

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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NANOSYS, INC.,  
Petitioner,

v.

THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ARKANSAS,  
Patent Owner.

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IPR2020-00503  
Patent 7,105,051 B2

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Before JEFFREY W. ABRAHAM, RAE LYNN P. GUEST, and  
JULIA HEANEY, *Administrative Patent Judges*.

HEANEY, *Administrative Patent Judge*.

JUDGMENT  
Final Written Decision  
Determining No Challenged Claim Unpatentable  
*37 C.F.R. § 318*

## I. INTRODUCTION

Nanosys, Inc. (“Petitioner”) filed a Petition to institute an *inter partes* review of claims 1–11 and 13–23 of U.S. Patent No. 7,105,051 B2 (Ex. 1001, “the ’051 patent”). Paper 2 (“Petition” or “Pet.”). The Board of Trustees of the University of Arkansas (“Patent Owner”) filed a Preliminary Response. Paper 7 (“Prelim. Resp.”). Taking into account the arguments presented in Patent Owner’s Preliminary Response, we determined the information presented in the Petition established that there was a reasonable likelihood that Petitioner would prevail in challenging at least one of claims 1–11 and 13–23 of the ’051 patent, and we instituted this *inter partes* review as to all challenged claims. Paper 8 (“Dec. on Inst.”).

During the course of trial, Patent Owner filed a Patent Owner Response (Paper 11, “PO Resp.”); Petitioner filed a Reply to the Patent Owner Response (Paper 16, “Pet. Reply”); Patent Owner filed a Sur-reply (Paper 23, “PO Sur-reply”). An oral hearing was held on May 19, 2021, and a transcript of the hearing is included in the record. Paper 26 (“Tr.”).

We have jurisdiction under 35 U.S.C. § 6. This decision is a Final Written Decision under 35 U.S.C. § 318(a) as to the patentability of claims 1–11 and 13–23 of the ’051 patent. For the reasons discussed below, we hold that Petitioner has not established by a preponderance of the evidence that any of the challenged claims are unpatentable.

## II. BACKGROUND

### A. *Related Proceedings*

The parties identify *NNCrystal US Corp. v. Nanosys, Inc.*, C.A. No. 1:19-cv-01307 (RGA) (D. Del.) as a related matter. Pet. 2; Paper 5, 1.

*B. The '051 Patent*

The '051 patent is titled “High Quality Colloidal Nanocrystals and Methods of Preparing the Same in Non-Coordinating Solvents.” Ex. 1001, code (54). According to the '051 patent, colloidal nanocrystals are of great interest for industrial applications and academic studies due to their unique size-dependent properties and flexible processing chemistry. *Id.* at 1:44–47. The '051 patent explains that conventional synthesis schemes were sometimes irreproducible, often provided low quality crystals, possessed high polydispersities, were plagued by impurities, and required the use of toxic, pyrophoric, and unstable reagents. *Id.* at 1:58–65. The '051 patent also explains that conventional synthesis methods for high quality nanocrystals used coordinating solvents or mixtures of several coordinating reagents as a solvent, which made it difficult to identify an appropriate solvent system for crystal growth. *Id.* at 2:41–66.

In view of these problems, the '051 patent identifies a need for an improved method of preparing nanocrystals that avoids the toxic solvents commonly used, provides greener approaches using more recyclable solvents, uses solvents that are liquid at room temperature to provide lower costs, and imparts the ability “to control the size of the nanocrystals produced, without sacrificing the desired narrow size distribution.” *Id.* at 3:8–19. The '051 patent states “[t]he present invention demonstrates that, despite the general belief that coordinating solvents are necessary for preparing semiconductor nanocrystals, these materials may in fact be prepared in non-coordinating solvents.” *Id.* at 20–23.

The '051 patent discloses providing colloidal nanocrystals that, in their as-prepared state, luminesce between about 500–700 nm, and are

highly monodispersed. *Id.* at 3:31–35. The '051 patent explains that “[h]igh quality colloidal nanocrystals are nanometer sized fragments formed in solution with well-controlled size, shape, surface structures, and excellent chemical processibility.” *Id.* at 1:40–43. With regard to processing, the '051 patent discloses “a method of synthesizing semiconductor nanocrystals by combining a cation precursor, a ligand, and a non-coordinating solvent to form a cation-ligand complex and then admixing an anion precursor dissolved in a non-coordinating solvent with the cation-ligand complex at a temperature sufficient to form nanocrystals.” *Id.* at 4:6–12.

The '051 patent explains that non-coordinating solvents allow more environmentally innocuous precursors and ligands to be used, and provides a greener and less expensive synthesis method. *Id.* at 3:65–4:3. The '051 patent describes four guidelines for selecting a non-coordinating solvent for preparing high quality semiconductor nanocrystals (*id.* at 8:64–9:20) and based on these guidelines, states that technical grade octadecene (ODE) is a good choice as a non-coordinating solvent. *Id.* at 4:4–5; 9:25–27. The '051 patent also states “in some preparations, certain ethers can constitute reasonable non-coordinating solvents.” *Id.* at 9:39–40. The '051 patent states that “cation precursors can be elements, covalent compounds, or ionic compounds, including coordination complexes or a metal salt, that serve as a source for the electropositive element or elements in the resulting nanocrystal” and “[a]nion precursors can also be elements, covalent compounds, or ionic compounds that serve as a source for the electronegative element or elements in the resulting nanocrystal.” *Id.* at 4:12–16, 4:18–21. For instance, the '051 patent explains that its methods are generally applicable to nanocrystals prepared from cation precursor

compounds of group II metals, group IV metals, or transition metals and anion precursors selected from the element itself, covalent compounds, or ionic compounds of group V elements, group VI elements, or group VII elements. *Id.* at 4:28–35, 4:45–49. According to the '051 patent, “the ligand is selected from fatty acids, amines, phosphines, phosphine oxides, or phosphonic acids” in a typical preparation. *Id.* at 4:42–44.

