Trials@uspto.gov
571-272-7822

Paper 47
Entered: May 16, 2022

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.

IPR2021-00184
Patent 7,803,423 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 1–16 and 21–25 ("the challenged claims") of U.S. Patent No. 7,803,423 B2 (Ex. 1001, "the '423 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 '423 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. §§ 102 and 103, effective March 16, 2013. Because the application from which the '423 patent issued has an effective filing date prior to March 16, 2013, the pre-AIA version of §§ 102 and 103 applies.

Claims Challenged	35 U.S.C. §	Reference(s)
1–3, 10, 11, 13, 22–24	102	Banin[2]
1–6, 10–14, 21–25	103(a)	Banin
7–9	103(a)	Banin, Bawendi[3]
1, 10–16, 21–24	103(a)	Zaban,[4] Ptatschek[5]
4–6, 25	103(a)	Zaban, Ptatschek, Yu[6]
7–9	103(a)	Zaban, Ptatschek, Bawendi
1, 4, 11–16, 21, 25	103(a)	Lucey,[7] Ahrenkiel[8]

After institution of trial, Patent Owner filed a Patent Owner Response to the Petition. Papers 25, 26 (collectively, "PO Resp.").[9] Patent Owner

[2] Banin et al., WO 03/097904 A1, published Nov. 27, 2003 ("Banin," Ex. 1005).
[3] Bawendi et al., US 6,576,291 B2, issued June 10, 2003 ("Bawendi," Ex. 1014).
[4] Zaban et al., *Photosensitization of Nanoporous TiO_2 Electrodes with InP Quantum Dots*, 14 LANGMUIR 3153–3156 (1998) ("Zaban," Ex. 1006).
[5] Ptatschek et al., *Quantized Aggregation Phenomena in II-VI-Semiconductor Colloids*, 102 PHYS. CHEM. 85–95 (1998) ("Ptatschek," Ex. 1008).
[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] Lucey et al., US 7,193,098 B1, issued Mar. 20, 2007 ("Lucey," Ex. 1011).
[8] Ahrenkiel et al., *Synthesis and Characterization of Colloidal InP Quantum Rods*, 3 (6) NANO LETTERS 833–837 (2003) ("Ahrenkiel," Ex. 1012).
[9] Patent Owner filed Paper 25 (unredacted Patent Owner Response) under seal and 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 29. 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 30. We granted

supported the Patent Owner Response with the Declaration of Brandi Cossairt, Ph.D. Ex. 2030.

Petitioner filed a Reply to the Patent Owner Response, Paper 32 ("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 39 ("PO Sur-reply").

On February 23, 2022, the parties presented arguments at an oral hearing. Paper 43.[10] The hearing transcript has been entered in the record. Paper 46 ("Tr.").

B. Real Parties-in-Interest

Petitioner identifies Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. as real parties-in-interest. Pet. 69. 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 '423 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, IPR2021-00183 for U.S. Patent No. 7,588,828, IPR2021-00185 for U.S. Patent No. 7,867,557, and IPR2021-00186 for U.S. Patent No. 8,524,365. Pet. 69; Paper 6, 2–3.

---

the motion. Paper 42. Therefore, the unredacted Patent Owner Response (Paper 25) is unsealed and part of the public record of this proceeding.

[10] Although we held a consolidated hearing for this case, IPR2021-00182, IPR2021-00183, IPR2021-00185, and IPR2021-00186, these cases are not consolidated. *See* Papers 43, 46.

D. The '423 Patent

The '423 patent is directed to the conversion of a nanoparticle precursor composition into nanoparticles, where "[t]he conversion is effected in the presence of a molecular cluster compound under conditions permitting seeding and growth of the nanoparticles." Ex. 1001, [57]. The Specification discloses that "[t]here has been substantial interest in the preparation and characterisation, because of their optical, electronic and chemical properties, of compound semiconductors consisting of particles with dimensions in the order of 2-100 nm" and such particles are "[o]ften referred to as quantum dots and/or nanocrystals." *Id.* at 1:11–15. The Specification explains that this interest in quantum dots is "mainly due to their size-tuneable electronic, optical and chemical properties and the need for the further miniaturization of both optical and electronic devices." *Id.* at 1:15–22. The Specification describes prior "bottom up techniques" to produced quantum dot but states that "early routes applied conventional colloidal aqueous chemistry, with more recent methods involving the kinetically controlled precipitation of nanocrystallites, using organometallic compounds." *Id.* at 1:23–29, 2:52–56.

With regard to its invention, the Specification describes

> a method of producing nanoparticles comprising effecting conversion of a nanoparticle precursor composition to the material of the nanoparticles, said precursor composition comprising a first precursor species containing a first ion to be incorporated into the growing nanoparticles and a separate second precursor species containing a second ion to be incorporated into the growing nanoparticles, wherein said conversion is effected in the presence of a molecular cluster compound under conditions permitting seeding and growth of the nanoparticles.

