A QDs, the ratio In:Zn is $10^3:1$." Ex. 1006, 3154. For reasons explained by Patent Owner and Dr. Cossairt, we find that this disclosure in Zaban reflects a process requiring a delicately balanced

¹⁹ We agree with Patent Owner that Petitioner appears to have given up on its proposed substitution of Zaban's zinc acetate with Farneth's cadmium-based compound. Sur-reply 22. In the Reply, Petitioner does not address Patent Owner's arguments directed to that proposed substitution. *See* Reply 17–23. Instead, Petitioner addresses only Patent Owner's contentions that one would not have been led to replace Zaban's zinc acetate dopant with Farneth's zinc-based compound. *Id.* Insofar as Petitioner does not withdraw its arguments based on modifying Zaban by replacing the zinc acetate with Farneth's cadmium-based compound, we find Petitioner's arguments about the proposed modification deficient because Petitioner fails to adequately explain why an ordinarily skilled artisan would have been led to fundamentally alter Zaban's process by completely eliminating zinc from the process, where Zaban discloses the use of zinc acetate as a dopant and instructs how that zinc compound functions to achieve the desired quantum dot product. Pet. 42–54; Ex. 1006, 3154.

doping ratio that provides on average one Zn^{2+} ion per quantum dot. *See* Ex. 2030 ¶¶ 160–166; Resp. 54–56. Yet, Petitioner does not explain persuasively how Farneth’s $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ compound may similarly function as a dopant, or how its use would maintain Zaban’s balanced doping ratio *and* resulting average of one Zn^{2+} ion per quantum dot.

In the Reply, Petitioner argues that “adjusting concentrations is well within the knowledge and common sense of” an ordinarily skilled artisan, and such an artisan “would have known that she could adjust the relative amounts of starting ingredients to control concentration,” namely, by increasing the amount of indium and phosphorus precursors present in Zaban’s process to accommodate the increased amount of zinc in Farneth’s $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ compound. Reply 21 (citing Ex. 1093 ¶ 57; Ex. 1002 ¶ 56; Ex. 1097, 5–6). We note that this explanation differs from the teachings of Zaban, which mixes indium and zinc in a particular ratio (and not indium, *phosphorus*, and zinc in a particular ratio).

In any event, of more concern, Petitioner’s explanation disregards the requirement in Zaban that the indium and zinc ratio is balanced “such that the resulting [quantum dots] contain on average one Zn^{2+} ion per particle.” Ex. 1006, 3154. Indeed, Petitioner does not contend that its proposed modification would provide quantum dots “that contain on average one Zn^{2+} ion per particle,” as Zaban’s mixture of indium and zinc provides. *See* Reply 20–23 (Petitioner proposing how to accommodate the increased amount of zinc supplied by Farneth’s $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ compound, without discussing Zaban’s teaching that that indium and zinc are mixed in a ratio to provide quantum dots containing on average “one Zn^{2+} ion per particle”).

As Patent Owner correctly asserts in its Sur-reply, Petitioner's argument on this matter "misses the mark" because "Farneth contains ten zinc atoms, and changing the concentration of *precursors* does nothing to change the fact that any quantum dot that includes Farneth's cluster will have at least ten times the amount of zinc required by Zaban." Sur-reply 23 (Patent Owner's emphasis). Petitioner does not explain adequately why substituting the zinc acetate dopant in Zaban's process with Farneth's $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ compound would not "change the nature" of Zaban's quantum dots, at least in that respect.

Although the challenged claims do not require quantum dots that contain on average one Zn^{2+} ion per particle, the issue here is that Petitioner fails to show persuasively that a person of ordinary skill in the art at the time of the invention would have had a rational reason to modify Zaban's process by swapping out the zinc acetate for another zinc-based compound that would alter the resulting number of zinc ions per quantum dot particle, relative to the "one Zn^{2+} ion per particle" that Zaban intends in its synthetic reaction. Ex. 1006, 3154; *see* Ex. 2030 ¶¶ 160–166 (Dr. Cossairt's well-supported opinion testimony on point).

