

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.,
SAMSUNG ELECTRONICS AMERICA, INC.,
Petitioners,

v.

NANOCO TECHNOLOGIES LTD.,
Patent Owner.

Case No. IPR2021-00186
U.S. Patent No. 8,524,365

**PATENT OWNER'S PRELIMINARY RESPONSE
PURSUANT TO 37 C.F.R. § 42.107(a)**

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TABLE OF EXHIBITS

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2001	Declaration of Michael C. Newman
2002	Declaration of Thomas H. Wintner
2003	Declaration of Matthew S. Galica
2004	Periodic table of the elements, Encyclopaedia Britannica, Inc., <i>available at</i> https://www.britannica.com/science/periodic-table (last visited Feb. 18, 2021)
2005	Samsung Global Newsroom. Quantum Dot Artisan: Dr. Eunjoo Jang, Samsung Fellow, November 30, 2017
2006	ACS Energy Lett. 2020, 5, 1316-1327. “Environmentally Friendly InP-Based Quantum Dots for Efficient Wide Color Gamut Displays”
2007	Wang, F., Dong, A. and Buhro, W.E., <i>Solution–liquid–solid synthesis, properties, and applications of one-dimensional colloidal semiconductor nanorods and nanowires</i> . Chemical Reviews, 116(18):10888-10933 (2016).
2008	Wang, F., et al., <i>Solution– liquid– solid growth of semiconductor nanowires</i> . Inorganic chemistry, 45(19):7511-7521 (2006).
2009	Madkour, L.H., <i>Synthesis Methods For 2D Nanostructured Materials, Nanoparticles (NPs), Nanotubes (NTs) and Nanowires (NWs)</i> . In <i>Nanoelectronic Materials</i> (pp. 393-456). Springer, Cham. (2019)
2010	Mushonga, P., et al., <i>Indium phosphide-based semiconductor nanocrystals and their applications</i> . Journal of Nanomaterials, 1-11 (2012).
2011	Luo, H., <i>Understanding and controlling defects in quantum confined semiconductor systems</i> , Doctoral dissertation, Kansas State University (2016).
2012	Sinatra, L., et al. <i>Methods of synthesizing monodisperse colloidal quantum dots</i> . Material Matters, 12:3-7 (2017)
2013	Pu, Y., et al., <i>Colloidal synthesis of semiconductor quantum dots toward large-scale production: a review</i> . Industrial & Engineering Chemistry Research, 57(6):1790-1802 (2018).
2014	Rao, C. N. R.; Gopalakrishnan, J., <i>Chapter 3: Preparative Strategies from New Directions in Solid State Chemistry</i> ; Cambridge University Press: Cambridge, UK (1986).

Exhibit	Description
2015	Glossary of Common Wafer Related Terms, BYU Electrical & Computer Engineering Integrated Microfabrication Lab, definition of degenerate semiconductor, available at https://cleanroom.byu.edu/ew_glossary (last visited Feb. 19, 2021)
2016	October 22, 2006 email between Eunjoo Jang and Nigel Pickett Re: Cd free quantum dots
2017	Weare, W.W., Reed, S.M., Warner, M.G. and Hutchison, J.E., <i>Improved synthesis of small (d core ≈ 1.5 nm) phosphine-stabilized gold nanoparticles</i> . Journal of the American Chemical Society, 122(51):12890-12891 (2000).
2018	Samsung's Motion to Stay Pending <i>Inter Partes</i> Review of the Asserted Patents in Case 2:20-cv-00038-JRG, filed on November 30, 2020
2019	Order denying Samsung's Motion to Stay Pending <i>Inter Partes</i> Review in Case 2:20-cv-00038-JRG, filed on January 8, 2021
2020	Standing Order Regarding the Novel Coronavirus (Covid-19) for the Eastern District of Texas Marshall Division, signed March 3, 2020
2021	Standing Order Regarding Pretrial Procedures In Civil Cases Assigned to Chief District Judge Rodney Gilstrap During the Present Covid-19 Pandemic, signed April 20, 2020
2022	Samsung's Preliminary Invalidity Contentions and Disclosures Pursuant To Patent Rules 3-3 and 3-4 (served November 9, 2020)
2023	Merriam-Webster Dictionary, online edition. Definition of "Halogen", available at https://www.merriam-webster.com/dictionary/halogen (last visited Feb. 23, 2021)
2024	Illustrated Glossary of Organic Chemistry, UCLA. Illustration of Halide, available at http://www.chem.ucla.edu/~harding/IGOC/H/halide.html (last visited Feb. 23, 2021)
2025	Mortvinova, N.E., Vinokurov, A.A., Lebedev, O.I., Kuznetsova, T.A., and Dorofeev, S.G., <i>Addition of Zn during the phosphine-based synthesis of indium phosphide quantum dots: doping and surface passivation</i> , Beilstein J Nanotechnol. 2015; 6: 1237-1246.
2026	Samsung's Proposed Claim Constructions (served December 11, 2020)

Exhibit	Description
2027	He, Z., Yang, Y., Liu, J.W. and Yu, S.H., <i>Emerging tellurium nanostructures: controllable synthesis and their applications</i> . Chemical Society Reviews, 46(10): 2732-2753 (2017)
2028	INTENTIONALLY LEFT BLANK
2029	Makkar, M. and Viswanatha, R., <i>Frontier challenges in doping quantum dots: synthesis and characterization</i> . Rsc Advances, 8(39):22103-22112 (2018).

I. INTRODUCTION AND SUMMARY OF ARGUMENT

For at least the following independent reasons, Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc.’s (collectively, “Samsung” or “Petitioner”) Petition should be denied institution.

First, the Board should deny institution of the Petition in view of its precedential *NHK* and *Fintiv* decisions because Nanoco Technologies Ltd. (“Patent Owner” or “Nanoco”) and Petitioner are scheduled to try the validity of the challenged patent in a district court jury trial seven months before the deadline of a Final Written Decision in this requested *inter partes* review. All six *Fintiv* factors weigh in favor denying institution.

Second, Samsung’s Petition fails to establish the required likelihood that it will prove that any challenged claim of Nanoco’s U.S. Patent No. 8,524,365 (Ex. 1001) (the “’365 patent”) is unpatentable.

The ’365 patent claims are directed to quantum dots and methods of producing quantum dots. Quantum dots are man-made semiconductor nanoparticles that can emit light at very particular wavelengths. Quantum dots were traditionally made of compounds such as cadmium selenide (CdSe). But cadmium is highly toxic, so there was a push to create cadmium-free quantum dots out of material such as indium phosphide (InP). And while it is difficult to make any quantum dot in commercially viable quantities, these problems are compounded when cadmium is not used. The

claims of the '365 patent are directed toward commercial quantities of quantum dots, including indium phosphide quantum dots, which are a viable cadmium-free option as a result.

The claimed nanoparticles and ways of preparing them involve a core semiconductor material disposed on a *molecular cluster compound* where the core material contains elements *that are not in* the molecular cluster compound. Ex. 1001 at 10:9-13. A molecular cluster compound is a small cluster 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. *Id.* at 5:19-25. Thus, for example, molecular clusters are identical to one another in the same way that one H₂O molecule is identical to another H₂O. *Id.* at 5:25-28.

Petitioner's proposed Grounds 1-4 rely on Banin as a primary reference. Banin does not disclose a molecular cluster compound. Banin's alleged "clusters" are simply melted gold droplets that have up to a 25% variation in their composition, and contain impurities. These metal droplets lack the sufficiently well-defined chemical structure of a molecular cluster compound. *See* Section VII.A *infra*. Moreover, Petitioner's secondary reference, Herron (Ground 3), discloses bulk metal intermediates that show no evidence of being able to liquefy (i.e., melt) and function as a catalyst in Banin's Solution-Liquid-Solid ("SLS") method for growing

nanorods. And Treadway which is added to Banin in Ground 4 for the purposes of accounting for shells with ternary and quaternary semiconductor materials, does not remedy Banin's deficiencies.

Petitioner's Ground 5 relies on Zaban as a primary reference. While Zaban makes indium phosphide quantum dots, Petitioner does not even allege that Zaban uses any "clusters" at all. And the cluster disclosed by the secondary reference, Farneth, is an intermediate isolated during a solid state reaction for making bulk metal zinc sulfide (ZnS). This bulk metal zinc sulfide process is very different from the process for growing indium phosphide quantum dots discussed in Zaban. Moreover, using Farneth's cluster in combination with Zaban, would not work. Zaban very deliberately adds a single zinc atom to each of its quantum dots. Applying Farneth's zinc-based clusters would result in up to 10 times the amount of zinc in Zaban's quantum dots, fundamentally changing their properties. And Yu, has little to do with either Farneth or Zaban and thus is a singularly poor choice for Petitioner's proposed combination. *See Section VII.B infra.*

The Petition's Grounds 6 and 7 are weaker still. These Grounds rely upon Lucey as a primary reference. Petitioner merely waves its hands at the critical claim element requiring a "core semiconductor material that comprises one or more elements not comprised within the molecular cluster compound" as required by all claims in the '365 patent. Lucey teaches the exact opposite of this. The alleged

“cluster compound” in Lucey is a precursor that contribute atoms to the semiconductor core. Therefore the “cluster compound” and “core semiconductor” have the same elements. Same with the Ahrenkiel secondary reference. Both of Ahrenkiel’s precursors provide indium phosphide to a growing indium phosphide semiconductor core. That both Lucey and Ahrenkiel provide exactly *the same* elements comprised in the core, not different ones. What’s more, Lucey actually teaches away from Ahrenkiel which uses precursors containing chlorine atoms in them—expressly what Lucey states should not be used in a precursor. *See* Section VII.C *infra*.

Because Petitioner’s grounds fail to disclose critical claim elements, and there is no reason to combine Banin with Herron or Treadway, Zaban with Farneth/Yu or Lucey with Ahrenkiel/Treadway other than Petitioner’s improper hindsight effort to assemble portions of divergent references to create something that might approximate the invention of the ’365 patent, there is no reasonable likelihood of success that Petitioner will prove any of the challenged claims are unpatentable, and the Board should thus deny institution.