Id. at 4:36–46. The Specification explains that "[a] nanoparticle may have a size falling within the range 2-100 nm" and that an important feature is that conversion of the precursor composition "is effected in the presence of a molecular cluster compound (which will be other than the first or second precursor species)," which "act as a template to direct nanoparticle growth." *Id.* at 4:57–61, 5:2–3.

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 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. Thus the molecular clusters are identical to one another in the same way that one H_2O molecule is identical to another H_2O molecule.

Id. at 5:3–12. According to the Specification, molecular cluster compounds ("MCC") can provide an essentially monodisperse population of nanoparticles and a "significant advantage of the method of the present invention is that it can be more easily scaled-up for use in industry than current methods." *Id.* at 5:14–21.

The Specification explains that "any suitable molar ratio of the first precursor species compared to the second precursor species may be used." *Id.* at 5:55–57. 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 5:63–6:4.

In addition, the Specification explains that "[t]he conversion of the precursor composition to the material of the nanoparticles can be conducted in any suitable solvent" but "it is important to ensure that when the cluster

compound and precursor composition are introduced in to the solvent the temperature of the solvent is sufficiently high to ensure satisfactory dissolution and mixing of the cluster compound and precursor composition." *Id.* at 6:28–35. The Specification discloses that after the precursor composition and cluster compound are dissolved in the solvent, the temperature of the solution is raise "to a temperature, or range of temperatures, which is/are sufficiently high to initiate nanoparticle growth" and the temperature of the solution can be maintained at that temperature or range of temperatures "for as long as required to form nanoparticles possessing the desired properties." *Id.* at 6:35–42.

E. Illustrative Claims

Petitioner challenges independent claims 1 and 25 and dependent claims 2–16 and 21–24 of the '423 patent. Independent claims 1 and 25, set forth below, are illustrative of the claimed subject matter.

> 1. A method of producing nanoparticles comprising:
>
> effecting conversion of a nanoparticle precursor composition to a material of the nanoparticles, said precursor composition comprising a first precursor species containing a first ion to be incorporated into the nanoparticles and a separate second precursor species containing a second ion to be incorporated into the nanoparticles,
>
> wherein said conversion is effected in the presence of a molecular cluster compound different from the first precursor species and the second precursor species under conditions permitting seeding and growth of the nanoparticles.

> 25. A method of producing nanoparticles comprising effecting conversion of a nanoparticle precursor composition to a material of the nanoparticles, said precursor composition comprising a first precursor species containing a first ion to be incorporated into the nanoparticles and a separate second precursor species containing a second ion to be incorporated into the nanoparticles, said conversion being effected in the presence of a molecular cluster compound different from the first precursor species and the second precursor species under conditions permitting seeding and growth of the nanoparticles, wherein the molecular cluster compound and nanoparticle precursor composition are dissolved in a solvent at a first temperature to form a solution and the temperature of the solution is then increased to a second temperature which is sufficient to initiate seeding and growth of the nanoparticles on the molecular clusters of said compound.

Ex. 1001, 19:65–20:9, 22:9–24.

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 anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Schering Corp. v. Geneva Pharms*, 339 F.3d 1373, 1379 (Fed. Cir. 2003) (quoting *Verdegaal Bros., Inc. v. Union Oil Co. of Cal.*, 814 F.2d 628, 631 (Fed. Cir. 1987)). It is well settled that "a reference can anticipate a claim even if it 'd[oes] not expressly spell out' all the limitations arranged or combined as in the claim, if a person of skill in the art, reading the reference, would 'at once envisage' the claimed arrangement or combination." *Kennametal, Inc. v. Ingersoll Cutting Tool Co.*, 780 F.3d 1376, 1381 (Fed. Cir. 2015) (quoting *In re Petering*, 301 F.2d 676, 681 (1962)).

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.[11] *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

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

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.

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. 18–19 (citing Ex. 1002 ¶ 70). Patent Owner neither addresses Petitioner's description of the level of ordinary skill in the art nor provides its own description. *See* PO Response.

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 ¶¶ 20–33; 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 '423 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 ("the '828 patent") states that the same term is widely understood as being limited to "clusters of 3 or more ***metal atoms*** and their associated ligands" (*compare* Ex. 1001, 5:3-9 *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. 19–20 (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 the same relative molecular mass." *Id.* at 20 n.7 (quoting Ex. 1001, 5:3–9).

Patent Owner contends that the '423 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 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.

PO. Resp. 27 (quoting Ex. 1001, 5:3–9). 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 28 (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 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.

