

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.

IPR2021-00183
Patent 7,588,828 B2

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

FRANKLIN, *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, 3–6, and 8–14 (“the challenged claims”) of U.S. Patent No. 7,588,828 B2 (Ex. 1001, “the ’828 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 set forth below, we determine that Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (collectively, “Petitioner”) have not shown, by a preponderance of the evidence, that the challenged claims are unpatentable.

A. *Procedural History*

Petitioner filed a Petition requesting an *inter partes* review of the challenged claims. Paper 1 (“Petition” or “Pet.”). Petitioner supported the Petition with the Declaration of Mark A. Green, Ph.D. (Ex. 1002). Nanoco Technologies Ltd. (“Patent Owner”) 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).

On May 19, 2021, pursuant to 35 U.S.C. § 314(a), we instituted trial to determine whether any challenged claim of the ’828 patent is unpatentable based on the grounds raised in the Petition. Paper 17 (“Inst. Dec.”). The following table sets forth the grounds asserted for the challenged claims:¹

¹ 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 application from which the ’828 patent issued 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, 3–6, 8–14	103(a)	Banin ² , Herron ³
1, 3	103(a)	Banin, Farneth ⁴
1, 3–6, 14	103(a)	Zaban, ⁵ Farneth, Yu ⁶
8–13	103(a)	Zaban, Farneth, Yu, Braun ⁷

After institution of trial, Patent Owner filed a Patent Owner Response to the Petition. Papers 25, 26 (collectively, “PO Resp.”).⁸ Patent Owner supported the Patent Owner Response with the Declaration of Brandi

² Banin et al., WO 03/097904 A1, published Nov. 27, 2003 (“Banin,” Ex. 1005).

³ Herron et al., *Crystal Structure and Optical Properties of Cd₃₂S₁₄(SC₆H₅)₃₆DMF₄, a Cluster with a 15 Angstrom CdS Core*, 259 SCIENCE 1426–1428 (1993) (“Herron,” Ex. 1016).

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

⁵ Zaban et al., *Photosensitization of Nanoporous TiO₂ Electrodes with InP Quantum Dots*, 14 LANGMUIR 3153–3156 (1998) (“Zaban,” Ex. 1006).

⁶ 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).

⁷ 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).

⁸ Patent Owner filed Paper 25 (unredacted Patent Owner Response) under seal and filed Paper 26 (redacted Patent Owner Response) in the public record. Patent Owner filed a Motion to Seal directed, in part, to Paper 25. Paper 27. Petitioner filed a Response to that motion. Paper 30. Thereafter, the parties filed a joint motion to withdraw the motion to seal based, in part, on their agreement that the Patent Owner Response does not need to be sealed because it does not contain confidential information. Paper 31. We granted the motion. Paper 43. Therefore, the unredacted Patent Owner Response (Paper 25) is unsealed and part of the public record of this proceeding.

Cossairt, Ph.D. Ex. 2030. Petitioner filed a Reply to the Patent Owner Response, Paper 33 (“Pet. Reply”), along with a Second Declaration of Mark A. Green, Ph.D. (Ex. 1093). Patent Owner filed a Sur-reply to Petitioner’s Reply. Paper 40 (“PO Sur-reply”).

On February 23, 2022, the parties presented arguments at an oral hearing. Paper 44.⁹ The hearing transcript has been entered in the record. Paper 47 (“Tr.”).

B. Real Parties-in-Interest

Petitioner identifies Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. as real parties-in-interest. Pet. 66. Patent Owner identifies Nanoco Technologies Ltd. as a real party-in-interest. Paper 6, 2.

C. Related Matters

Petitioner and Patent Owner provide notice of a district court litigation involving the ’828 patent: *Nanoco Technologies Ltd. v. Samsung Electronics Co., Ltd.*, No. 2:20-cv-00038 (E.D. Tex.) (the “District Court case”). Pet. 66; Paper 6, 2.

The parties further identify petitions for the four other patents asserted in the District Court case: IPR2021-00182 for U.S. Patent No. 9,680,068, IPR2021-00184 for U.S. Patent No. 7,803,423, IPR2021-00185 for U.S. Patent No. 7,867,557, and IPR2021-00186 for U.S. Patent No. 8,524,365. Pet. 66; Paper 6, 2–3.

⁹ Although we held a consolidated hearing for this case, IPR2021-00182, IPR2021-00184, IPR2021-00185, and IPR2021-00186, these cases are not consolidated. See Papers 44, 47.

D. The '828 Patent

In the invention of the '828 patent, the “conversion of a precursor composition to nanoparticles is effected in the presence of a molecular cluster compound.” Ex. 1001, 3:20–22. The Specification discloses that “[t]here has been substantial interest in the preparation and characterization of compound semiconductors in the form of particles with dimensions in the order of 2-50 nanometers (nm), often referred to as quantum dots, nanoparticles, or nanocrystals.” *Id.* at 1:17–21. The Specification explains that this interest is “due to the size-related electronic properties of these materials that can be exploited in many commercial applications.” *Id.* at 1:21–27. The Specification describes prior “bottom-up techniques” to produce quantum dot but states that “[e]arly routes applied conventional colloidal aqueous chemistry, with more recent methods involving the kinetically controlled precipitation of nanocrystallites, using organometallic compounds.” *Id.* at 1:58–61, 3:12–15.

With regard to its invention, the Specification explains that the molecules of a cluster compound act as a seed or nucleation point for nanoparticle growth. *Id.* at 3:23–25. The Specification states

“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 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. (When the molecules possess the same relative molecular formula, the molecular clusters are identical to one another in the same way that one H₂O molecule is identical to another H₂O molecule.)

Id. at 3:28–37. According to the Specification, molecular cluster compounds (“MCC”) can provide an essentially monodisperse population of

nanoparticles and “[a] significant advantage of this method is that it can be more easily scaled-up to production volumes when compared to other methods of nanoparticle generation.” *Id.* at 3:40–44.

The Specification describes an embodiment of “a nanoparticle including a molecular cluster compound incorporating ions from groups 12 and 16 of the periodic table, as well as a core semiconductor material incorporating ions from groups 13 and 15 of the periodic table provided on the molecular cluster compound.” *Id.* at 3:49–54. According to the Specification, “[t]he group 16 ions may include at least one member of the group consisting of oxide ions, sulfide ions, selenide ions, and telluride ions,” “[t]he group 13 ions may include at least one member of the group consisting of aluminum ions, gallium ions, and indium ions,” and “[t]he group 15 ions may include at least one member of the group consisting of nitride ions, arsenide ions, and antimonide ions.” *Id.* at 3:59–65.