II. THE BOARD SHOULD DENY INSTITUTION UNDER 35 U.S.C. § 314(a)

The ’365 patent is owned by Nanoco, a leading pioneer in the development of nanomaterials and quantum dots for use in TV displays. Nanoco sued Petitioner for

infringement of the '365 patent in the District Court for the Eastern District of Texas, captioned *Nanoco Technologies Ltd. v. Samsung Electronics Co., Ltd.*, No. 2:20-cv-00038 (E.D. Tex.), filed February 14, 2020 (“Parallel Proceeding”). Petition at 66. In that Parallel Proceeding, Petitioner has raised a plethora of invalidity defenses, including all of the ones presented in the Petition. Ex. 2022 at 184-199. As Petitioner concedes, the district court has scheduled a trial to begin in October 2021, more than *seven months before* any final written decision deadline will become due in the requested IPR. Petition at 62. In light of the overlapping invalidity issues presented, as well as the resources required by both parties in the Parallel Proceeding, a discretionary denial of the Petition under the Board’s controlling precedent is appropriate. *See, e.g., Apple Inc., v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (PTAB Mar. 20, 2020) (precedential) (“*Fintiv*”); *NHK Spring Co., Ltd. v. Intri-Plex Techs., Inc.*, IPR2018-00752, Paper 8 at 20 (PTAB Sept. 12, 2018).¹

¹ *See also Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01018, Paper 12 (PTAB Dec. 1, 2020) (precedential); *Snap, Inc. v. SRK Technology LLC*, IPR2020-00820, Paper 15 (PTAB Oct. 21, 2020) (precedential).

A. All of the factors considered under *Fintiv* support a discretionary denial in order to promote the most efficient and fair adjudication of the parties' dispute.

1. The district court denied Petitioner's motion for a stay

The first factor favors denying the Petition in light of the earlier-scheduled district court trial and the district court's denial of a motion to stay. As noted in Patent Owner's Mandatory Notice, both Petitioner and the Patent Owner are involved in the Parallel Proceeding, filed over a year ago, involving the same patent: *Nanoco Technologies Ltd. v. Samsung Electronics Co., Ltd.*, No. 2:20-cv-00038 (E.D. Tex.). *See* Petition at 71. Petitioner discusses *Fintiv* factor 1 by contending that the Board "finding the Challenged Claim unpatentable will relieve the district court of the need to continue with the District Court case," and that Petitioner would move to stay the district court proceeding to further promote "simplification." *Id.* at 67. Petitioner brought a motion to stay and similarly argued to the district court that "[a] stay would save precious judicial and party resources." Ex. 2018 at 6.

Petitioner's arguments about efficiency and simplification are greatly diminished by the unnecessary duplication and overlap between the grounds presented in the Petition and the all-inclusive grounds in the invalidity contentions served in the Parallel Proceeding. *See* Section II.A.4, *infra* (discussing the fourth *Fintiv* factor). Moreover, since the district court promptly *denied* Petitioner's motion

for a stay, this factor weighs in favor of the Board exercising discretion to deny the Petition. Ex. 2019 at 3.

2. The district court’s trial date will precede the Board’s projected statutory deadline for a final written decision by approximately seven months

Factor two weighs in favor of denying institution, and Petitioner does not argue otherwise. Petition at 68 (“[T]his factor is neutral or weighs at most only slightly *in favor of PO.*”) (emphasis added). Indeed, as Petitioner acknowledges, the district court has scheduled jury selection for October 4, 2021. Petition at 67; Ex. 1018. This is more than seven months earlier than the projected statutory deadline for a final written decision of the requested IPR, which would issue sometime in May 2022. *See* Ex. 1018; IPR2021-00186 at Paper 4; 35 U.S.C. § 314(a); 37 CFR § 42.100(c).

This factor is nowhere close to being “neutral.” The circumstances here are even more compelling than those in *Fintiv*, where the trial was scheduled to begin only two months before the final written decision was due, or those of *NHK*, where the Board determined that an *inter partes* review that would not conclude until almost six months after a district court trial “would be an inefficient use of Board resources.” *See Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 15 at 13 (PTAB May 13, 2020); *NHK*, IPR2018-00752, Paper 8 at 20. The circumstances of this proceeding are also the exact opposite of what *Fintiv* identified as those in which

“the Board may be less likely to deny institution under 35 U.S.C. § 314(a) based on district court trial timing,” i.e., where “the district court has set a date *after* the Board’s deadline to issue a final written decision.” *Fintiv* at 3 (emphasis in original).

Despite acknowledging that this factor is not favorable to them, Petitioner attempts to cast doubt on the anticipated trial date due to the Covid-19 pandemic. While short-citing to non-precedential Board institution decisions, Petitioner represents that the Board has recognized that *Fintiv* factor 2 is diminished by uncertainties due to the ongoing pandemic. Petition at 67-68 (citing *Apple Inc. v. Seven Networks, LLC*, IPR2020-00235, Paper 10 at 8-9 (PTAB July 28, 2020) and *Sand Revolution II, LLC v. Cont’l Intermodal Grp.-Trucking LLC*, IPR2019-01393, Paper 24 at 9-10 (PTAB June 16, 2020)). Petitioner’s cited cases are inapposite. In both, the Board relied heavily on the fact that the parties had previously agreed to extend scheduled dates, including the trial date. *See Sand Revolution*, IPR2019-01393, Paper 24 at 9-10 (relying in particular on “the number of times the parties have jointly moved for and the district court agreed to extend the scheduling order dates.”); *see also Apple*, IPR2020-00235, Paper 10 at 9 (noting the parties’ agreements to move the trial date while determining that *Fintiv* factor 2 still weighs in favor of Patent Owner).

Here, there have been no extensions of the trial schedule in the Parallel Proceeding, nor has Judge Gilstrap indicated that he has any intention of moving the

trial date until after the deadline for a final written decision. In addition to rejecting Petitioner's motion to stay in the Parallel Proceeding, Judge Gilstrap issued a standing order on March 3, 2020 that counsels the parties to come together to minimize the impact of any potential issues related to Covid-19, including exploring any "appropriate means to conduct the hearing, trial, or deposition," such as by videoconference. Ex. 2020; *see also* Ex. 2021 (Standing Order Regarding Pretrial Procedures). Notably, in *Google LLC, Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. v. AGIS Software Development LLC*, which also involved a parallel proceeding before Judge Gilstrap, the petitioners similarly argued that the trial date was uncertain, but the Board rejected the argument:

On the record before us at this time, the only persuasive *facts* that we have regarding the proximity of the court's trial date to the Board's projected statutory deadline for a final written decision is an Order by the District Court that sets trial for April 5, 2021, which will require "good cause" to be changed, and our projected statutory deadline, which would be toward the end of November 2021. While we appreciate that the trial date is susceptible to change if and when the District Court determines good cause exists to do so, we decline to speculate whether such a contingency will occur. Instead, we must base our evaluation on the existing facts supported by the evidence of record. This factor, therefore, significantly favors the exercise of discretionary denial.

IPR2020-00870, Paper 16 at 11 (PTAB Nov. 25, 2020) (denying institution) (emphasis in original).²

The outcome should be the same here. The seven month gap between the start of trial and a final written decision from the Board should control in the absence of any evidence demonstrating that the trial will be postponed. *See Apple*, IPR2020-00019, Paper 15 at 13 (“We generally take courts’ trial schedules at face value *absent some strong evidence to the contrary.*”) (emphasis added). *Fintiv* factor 3 weighs in favor of the Board exercising its discretion to deny the Petition.

3. The parties have invested significant resources in the Parallel Proceeding

The Parallel Proceeding is already well underway. The parties began producing documents and serving their infringement and invalidity contentions³ last year. Ex. 1018. The parties have already substantially completed discovery. *Id.* Well before the Board decides whether or not to institute, the parties will have filed and

² The Board offered the same analysis while denying institution of the other IPR petitions brought by the same petitioners in IPR2020-00871, Paper 16 at 11 (PTAB Nov. 25, 2020), IPR2020-00872, Paper 16 at 9-10 (PTAB Nov. 25, 2020), and IPR2020-00873, Paper 16 at 9-10 (PTAB Nov. 25, 2020).

³

exchanged claim construction briefs and conducted the Markman hearing, which is scheduled for March 26, 2021. *Id.* Moreover, by the time the Board issues its decision on whether to institute the requested IPR, the parties will have served initial expert reports, fact discovery will have closed, and dispositive motions will be a month out. *Id.* This will require immense time and effort for both sides. Petitioner's argument that "[t]he parties and district court will have invested limited resources in the District Court case" prior to the deadline for the Board's institution decision, (Petition at 68), simply does not hold water.

Petitioner applauds its purported efforts to file the Petition "promptly," Petition at 68-69, it was served concurrently with Petitioner's invalidity contentions in the Parallel Proceeding. Petitioner's statement that "Here, Petitioner filed its Petition before serving its invalidity contentions," is untrue or even if technically true, highly misleading. *See* Petition at 69. The Petition was filed and served *on the same day* that Petitioner served its Invalidity Contentions in the Parallel Proceeding. Compare Petition at Certificate of Service with Ex. 2022 at 204 (Certificate of Service). Given how far along the Parallel Proceeding will be by the time of an institution decision and the resources both Parties will have to expend before that time, this factor strongly favors denial.

4. There is substantial overlap between the issues raised in the petition and in the Parallel Proceeding

Factor four also weighs in favor of denying the Petition. Petitioner does not deny the nearly complete overlap between the invalidity issues raised in the Petition and in the Parallel Proceeding. Petition at 69. All of the grounds raised in the Petition are being raised, or are reserved to be raised, in the Parallel Proceeding. Petitioner notes that it has represented that “if this IPR proceeding is instituted, [Petitioners] will not pursue invalidity on the same grounds or grounds based on the same primary references in the District Court case.” Petition at 69. But this is an empty promise.

Petitioner’s representation that it will forgo pursuing the proposed grounds, or grounds based on the same primary references if the Board institutes a trial, is meaningless given that the primary references (Banin, Zabin and Lucey) identified in the Petition are just two of many references that Petitioner contends, through its district court invalidity contentions, either anticipate or render obvious the ’365 Patent claims. Ex. 2022 at 184-199. Petitioner’s kitchen-sink approach to invalidity in the district court demonstrates that Petitioner intends to litigate validity issues in both forums, no matter what. *See, e.g., Google and Samsung*, IPR2020-00870, Paper 16 at 15-16 (noting that such ambiguously worded “conditional stipulations” that limit any waiver to the conditional grounds in the petition do not alleviate the concerns of potential inefficiencies and conflicting decisions).

Petitioner's proposal gives up far less than the statutory estoppel to which Petitioner would already be subject after a final written decision. *Compare* Petition at 69 (representing that Petitioners will not pursue invalidity ***on the same grounds or grounds based on the same primary references*** in the District Court case") with 35 U.S.C. § 315 (barring a Petitioner from asserting in district court proceeding that a claim "is invalid on any ground that the petitioner raised ***or reasonably could have raised*** during that inter partes review"); *see also* Ex. 1022. Petitioner's carefully worded stipulation also falls far short of the standard created by the precedential *Sotera* decision, where the Board cited and relied upon a stipulation from the Petitioner that eliminated ***any*** potential overlap with the related district court litigation. *See Sotera*, IPR2020-01018, Paper 12 at 18.