Ex. 1001, 5:3–9. We note that the District Court determined that "the term 'molecular formula' as opposed to 'molecular mass' is most appropriate. By necessity, a compound with the same molecular formula will necessarily have the same molecular mass." Ex. 1091, 16. The District Court explained also, "it appears that the difference between a molecular formula and a molecular mass, at least for purposes of this claim construction, in inconsequential." *Id.* We agree and do not find any dispute on the current record from the parties on this matter. Accordingly, for purposes of this Decision, we agree with the District Court that the term "molecular cluster compound" means "clusters of 3 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 18.

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. Anticipation by Banin

Petitioner asserts that claims 1–3, 10, 11, 13, and 22–24 are anticipated by Banin. Pet. 20–28; Pet. Reply 2–11. Patent Owner disagrees. PO Resp. 29–44; PO Sur-reply 1–15.

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 7:9–11.

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

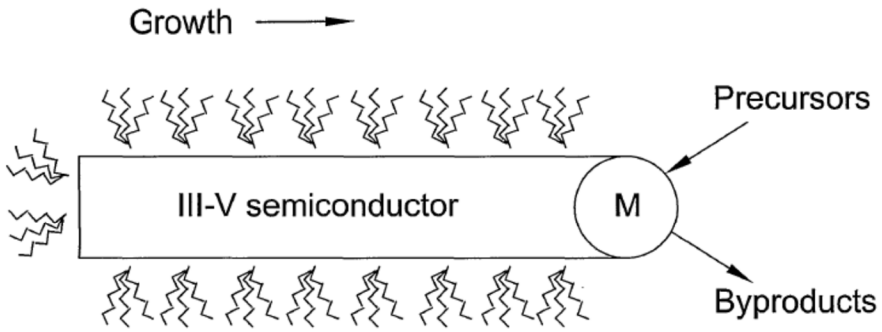


FIG. 1

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 $InCl_3$ in trioctylphosphine-oxide (TOPO), using metallic indium or gold as the catalyst." *Id.* at 134:9–11. 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 $Au_{101}(PPh_3)_{21}Cl_5$" were used to prepare InAs rods. *Id.* at 13:12–17. Banin further discloses that its metal catalyst can be "Fe [iron], Zn, Pd [palladium], Pt [platinum], Ni [nickel], Co [cobalt], Mn, Ag [silver], Cd or alloys and layered particles thereof." *Id.* at claim 30.

2. Discussion

Each of claims 1–3, 10, 11, 13, and 22–24 is directed to a method of producing nanoparticles comprising "effecting conversion of a nanoparticle precursor composition to a material of the nanoparticles . . . wherein said conversion is effected in the presence of a [MCC]." Petitioner's challenge of each claim relies, in part, on its assertion that Banin's Au-based clusters (also referred to herein as Banin's "Au-based clusters," "gold clusters," "metal catalyst" and "gold metal catalyst") are MCCs. Because the parties dispute this contention and we consider the issue dispositive, we focus our following discussion on this matter.

For purposes of this proceeding, both parties agree that the MCC recited in independent claim 1 refers to, at least, clusters of 3 or more metal atoms and their associated ligands of sufficiently well-defined chemical structure (either by molecular formula or molecular mass). Ex. 1001, 5:3–9; Pet. 19–20; Pet. Reply 7; Ex. 1093 ¶ 26; PO Resp. 28–29. According to Petitioner, based on that description, Banin's small Au clusters are MCCs. Pet. 22–24; Pet. Reply 7; Ex. 1002 ¶¶ 89–92; Ex. 1093 ¶ 26.

In particular, Petitioner relies on Banin's example, wherein the first precursor species, $InCl_3$ and the second precursor species, $(TMS)_3As$, are converted into InAs nanorods in the presence of small Au clusters having the suggested formula $Au_{101}(PPh_3)_{21}Cl_5$. Pet. 23 (citing Ex. 1005, 6:3–8, 17:22–25, 20:12–27; Ex. 1002 ¶ 90). According to Petitioner and Dr. Green, a skilled artisan would have recognized those small Au clusters as MCCs because they would have understood them to be "'clusters of 3 or more metal' atoms with 'associated ligands' that 'are *identical to one another*' and 'act[] as a seed or nucleation point upon which nanoparticle growth can be initiated.'" *Id.* (quoting Ex. 1001, 4:61–5:12) (emphasis added) (citing Ex. 1002 ¶ 90). Dr. Green testifies that a person of ordinary skill in the art would have understood that the gold clusters having a suggested formula $Au_{101}(PPh_3)_{21}Cl_5$ are "'clusters of 3 or more metal' atoms (i.e., because they contain 101 gold atoms)," and that "each cluster is 'identical to one another.'" Ex. 1002 ¶ 90 (citing Ex. 1001, 4:61–5:12). 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 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 asserts that Petitioner has not demonstrated that any challenged claim is anticipated by Banin because Banin does not disclose an MCC. PO Resp. 29. Patent Owner begins by asserting that Banin's process for creating nanoparticles uses the Solution-Liquid-Solid ("SLS") method, which uses "a metal nanoparticle as a catalyst for rod growth." *Id.* at 31 (quoting Ex. 1005, 14) (emphasis omitted). Patent Owner asserts that because the metal catalyst acts as a solvent in the SLS method, it must melt