The Specification explains that “[a]ny suitable molar ratio of a first precursor species to a second precursor species may be used.” *Id.* at 5:25–26. For example, approximately equal amounts of first and second precursor species can be used or approximately twice the number of moles of one precursor species can be used relative to another. *Id.* at 5:31–33, 5:35–38. The Specification discloses that “[s]uitable precursors include single-source precursors which comprise the two or more ions to be incorporated into the growing nanoparticle, or multi-source precursors in which two or more separate precursors each contain at least one ion to be included in the growing nanoparticle.” *Id.* at 43–47. The Specification also explains that precursors may include elements other than those in a molecular cluster and a molecular cluster may have a different chemical formula than a nanoparticle form on and around the molecular cluster. *Id.* at 10:2–11.

E. Illustrative Claims

Petitioner challenges independent claims 1 and 14 and dependent claims 3–6 and 8–13 of the '828 patent. Independent claims 1 and 14, set forth below, are illustrative of the claimed subject matter.

1. A nanoparticle comprising:
 (i) a molecular cluster compound incorporating ions from groups 12 and 16 of the periodic table, and
 (ii) a core semiconductor material provided on said molecular cluster compound,
 wherein the core semiconductor material incorporates ions from groups 13 and 15 of the periodic table.

14. A method of producing nanoparticles, the method comprising the steps of:
 providing a nanoparticle precursor composition comprising group 13 ions and group 15 ions; and
 effecting conversion of the nanoparticle precursor into nanoparticles,
 wherein said conversion is effected in the presence of a molecular cluster compound incorporating group 12 ions and group 16 ions under conditions permitting nanoparticle seeding and growth.

Ex. 1001, 22:61–67, 24:12–21.

II. ANALYSIS

A. Principles of Law

To prevail in this *inter partes* review, 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).

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.¹⁰

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 asserted grounds of unpatentability in accordance with the above-stated principles.

¹⁰ Patent Owner does not assert or rely on objective evidence of nonobviousness in this case.

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)).

Petitioner asserts that a person of ordinary skill in the art at the time of the invention 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. 20 (citing Ex. 1002 ¶¶ 72–75). Patent Owner neither addresses Petitioner’s description of the level of ordinary skill in the art, nor provides its own description. *See* PO Resp.

Accordingly, we adopt Petitioner’s definition as we find it is unopposed and consistent with the level of skill in the art at the time of the invention as reflected by the prior art in this proceeding.

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.

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

[w]hile the full scope of the term “molecular cluster compound” is unclear—the ’828 patent states that the term is “widely understood in the relevant technical field” as relating to “clusters of three or more **metal atoms** and their associated ligands,” but the related ’423 patent states that the same term is widely understood as being limited to “clusters of 3 or more **metal or nonmetal atoms** and their associated ligands” (*compare* Ex. 1001, 3:28-35 with Ex. 1055, 5:3-12)—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. 20–21 (footnote omitted). Petitioner acknowledges that the Specification states also that the molecular clusters are “of sufficiently well-defined chemical structure such that all molecules of the cluster compound possess approximately same relative molecular formula.” *Id.* at 21 n.5 (quoting Ex. 1001, 3:28–34).

Patent Owner contends that the '828 patent expressly defines “molecular cluster compound” by stating:

“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 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.

PO Resp. 28 (quoting Ex. 1001, 3:28–34). Patent Owner notes that “the District Court resolved the parties’ dispute by construing 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.’” *Id.* at 29 (quoting Ex. 1091, 18). Patent Owner agrees with Petitioner that “the parties’ dispute over the meaning of the term need not be resolved here.” *Id.* According to Patent Owner, “[r]esolution of the Petition does not revolve around any disputed aspects of the term ‘molecular cluster compound.’” *Id.*

Petitioner asserts in the Reply that the challenged claims are unpatentable “under any possible construction.” Pet. Reply 1 n.1.

Based on our consideration of the record as a whole, we find that the Specification expressly defines the term “molecular cluster” in a manner that refers to the cluster compound. According to the Specification,

“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 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. 1001, 3:28–34 (emphasis added). As there is no dispute that the term “molecular cluster compound” refers to “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,” we agree with the parties that no further construction of the claim is necessary for purposes of rendering this Decision.

Additionally, we find that express construction of any remaining claim terms is unnecessary for purposes of rendering 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. Obviousness over Banin and Herron

Petitioner asserts that claims 1, 3–6, and 8–14 are rendered obvious by the combined teachings of Banin and Herron. Pet. 21–37; Pet. Reply 1–18. Patent Owner disagrees. PO Resp. 30–58; PO Sur-reply 1–20.

1. Banin

Banin “relates to a method for synthesizing rod-shaped semiconductor nanocrystals, *inter alia* rod shaped Group III-V semiconductor nanocrystals.” Ex. 1005, 1:2–4. 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 6:3–6. Banin discloses that “[t]he metal catalyst can be made, for example, of a transition metal, e.g. Zn [zinc], Cd [cadmium], Mn [manganese], etc., a Group IIIa metal, e.g. In [indium], Ga [gallium], Al

[aluminum], alloys of such metals such as for example Au-In [gold-indium], or core/shell layered metal particle.” *Id.* at 6:9–11.

An embodiment of Banin’s process is depicted in Figure 1, set forth below.

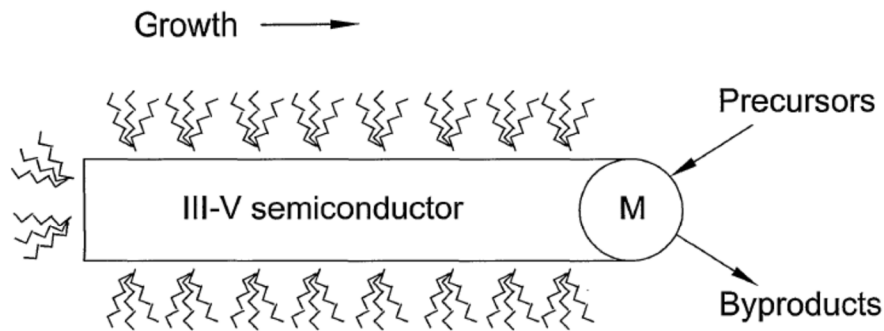


FIG. 1

Figure 1 illustrates the growth mechanism of InAs nanorods for Banin’s invention. *Id.* at 10:11–12. 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 13:9–11. Banin explains that the 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 13:11–16.