Petitioner's purported efforts to eliminate overlapping invalidity issues are illusory. And with regard to the Petitioner's statement that the Board should favor an institution because the Petition includes challenges to additional claims that are not asserted in the related district court case, (Petition at 69), Patent Owner is not going to assert those claims in the Parallel Proceeding, regardless of whether the Board institutes an *inter partes* review or not. Institution of this Petition would unfairly subject Patent Owner to defending the patent's validity in two proceedings at different times and with no coordination between the two. Factor four strongly favors a denial of the Petition.

5. The Petitioner and the Defendant in the Parallel Proceeding are the same party

Factor five also weighs in favor of a denial. Petitioner in this proceeding, and Defendant in the Parallel Proceeding, are the same party: Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. Petition at 70 (“Petitioner here and the defendant in the District Court case are the same party[.]”). Petitioner’s argument that this factor alone does not control is irrelevant, particularly where every other factor also counsels against institution.

6. Additional circumstances weigh in favor of the Board’s exercise of discretion

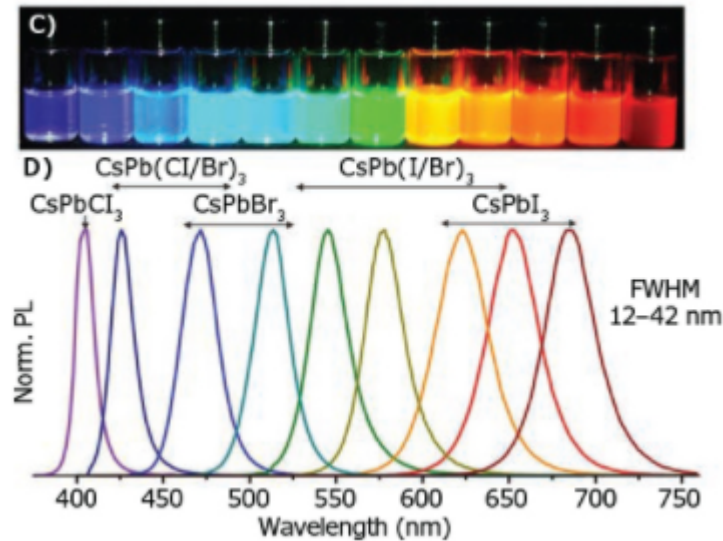
Factor six also weighs in favor of a denial. The Parties are not strangers to each other. Petitioner and Patent Owner have been aware of each other’s work and have exchanged information pursuant to confidentiality agreements for more than a decade. Petitioner and Patent Owner were also in negotiations concerning patents that include the ’365 patent, up until Petitioner walked away from the negotiations and Patent Owner initiated the Parallel Proceeding. Petitioner has had multiple opportunities to avoid litigation, and were well aware of the ’365 patent long before they were served with the complaint from the Parallel Proceeding. Moreover, as discussed herein *infra*, the Petition’s grounds are weak and do not justify instituting on the merits.

In sum, the circumstances here are materially the same as those in *NHK* and even more compelling than in *Fintiv*. In each of those precedential decisions, the Board denied institution under 35 U.S.C. § 314(a) where, as here, the district court action was set to be tried months before the IPR’s final written decision would have issued, and the petitioner had raised substantially the same prior art and arguments in both proceedings. With all six *Fintiv* factors weighing in favor of denying the present Petition, an institution of this proceeding would not be consistent with the objective of the AIA to “provide an effective and efficient alternative to District Court litigation.” *NHK*, IPR2018-00752, Paper 8, at 20 (quoting *Gen. Plastic Indus. Co., Ltd. v. Canon Kabushiki Kaisha*, IPR2016-01357, Paper 19, at 16–17 (PTAB Sept. 6, 2017) (precedential)). Instead, it would unnecessarily subject the parties to expensive and duplicative proceedings to adjudicate the validity of the ’365 patent and create an air of uncertainty over any decision coming from Judge Gilstrap in the district court. Accordingly, the Board should deny institution.

III. OVERVIEW OF QUANTUM DOTS

The challenged claims are directed to nanoparticles such as quantum dots. Quantum dots are man-made semiconductors that can emit light at very particular wavelengths. They are tiny, ranging in size from 2-100 nanometers (nm), and it is their size that dictates the wavelength, and thus the color, of light being emitted—

moving across the traditional spectrum from violet to red as the dots grow larger in diameter. Ex. 1001 at 1:21-25.



Ex. 2013 at 1792. To achieve color precision, it is vital that all of the quantum dots in a particular batch are sufficiently uniform in size (i.e., “monodisperse quantum dots”). Monodisperse quantum dots are useful in televisions because of their fine-tunable color-generating properties. Ex. 1001 at 1:25-27. When such quantum dots are added to a film that sits in front of a television’s backlight, they reveal a wider and more saturated range of colors than would otherwise be possible. Nanoco, an early pioneer in the manufacture of quantum dots, developed ways to manufacture

monodisperse quantum dots in large quantities, and developed ways to make quantum dot films for use in displays.⁴

At the time of the invention, the most studied quantum dot material was cadmium selenide (“CdSe”). This is because one can precisely control the size of CdSe quantum dots, and thus fine-tune the color they emit over the visible spectrum. Ex. 1001 at 1:40-43. These CdSe quantum dots are made up of elements from columns 12 and 16 of the periodic table (also known as group II-VI quantum dots).

⁴ In separate IPRs Samsung challenges Nanoco’s U.S. Patent Nos. 7,588,828, 7,803,423, 7,867,557, and 9,680,086, which are also directed toward these inventions.

Prior to Nanoco's innovations, quantum dots using group III-V materials could not be made in commercial quantities with the necessary size precision. Existing commercial methods required taking a solution of precursors—i.e., chemicals that contribute the indium and/or the phosphorus ions to an InP quantum dot core—and rapidly injecting them into a hot solvent. Ex. 1001 at 3:54-4:3. This “hot injection” method worked well enough for small-scale productions of quantum dots, where the amounts of each solution were small enough that one solution could be added to another and still maintain uniform temperature throughout the reaction. *Id.* However, it did not work for larger scale productions because large volumes of solutions that are rapidly injected into one another create temperature differentials throughout the solution. *Id.* These temperature differentials results in quantum dots of many different sizes. *Id.* As discussed above, a large size distribution defeats the purpose of quantum dots by eliminating the ability to fine-tune their optical properties. *Id.*

Nanoco solved this problem by converting precursors (such as an indium-containing precursor and a phosphorus-containing precursor) into a quantum dot core in the presence of a *molecular cluster compound*. *Id.* at 4:51-58, 5:5-9. Nanoco's patented “cluster assisted” growth methods enabled large-scale synthesis of high-quality, uniform, cadmium-free quantum dots.

Notably, at the time of Nanoco's invention, Petitioner was still trying to solve the problems associated with producing cadmium-free quantum dots, but they were not having much luck. Petitioner was able to create cadmium-containing quantum dots, but not cadmium-free ones. Indeed, Samsung's research lead, Dr. Eunjoo Jang, expressed publicly that Samsung found developing cadmium-free quantum dot technology "to be quite a challenge." Ex. 2005, at 3 (Quantum Dot Artisan: Dr. Eunjoo Jang, Samsung Fellow). As she further stated:

At first, we could not even imagine a Cd-free quantum dot, but in Samsung's commitment to being a globally responsible manufacturer, the vision was to make it work. I was able to relatively quickly complete a cadmium-containing quantum dot, but I wanted to do something that no one else had. So, I worked another three years on Cd-free quantum dot.

Id.; see also Ex. 2006 (Environmentally Friendly InP-Based Quantum Dots for Efficient Wide Color Gamut Displays) at 1316 (noting that "optimization of synthesis methods of *InP QDs* has been relatively difficult compared to *II-VI QDs*") (emphasis added).

Unable to make quality cadmium-free quantum dots, Dr. Jang looked to Nanoco. In October, 2006 she emailed Nanoco's inventor Nigel Pickett to learn about Nanoco's cadmium-free quantum dots. Ex. 2016 ("We are interested in your Cd-free quantum dots."). This was four years after Dr. Jang began trying. Ex. 2005

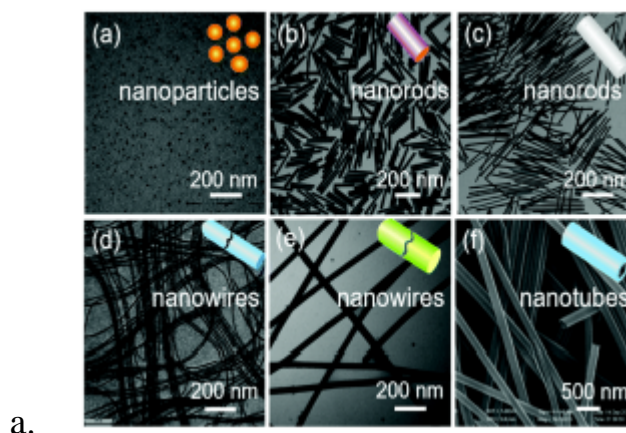
at 2 (noting that “she started the project at SAIT in 2002”). Dr. Jang sought a technical discussion with Nanoco concerning cadmium-free quantum dot synthesis methods, as well as protocols for manufacturing quantum dots containing epoxy resins. Samsung and Nanoco subsequently signed a non-disclosure agreement in 2007. After many years of detailed technical discussions regarding Nanoco’s cadmium-free quantum dots, Samsung, through Dr. Jang, was finally able to produce Cd-free quantum dots, after which Samsung terminated the relationship with Nanoco and introduced its first cadmium-free quantum dot TV in January 2015.

After all of this, Samsung awarded Dr. Jang with the Samsung Award of Honor, “also referred to as ‘Samsung’s Nobel Prize,’” in recognition of the challenges she had overcome in making Cd-free quantum dots. Ex. 2005. Nanoco believes that Samsung misappropriated its patented quantum dot technology, which led Nanoco to file a lawsuit for patent infringement against Samsung in Eastern District of Texas asserting the same patent that is challenged in this IPR.

IV. OVERVIEW OF NANOPARTICLE SYNTHESIS METHODS

There are many different types of chemical reactions that can be used to manufacture many different kinds of nanoparticles with many different characteristics. Petitioner mixes and matches components from these various methods in its efforts to challenge the ’365 patent claims. But each method has its own set of highly specific conditions, reagents, and other requirements, all to achieve

their own highly specific objectives. For example, some reactions produce spherical nanoparticles (quantum dots). Other reactions produce rod-shaped nanoparticles (nanorods). Still others produce quantum wires, ribbons, tubes, or sheets. Representative pictures of these differing structures are shown below:



Ex. 2027 (He, Fig. 8).

Reaction conditions for producing nanoparticles vary widely. Some reactions are performed at extremely high temperatures, while others can be carried out at room temperature or with mild heat. Some reactions use single-source precursors (i.e., precursors that contain all of the atoms that go into the nanoparticle), while others use multiple precursors each supplying a different atom to the nanoparticle. Some reactions use solid or vaporized precursors while others mix the precursors in a colloidal solutions (a colloid is a mixture in which particles remain evenly distributed through the solution). All of these different reactions have their own particular set of conditions and requirements—and they are all targeted to obtain

their own particular set of characteristics in the resulting nanoparticle, such as the composition of the nanoparticle, the quantity and purity desired, and so on.