into droplets so that the precursors can dissolve to form the solution that precipitates to form a nanorod. *Id.* (citing Ex. 1005, 6; Ex. 2030 ¶¶ 25, 30, 83, 100). Patent Owner contends that Banin's gold particles are not MCCs, but instead are "molten metal SLS catalyst droplets that lack the sufficiently well-defined chemical structure of MCCs." *Id.* (citing Ex. 2030 ¶¶ 84, 99–100, 103; Ex. 1001, 5:7–12).

In particular, Patent Owner emphasizes that Banin describes the formula $Au_{101}(PPh_3)_{21}Cl_5$ for the Au clusters as only a "suggested formula." *Id.* at 32 (citing Ex. 2030 ¶¶ 103–108; Ex. 1005, 20). In that regard, Patent Owner notes that Banin discloses that the Au clusters were "synthesized by the published procedures" in Hutchison.[12] *Id.* at 32–36 (citing Ex. 2017). According to Patent Owner, "[t]he Hutchison process used by Banin creates gold particles of many different sizes," ranging from 0.75 nm to 2.25 nm. *Id.* at 32–33 (citing Ex. 2017, 12891). Patent Owner contends that those "different sizes are averaged out, and then using the *average size* of the particle, it is estimated that the average number of gold atoms is approximately 101," which leads to the estimated formula $Au_{101}(PPh_3)_{21}Cl_5$. *Id.* at 33 (citing Ex. 2017, 12891; Ex. 2030 ¶¶ 105–106). Additionally, Patent Owner asserts that the particles created by Hutchison's process have significant impurities. *Id.* at 35 (citing Ex. 2017, 12890–12891; Ex. 2030 ¶ 112).

Further, Patent Owner contends that the diameter of the nanorods created by Banin is dictated by the size of the gold particle and, therefore, since Banin discloses that the diameter of its nanorods vary up to 25%, then

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

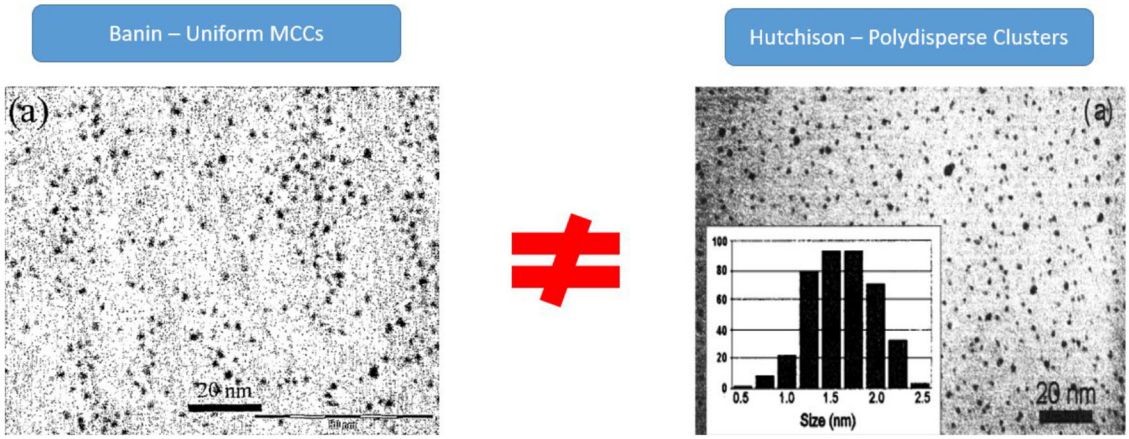
the diameter of the gold particles varies similarly. *See id.* at 35–36 (citing Ex. 1005, 7, 23; Ex. 2030 ¶ 116). According to Patent Owner, such a wide size distribution in diameter of the nanorods reflects the wide size distribution of the gold clusters taught by Hutchison and demonstrates that Banin's gold clusters are not MCCs. *Id.* at 36 (citing Ex. 2030 ¶¶ 109, 119, 124).

Patent Owner asserts also that Petitioner's expert, Dr. Green, agreed, during his deposition, that uncharacterized mixtures of clusters are not MCCs "because they wouldn't have the same relative molecular formula" and would not be identical. PO Resp. 37–38 (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 40.

In the Reply, Petitioner maintains that "Banin discloses clusters with a single molecular formula ($Au_{101}(PPh_3)_{21}Cl_5$) and size (1.4 nm), which is sufficient to inform a POSITA that those clusters are MCCs." Pet. Reply 6–7. 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.*, $Au_{101}(PPh_3)_{21}Cl_5$) and size (1.4 nm) with more than three metal atoms—which a POSITA would recognize as a[n] MCC." *Id.* at 3 (emphasis omitted).