Banin also discloses “[t]he use of small Au clusters (1.4 nm in mean diameter) instead of Au particles (2 nm in mean diameter)” and describes an experiment in which “triphenylphosphine coated Au clusters with [a] diameter of 1.4 nm and the suggested formula Au₁₀₁(PPh₃)₂₁Cl₅” were used to prepare InAs rods. *Id.* at 20:12–17. Banin further discloses that its metal catalyst can be selected from “Fe [iron], Zn [zinc], Pd [palladium], Pt

[platinum], Ni [nickel], Co [cobalt], Mn, Ag [silver], 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. *Discussion*

Each of claims 1, 3–6 and 8–14 requires an MCC incorporating ions from groups 12 and 16 of the periodic table. Petitioner’s challenge of each claim relies, in part, on its assertion that Banin’s Au-based cluster is an MCC and that a skilled artisan would have been motivated to substitute it with Herron’s 12-16 MCC. *See* Pet. 21–37. Because the parties’ disputes center on these contentions, our discussion will likewise focus on these issues.

a) *Whether Banin’s “small Au clusters” are MCCs*

We first consider whether Petitioner has shown persuasively that Banin’s “small Au clusters” (also referred herein to Banin’s “Au-based

clusters,” “gold clusters,” “metal catalyst” and “gold metal catalyst”) are MCCs. For purposes of this proceeding, both parties agree that the MCC recited in independent claims 1 and 14 refers to “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,” as described in the Specification. Ex. 1001, 3:28–34; Pet. 20–21; PO Resp. 28. According to Petitioner, based on that description, Banin’s small Au clusters are MCCs. Pet. 25; Ex. 1002 ¶ 103. To support that position, Petitioner relies on Banin’s disclosure that the Au-based clusters have “the suggested formula $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$,” Ex. 1005, 20:14–15, and the testimony of Dr. Green, *see, e.g.*, Ex. 1002 ¶¶ 86–88, 103–107.

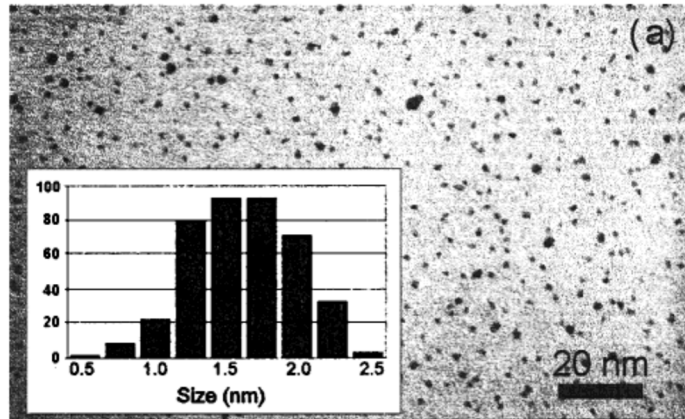
Dr. Green testifies, “It is my opinion that a POSITA [(person or ordinary skill in the art)] would have understood that those gold clusters $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ are MCCs, because they are ‘clusters with three or more metal atoms and their associated ligands’ and each cluster is ‘*identical to one another.*’” Ex. 1002 ¶ 103. Dr. Green continues by stating that “[t]hese Au-based clusters have 101 gold atoms, which are metal atoms, and thus are ‘clusters of 3 or more metal’ atoms that are ‘identical to one another.’” Ex. 1002 ¶ 104 (citing Ex. 1001, 3:28–38, 11:28–29; Ex. 1005, 17:22–25, 20:12–27). In other words, Dr. Green considers the gold cluster 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. At the petition stage, that is the extent of Petitioner and Dr. Green’s explanation for their position that Banin’s gold clusters are MCCs.

Patent Owner contends that Banin does not disclose an MCC. PO Resp. 30 (citing Ex. 2030 ¶¶ 99–118). According to Patent Owner, Banin’s gold clusters “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.* Patent Owner asserts that Banin does not describe these gold clusters as “identical to one another,” as Petitioner contends. *Id.* at 32 (citing Ex. 1005, 20; Ex. 2030 ¶ 102; Pet. 22). Rather, according to Patent Owner, Banin’s clusters range in size. *Id.* at 30 (citing Ex. 2030 ¶¶ 99–118).

In particular, Patent Owner emphasizes that Banin describes the molecular formula $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ as a “suggested formula” for the Au clusters. PO Resp. 32 (citing Ex. 1005, 20; Ex. 2030 ¶ 102). Additionally, Patent Owner notes that Banin discloses that the Au clusters were “synthesized by the published procedures” in Hutchison.¹¹ *Id.* (citing Ex. 1005, 3, 21; Ex. 2030 ¶ 102). Regarding those disclosures, Patent Owner’s expert, Dr. Cossairt, testifies that “the gold catalysts in Banin are not well-defined and were assigned the molecular formula $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$ based on a calculation that relied on the average of a wide distribution of particle sizes reported in the literature by Hutchison.” Ex. 2030 ¶ 102 (citing Ex. 2017, 12891). In support of that position, Dr. Cossairt examines and discusses Hutchison. Ex. 2030 ¶ 103; PO Resp. 33.

Specifically, referring to Hutchison Figure 1(a), set forth below, Dr. Cossairt testifies that “[t]he Hutchison process creates gold particle agglomerations of many different sizes.” Ex. 2030 ¶ 103.

¹¹ 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). She explains 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 ¶ 103. According to Dr. Cossairt, the image in Hutchison’s Figure 1(a) “shows and the histogram confirms with its variety of differently sized black dots, the sizes of the gold clusters vary considerably with sizes ranging from at least 0.75 nm to 2.25 nm.” *Id.* Dr. Cossairt continues by stating that “[t]hese different sizes [of gold clusters] are averaged out, and then using the *average size* of the particles, it is estimated that the average number of gold atoms [in the metal core] is approximately 101.” *Id.* ¶ 104 (citing Ex. 2017, 12891). Additionally, Dr. Cossairt notes that Hutchison uses the tilde symbol, “~”, when referring to the estimated particle size, i.e., “~101” meaning that the disclosed particle size of 101 is “only an approximate formula for an average-sized particle, not a well-defined formula.” *Id.*

Dr. Cossairt also directs us to Hutchison’s disclosure that Figure 1(a) provides “[d]irect evidence of nanoparticle size and dispersity.” *Id.* ¶ 105 (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/nanoparticles resulting from Hutchison’s process is over 25%, which “is not considered monodisperse in the art.” *Id.* ¶ 106 (citing

Ex. 2017, 12890). Dr. Cossairt testifies that “[a] POSITA 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.” *Id.* ¶ 109.

Further, Patent Owner and Dr. Cossairt note that Banin uses molten gold in a Solution—Liquid—Solid Synthesis (“SLS”) method to create group III–V nanorods. PO Resp. 31; Ex. 2030 ¶ 100; Ex. 1005, 14:3–9, 22:25–23:14. According to Dr. Cossairt, “[b]y using particles that are not sufficiently well-defined, Banin’s SLS process [of forming its group III–V nanorods] fails to achieve the goal of the ’828 patent, which is to make a population of semiconductor nanoparticles that is essentially monodisperse.” Ex. 2030 ¶ 112 (citing Ex. 1001, 3:37–42, 5:1–4). Referring to Banin’s disclosure that “[t]he 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,” Ex. 2030 ¶ 112 (quoting Ex. 1005, 7:6–8), Dr. Cossairt testifies that “[i]n Banin’s SLS method, the diameter of the nanorods is dictated by the size of the gold particle,” Ex. 2030 ¶ 112; *see* PO Resp. 36. As a result, according to Dr. Cossairt, “the diameter of Banin’s nanorods vary by up to 25%, just like the gold particles do.” Ex. 2030 ¶ 112 (citing Ex. 1005, 23:17–18) (describing the width of the diameter distribution in three nanorod fractions as 20–25%).