Thus, we find that Petitioner's asserted reason to combine Zaban and Farneth — based on alleged "production cost savings" (Pet. 44) — is not adequately supported on this record. Petitioner fails to persuade us that an ordinarily skilled artisan would have recognized Farneth's $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ cluster as an interchangeable alternative serving a common function with the zinc acetate dopant in Zaban's process.

2. Indications of Impermissible Hindsight Reconstruction

Based on our consideration of the record as a whole, we agree with Patent Owner that Petitioner's proposed combination of Zaban and Farneth appears to rely on impermissible hindsight reconstruction. Resp. 53–58. As Patent Owner asserts, “Chemistry is specific” and “reagents, precursors, catalysts and other materials must be precisely chosen to obtain the specific result sought.” *Id.* at 54–55 (citing Ex. 2030 ¶ 162). Given the unpredictability in the field of the invention, we find that Petitioner fails to come forward with persuasive art-based reasons for replacing the zinc dopant in Zaban's process with Farneth's zinc-based or cadmium-based cluster compound.

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 Farneth's cluster compound to attain a synthetic method that meets the limitations of a challenged claim. Reply 19. 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 rationale that persuasively demonstrates 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. 44 (citing Ex. 1002 ¶ 158).

Thus, we find that 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. 52–58 (citing Ex. 2030 ¶¶ 156–169).

3. Conclusions on the Ground that Asserts Zaban and Farneth

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 the ground that asserts Zaban and Farneth. Dec. 25–26.

Having considered the record as a whole, we determine that Petitioner does not show by a preponderance of the evidence that the challenged claims are rendered obvious by the combined teachings of Zaban and Farneth. In particular, for the reasons discussed above, we find that Petitioner does not show persuasively that a person of ordinary skill in the art would have substituted Zaban's zinc dopant with Farneth's $Zn_{10}S_6Ph_{12}$ compound. Additionally, we find that Petitioner's proposed modification appears to rely on impermissible hindsight reconstruction. Petitioner directs us to no disclosures in Yu that cure the above-discussed deficiencies with the proposed combination. Accordingly, we conclude that Petitioner does not establish the unpatentability of any challenged claim based on the ground that relies on the combined disclosures of Zaban and Farneth.

G. Grounds that Assert Lucey

Petitioner asserts that claims 1–2, 4, 7–12, 17, 18, 22, and 23 are unpatentable as obvious over Lucey and Ahrenkiel. Pet. 15, 54–63. Petitioner further asserts that claims 13–16 are unpatentable as obvious over

Lucey, Ahrenkiel, and Treadway. *Id.* at 15, 63–66. 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 these grounds. Dec. 26–28. The parties nevertheless addressed both grounds in the trial phase. Resp. 58–65; Reply 24–25; Sur-reply 24–26.

At the final hearing, Petitioner withdrew these grounds from contention. Tr. 49–50. Because Petitioner has withdrawn these grounds, we do not address them 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, 7–12, 17, 22, 23	102	Banin		1, 7–12, 17, 22, 23
1, 7–12, 15–17, 22, 23	103(a)	Banin		1, 7–12, 15–17, 22, 23
2–6, 18–21	103(a)	Banin, Herron		2–6, 18–21
13, 14	103(a)	Banin, Treadway		13, 14
1–9, 17–23	103(a)	Zaban, Farneth, Yu		1–9, 17–23

Claims	35 U.S.C. §	References	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1, 2, 4, 7–12, 17, 18, 22, 23	103(a)	Lucey, Ahrenkiel ²⁰		
13–16	103(a)	Lucey, Ahrenkiel, Treadway		
Overall Outcome				1–23

VI. ORDER

It is

ORDERED that claims 1–23 of the '365 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.

²⁰ This Final Written Decision does not address either ground that asserts Lucey because both were withdrawn by Petitioner's counsel at the final hearing. Tr. 49–50.

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