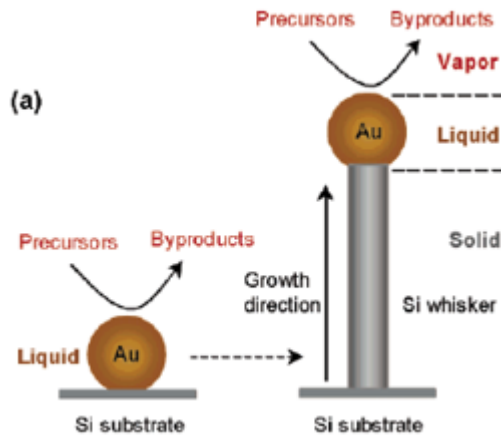
A. Nanorods and Nanowires

Nanorods and nanowires are elongated forms of nanoparticles. To achieve their elongated shape, nanorods and nanowires grow in one dimension. Two common ways of achieving this one-dimensional growth are (1) the Vapor-Liquid-Solid method, and (2) the Solution-Liquid-Solid method.

1. The Vapor-Liquid-Solid Method

The Vapor-Liquid-Solid (“VLS”) method was first discovered when researchers noticed that silicon (Si) “whiskers” would grow on gold (Au) decorated silicon substrates when they were subjected to a process called chemical vapor deposition (“CVD”). *See* Ex. 2008 (Solution-Liquid-Solid Growth of Semiconductor Nanowires) at 7513. As its name suggests, CVD uses a *vaporized* precursor to *deposit* silicon atoms directly onto a substrate. At the high temperatures required for this process, the gold melts into various size droplets. *Id.* These liquid gold droplets then dissolve silicon atoms until the droplets become supersaturated, at which point crystalline silicon whiskers begin forming at the bottom of the gold droplet (the part of the droplet that is touching the substrate). Because the growing crystals form where the droplet is already touching the silicon, they push the droplet upwards as the elongated crystal forms below it. Growth like this in one dimension

creates rod-shaped nanoparticles. *Id.* The silicon “whiskers” will continue to grow in this manner until the precursors are used up. *Id.* The researchers who discovered this process called it “VLS” in light of the three phases involved: Vapor-phase (silicon precursors), Liquid phase (melted gold droplets, also called the “catalyst”), and Solid phase (crystalline whiskers). *Id.* A rendering of the process is shown below:



Ex. 2008 (Wang 1) at 7514.

While other metals besides gold can be used in VLS, there are very particular requirements that must be considered when choosing metals that will work. The requirements include, but are not limited to:

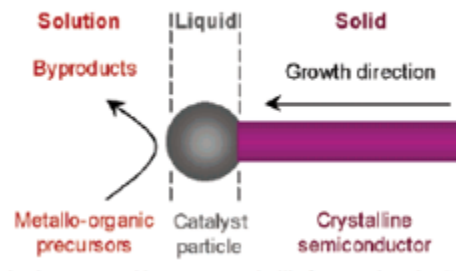
- (1) the metal must be able to form a liquid solution with the crystalline growth material at the nanowire growth temperature—i.e., the liquid metal (e.g., gold) must be able to dissolve the substrate (e.g., silicon);

- (2) the solubility of the substrate must be low enough in the metal that supersaturation can be achieved;
- (3) the vapor pressure of the catalyst over the liquid metal must be small so that the droplet does not vaporize, shrink in volume (and therefore radius), or decrease the radius of the growing wire until, ultimately, growth is terminated;
- (4) the catalyst must be inert to the reaction products during nanowire growth;
- (5) the vapor–solid, vapor–liquid, and liquid–solid interfacial energies must be examined before choosing a suitable catalyst.

See Ex. 2009 at 422-427.

2. The Solution-Liquid-Solid Method

The Solution-Liquid-Solid (“SLS”) method is related to VLS and also uses a melted metal to dissolve precursors to create one dimensional crystal growth. However, in contrast to VLS, SLS (1) is typically performed at lower temperatures, (2) replaces the vapor precursor with a liquid precursor, and (3) takes place in solution, meaning that the rods are not bound to a substrate. Ex. 2008 at 7514. The SLS process is depicted below:



Id.

Similar to VLS, there are particular requirements that must be considered when choosing metals to use in the SLS method—including melting points, solvating abilities, and reactivities. Ex. 2008 at 7514. Additionally, at least one of the components of the solid semiconductor phase must have limited solubility in the catalyst material, so that high supersaturation can be achieved. *Id.* at 7514-7515. Also, the catalyst should not react with or form a solid solution with the target semiconductor. *Id.* at 7515. The melting points, semiconductor-component solubilities, and reactivities are important criteria for judging candidate metals or metal alloys as potential SLS-catalyst materials. Nanoparticles made of low melting metals have proved useful for the SLS growth of semiconductor materials under typical reaction conditions (200–350 °C). Today, the most generally used metal for SLS nanoparticle growth is bismuth (Bi), whereas in the early days of SLS gold (Au) was more commonly used. *Id.*

Petitioner’s Banin and Ahrenkiel references use the SLS method to create nanorods. *See* Ex. 1005 (describing “rods with gold particles on the end,

demonstrating the SLS growth mechanism”); Ex. 1012 (describing “growth of InP quantum rods and quantum wires by the solution-liquid-solid mechanism...”).

B. Quantum Dots

Quantum dots, as their name suggests, are spherical. To achieve this shape, they must grow at equal rates in all directions at the same time. In the time since researchers first described the size-dependent properties of quantum dots, a variety of different methods of making them have been developed, each with its own challenges. One particular challenge is the synthesis of uniform size (“monodisperse”) and narrow size-distributed quantum dots, for which a number of different methods have been developed, as described further below. *See* Ex. 2003 at 1. The last of these methods is Nanoco’s patented “cluster-assisted” method.

1. The Solid-State Method

Unlike solvent-based methods, solid-state preparations of nanoparticles do not use solvents at all. The method has advantages in that it eliminates waste, forms few side products, and does not require extensive purification to remove traces of solvent or impurities. Solid-state reaction (“SSR”) methods often rely on a mixture of different solid starting materials. The solid starting materials are selected to not react with each other at room temperature, but when baked together at much higher temperatures (often 1000 °C or more) the necessary reaction occurs. *See e.g.*, Ex. 2014 at 116 (“The most common method of preparing solids

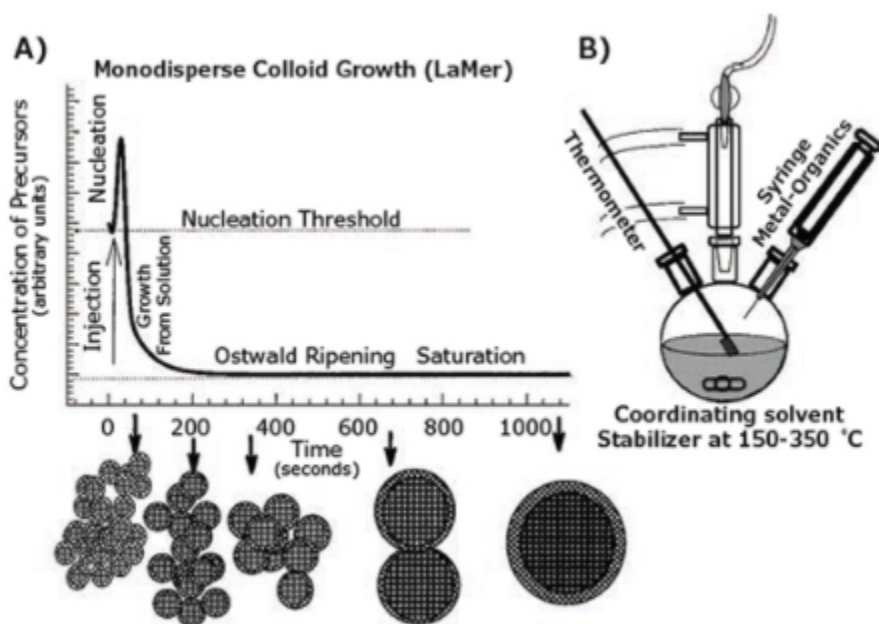
is by the reaction of the component materials at elevated temperatures.”). The feasibility and rate of a solid state reaction can be influenced by the reaction conditions such as temperature and pressure, as well as the chemical and structural properties of the reagents.⁵

2. The Hot-Injection Method

The hot-injection method involves the rapid injection of a room temperature solution of precursors into an extremely hot reaction medium in the presence of carefully chosen surfactant molecules. Ex. 2010 (Mushonga) at 2. The rapid injection of the precursor molecules induces a sudden supersaturation of the solution, resulting in a short burst of nucleation (i.e., initial crystals are formed). *Id.* After the reaction temperature drops in response to addition of the cold precursor solution, coupled with the low concentration of the remaining precursor molecules, further nucleation is halted. Growth of the quantum dots then follows at a lower temperature than that of the nucleation process. This sequential separation of the nucleation and growth processes generally leads to control of the size and shape of the semiconductor nanocrystals.

⁵ Unlike the grounds presented in the petitions of IPRs 2021-00183, 2021-00185, and IPR2021-00186, Petitioner does not rely on a solid-state reference in this proceeding.

There are two types of hot-injection methods: those in which a single precursor containing all the elements to be incorporated into the quantum dot is injected (single-source precursors), and those in which two precursors are used (dual-injection). Dual-injection is restrictive because the precursors usually cannot be pre-mixed. As a consequence, localized variation of precursor concentration can occur. This can be a major drawback because it can result in broadened size distribution of the initial nucleated crystals. Single-source precursors are therefore often preferred. Ex. 2011 (Luo) at 11. The hot-injection method is depicted below:



Ex. 2012 (LaMer Model) at Fig. 1A.