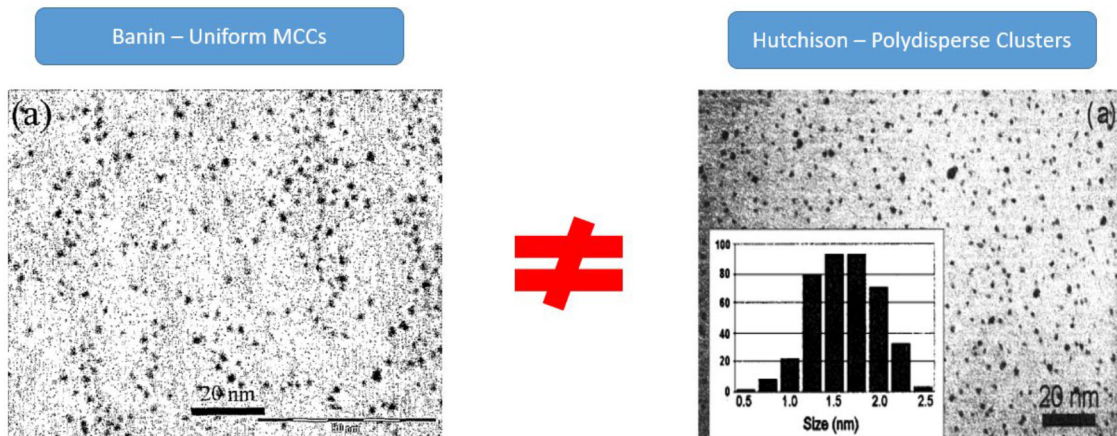
Dr. Cossairt explains that “[t]his size distribution reflects the same size distribution of the gold particles taught by Hutchison,” i.e., Figure 1(a) “showing particles of $1.5\text{ nm} \pm 0.4\text{ nm}$ [a 25% difference]” *Id.* (citing Ex. 2017, Fig. 1(a)). According to Dr. Cossairt, “[t]hese uncharacterized gold particles with a large size distribution do not have ‘sufficiently well-

defined chemical structure such that all molecules of the cluster compound possess the same relative molecular formula.” *Id.*

Patent Owner asserts also that Petitioner’s expert, Dr. Green, agreed, during his deposition, that a mixture of clusters is not a MCC “because they wouldn’t have the same relative molecular formula,” and would not be identical. PO Resp. 38 (citing Ex. 2031, 68:6–14). According to Patent Owner, because the gold clusters in Banin are made by the Hutchison process which creates cluster mixtures with a range of sizes, and the average molecular formula is estimated based on an average size, Banin’s gold clusters/metal catalysts are not MCCs as required by the challenged claims. *Id.* at 41.

In the Reply, Petitioner maintains 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 a POSITA that those clusters are MCCs.” Pet. Reply 6. Moreover, Petitioner asserts that Patent Owner’s assertion that Banin does not disclose an MCC is unsupported. *Id.* at 2. To that end, Petitioner asserts again that “a POSITA would recognize that Banin identifies only one specific cluster—having a single formula (i.e., $\text{Au}_{101}(\text{PPh}_3)_{21}\text{Cl}_5$) and size (1.4 nm) with more than three metal atoms—which is a[n] MCC.” *Id.* at 3.

Additionally, Petitioner alleges that Banin’s TEM image “shows that its Au_{101} clusters do not have the size distribution that the clusters in Hutchinson do.” *Id.* (comparing Ex. 1005, 11:15, Fig. 10(a) with Ex. 2017, Fig. 1(a)). Petitioner’s side by side comparison of Banin’s TEM and Hutchison’s TEM is set forth below:



Pet. 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 allegedly showing "Uniform MCCs" and Hutchison's figure allegedly showing "Polydisperse Clusters," along with a "≠" (not equal to) sign between the figures. Petitioner's expert, Dr. Green, testified 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 TEM images, "a POSITA would recognize 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." Ex. 1093 ¶ 18; Pet. Reply 4.

Dr. Green explains that the image of Banin's MCCs may appear varied in the TEM image because: (a) the clusters are non-spherical and will be oriented differently; and (b) the clusters can aggregate next to one another, "mak[ing] two MCCs appear as one." Ex. 1093 ¶ 19. Further, Dr. Green relies on Banin's disclosure that the MCCs are depicted "without

further size selection,” which he considers to mean that Banin employed a previous size selection to obtain a particular size particle. *Id.* ¶ 22 (quoting Ex. 1005, 22:26–28) (emphasis by Dr. Green); Pet. Reply 4.

Petitioner also contends that Patent Owner improperly correlates the 25% width in the size distribution in Banin’s gold nanorods with the 25% size distribution in Hutchinson’s gold particles. Pet. Reply 5 (citing PO Resp. 36). Petitioner contends that “there is no such size distribution shown in Banin’s MCCs as depicted in Banin Fig. 10A.” *Id.* (citing Ex. 1093 ¶ 24; Ex. 1005, Fig. 10A). Further, Petitioner asserts that Banin discloses that there could be reasons for a nanorod size distribution that are unrelated to the size of the gold cluster. *Id.* (citing Ex. 1005, 7:9–12; Ex. 1099, 64:6–65:9).

In the Sur-reply, Patent Owner notes that it is undisputed by Petitioner that “Hutchison’s process used by Banin produces differently sized gold clusters which are averaged to assign a ‘suggested’ formula of Au₁₀₁.” PO Sur-reply 3 (citing Pet. Reply 3–4). According to Patent Owner, Hutchison’s process does not make MCCs because the particles produced “do not have the sufficiently well-defined structure of a MCC.” *Id.* Because Banin uses the Hutchison process to make its gold clusters/catalyst, Patent Owner contends that Banin’s gold clusters/catalyst are also not MCCs. *Id.* at 3–5.

Insofar as Petitioner alleges that Banin size-selects its catalysts such that they have the same size and molecular formula, Patent Owner asserts that is a new argument or theory improperly raised in the Reply. *Id.* at 5. Further, Patent Owner asserts that “[n]othing in Banin suggests that the gold catalysts are size-selected after being made by Hutchison’s process.” *Id.* at 6. Rather, Patent Owner asserts that Banin size-selects only its nanorod end-

products, not its gold catalysts. *Id.* at 10 (citing Ex. 1005, 24:15–23). Contrary to Petitioner’s assertion, Patent Owner contends that “Banin and Hutchison’s TEM images are practically indistinguishable,” and that both images “depict particles of various sizes.” *Id.* at 6. Patent Owner asserts that the Hutchison process is a form of size selection because Hutchison explains that its “synthesis allows size control.” *Id.* at 7 (citing Ex. 2017, 12891). According to Patent Owner, Banin’s explanation that its TEM image of the gold clusters is “without further size selection,” does not refer to some prior size selection as Petitioner asserts. *Id.*

Patent Owner asserts that Banin’s gold catalysts are not the same size of 1.4 nm, as Petitioner asserts in the Reply. *Id.* at 10. Instead, Patent Owner notes that Banin describes the clusters as “1.4 nm in mean diameter,” which Patent Owner asserts indicates a size dispersion. *Id.* (citing Ex. 1005, 20:12–16).