Additionally, Petitioner alleges that Banin's TEM image "shows that Banin's 'Au_{101} clusters' do not have the size distribution that the clusters in Hutchison 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 ¶ 18. Petitioner's side-by-side comparison of Banin's Figure 10A ("a TEM image of the Au_{101} 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 $Au_{101}(PPh_3)_{21}Cl_5$ 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." *Id.*; Pet. Reply 3.

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. Ex. 1093 ¶ 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 Hutchison's gold particles. Pet. Reply 5 (citing PO Resp. 35–36). Petitioner contends that "there is no such size distribution shown in Banin's MCCs as depicted in Banin Fig. 10A." *Id.* at 5–6 (citing Ex. 1093 ¶ 24; Ex. 1005, Fig. 10A) (emphasis omitted). 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.* at 6 (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 Au_{101}." PO Sur-reply 3 (citing Pet. Reply 3). 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 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 8–9 (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.* at 11 (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 5–6, 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 nanonrods 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 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 of three or more metal atoms with their associated ligands and "each cluster is '*identical to one another*.'" Ex. 1002 ¶ 90; Pet. 23. 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 ¶ 90; Pet. 23. 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 $Au_{101}(PPh_3)_{21}Cl_5$" 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 ¶ 103(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 $Au_{101}(PPh_3)_{21}Cl_5$.

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 a*verage 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; Ex. 1093 ¶ 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,[13] 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 relies on to support that

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

testimony relates to the purification of the size-selected *nanorods* and not the gold 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 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 Au_{101} 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 Banin's gold clusters/gold metal catalysts are MCCs. Thus, Petitioner has not established that Banin discloses each and every element of the challenged claims.

Accordingly, based on the record as a whole, we conclude that Petitioner has not established, by a preponderance of the evidence, the unpatentability of any challenged claim based on anticipation by Banin.

E. Obviousness over Banin Alone or in Combination with Bawendi

Petitioner asserts that claims 1–6, 10–14, and 21–25 are rendered obvious by Banin. Pet. 28–34; Pet. Reply 11–13. Additionally, Petitioner asserts that claims 7–9 are rendered obvious by the combined teachings of Banin and Bawendi. Pet. 35–38; Pet. Reply 13–15. Patent Owner disagrees with both contentions. PO Resp. 44–48; PO Sur-reply 15–18. We incorporate here our discussion of Banin set forth above in Section II.D.

1. Bawendi

Bawendi "relates to methods of manufacturing a nanocrystallite." Ex. 1014, 1:12–13. Bawendi discloses that the nanocrystallite can have a narrow size distribution, "can be a sphere, rod, disk, or other shape," and can have a core of semiconductor material with an overcoating on the core that has a different composition than the core. *Id.* at 1:38–45.

Bawendi's method "can include monitoring the size distribution of a population including of the nanocrystallite, lowering the temperature of the mixture in response to a spreading of the size distribution, or increasing the temperature of the mixture in response to when monitoring indicates growth appears to stop." *Id.* at 2:45–49. Bawendi explains that monitoring the adsorption line widths of particles can be used to monitor size distribution during growth. *Id.* at 4:59–61. Bawendi teaches that "[b]y stopping growth

at a particular nanocrystallite average diameter and choosing the proper composition of the semiconducting material, the emission spectra of the nanocrystallites can be tuned continuously over the wavelength range of 400 nm to 800 nm." *Id.* at 4:66–5:3.

2. Discussion

Petitioner asserts, "[f]or the same reasons that Banin anticipates claims 1–3, 10–11, 13, and 22–24, as explained [in the anticipation ground], Banin would also render those claims obvious to a [person of ordinary skill in the art]." Pet. 28. For claims 4–6, 12, 14, 21, and 25, Petitioner asserts how Banin teaches or suggests each limitation of those claims. *Id.* at 28–34. For claims 7–9, Petitioner asserts how the combination of Banin and Bawendi teach the additional limitations of those claims, as well as providing a reason why a person of skill in the art would have combined the methods taught by each reference in the proposed manner with a reasonable expectation of success. *Id.* at 35–38.

For each of claims 1–14 and 21–25, Petitioner relies only on Banin as disclosing the required MCC for the same reasons discussed for its anticipation ground, i.e., that a person of ordinary skill in the art would have considered Banin's Au clusters to be MCCs. *See* Pet. 28–38.

Thus, for the same reasons discussed above in Section II.D. for the anticipation ground, we determine that Petitioner has not shown persuasively that Banin's Au clusters are MCCs. Accordingly, because Petitioner has failed to show that Banin teaches or suggests that limitation of the challenged claims, we conclude that Petitioner has not established, by a preponderance of the evidence, the unpatentability of any challenged claim based on obviousness over Banin alone or in combination with Bawendi.