To this day, the hot-injection method remains the most common method by which cadmium-based quantum dots are synthesized. Ex. 2003 at 1. But it has not been successfully employed to produce large scale quantities of cadmium-*free*

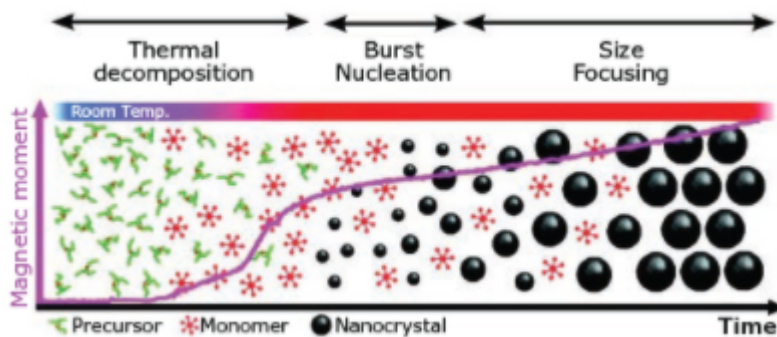
quantum dots. It is more difficult to separate nanoparticle nucleation and growth via a high temperature dual injection synthesis in certain cadmium-free quantum dots. *See* Ex. 1037 at 81-82 and Ex. 1047 at 1028. This is because the bonding in certain cadmium-free quantum dots, such as group III-V quantum dots (such as InP), is more covalent than that in group II-VI quantum dots (such as CdSe). Ex. 1037 at 80. Also, the hot-injection method has problems in larger scale productions of any quantum dots because large volumes of solutions that are rapidly injected into one another create a temperature differential throughout the solution. Ex. 2013 at 1792. This temperature differential results in quantum dots of many different sizes. *Id.* A large size distribution defeats the purpose of quantum dots by eliminating the ability to fine-tune the optical properties.

Petitioner's Lucey reference uses the hot injection method to make quantum dots from a single-source precursor. *See e.g.*, Ex. 1011 at 10:38-41 ("The initiation of the reactions occurs when the ER_n source is rapidly injected into a heated solution of ML_n source in the non-coordinating solvent.")

3. The Heat-Up Method

The heat-up method is a non-injection approach that involves steadily heating the precursors. Ex. 2012 at 2. It is generally considered to be a more efficient approach to preparing nanocrystals than hot-injection because it allows them to be prepared in a single pot, and skips the injection step. *Id.* at 2-3. While the majority

of the heat-up synthesis methods result in quantum dots with a large particle size-distribution (because nucleation events are spread over an appreciable period of time), it is nevertheless possible to obtain monodisperse quantum dots with this method if precursors with a suitable level of reactivity are used. *Id.* In a similar strategy to the hot-injection method, the key is to employ a homogeneous nucleation process through the use of precursors that are highly reactive only when they reach a certain temperature. In general, the precursors should exhibit no, or very low, reactivity below the desired temperature to allow growth of the target quantum dots to predominate, as shown below:

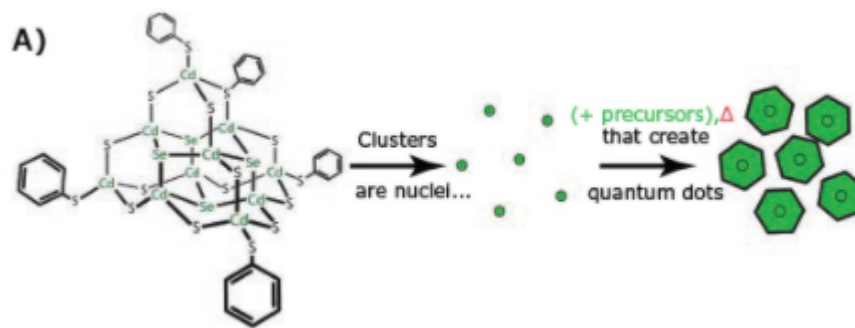


Ex. 2012 (Fig. 3).

Petitioner's Zaban reference uses the heat-up method. Ex. 1006 at 3154 ("the reactants are heated for 3 days at 260-280 °C in the presence of trioctylphosphine oxide (TOPO) and trioctylphosphine (TOP).").

4. The Molecular Cluster-Assisted Method

The molecular cluster-assisted method is the method that Nanoco invented. The cluster-assisted method utilizes uniform clusters within the reaction system. These may act as nuclei and induce a controlled growth of the nanocrystals. The reaction is typically initiated by combining a known concentration of a small molecular cluster with a coordinating solvent in the presence of semiconductor precursors before slowly increasing the temperature. This results in the clusters evolving into quantum dot nucleation sites as shown below:



Ex. 2012, at Fig. 4A.

Subsequent studies have shown that the presence of the molecular cluster compounds directly impacts the concentration and size of the quantum dots. *Id.* (citing Nanoco's expert in the Parallel Proceeding, Dr. Preston Snee). The resulting concentration of quantum dots is almost equal to the number of the cluster seeds (within 10%). *Id.* Furthermore, the number of quantum dots produced via this method is approximately 20 times higher than that obtained via a standard rapid

injection procedure that employs the same amount of precursors. *Id.* Increasing the cluster seed concentration decreases the size of the quantum dots due to the increasing number of quantum dot nuclei competing for the finite number of available precursors. *Id.* This approach has proven to be a versatile method of controlling the concentration of quantum dots, and it produces a large quantity of quantum dots from a single reaction at a lower temperature. *Id.*

V. THE CHALLENGED '365 PATENT

Nanoco's '365 patent describes a cluster-assisted alternative to the heat-up and hot-injection methods of making quantum dots. Ex. 1001 at 4:4-32 (describing prior art hot injection method of making group III-V and IV-VI quantum dots). The '365 patent describes a nanoparticle with a core semiconductor material disposed on a molecular cluster compound that is different from the core semiconductor. That is, the core "semiconductor material comprises one or more *elements not comprised within the molecular cluster compound.*" Ex. 1001 at 20:9-13 (emphasis added). The '365 patent also describes quantum dots prepared by converting multiple precursors into a quantum dot core. The first precursor species contains a first ion (such as indium), and a separate second precursor species contains a second ion (such as phosphorus), with each precursor providing an ion to be incorporated into the growing quantum dot core (such as indium phosphide). Ex. 1001 at 4:51-58. An important feature of the invention is that conversion of these precursor species into

the quantum dot core takes place in the presence of a molecular cluster compound. *Id.* at 5:5-9. Unlike the single-source precursors, which fragment into separate atoms to be incorporated into the growing semiconductor lattice, the molecular cluster compound is a *completely separate compound from the precursor species*. *Id.* at 20:9-13, 20:63-65.

The Nanoco inventors describe one possible mechanism by which nanoparticle growth may take place in this way: namely, that each identical molecule of the cluster compound acts as a seed or nucleation point upon which nanoparticle growth can be initiated. Ex. 1001 at 5:9-14. In this way, nanoparticle nucleation is not necessary to initiate nanoparticle growth because suitable nucleation sites may already be provided in the system by the molecular clusters. *Id.* at 5:14-17. The molecules of the cluster compound may act as a template to direct nanoparticle growth. *Id.* at 5:17-18. Because of this, the molecular cluster compounds must be substantially identical. The '365 patent defines "molecular cluster" to mean "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. *Id.* at 5:18-25 (emphasis added). That is, "the clusters are defined *identical molecular entities*, as compared to ensembles of small nanoparticles." *Id.* at 7:51-52. Nanoco's molecular cluster compound approach is able to make high-quality nanoparticles that are essentially monodisperse. Ex.

1001 at 5:28-29. Previous methods were unable to produce commercial quantities of high-quality quantum dots, while the claimed cluster-assisted method was—even for the notoriously difficult cadmium-free quantum dots.

VI. CLAIM CONSTRUCTION

Claims in an IPR are construed under the claim construction principles set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc); 37 CFR § 42.100(b). “Petitioner does not believe any claim terms need to be construed to resolve the prior art issues presented” in its petition. Petition at 19.

A. Molecular Cluster Compound

The term “molecular cluster compound” appears in all asserted claims of the ’365 patent, and is described as being an “important feature of the invention.” Ex. 1001 at 5:5-9. Because of this importance, the patentee chose to expressly define the term to ensure its clarity. The ’365 specifications 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.

Ex. 1001 at 5:19-25.

In the Parallel Proceeding, Petitioner contends:

To the extent the term is not indefinite, it means 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 mass, where ligand means an atom or group bound to a central atom of a complex.

Ex. 2026 at Ex. A, 1. The parties' dispute over the meaning of the term need not be resolved. Resolution of the Petition does not revolve around any disputed aspects of the term "molecular cluster compound." To the extent Patent Owner relies on the term at all in this Preliminary Response, it is with respect to aspects of the definition that both parties agree on. For example, both parties' definitions, as shown above, require that the molecular cluster compound possess "*of sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular mass.*"⁶ See also Ex. 1001 at 5:25-28 (describing molecular cluster compounds to be of "sufficiently well-defined chemical structure" such that "the molecular clusters are identical to one another in the same way that one H₂O molecule is identical to another H₂O molecule"). That

⁶ The parties dispute whether "sameness" is measured in terms of "molecular formula" or "molecular mass" of the cluster compound—but this is a distinction without a difference for purposes of this IPR proceeding. See Petition at 22-23.

is important for assessment of the Banin reference, which discloses a nebulous agglomeration of different sized gold particles that cannot meet the agreed-on portions of the definition.

VII. THE PETITION SHOULD BE DENIED BECAUSE IT DOES NOT ESTABLISH THE REQUIRED REASONABLE LIKELIHOOD OF SUCCESS OF PROVING CHALLENGED CLAIMS UNPATENTABLE

A. The Proposed Grounds 1-4: Banin⁷

1. Banin Does Not Disclose a Molecular Cluster Compound

The challenged '365 patent claims require a molecular cluster compound, but Petitioner's primary reference, Banin, does not disclose a molecular cluster compound. Banin describes a process for creating nanoparticles that is completely different from the '365 patent's cluster-assisted method. Banin discloses using the SLS method to create group III-V nanorods. *See* 1005 at 14, 15, 23 (describing Banin's SLS method). The SLS method does not use a molecular cluster compound, as required by all challenged claims of the '365 patent. Instead, as Banin points out, the SLS method uses "a metal nanoparticle as a catalyst for rod growth." *See* 1005

⁷ Although Ground 4 adds a second reference, Treadway with respect to the "ternary and quaternary" claim elements of dependent claims 13 and 14, Petitioner does not contend that Treadway discloses a molecular cluster compound. Thus, the shortcomings persist for the same reasons provided in relation to Grounds 1-3.

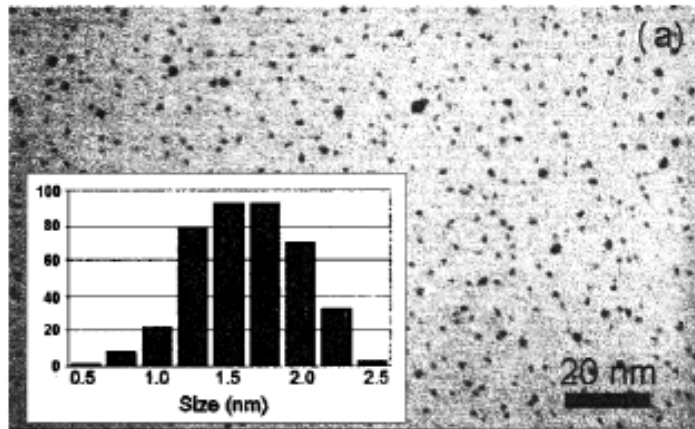
at 15 (emphasis added). This metal nanoparticle catalyst acts as a solvent, and thus must melt into droplets so that the precursors can dissolve to form the necessary supersaturated solution that precipitates to form a nanorod. Ex. 1005 at 7 (“the reaction precursors dissolve in the metal nanoparticles and the semiconductor nanorods grow from these particles.”).