Regarding Petitioner’s assertion that “there is no evidence that distributed nanorod size is due to an alleged size distribution of Banin’s clusters,” Pet. Reply 5, Patent Owner responds as follows:

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*”). 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...”). 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, ¶116; Ex. 1005, 23:17-18 (20-25% distribution); Ex. 2017, Fig.1(a) (25% distribution).

PO Sur-reply 11–12.

Having considered the record as a whole, we agree with Patent Owner that Petitioner has not shown persuasively that a person of ordinary skill in the art would have considered Banin’s small Au clusters to be MCCs. According to Petitioner and Dr. Green, Banin’s gold clusters are MCCs because they are ‘clusters with three or more metal atoms and their associated ligands’ and each cluster is ‘*identical to one another.*’” Ex. 1002 ¶ 103; Pet. 25. To begin, we do not find that the record supports Petitioner’s contention or Dr. Green’s opinion that “each cluster is ‘identical to one another.’” Ex. 1002 ¶ 103; Pet. 25. Petitioner and Dr. Green do not identify any disclosure in Banin describing the clusters as being 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.” In doing so, Petitioner and Dr. Green do not meaningfully address or adequately explain how Banin derived its “suggested” molecular formula for the gold clusters or why Banin reported a “mean” diameter for those clusters. To that end, Petitioner and Dr. Green have failed to provide any reason why a skilled artisan would have understood Banin’s disclosures of a “suggested formula” and a “mean diameter” to convey that the Au clusters are identical.

On the other hand, we find that Patent Owner’s expert, Dr. Cossairt explains persuasively that Banin’s gold clusters range in size and that the “suggested formula” assigned to them is “based on a calculation that relied

on the average of a wide distribution of particle sizes reported in the literature by Hutchison.” Ex. 2030 ¶ 102 (citing Ex. 2017, 12891). We assign persuasive weight to her testimony because it is based upon the disclosures in Hutchison, which Banin explicitly identifies as the published procedures by which it synthesized its clusters. In particular, Dr. Cossairt’s testimony is supported by the following discussion in Hutchison:

To calculate an average molecular formula for 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, Hutchison explains that it calculated an *average molecular formula* for its synthesized nanoparticles 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 has recognized, Banin’s “suggested formula” is exactly the same molecular formula that Hutchison discloses as the “average molecular formula” for its nanoparticles. Thus, we determine that the record as a whole supports finding that 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 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.

To the extent that Petitioner seeks to distinguish Banin from Hutchison at the Reply stage, we are unpersuaded. Petitioner and Dr. Green acknowledge that Hutchison’s TEM image is “consistent with a size distribution of clusters.” Pet. Reply 3–4; Ex. 1093 ¶¶ 17–18. Although produced by Hutchison’s method, Petitioner asserts and Dr. Green testifies

that Banin's TEM image shows that its clusters do not have the size distribution that the clusters in Hutchison do. *Id.* According to Dr. Green, a skilled artisan would recognize from Banin's TEM image that Banin's MCCs represent "purified and size selected" MCCs. 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, Pet. Reply 3; Ex. 1093 ¶ 17, we are unable to discern any meaningful distinction between the images. Moreover, we do not assign Dr. Green's testimony in that regard 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 the 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,¹² 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)). Insofar as Dr. Green testifies that Banin's gold clusters depicted in the TEM image reflect "purified and size selected" MCCs, Ex. 1093 ¶ 18, we remain unpersuaded as Dr. Green does not direct us to any disclosure in Banin reporting any size selection of the gold clusters after being synthesized by Hutchison's process and prior to the TEM imaging. We note that the centrifugation step in Banin that Dr. Green refers to support that testimony relates to the purification of the size-selected *nanorods* and not the gold

¹² Patent Trial and Appeal Board Consolidated Trial Practice Guide (November 2019), available at <https://www.uspto.gov/sites/default/files/documents/tpgnov.pdf> ("CTPG").

metal catalysts/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.”).

Based on our review, we find that the preponderance of the evidence supports Patent Owner’s position that “[n]othing in Banin suggests that the gold catalysts are size-selected after being made by Hutchison’s process.” PO Sur-reply 6. We find that the record supports Patent Owner’s assertion that the Hutchison’s process is a form of size selection, *id.* at 7, as Hutchison explains that its “synthesis allows size control,” Ex. 2017, 12891. Based on that disclosure, we find that a skilled artisan would have reasonably considered 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 process served as a form of size selection and that no other means of size selection was performed on the clusters reflected in the TEM image.

This finding is also consistent with Banin’s disclosures that the gold clusters have a “mean diameter” of 1.4 nm, Ex. 1005, 20:12, i.e., an average of a number of diameters, and have a “suggested formula,” *id.* at 20:15, that we have found to represent an estimated molecular formula based upon a calculated average of a different gold cluster sizes. If Banin’s clusters were purified and size-selected, Petitioner and Dr. Green have not explained why Banin would have assigned only a “mean” diameter and a “suggested” or average molecular formula to allegedly identical clusters.

Thus, based on the foregoing, we determine that Petitioner has not shown persuasively that a person of ordinary skill in the art would have considered Banin's gold clusters/ gold metal catalysts to be MCCs.

b) Whether a Motivation to Combine Exists

Although alleging that Banin's gold clusters are MCCs, Petitioner acknowledges that those clusters do not incorporate ions from groups 12 and 16 of the periodic table, as required by the challenged claims. For that limitation, Petitioner turns to Herron. Specifically, Petitioner asserts that "Herron discloses 'a large, well-characterized semiconductor molecular cluster' having the formula ' $\text{Cd}_{32}\text{S}_{14}(\text{SC}_6\text{H}_5)_{36}\cdot\text{DMF}_4$ ' that can be used to form semiconductors in solution." Pet. 22 (quoting Ex. 1016, Abstract, 1426, 1428). Petitioner notes that molecular formula for Herron's clusters includes "Cd," an element from group 12, and "S," an element from group 16. *Id.* (citing Ex. 1016, Abstract, 1426, 1428; Ex. 1001, 3:28–38; Ex. 1002 ¶¶ 108–109).