F. Obviousness over Combinations Including Zaban and Ptatschek

Petitioner asserts that claims 1, 10–16, and 21–24 are rendered obvious by the combined teachings of Zaban and Ptatschek. Pet. 39–48. Petitioner asserts also that claims 4–6 and 25 are rendered obvious by the combined teachings of Zaban, Ptatschek, and Yu. *Id.* at 48–52. Additionally, Petitioner asserts that claims 7–9 are rendered obvious by the combined teachings of Zaban, Ptatschek, and Bawendi. *Id.* 52–54. Patent Owner disagrees. PO Resp. 48–54. We incorporate here our discussion of Bawendi set forth above in Section II.E.

1. Zaban

Zaban is a journal article describing quantum dots (QDs) on indium phosphide (InP). Ex. 1006, Abstract. Zaban describes synthesizing the quantum dots (QDs) via colloidal chemistry by heating indium oxalate and tris(trimethylsilyl)-phosphine ($P(SiMe_3)_3$) 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. Ptatschek

Ptatschek is a journal article that discusses semiconductor quantum dot solutions for coating applications that "can be synthesized employing chalcogenolysis and condensation of functionalized cluster-like cadmium and zinc ethoxy-acetates." Ex. 1008, Abstract. Ptatschek addresses the sol-gel chemistry of metal oxides and describes the "metal ethoxy-acetate derived synthesis of II-VI chalcogenide quantum dots" and "the cluster-

cluster aggregate evolution mechanism." *Id.* at 85. For instance, Ptatschek explains "that in alcoholic CdSe sols the initially nucleated 'seeds' are highly reactive." *Id.* at Abstract. Ptatschek also describes "the production of crystalline powders composed of well known pyramidal $[Zn_4O(OAc)_6]$-clusters," wherein "OAc" represents "acetate." *Id.* at 86. Ptatschek employs those known crystalline powders in a chemical reaction to form a product that, upon study, "revealed the presence of $[Zn_{10}O_4(OAc)_{12}]$-clusters associated with 7 ethanol ligands and 1 water molecule." *Id*.

3. Yu

Yu is a journal article that is directed to Heterogeneous seeded growth of monodisperse metallic nanoparticles, particularly the "growth of nearly monodisperse Bi, Sn, 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.*

4. Discussion

For each of the challenged claims, Petitioner asserts that "[a person of ordinary skill in the art] would have been motivated to replace Zaban's Zn-based precursor with the Zn-based MCC taught in Ptatschek at least because

it was known that MCCs allow faster nanoparticle growth at lower temperatures while maintaining the quality of the final nanoparticle." Pet. 39 (citing Ex. 1002 ¶ 148); *see id*. at 42–43, 48, 52 (referring back to this same motivation). Specifically, Petitioner asserts that a 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 (e.g., higher nanoparticle yields of nearly uniform size)." *Id.* at 40 (citing Ex. 1002 ¶¶ 151–152). Petitioner alleges that a skilled artisan "would have reasonably expected such a substitution to succeed in achieving improved nanoparticle growth at least because the prior art discloses the successful use of MCCs like the one disclosed in Ptatschek to grow nanoparticles." *Id.* at 40–41 (citing Ex. 1005, 17:22–30; 20:12–27; Ex. 1010, 9189–9199; Ex. 1002 ¶ 152).

For claims 4–6 and 25, Petitioner adds Yu to the combination of Zaban and Ptatschek, asserting that Yu teaches "'seeded growth' of a nanoparticle from the elements of a precursor deposited on a MCC seed at temperatures of 140-150 °C." *Id.* at 50. According to Petitioner, a skilled artisan would have been motivated to perform Zaban's QD synthesis method using the Ptatschek's $Zn_{10}O_4(OAc)_{12}$-clusters at Yu's temperatures with a reasonable expectation of successfully doing so because the artisan would have understood that 140-150 °C is sufficient to allow Ptatschek's Zn-clusters to act as nucleated seeds for the formation of nanoparticles in solution. *Id.* at 51 (citing Ex. 1008, Abstract).

For claims 7–9, Petitioner adds Bawendi to the combination of Zaban and Ptatschek, asserting that "Bawendi discloses monitoring the size distribution of nanoparticles and terminating nanoparticle synthesis when the final nanoparticle reaches the target size." *Id.* at 52 (citing Ex. 1014, 1:12–

13, 2:44–49, 4:59–5:5). According to Petitioner, a person of ordinary skill in the art would have been "motivated to combine Bawendi's average-size-monitoring technique with the teachings of Zaban in view of Ptatschek to provide more efficient and effective control over the average size of the resulting nanoparticles." *Id.* (citing Ex. 1002 ¶¶ 201–202; Ex. 1006, 3153). Petitioner asserts further that the skilled artisan would have reasonably expected success in the combination because Bawendi's technique would not interfere with Zaban's method of synthesizing nanoparticles. *Id.* at 53 (citing Ex. 1002 ¶ 203).