Banin uses a gold droplet, and discusses the importance of gold’s melting point to the success of the SLS method. Ex. 1005 at 20; *see also id.* at 19 (“[growth] conditions are ***at the onset of melting.***”) (emphasis added); *id.* at 21 (“Metal alloy nanoparticles are interesting catalysts for the growth of semiconductor rods ***due to their reduced melting temperature.***”) (emphasis added); *see also* Ex. 2007 at 10889 (“SLS growth is conducted with a *solution* phase (normally employing organic solvents), typically at temperatures of 200–350 °C, in which low-melting metallic nanoparticles (in the molten, liquid form under the reaction conditions) catalyze the decomposition of metalloorganic precursors at the solution–liquid interface and dissolve the semiconductor components so obtained[.]”) (emphasis in original). Consistent with the SLS method, Banin’s process results in rods with the melted gold particles on the top of them. Ex. 1005 at 23 (“The inset of Fig. 10B shows rods with gold particles on the end, demonstrating the SLS growth mechanism.”).

Petitioner identifies Banin’s gold particles as purportedly being “molecular cluster compounds” as defined by the ’365 patent’s specification. They are not. They

are SLS metal catalysts that lack the sufficiently well-defined chemical structure of molecular cluster compounds. *See* Ex. 1001 at 5:23-28 (describing molecular cluster compound to be of “sufficiently well-defined chemical structure” such that “the molecular clusters are identical to one another in the same way that one H₂O molecule is identical to another H₂O molecule”). The gold catalysts in Banin are not well-defined, and certainly not identical in the way an H₂O molecule is identical to another H₂O molecule. Petitioner’s points to the formula Au₁₀₁(PPh₃)₂₁Cl₅ to suggest that the gold catalysts are identical to one another. Petition at 22, 33. But Banin admits that this formula is merely a “suggested formula.” Ex. 1005 at 20. If Petitioner had reviewed the reference Banin cites to describe how he synthesized his gold particles, it would have seen that these particles cannot be considered molecular cluster compounds. *See* Ex. 1005 at 3 and 21 (disclosing that the liquid gold particles with the “suggested formula Au₁₀₁(PPh₃)₂₁Cl₅ (denoted as Au101) were synthesized by the published procedures [W.W. Hutchison, S. M. Reed, M. G. Marvin and J.E. Hutchison, *J Am. Chem. Soc.*, 122, 12890 (2000)] (“Hutchinson”).”).

The Hutchinson process used by Banin creates gold particle agglomerations of many different sizes, as shown in the figure below:



Ex. 2017 (“Hutchinson”) at 12891. These different sizes are clearly discernable by looking at the different sized black dots in the figure—and the graph shows a size difference ranging from 0.75 nm to 2.25 nm. These different sizes are averaged out, and then it is estimated that the average number of gold atoms is approximately 101. *Id.* at 12891 (“Given the *average* particle size (1.5 nm) is *estimated* to be ~101 ... leads to an *estimated* formula of Au₁₀₁(PPh₃)₂₁Cl₅.”). The “~” symbol shows that Hutchinson discloses only an approximate formula for an average-sized particle. Moreover, the particles created by the Hutchinson method have significant impurities. *Id.* at 12890-12891 (“[analysis of the nanoparticles] show 3.7 mass percent of the sample is the impurity AuCl(PPh₃).” Hutchinson’s gold particle is precisely the type of amorphous impure nanoparticle that the ’365 patent distinguishes from “molecular cluster compounds” in the specification. *See* ’365 patent at 7:37-39 (That is, “the clusters are defined identical molecular entities, as compared to ensembles of small nanoparticles.”).

By using gold particles that are not sufficiently well-defined, Banin's process does not achieve the goal of the '365 patent, which is to make a population of nanoparticles that is essentially monodisperse. Ex. 1001 at 5:28-29. In Banin's SLS method, the diameter of the nanorods is dictated by the size of the gold particle. As such, Banin's nanorods vary by up to 25%. Ex. 1005 at 24 (“[t]he width of the diameter distribution is 20-25%...”); *see also id.* at 16 (Diameter was between 3-4 nm [a 25% difference]). This wide size distribution reflects the wide size distribution of the gold particles taught by Hutchinson. *See* Ex. 2017 at Fig. 1(a) (showing particles of 1.5 nm \pm 0.4 nm). These gold particles in Banin do not have “sufficiently well-defined chemical structure such that all molecules of the cluster compound possess the same relative molecular mass.” Thus, the gold nanoparticles used by Banin are not molecular cluster compounds at all. They are common gold nanoparticle catalysts used in the traditional and well-known prior art SLS nanorod production method.

Petitioner also confuses this SLS method with seeded growth. Petitioner calls out Banin's disclosure that metal particles “provid[e] large seeds for rapid InAs [nanoparticle] growth.” Petition at 35-36. Petitioner seizes on this use of the word “seed,” but this “seed” is nothing more than an agglomeration of molten metal droplets—even less well-defined in structure than the gold droplets themselves—and this was just Banin's best guess at what “most likely” happened during some

experiments using various concentrations of gold. Ex. 1005 at 24 (“the relative molar ratio of gold to (TMS)₃As in the precursor solution was varied between 2.5 to 20%.”). At low gold concentration, there was a problem with low yields of quantum rods. *Id.* At high gold concentration, there was a problem of quantum rods precipitating too quickly. *Id.* Banin theorized that this immediate precipitation was caused by the “**aggregation of the gold clusters** providing large seeds for rapid InAs growth.” *Id.* at 23. This aggregation of already ill-defined metal droplets does not constitute a molecular cluster compound of sufficiently well-defined structure. Notwithstanding Banin’s use of the word “seed,” the gold particles agglomerations are exactly the type of “ensembles of small nanoparticles” that are ***expressly distinguished*** by the ’365 patent. Ex. 1001 at 7:48-53.

2. Adding Herron to Banin Cannot Render Obvious Any of the Challenged ’365 Patent Claims

Because the particles in Banin are made of gold (a group 11 element), not out of group 2, 12, 14, 15, or 16 element as required by certain claims, Petitioner has added Herron (Ground 3) to purportedly remedy this deficiencies. *See e.g.*, Petition at 33, 39. But the only reason that these references are being combined is not because they complement one another in a logical way, but merely as means to satisfy the missing claim limitations. That is hindsight. *See Kinetic Concepts, Inc. v. Smith Nephew, Inc.*, 688 F.3d 1342, 1368 (Fed. Cir. 2012) (forbidding hindsight

reconstruction of references without an explanation of how or why the references would have been combined) (citing *Innogenetics, NV v. Abbott Laboratories*, 512 F.3d 1363, 1374, n.3 (Fed. Cir. 2008)). For neither proposed combination has the Petitioner articulated a logical motivation to combine or any reasonable expectation of success.

a. Banin and Herron (Ground 3)

Banin teaches using the SLS method discussed above in which a *liquid* metal catalyst made of gold is used to grow nanorods. *See supra* Section VII.A.1. The method is expressly depicted in Figure 1 of Banin:

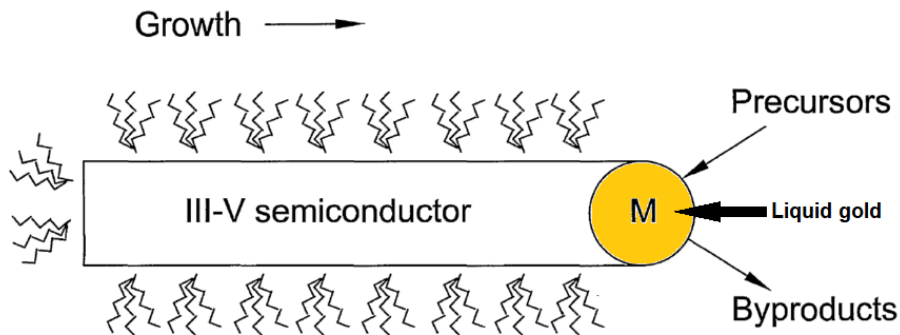


FIG. 1

Ex. 1005 at Figure 1; *see also* Ex. 1005 at 6 (“[I]t is proposed that the reaction precursors dissolve in the metal nanoparticles and the semiconductor nanorods row from these particles.”).

Banin further teaches that the disclosed SLS method was largely made possible by the discovery of a “surprisingly low” melting point for the gold particles that facilitated nanorod growth:

It should be pointed out that *the reaction temperature in the method described above is surprisingly low* (about 700 degrees below the melting point of bulk gold). This is possible because of the phenomena of decrease in the melting temperature of nanocrystals with reduced size. It was found by the inventors that syntheses at a lower reaction temperature of 300 °C, does not yield one-dimensional growth in this specific case indicating that the conditions are at the onset of melting.

Ex. 1005 at 19 (emphasis added).

In contrast to Banin’s method, Herron discloses a modified crystalline fragment of bulk cubic cadmium sulfide (CdS). Ex. 1016 (Herron) at 1426. Herron recrystallized the cluster from a “spherical chunk of the sphalerite form of bulk CdS” which was identified as an intermediate that formed during a solid-state crystal growth process. *Id.* at 1046 (describing the carefully controlled conditions, including sustained high heat, that are used to convert starting materials to bulk crystalline CdS). While Herron does not disclose any melting point for the modified CdS cluster, it was derived from a material that would normally be heated to 500 °C to form bulk CdS. *Id.*

The Petition offers no credible reason to modify Banin in view of Herron. Banin's method depends upon the existence of physical states of matter (namely, molten metal) that Herron never discloses. Banin also sought to grow nanorods and not quantum dots, which is how Herron characterized his CdS intermediate cluster. *Compare* Ex. 1005 (Banin) at 6 (“There is a need in the art to facilitate preparation of nanocrystalline semiconductors, especially Group III-V semiconductors, having rod-like shape of controlled dimensions in a controllable and repeatable manner, which are not available to date.”), *with* Ex. 1016 (Herron) at 1426 (“With such a well-defined molecular cluster, we examined the intrinsic optical properties of a single-sized, 15 Å quantum dot without ambiguities from size dispersion or poorly defined surfaces.”).

Petitioner contends that the “clusters” disclosed by Banin and Herron are interchangeable due to Banin's mere mention of possibly using Cd-based compounds in the disclosed SLS method. Petition at 34. Petitioner also cites to purported cost savings that would be achieved by swapping out the gold in Banin. *Id.* Petitioner's uncorroborated expert testimony on both of these points is entitled to little or no weight. *See* Ex. 1002 at ¶127 (uncited); *In re Am. Acad. of Sci. Tech. Ctr.*, 367 F.3d 1359, 1368 (Fed. Cir. 2004) (“[T]he Board is entitled to weigh the declarations and conclude that the lack of factual corroboration warrants discounting the opinions expressed in the declarations.”); 37 CFR § 42.65 (“Expert testimony

that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.”).