Petitioner contends that a skilled artisan "would have been motivated to replace Banin's Au-based MCC with Herron's group 12-based MCC" to synthesize Banin's nanoparticle because: (a) Banin teaches using group 12-based compounds, i.e., "Zn" or "Cd," as the cluster metal catalyst, *id.* at 22 (citing Ex. 1002 ¶¶ 86–99), *id.* at 25–26 (citing Ex. 1005, claim 30; Ex. 1002 ¶ 108); (b) group 12-based compounds were known and widely used in the field, *id.* at 22 (citing Ex. 1002 ¶¶ 86–99); (c) group 12-based MCCs were less expensive to obtain than Au-based MCCs, *id.* (citing Ex. 1002 ¶¶ 86–99); and (d) a group 12-based MCC was preferable over a non-MCC group 12-based compound because MCC's were known to provide desirable benefits during nanoparticle synthesis, *id.* at 22–23, 26; Ex. 1002 ¶ 92.

According to Petitioner, “it would have been a matter of routine optimization to use a group 12-16 MCC, such as a Zn or Cd-based MCC, in place of the Au-based MCC expressly identified in Banin.” Pet. 23 (citing Ex. 1002 ¶ 93).

Petitioner contends also that a skilled artisan would have understood that a MCC containing elements from groups 12 and 16 of the periodic table would have been compatible with Banin’s nanoparticle cores, which contain elements from groups 13 and 15, because Banin discloses “Zn or Cd alloys as metal catalysts to grow 13-15 cores, and CdSe and ZnSe (12-16) shells on top of InAs (13-15) cores.” *Id.* (citing Ex. 1005, claim 30, 25:12–15; Ex. 1002 ¶ 94).

Patent Owner asserts that Petitioner relies on improper hindsight by combining the references merely as a means to satisfy the claim limitation requiring the MCC to incorporate ions from groups 12 and 16 of the periodic table. PO Resp. 44–45. According to Patent Owner, Petitioner otherwise fails to articulate a logical motivation to combine. *Id.* In particular, Patent Owner asserts that the catalyst used in Banin must be metal, whereas the cadmium sulfide in Herron is a semiconductor material. *Id.* at 47–48. Patent Owner contends that “[a] POSITA would not have been motivated to replace the metal catalysts disclosed in Banin with a semiconductor material disclosed in Herron.” *Id.* at 48–49 (citing Ex. 2030 ¶ 131). 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. *Id.* at 53 (citing Ex. 2030 ¶ 137).

Further, Patent Owner contends that Petitioner and Dr. Green fail to address key considerations for choosing a metal catalyst for SLS, including the metal's melting point, solvating ability, and reactivity. *Id.* at 49 (citing Ex. 2030 ¶ 132; Ex. 2008, 7514).

In the Reply, Petitioner asserts that it is “irrelevant” whether Banin discloses an MCC because Petitioner relies on Herron's disclosure of MCCs. Pet. Reply 2 (citing Pet. 25–26). Additionally, Petitioner asserts that, “[e]ven if Banin did not disclose a MCC (which it does), it is indisputable that Banin renders a MCC obvious.” *Id.* at 8.

Regarding Patent Owner's assertion that a POSITA would not have been motivated to replace Banin's metal catalyst with Herron's semiconductor MCC, Petitioner asserts that “semiconductor MCCs had been used to seed growth of nanoparticles before the alleged invention.” Pet. Reply 14. Therefore, according to Petitioner, “a POSITA 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 14–15 (citing Ex. 1093 ¶ 43).

Petitioner asserts also 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.* at 15–16 (citing PO Resp. 51, 55). Further, Petitioner asserts that “the prior art taught the use of MCCs to make semiconductor nanoparticles in solution.” *Id.* at 16 (citing Ex. 1002 ¶¶ 55–56).

In the Sur-reply, Patent Owner maintains its position that Petitioner has not met its burden of demonstrating that a skilled artisan would have been motivated to combine Banin and Herron because Banin uses metals and not Zn- or Cd-based semiconductor compounds, and Petitioner has not

shown that a skilled artisan would have understood that a semiconductor could replace the metal catalyst used in Banin's SLS process. PO Sur-reply 20.

Based on our consideration of the arguments and the evidence, we determine that Petitioner has not demonstrated that a person of ordinary skill in the art would have been motivated to substitute Banin's gold metal catalyst with Herron's Zn- or Cd-based 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 asserts numerous times in the Petition that basis for its combination. *See* Pet. 22 ("A POSITA would have been motivated to replace Banin's Au-based MCC with Herron's group 12-based MCC"); *id.* at 23 ("A POSITA would have understood that it would have been a matter of routine process optimization to use a group 12-16 MCC, such as a Zn or Cd-based MCC, in place of the Au-based MCC expressly identified in Banin"); *id.* at 26 ("A POSITA would have been motivated to use Herron's 12-16 MCC instead of Banin's Au-based MCC in Banin's method of nanoparticle synthesis"). Because we have found that Petitioner has not demonstrated 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 has not demonstrated persuasively that a skilled artisan would have been motivated to replace Banin's metal catalyst with Herron's cluster compound. PO Resp. 44–49. Petitioner's expert, 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 a cadmium sulfide

semiconductor. Ex. 1002 ¶ 80; 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. PO Resp. 53; Ex. 2030 ¶ 137. We agree and determine that Petitioner has not shown 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* Pet. Reply 12. In any event, we find that the Petition fails to support a motivation to combine Herron's cadmium sulfide semiconductor with Banin's process because the Petition fails to address sufficiently (or at all) the differences between metal catalysts and Herron's semiconductor material and to 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.

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

c) Summary

Having considered the record as a whole, we determine that Petitioner has not shown by a preponderance of the evidence that the challenged claims are rendered obvious by the combined teachings of Banin and Herron. In particular, for the reasons discussed above, we find that Petitioner has not shown persuasively that a person of ordinary skill in the art would have considered Banin's gold metal catalysts to be MCCs or would have been motivated to substitute Banin's gold metal catalyst with Herron's 12-16 semiconductor cluster.

E. Obviousness over Banin and Farneth

Petitioner asserts that claims 1 and 3 are rendered obvious by the combined teachings of Banin and Farneth. Pet. 38–44; Pet. Reply 1–18. Patent Owner disagrees. PO Resp. 30–58; PO Sur-reply 1–20. We incorporate our discussion of Banin above, in Section II.D., here.

1. 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(NMe₄SPh) is lost to produce the intermediate solid Cd₁₀S₁₆Ph₁₂. *Id.* at 918. A second reaction caused by the loss of S₆Ph₁₂ 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.