Patent Owner contends that a person of ordinary skill in the art would not have been motivated to combine the teachings of Zaban and Ptatschek because "[t]he differences between the references are considerable." PO Resp. 49. Specifically, Patent Owner asserts that Zaban discloses a process for creating group III-V (InP) QDs, whereas Ptatschek's discloses a process for making group II-VI (e.g., Cd and Zn) QDs. *Id.* According to Patent Owner, because Zaban is directed to synthesizing InP QDs, Patent Owner contends that there would have been "little need to look for zinc-based precursors." *Id.*

Additionally, Patent Owner a skilled artisan would not have substituted Zaban's zinc acetate with Ptatschek's zinc precursor because it would have changed the nature of Zaban's QDs. *Id.* at 50. For this argument, Patent Owner notes that Zaban describes its usage of zinc as a dopant, which "is not the core semiconductor material itself, but rather it is a small impurity intentionally added to change the core semiconductor's electrical properties." *Id.* (citing Ex. 1049, 42–44; Ex. 2030 ¶ 141). 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.* at 50–52 (citing Ex. 1023, 3154; Ex. 2030 ¶ 141). 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 51–52; Ex. 2030 ¶ 144; Ex. 2025, 3. To that end, Patent Owner contends that Petitioner has not shown why a skilled artisan would have combined Ptatschek's zinc precursor, which has ten zinc atoms, into Zaban's process. *Id.* at 52. Patent Owner asserts that the skilled artisan would not have been motivated to use Ptatschek's zinc intermediate because doping with its increased quantity of zinc would result in smaller QDs, contrary to Zaban's goal. *Id.* at 52 (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 Ptatschek's Zn-based precursor. *Id.* (citing Pet. 39–40; Ex. 2030 ¶ 145). 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 10^3:1." *Id.* (quoting Ex. 1006, 3154; citing Ex. 2030 ¶ 145). Patent Owner notes that "Ptatschek teaches a zinc:indium ratio that is orders of magnitude different." *Id.* at 52 (citing Ex. 1008, 86). According to Patent Owner, a skilled artisan would not have been motivated to use Ptatschek's precursor in place of Zaban's zinc acetate in view of Zaban's disclosed In:Zn ratio because it would have increased the zinc content in Zaban and "change[d] the nature of Zaban's quantum dots." *Id.* at 52–53 (citing Ex. 2030 ¶ 145).

Further, Patent Owner asserts that Petitioner's suggestion that one would swap Zaban's zinc acetate dopant for Ptatschek's precursor applies

impermissible hindsight as it involves picking and choosing only the element necessary to reconstruct the claimed invention from the prior art. *Id.* at 53.

Additionally, Patent Owner contends that Petitioner's addition of Yu in the second Zaban ground fails to assist the combination of Zaban and Ptatschek, as Yu "does not even describe the synthesis of semiconductor nanoparticles." *Id.* at 48 n.4. Patent Owner similarly contends that Petitioner's addition of Bawendi in the third Zaban ground does not remedy the deficiencies that it alleges for Petitioner's proposed combination of Zaban and Ptatschek. *See id.*

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 Ptatschek's Zn-based precursor. 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.

Petitioner recognizes that Zaban's zinc acetate "dopes zinc into the nanoparticles." Pet. 15. 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 with Patent Owner and Dr. Cossairt that disclosure reflects a process requiring a "carefully metered dopant," that provides on average one Zn^{2+} ion per QD. *See* Ex. 2030 ¶¶ 145–146; PO Resp. 50–53. Yet, Petitioner has not

explained persuasively how Ptatschek's $Zn_{10}O_4(OAc)_{12}$-clusters may similarly function as a dopant, or how it's 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 the relative amounts of starting ingredients in a nanoparticle synthesis to control the concentration of components in a reaction and their presence in the finally formed QDs was within the ordinary skill of a [person of ordinary skill in the art]," i.e., by increasing the amount of indium and phosphorus precursors present in Zaban's process to accommodate the increased amount of zinc in Ptatschek's $Zn_{10}O_4(OAc)_{12}$ cluster. Pet. Reply 20–21 (citing Ex. 1093 ¶ 49; Ex. 1002 ¶ 56). 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 20–21 (Petitioner proposing how to accommodate the increased amount of zinc supplied by Ptatschek's $Zn_{10}O_4(OAc)_{12}$ cluster, 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 "Ptatschek's $Zn_{10}O_4(OAc)_{12}$ cluster contains ten zinc atoms, and changing the concentration of precursors does nothing to change the fact that any quantum dot that includes Ptatschek's cluster will have at least ten times the amount of zinc required by Zaban."