As an initial matter, Petitioner’s assertion that Herron discloses molecular cluster compounds “that can be used to form semiconductors in solution,” does not come from any teaching of Herron but rather the method disclosed in the ’365 patent. *See* Petition at 34 (citing the ’365 patent at 5:5-25). While Herron discusses the solubility of the intermediate cluster and using solvents to isolate it, it is a paper investigating what occurs during solid-state “bulk cubic CdS” crystal formation. *See generally* Ex. 1016 (Herron). In terms of utility, Herron describes using the cluster’s solubility as a way to adding it (the cluster itself) to films, not to prepare larger semiconductors made in solution. *See* Ex. 1016 at 1428 (“Finally, the solubility of this new crystalline cluster may be used in the production of polymer films, such as polyvinylcarbazole, *doped with the CdS cluster simply by spincoating from a pyridine solution.*”) (emphasis added).

Moreover, while Petitioners’ expert opines why a POSITA would have believed that Herron’s cluster *could* be used in place of Banin’s liquid gold particles, *see* Ex. 1002 at ¶130 (“It was known that MCCs like the one disclosed in Herron *could be used* to grow nanoparticles. *See, e.g.,* Ex. 1005, 17:22-30; 20:12-27 (using Au clusters to grow InP nanoparticles); Ex. 1010, 9198-99 (using MCCs as seed nuclei to grow nanoparticles from the ions of a separate precursor).”), that is the

wrong legal standard for evaluating a motivation to combine. Even if Herron’s cluster did not suffer from such clear shortcomings relative to Banin’s teachings, the hypothetical musings about what a POSITA “could have done” does not supply an adequate reason to modify Banin’s method. *See e.g., Samsung Electronics Co., Ltd. et al v. Red Rock Analytics, LLC*, IPR2018-00555, Paper 16 at 20-21 (PTAB Aug. 30, 2018) (rejecting unsupported expert testimony about what a POSITA could have done) (citing *Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015) (“[O]bviousness concerns whether a skilled artisan not only **could have made** but **would have been motivated to make** the combinations or modifications of prior art to arrive at the claimed invention.”) (emphasis in original)).

Finally, Petitioner’s contention that a POSITA would have combined these references in order to carry out the teachings of the ’365 patent based merely on each disclosing a “cluster” that purportedly meets the parties’ definition of an molecular cluster compound is not a reason to combine at all. *See* Petition at 35 (“Banin and Herron occupy the same field of art as the ’365 patent: nanoparticles and their formation.”). As the Federal Circuit has explained, where similarities between teachings are relied upon without any identification of a reason or motivation to combine, “the analysis would impermissibly rely upon ex post reasoning.” *See Otsuka Pharmaceutical Co., Ltd. v. Sandoz, Inc.*, 678 F.3d 1280, 1292 (Fed. Cir. 2012); *see also* MPEP § 2143.01 (citing *In re Kahn*, 441 F.3d 977, 986 (Fed. Cir.

2006) for its discussion of the rationale behind using the former motivation-suggestion-teaching test as a guard against hindsight). That is precisely the situation here. Banin is a patent application about the SLS method of nanorod formation, which necessarily requires a molten (liquefied) metal catalyst. Herron is a paper about a use of a bulk solid material. There is no reason identified for a POSITA to combine those two techniques, let alone any suggestion that such a far-fetched combination would be successful.

B. Proposed Ground 5: Zaban in View of Farneth/Yu

1. A Person of Skill in the Art Would Not Combine Zaban's Group III-V Quantum Dot Process with Farneth's Group II-VI Solid-state Intermediate

Petitioner's fifth proposed ground once again presents a combination of references that teach entirely different things. Zaban presents an improved way to create an electrode using a titanium dioxide film embedded with *indium phosphide* quantum dots. *See* Ex. 1006 at 3153. Zaban teaches that larger InP quantum dots work much better on titanium dioxide films than smaller ones. *Id.* at 3154 ("We found that large InP particles adsorb better onto TiO₂ nanoparticles than small ones."). Zaban discloses making these InP (group III-V) quantum dots using the heat-up method. *See supra*, at IV.B.3.

Farneth, on the other hand, has nothing to do with group III-V quantum dots. Farneth investigates changes that occur when solid precursors are heated to form

bulk metal using a solid-state (i.e., solvent-free) method. *See* Ex. 1009 at title (“Bulk Semiconductors from Molecular Solids: A Mechanistic Investigation”); *see also id.* at 916 (“In this paper we report on the mechanism of the solid-state conversion of a particular series of II/VI precursors of general formula $(R_4N^+)_4[S_4M_{10}(SPh)_{16}]^{4-}$ (R = Me, Et; M = Cd, Zn) *to the bulk metal sulfide structure.*”) (emphasis added). The purported zinc “precursor” that Petitioner identifies in Farneth is an “intermediate solid” that required extensive purification steps to produce. *See id.* at 917-918 (Experimental Section). As Zaban is synthesizing indium phosphide quantum dots, it has little need to look for zinc-based precursors, let alone ones that require such elaborate purification steps.

a. A Person of Skill in the Art Would Not Swap Zaban’s Zinc Acetate for Farneth’s 10-Zinc Precursor Because It Would Change the Nature of Zaban’s Quantum Dots

Petitioner contends that one would be motivated to replace Zaban’s zinc acetate with Farneth’s $Zn_{10}S_6Ph_{12}$ bulk-metal intermediate. Notwithstanding Petitioner’s repeated references to Zaban’s zinc acetate as a “precursor” (Petition at 17, 42, 44, 51), the zinc disclosed by Zaban is actually a dopant. *See* Ex. 1023 at 3154. A dopant is not part of the core semiconductor material itself, but rather it is a small impurity intentionally added to change the core semiconductor’s electrical properties. *See generally* Ex. 1049 at 42-44. Zaban uses zinc acetate to carefully

dope the quantum dots with very low and very precise amount of zinc. Specifically, Zaban adds one Zn^{2+} ion per quantum dot. *Id.* at 3154 (“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-Å QDs, the ratio In:Zn is $10^3:1$.”)

Petitioner suggests that mere presence of zinc in some molecule is sufficient motivation to use it in place of another zinc-containing molecule. It is not. Chemistry is specific, and as explained above, reagents, precursors, catalysts and other materials must be precisely chosen to obtain the specific result sought. This is especially true with dopants, and to this day zinc acetate is used to dope InP quantum dots. *See* Ex. 2025 at 16 (“[f]or synthesis we used ... zinc acetate dehydrate ($\text{Zn}(\text{OAc})_2$...)”). Moreover, there are many issues and challenges in doping quantum dots. Solving issues related to doping quantum dots continues to generate great research interests in this field. Ex. 2029. Generally, dopants could be undesirable as they reduce conductivity and mechanical integrity of the crystalline material. *Id.* In semiconducting nanoparticles, defects could potentially lower their photoluminescent efficiency by creating states that do not result in light emission at desired wavelength. Ex. 2025 at 5. However, in very certain cases, dopants can induce chemical, electrochemical and spectroscopic changes that could be beneficial to various applications. Ex. 2029. A semiconductor can be doped to such high levels

that it acts more like a conductor than a semiconductor. This is referred to as a degenerate semiconductor. *See* Ex. 2015. In short, a change in the amount of zinc dopant leads to a change in the properties of the resultant quantum dot. *See* Ex. 2025 at 3 (“Increasing the Zn amount leads to broader peak shapes, which suggests a decrease of the QD size”). Here, there has been no showing as to why a POSITA would think to combine Farneth’s zinc intermediate into Zaban’s process. Farneth’s zinc intermediate has *ten* zinc atoms. If Zaban incorporated such a molecule into his quantum dots as suggested, it would result in many times the amount of zinc that Zaban wanted in the quantum dots. Doping with too much zinc would thus make smaller quantum dots, but Zaban “found that large InP particles adsorb better onto TiO₂ nanoparticles.” Thus, a POSITA would have been motivated to increase the zinc content of Zaban with Farneth’s ten-zinc intermediate.

The Petition fails to address Zaban’s careful ratio of zinc to indium while suggesting that Farneth’s zinc-based “precursor” could be used in place of zinc acetate in Zaban’s method. *See* Petition at 44, 51. Zaban taught the use of 1 zinc ion for every 1000 indium ions. Ex. 1006 (Zaban) at 3154 (“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 Zn²⁺ ion per particle. For example, for 40-A QDs, the ratio In:Zn is 10³:1.”). In contrast, Farneth’s Zn₁₀S₆Ph₁₂ intermediate, which has no

indium ions, would not only introduce sulfur to unknown effects, it would eviscerate the delicately balanced doping ratio and change the nature of Zaban's quantum dots.

b. Petitioner's purported motivation does not come from any of the references

Petitioner's far-fetched rationales for combining Zaban and Farneth are hard to understand unless one was working backwards from the '365 patent. In arguing that a POSITA would have immediately recognized that Farneth's cluster could unlock entirely new synthesis methods, the Petition relies on Banin, which teaches yet another method (SLS) entirely specific to nanorods. *See* Petition at 43 (claiming that it was known to a POSITA "that MCCs are useful to improve the efficiency of solution-based nanoparticle syntheses" while citing Banin). The Petition goes on to argue that because Petitioners' third reference, Yu (Ex. 1010), purportedly discloses "heterogeneous seeded growth" of metallic nanoparticles on gold (Au) seeds at temperatures ranging from room temperature to 150°C, a POSITA would have motivated to invent a hybrid method not taught by any of these three references, in order to promote efficiency. *See, e.g.*, Petition at 44-46.

Petitioners' approach purportedly results in something similar to the patented invention, but only after hindsight has been applied to allow Petitioners to pick and choose only the elements necessary to reconstruct the patented invention from the prior art. Petitioner's suggestion that one would swap Zaban's zinc acetate dopant

for Farneth's $Zn_{10}S_6Ph_{12}$ intermediate is simply another backwards looking effort by Petitioner to pick and choose the elements necessary to reconstruct the patented invention from the prior art. And nothing in the disclosure of Yu, which uses an entirely different method utilizing gold, aligns with Zaban's heat-up colloidal process or Farneth's solid state method. If anything, Yu promotes the use of gold clusters as "potent heterogeneous nucleants" and would not have directed a POSITA in any way to Farneth's solid state method. *See* Ex. 1010 at 9199.