2. Discussion

Petitioner relies on Banin here in a similar manner as discussed above in Section II.D. regarding the combination of Banin and Herron. *Id.* at 41–42. In particular, Petitioner’s challenge of each claim similarly relies on its assertion that Banin’s Au-based cluster is an MCC and that a skilled artisan would have been motivated to substitute it with a 12-16 MCC. Pet. 38–44. For this ground, Petitioner relies on Farneth as disclosing 12-16 MCCs. *Id.* Specifically, Petitioner asserts that Farneth disclosed MCCs with the formulas Cd₁₀S₆Ph₁₂ and Zn₁₀S₆Ph₁₂, which include elements from group 12 (Cd or Zn) and group 16 (S). *Id.* at 42–43. According to Petitioner, “[a] POSITA would have been motivated to replace Banin’s Au-based MCC with Farneth’s group 12-based MCC because Banin teaches using group 12-

based compounds including Zn, Cd, and alloys thereof, group 12-based MCCs were known and widely used in the field, and group 12-based MCCs were less expensive to obtain than Au-based MCCs.” *Id.* at 39 (citing Ex. 1002 ¶ 154).

Patent Owner’s arguments largely mirror the contentions raised for the combination of Banin and Herron. PO Resp. 54–58. Specifically, Patent Owner argues that Petitioner has not shown that Banin’s Au-based clusters are MCCs and that Petitioner has failed to demonstrate a rationale reason to substitute Banin’s Au-based clusters, which are metal catalysts, with Farneth’s semiconductor clusters. *Id.* Petitioner responds to Patent Owner’s arguments regarding the combination of Banin and Farneth in the same manner and based upon the same reasons discussed for the combination of Banin and Herron. *See* Pet. Reply 1–18.

Based upon our review and consideration of the record as a whole, we determine that Petitioner has not shown by a preponderance of the evidence that the challenged claims are rendered obvious by the combined teachings of Banin and Farneth for the same reasons discussed above regarding the combination of Banin and Herron. In particular, we find that Petitioner has not shown persuasively that a person of ordinary skill in the art would have considered Banin’s gold metal catalysts to be MCCs or would have been motivated to substitute Banin’s gold metal catalyst with Farneth’s 12-16 semiconductor cluster.

F. Obviousness over Combinations Including Zaban

Petitioner asserts that claims 1, 3–6, and 14 are rendered obvious by the combined teachings of Zaban, Farneth, and Yu. Pet. 45–55; Pet. Reply 18–25. Petitioner asserts that claims 8–13 are rendered obvious by the combined teachings of Zaban, Farneth, Yu, and Braun. Pet. 56–61;

Pet. Reply 18–25. Patent Owner disagrees with Petitioner’s contentions.
PO Resp. 59–67. We incorporate here our discussion of Farneth above, in Section II.E., here.

1. *Zaban*

Zaban is a journal article describing quantum dots (QDs) of indium phosphide (InP). Ex. 1006, 3153, Abstract. *Zaban* describes synthesizing colloidal InP QDs via colloidal chemistry by heating indium oxalate and tris(trimethylsilyl)-phosphine ($\text{P}(\text{SiMe}_3)_3$) for three days at 260–280°C in the presence of trioctylphosphine oxide (TOPO) and trioctylphosphine (TOP). *Id.* at 3154. *Zaban* explains that the quantum dots are capped with TOPO/TOP during synthesis, which produces “a compact hydrophobic shell on the QD surface.” *Id.* For synthesis of p-type InP QDs, *Zaban* explains that “indium oxalate was mixed with zinc acetate in a ratio such that the resulting QDs contain on average one Zn^{2+} ion per particle.” *Id.*

2. *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 $\text{Bi}[\text{N}(\text{SiMe}_3)_2]_3$, $\text{Sn}(\text{NMe}_2)_2$, or $\text{In}(\text{C}_5\text{H}_5)$ 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.*

3. *Braun*

Braun is a journal article describing the precipitation of HgS and CdS from aqueous solution to obtain nanoparticles having two HgS quantum wells separated by a double layer of CdS. Ex. 1013, 5548 Abstract. For instance, Braun discloses a double-layer well having a CdS core surrounded by a double-layer of HgS and capped by a monolayer of CdS. *Id.* at 5549. Braun also discloses a system having a CdS, core a monolayer of HgS, two monolayers of CdS, a second monolayer of HgS, and a final CdS monolayer as a capping. *Id.*

4. *Discussion*

For both of the Zaban grounds, Petitioner relies on Zaban, Farneth, and Yu in the same manner.¹³ In particular, Petitioner asserts that “Zaban discloses InP QDs synthesized in solution from In-based and P-based precursors in the presence of a Zn-based precursor.” Pet. 45 (citing Ex. 1006, 3154). Petitioner relies on Farneth as disclosing the Zn-based and Cd-based MCC $M_{10}S_{16}Ph_{12}$, 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 motivated to replace Zaban’s Zn-based precursor 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.” *Id.* at 46 (citing Ex. 1002 ¶

¹³ In the second Zaban ground, Petitioner adds the Braun reference to reach limitations of dependent claims 8–13. Pet. 56–61.

180). 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 47 (citing Ex. 1002 ¶ 182). 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 46 (citing Ex. 1010, 9198). 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.* 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 Farneth's Zn-based MCC. *Id.* at 47–48 (citing Ex. 1002 ¶¶ 182–183).

According to Petitioner, the 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's use of Au clusters to grow InAs nanoparticles, and Yu's use of MCCs as seed nuclei to grow nanoparticles from ions of a separate precursor at temperatures ranging from room temperature to 150 °C. *Id.* at 48 (citing Ex. 1002 ¶ 184; Ex. 1005, 17:22–30, 20:12–27; Ex. 1010, 9189–9199). Additionally, Petitioner asserts that such motivation is supplied by the fact that Zaban, Farneth, and Yu occupy the same field of art at the '828 patent, i.e., nanoparticles and their formation, and addresses a problem alleged to have been solved by the '828 patent, i.e., an MCC

capable of maintaining its structural integrity during a reaction. *Id.* (citing Ex. 1002 ¶ 184; Ex. 1001, 3:20–48, 5:53–6:11).

Patent Owner contends that a person of ordinary skill in the art would not have been motivated to combine the teachings of Zaban, which discloses a process of making InP (group III-V) QDs using the heat-up method, with Farneth, a reference that investigates the mechanism of solid-state conversion of a particular series of II-VI precursors to the bulk metal sulfide structure and “has nothing to do with group III-V quantum dots.” PO Resp. 59–60. Specifically, Patent Owner argues that a skilled artisan would not have swapped Zaban’s zinc acetate for Farneth’s $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ bulk-metal intermediate. *Id.* at 60.

To begin, Patent Owner asserts 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.* (citing Ex. 2030 ¶ 157; Ex. 1049, 42–44). According to Patent Owner and Dr. Cossairt, Zaban carefully dopes the QDs with a very low and precise amount of zinc, i.e., one Zn^{2+} ion per QD, which results in an indium to zinc ratio of 1000 to 1. *Id.* (citing Ex. 2030 ¶ 158; Ex. 1023, 3154). Patent Owner asserts that such precision is necessary because “a change in the amount of zinc dopant leads to a change in the properties of the resultant quantum dot.” *Id.* at 61–62; Ex. 2030 ¶ 159. To that end, Patent Owner contends that Petitioner has not shown why a skilled artisan would have combined Farneth’s zinc intermediate, which has ten zinc atoms, into Zaban’s process. PO Resp. 62. Patent Owner asserts that the skilled artisan would not have been motivated to use Farneth’s zinc intermediate because doping with its increased quantity of zinc would result in smaller QDs, contrary to Zaban’s goal. *Id.* (citing Ex. 1006, 3154; Ex. 2030 ¶ 160).