PO Sur-reply 20. Thus, Petitioner has not demonstrated that substituting the zinc acetate disclosed in Zaban with Ptatschek's $Zn_{10}O_4(OAc)_{12}$ cluster 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 ¶ 145.

Moreover, insofar as Petitioner asserts in the Reply that "additional zinc would have encouraged, not discouraged" in Zaban's process with the proposed substitution, we find that assertion unsupported by the record. Pet. Reply 19. To support that assertion, Petitioner points to Zaban's "teaching that adding zinc to the InP QDs improved the stability of the electrodes to which they were applied." *Id.* (citing Ex. 1006, 3156). According to Petitioner, because Zaban explained that "[t]he reason for this behavior is not understood," Ex. 1006, 3156, "a [skilled artisan] would have been motivated to use Ptatschek's MCCs not only because of the benefits of MCCs generally, but because they provide additional zinc," Pet. Reply 19 (citing Ex. 1093 ¶ 47). However, the "behavior" in Zaban's chemical reaction that Zaban refers to as being "not understood" is the relative photo-stability, during illumination, of "p-type InP/TiO_2 electrodes" as compared to "n-type InP/TiO_2 electrodes" (Ex. 1006, 3156). It is not clear on this record, and Petitioner does not explain adequately, why that disclosure supports Petitioner's view that the use of "additional zinc would have [been] encouraged" in Zaban's process. Pet. Reply 18.

Thus, we find that Petitioner's asserted motivation to combine Zaban and Ptatschek based on alleged "production cost savings," *see* Pet. 40–43, is unsupported as Petitioner fails to persuade us that a skilled artisan would have recognized Ptatschek's $Zn_{10}O_4(OAc)_{12}$ 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 Ptatschek appears to rely on impermissible hindsight reconstruction. PO Resp. 53–54. 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 51. 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 Ptatschek's zinc-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 Ptatschek's $Zn_{10}O_4(OAc)_{12}$ cluster to attain a synthetic method that meets the limitations of a challenged claim. *See* Pet. Reply 18. 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. 40 (citing Ex. 1002 ¶ 151).

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. 53.

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 Ptatschek. 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 Ptatschek's $Zn_{10}O_4(OAc)_{12}$ cluster. Additionally, we find that Petitioner's proposed modification of Zaban and Ptatschek appears to rely on impermissible hindsight reconstruction. Further, Petitioner directs us to no disclosures in Yu or Bawendi that cure the above-discussed deficiencies with the proposed combination of Zaban and Ptatschek. Accordingly, we conclude that Petitioner has not established, by a preponderance of the evidence, the unpatentability of any challenged claim based on the asserted grounds that rely on a combination of Zaban and Ptatschek.

G. Obviousness over Lucey and Ahrenkiel

Petitioner asserts that claims 1, 4, 11–16, 21, and 25 are rendered obvious by the combined teachings of Lucey and Ahrenkiel. Pet. 54–64: Pet. Reply 23–25. Patent Owner disagrees. PO Resp. 54–59; PO Sur-reply 22–23.

At the final oral hearing, Petitioner withdrew this ground from contention. Tr. 49–50. Accordingly, we do not consider this ground in this Final Written Decision.

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. §	Reference(s)	Claims Shown Unpatentable	Claims Not shown Unpatentable
1–3, 10, 11, 13, 22–24	102	Banin		1–3, 10, 11, 13, 22–24
1–6, 10–14, 21–25	103(a)	Banin		1–6, 10–14, 21–25
7–9	103(a)	Banin, Bawendi		7–9
1, 10–16, 21–24	103(a)	Zaban, Ptatschek		1, 10–16, 21–24
4–6, 25	103(a)	Zaban, Ptatschek, Yu		4–6, 25
7–9	103(a)	Zaban, Ptatschek, Bawendi		7–9
1, 4, 11–16, 21, 25	103(a)	Lucey, Ahrenkiel[14]		
Overall Outcome				1–16, 21–25

[14] As noted above in Section II.G., we have not considered the ground based on Lucey and Ahrenkiel because Petitioner has withdrawn the ground.

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner has not shown by a preponderance of the evidence that claims 1–16 and 21–25 of the ’423 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.

For PETITIONER:

F. Christopher Mizzo
Gregory Arovas
Stefan Miller
Todd Baker
KIRKLAND & ELLIS LLP
chris.mizzo@kirkland.com
greg.arovas@kirkland.com
stefan.miller@kirkland.com
todd.baker@kirkland.com

For PATENT OWNER:

William Meunier
Peter Cuomo
MINTZ, LEVIN, COHN, FERRIS, GLOVSKY AND POPEO, P.C.
wameunier@mitz.com
pjcuomo@mintz.com