As with Grounds 3 and 4, Petitioner has pointed to nothing specific in the references or general art to support the proposed combination of Zaban, Farneth, and Yu, and has fallen far short of identifying a legitimate motivation to combine. *See In re NuVasive, Inc.*, 842 F.3d 1376, 1381-82 (Fed. Cir. 2016). With no suggestion in the art or any of the references themselves to make the proposed modifications, Petitioner's approach of lifting individual elements from various art references and rearranging them as they appear in the challenged claims is untenable. *See Sanofi-Synthelabo v. Apotex, Inc.*, 550 F.3d 1075, 1086 (Fed. Cir. 2008) ("The determination of obviousness is made with respect to the subject matter as a whole, not separate pieces of the claim."); *In re Fritch*, 972 F.2d 1260, 1266 (Fed. Cir. 1992) ("It is impermissible to use the claimed invention as an instruction manual or 'template' to piece together the teachings of the prior art so that the claimed invention is rendered obvious."); *In re Fine*, 837 F.2d 1071, 1075 (Fed. Cir. 1988)

“One cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention.”). As such, Petitioner’s ground 5 is not likely to succeed, and should not be instituted.

C. Proposed Grounds 6 and 7: Lucey in View of Ahrenkiel⁸

1. Lucey Uses the Hot-Injection Method to make Quantum Dots, While Ahrenkiel Uses the SLS Method to Make Quantum Rods

Lucey uses the hot-injection method to create InP nanoparticles. Ex. 1011 at 12:38-41 (“The initiation of the reaction occurs when the ER_n source is rapidly injected into a heated solution of ML_n source in the non-coordinating solvent.”). By contrast, Ahrenkiel uses the SLS method to create quantum rods. Ex. 1012 at 834 (disclosing “[t]he growth of InP quantum rods and quantum wires by the solution-liquid-solid mechanism”). Despite this fundamental difference between the references, Petitioner argues that “a POSITA would have been motivated to replace

⁸ Although Ground 7 adds a second reference, Treadway, with respect to the “ternary and quaternary” claim elements of certain dependent claims, Petitioner does not contend that Treadway discloses a molecular cluster compound, a semiconductor material comprising one or more elements not comprised within the molecular cluster compound, or multiple precursors. Thus, the shortcomings persist for the same reasons provided in relation to Ground 6.

Lucey's single group 15 or 16-based precursor with Ahrenkiel's multiple precursors because it would maximize the optical efficiency of the resulting nanoparticles by affecting their size and shape." Petition at 55. There are many problems with this argument.

2. Even Replacing Lucey's Precursor with Ahrenkiel's Multiple Precursors Would Not Practice the Claims of the '365 Patent Because Both of Ahrenkiel's Precursors Provide the Ions to Be Incorporated into the Semiconductor Core

Lucey does not disclose "the semiconductor material comprises one or more elements not comprised within the molecular cluster compound" as required by all claims of the '365 patent. Ex. 1001 at 20:9-13. Petitioner's alleged molecular cluster compounds in Lucey are actually precursors that contribute atoms to the semiconductor core, and therefore provide exactly *the same* elements comprised in the core, not different ones.

Petitioner points to three potential molecular cluster compounds in Lucey: $[\text{Me}_2\text{GaNH}_2]_3$, $[\text{Me}_2\text{GaN}(\text{H})(\text{Me})]_3$, and $[\text{Me}_2\text{GaN}(\text{Me})(\text{Ph})]_3$. These compounds are precursors that contribute group III atoms (in this case gallium (Ga)) to a group III-V semiconductor core. Ex. 1011 at 1:57-61 (the compounds "may be used as precursors for synthesis of III-V semiconductor nanocrystals"). One aspect of the alleged invention in Lucey is a process for making these group III precursors. Ex. 1011 at 4:31-34 ("Another aspect of the present invention is a process for producing

compounds useful as *Group III precursors for producing III-V nanocrystals* in accordance with processes of the present invention”) (emphasis added). Ex. 1011 at 8:55-12:17. Because the clusters serve as precursors and contribute the group III atom to the group III-V semiconductor core, they comprise the same atoms as in the semiconductor, and thus cannot satisfy the claim element “the semiconductor material comprises one or more elements not comprised within the molecular cluster compound.”

Even if one replaced Lucey’s precursor with Ahrenkiel’s multiple precursors, the resultant process would still not disclose the claim element “the semiconductor material comprises one or more elements not comprised within the molecular cluster compound.” Ahrenkiel’s precursors provide indium phosphide (InP) itself to an InP semiconductor. Ex. 1012 at 833 (“we used an organometallic precursor that decomposes thermally into InP”); *see also id.* at 834 (“we used a mixture of [(t-Bu)2InP(SiMe₃)₂]₂ and [Cl2InP(SiMe₃)₂]₂ precursors”) (emphasis added). Thus, the combination of Lucey with Ahrenkiel does nothing to disclose “the semiconductor material comprises one or more elements not comprised within the molecular cluster compound.”

Also, many claims of the ’365 patent require that the first precursor species contains a first ion (such as indium), and a separate second precursor species contains a second ion (such as phosphorus), with both precursors providing a

different ion to be incorporated into the growing quantum dot core. Ex. 1001 at 20:57-63 (“the precursor composition comprising a first precursor species containing a first ion to be incorporated into the core semiconductor material and a separate second precursor species containing a second ion to be incorporated into the core semiconductor material”); *see also id.* at 4:51-58. Ahrenkiel’s precursors do not provide separate indium and phosphorus ions to be incorporated into the nanorods, but rather both provide indium phosphide (InP) itself. Ex. 1012 at 833-834 (showing [(t-Bu)2InP(SiMe₃)₂]₂ and [Cl2InP(SiMe₃)₂]₂ precursors). Because both precursors provide the exact same thing, namely InP, the precursor combination used by Ahrenkiel does not disclose “a first precursor species containing a first ion to be incorporated into the core semiconductor material and a separate second precursor species containing a second ion to be incorporated into the core semiconductor material.” of the ’365 patent. Ex. 1001 at 20:57-63; *see also id.* at 4:51-58.

3. Lucey’s Expressly Teaches Away from Ahrenkiel’s Chlorine-Based Precursors

Lucey expressly teaches away from the Ahrenkiel’s precursors. Ahrenkiel’s second precursor ([Cl2InP(SiMe₃)₂]₂) has chlorine (Cl) atoms in it. Chlorine belongs to a class of elements known as halogens. *See* Ex. 2023 (“Halogen: any of the five elements fluorine, chlorine, bromine, iodine, and astatine that form part of group

VIIA”). Compounds that contain halogens such as chlorine are called halides. Ex. 2024 (“Halide: (1) A compound containing a halogen atom”). Lucey is very specific that halide-containing precursors should not be used. *See* Ex. 1011 at 3:53-57 (“The most common precursors are the Mm(halides)₃. When utilizing these precursors, the resultant semiconductor nanocrystals have the propensity to have halide impurities. These impurities hinder the desired electronic or optical properties of the nanocrystals.”); *see also id.* at 5:14-15 (“The Group III precursors prepared in accordance with the present invention ***do not contain halide*** impurities”); *id.* at 8:61-62 (“The following describes the preparation of very pure Group III precursors which ***do not contain halide*** impurities.”) (emphasis added). An artisan would not be motivated to combine Ahrenkiel’s chlorine-based halogen precursor with Lucey in light of Lucey’s clear teaching away from such precursors.

4. There Is No Motivation to Combine Lucey and Ahrenkiel, and No Reasonable Expectation of Success

There is no motivation to combine Ahrenkiel with Lucey because Ahrenkiel is directed to the SLS method of creating quantum rods while Lucey is directed to the hot-injection method of making quantum dots. *Compare* Ex. 1012 at 834 (Ahrenkiel describing “[t]he growth of InP quantum rods and quantum wires by the solution-liquid-solid mechanism”), *with* Ex. 1011 at 5:49-51 and Fig. 3 (Lucey describing FIG. 3 as the “nanocrystal of the present invention”)

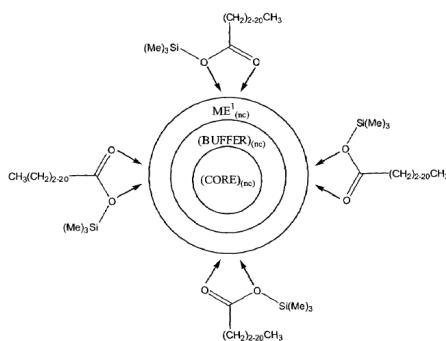


FIGURE 3

As discussed above, the SLS method involves a melted metal droplet that dissolves precursors until they are supersaturated and deposited on a growing nanorod. *See* Ex. 2009 at 422. The reason Ahrenkiel uses two precursors is very specific to this SLS method and to quantum rods in particular. It has no application to hot-injection methods of making quantum dots.

Ahrenkiel uses its precursors to accomplish two things: (1) the precursors create melted metallic indium droplets to enable the SLS growth method, and (2) the precursors provide the InP to be deposited on the growing nanorod. *See* Ex. 1012 at 834 (“the *solution-liquid-solid* mechanism requires the presence of extremely *small metal indium particles that serve as a catalyst* for the growth of InP. The diameter of the indium particles determines the diameter of the nanorods. Indium particles can be . . . *produced simultaneously during InP growth from an organometallic molecular precursor* . . .”). Because Lucey does not use the SLS method, there is no need for Lucey to use precursors that thermally decompose into molten indium.

Moreover, Ahrenkiel gives a very specific reason for using two precursors. Specifically, Ahrenkiel explains that “[w]hen only the [one] precursor was present in the system, a large number of indium droplets and short InP fibers were produced.” Ex. 1012 at 834. “Because of that,” Ahrenkiel added a second InP precursor to the first InP precursor “to increase the total InP precursor concentration and, consequently, the length of the InP nanorods.” Ex. 1012 at 834. Thus, Ahrenkiel uses two precursors is to the increase the *length* of the nanorods—but the optical properties of nanorods are dictated by their diameter and shape, not their length. Ex. 1012 at 823 (“The electrical and optical properties of semiconductor nanowires and nanorods are controlled by their diameter and shape.”). Therefore, Petitioner is incorrect that Ahrenkiel’s “multiple precursors allows tailoring the physical dimensions of the nanoparticle and tuning its optical efficiency.” Petition at 55. As Lucey was creating spherical quantum dots, there would be no motivation to use precursors that created longer nanorods.

VIII. CONCLUSION

For each and all the foregoing reasons, the Board should deny the Petition.

Dated: February 24, 2021

Respectfully submitted,

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CERTIFICATE OF WORD COUNT

Pursuant to 37 CFR § 42.24(d), Patent Owner hereby certifies, in reliance on the word count of the word-processing system (Microsoft Office Word 2016) used to prepare this preliminary response, that the number of words in this paper is 12,608. This word count excludes the tables of contents, tables of authorities, certificate of word count, certificate of service, and table of exhibits.

Dated: February 24, 2021

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CERTIFICATE OF SERVICE

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