Patent Owner asserts also that Petitioner fails to address Zaban's careful ratio of zinc to indium while suggesting its modification with Farneth's $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ intermediate. *Id.* (citing Pet. 46, 54; Ex. 2030 ¶ 161). Patent Owner refers to Zaban's disclosure that "[f]or 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 103:1." *Id.* (quoting Ex. 1006, 3154; citing Ex. 2030 ¶ 161). 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. *Id.* at 62–63 (citing Ex. 2030 ¶ 161). Further, Patent Owner asserts that Petitioner's suggestion that one would swap Zaban's zinc acetate dopant for Farneth's intermediate applies impermissible hindsight as it involves picking and choosing only the element necessary to reconstruct the claimed invention from the prior art. *Id.* at 64.

Additionally, Patent Owner contends that Yu fails to assist the combination of Zaban and Farneth, as Yu "does not even concern semiconductor nanoparticles," and "does not align with Zaban's heat-up colloidal process or Farneth's solid state method." *Id.* (citing Ex. 2030 ¶ 164). Patent Owner asserts, "[i]f anything, Yu promotes the use of gold clusters as 'potent heterogenous nucleants' and would have directed a POSITA away from using Farneth's solid state method." *Id.*

Regarding Petitioner's addition of Braun, in the second Zaban ground to reach limitations of dependent claims 8–13, *see* Pet. 56–61, Patent Owner asserts, among other things, that Braun does not remedy the deficiencies that

it alleges for Petitioner's proposed combination of Zaban, Farneth, and Yu. PO Resp. 65 (citing Ex. 2030 ¶ 167).

a) 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.¹⁴ In particular, we find that Petitioner has not sufficiently addressed the differences between those materials or demonstrated 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. 18. However, the Petition 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. We agree

¹⁴ We agree with Patent Owner that Petitioner appears to have given up on its proposed substitution of Zaban's zinc dopant with Farneth's Cd-based compound. PO Sur-reply 21. In the Petitioner Reply, Petitioner does not address challenges to that proposed substitution. See Pet. Reply 18–25. Instead, Petitioner addresses Patent Owner's challenges only with respect to replacing Zaban's "Zn-based precursor with a Zn-based MCC"). Insofar as Petitioner has not withdrawn its arguments based on modifying Zaban with Farneth's Cd-based compound, we find that proposed modification is deficient because the Petition fails to adequately explain why a skilled artisan would have been motivated to fundamentally alter Zaban's process by completely eliminating zinc from the process when Zaban discloses the use of zinc as a dopant and how it functions to achieve the desired QD product.

with Patent Owner and Dr. Cossairt that disclosure reflects a process requiring a “delicately balanced doping ratio,” that provides on average one Zn^{2+} ion per QD. *See* Ex. 2030 ¶ 161; PO Resp. 62. Yet, Petitioner has not explained 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 QD.

In the Reply, Petitioner argues that “adjusting concentrations is well within the knowledge and common sense of a POSITA,” and “[a] POSITA would have known that she could adjust the relative amounts of starting ingredients to control concentration,” i.e., 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. Pet. Reply 22–23 (citing Ex. 1093 ¶ 58; Ex. 1002 ¶ 57). We note that 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).

Of more concern is that Petitioner’s explanation disregards the requirement in Zaban that the indium and zinc ratio is balanced “such that the resulting QDs contain on average one Zn^{2+} ion per particle.” Ex. 1006, 3154. Indeed, Petitioner does not contend that its proposed modification would provide “QDs that contain on average one Zn^{2+} ion per particle,” as Zaban’s mixture of indium and zinc provides. *See* Pet. Reply 21–23 (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 QDs 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.” PO Sur-reply 22. Thus, Petitioner has not demonstrated that substituting the zinc acetate disclosed in Zaban with Farneth’s $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ compound would not “change the nature” of Zaban’s QDs, in at least that respect.

While the challenged claims do not recite QDs that contain on average one Zn^{2+} ion per particle, the issue here is that Petitioner has not shown persuasively that a person of skill in the art at the time of the invention would have been motivated to modify Zaban’s process by substituting zinc acetate for another zinc-based compound that would necessarily alter the resulting number of zinc ions per QD from what Zaban’s process was intended to provide. Ex. 1006, 3154; Ex. 2030 ¶ 161. Thus, we find that Petitioner’s asserted motivation to combine Zaban and Farneth based on alleged “production cost savings,” *see* Pet. 46, is unsupported as Petitioner fails to persuade us that a 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.

b) 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. PO Resp. 64–65. As Patent Owner asserts, “[c]hemistry is specific” and “reagents, precursors, catalysts and other materials must be precisely chosen to obtain the specific result sought.” *Id.* at 61. 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 Cd-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 objective 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. *See* Pet. Reply 20. 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 in the manner claimed. Pet. 46 (citing Ex. 1002 ¶ 180).

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. PO Resp. 63–65 (citing Ex. 2030 ¶¶ 163–165).

c) Summary

Having considered the record as a whole, we determine that Petitioner has not shown 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 has not shown persuasively that a person of ordinary skill in the art would have substituted Zaban's zinc dopant with Farneth's $\text{Zn}_{10}\text{S}_6\text{Ph}_{12}$ compound. Additionally, we find that Petitioner's proposed modification of Zaban and

Farneth appears to rely on impermissible hindsight reconstruction. Further, Petitioner directs us to no disclosures in Yu or Braun that cure the above-discussed deficiencies with the proposed combination of Zaban and Farneth. Accordingly, we conclude that Petitioner has not established the unpatentability of any challenged claim based on either ground that relies on a combination of Zaban and Farneth.

III. CONCLUSION

For the foregoing reasons, we conclude that Petitioner has not shown by a preponderance of the evidence that the challenged claims are unpatentable.

In summary:

Claims	35 U.S.C. §	References	Claims Shown Unpatentable	Claims Not shown Unpatentable
1, 3–6, 8–14	103(a)	Banin, Herron		1, 3–6, 8–14
1, 3	103(a)	Banin, Farneth		1, 3
1, 3–6, 14	103(a)	Zaban, Farneth, Yu		1, 3–6, 14
8–13	103(a)	Zaban, Farneth, Yu, Braun		8–13
Overall Outcome				1, 3–6, 8–14

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner has not shown by a preponderance of the evidence that claims 1, 3–6, and 8–14 of the '828 patent are unpatentable; and

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

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Patent 7,588,828 B2

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