*C. The Challenged Claims*

Petitioner challenges claims 1–11 and 13–23 of the '051 patent.

Pet. 1. Claims 2–11 and 13–21 depend from claim 1, and claim 23 depends from claim 22. Claim 1, reproduced below, is illustrative of the subject matter of the challenged claims:

1. A method of synthesizing colloidal nanocrystals, comprising:
  - a) combining a cation precursor, a ligand, and a noncoordinating solvent to form a cation-ligand complex; and
  - b) admixing an anion precursor with the cation-ligand complex at a temperature sufficient to form nanocrystals.

Ex. 1001, 19:26–33.

Claim 22, the other independent claim challenged by Petitioner, is reproduced below:

22. A method of synthesizing colloidal nanocrystals, comprising:
  - a) combining a cation precursor, a ligand, and a noncoordinating solvent to form a cation-ligand complex; and
  - b) admixing an anion precursor with the cation-ligand complex at a first temperature sufficient to induce

reaction between the cation-ligand complex and the anion precursor; and

c) adjusting the temperature of the mixture to a second temperature sufficient to form nanocrystals of the reaction product.

Ex. 1001, 20:24–34.

*D. Instituted Grounds of Unpatentability*

We instituted trial to determine whether the challenged claims are unpatentable based on the following grounds:

Ground	Challenged Claim(s)	35 U.S.C. § <sup>1</sup>	Reference(s)/Basis
1	1–9, 11, 14, and 21	102(b)	Trentler <sup>2</sup>
2	10	103	Trentler, Aldrich Catalog <sup>3</sup>
3	2, 3, 15–18	103	Trentler, Murray 1993 <sup>4</sup>
4	13	103	Trentler
5	4, 19, 20	103	Trentler, Alivisatos <sup>5</sup>
6	1–9, 11, 13, 14, 19–21	103	Alivisatos, Trentler
7	22, 23	102(b)	Gao <sup>6</sup>

<sup>1</sup> The Leahy-Smith America Invents Act (“AIA”) included revisions to 35 U.S.C. § 103 that became effective on March 16, 2013. Because the ’051 patent issued from an application filed before March 16, 2013, we apply the pre-AIA versions of the statutory bases for unpatentability.

<sup>2</sup> Trentler, T.J., *et al.*, “Synthesis of TiO<sub>2</sub> Nanocrystals by Nonhydrolytic Solution-Based Reactions,” *J. Am. Chem. Soc.*, 121(5), 1613–1614 (1999) (Ex. 1005)

<sup>3</sup> Aldrich Catalog Handbook of Fine Chemicals 199 (1997) (Ex. 1006).

<sup>4</sup> Murray, C.B., *et al.*, “Synthesis and Characterization of Nearly Monodisperse CdE (E = S, Se, Te) Semiconductor Nanocrystallites,” *J. Am. Chem. Soc.*, 115(19), 8706–15 (1993) (Ex. 1022).

<sup>5</sup> U.S. Patent No. 5,505,928 to Alivisatos *et al.* (Ex. 1008).

<sup>6</sup> Gao, S., *et al.*, “Study on the factors affecting the particles size of GaP nanocrystalline materials,” *Journal of Crystal Growth*, 192(1-2), 89–92 (1998) (Ex. 1009).

Ground	Challenged Claim(s)	35 U.S.C. § <sup>1</sup>	Reference(s)/Basis
8	22, 23	102(b)	Alivisatos

Pet. 3. Petitioner relies on the Declaration of Dr. Jonathan S. Owen. (Ex. 1003) and Second Declaration of Dr. Jonathan S. Owen (Ex. 1027). Patent Owner relies on the Declaration of Dr. Javier Vela-Becerra (“Dr. Vela”) (Ex. 2001).

### III. ANALYSIS

#### A. Claim Construction

In the Institution Decision, we determined that the preamble claim term “method for synthesizing colloidal nanocrystals,” if it were given patentable weight, should be construed to encompass methods for producing nanocrystals that are dispersed as a colloid or could be dispersed as a colloid, as argued by Petitioner.

For the reasons set forth in the discussion below, we have determined it is not necessary to further address the parties’ dispute as to the construction of “method for synthesizing colloidal nanocrystals” in order to resolve each of Petitioner’s grounds of unpatentability against the challenged claims. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (“we need only construe terms ‘that are in controversy, and only 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. 2011))). Therefore, for purposes of this Decision, we do not construe any claim term.

*B. Level of Ordinary Skill in the Art*

Factors pertinent to a determination of the level of ordinary skill in the art include “(1) educational level of the inventor; (2) type of problems encountered in the art; (3) prior art solutions to those problems; (4) rapidity with which innovations are made; (5) sophistication of the technology; and (6) educational level of workers active in the field.” *Envtl. Designs, Ltd. v. Union Oil Co.*, 713 F.2d 693, 696–697 (Fed. Cir. 1983) (citing *Orthopedic Equip. Co. v. All Orthopedic Appliances, Inc.*, 707 F.2d 1376, 1381–82 (Fed. Cir. 1983)). Not all such factors may be present in every case, and one or more of these or other factors may predominate in a particular case. *Id.*

In our Institution Decision, we adopted Petitioner’s formulation of the level of ordinary skill in the art and determined that a person of ordinary skill in the art at the time of the invention “in the field of the ’051 patent would have had knowledge of scientific literature and skills relating to that field, including the synthesis of nanocrystals before July 30, 2001” and a person of ordinary skill in the art “would have had a Masters or Ph.D. in chemistry or material sciences, or a related discipline, with at least three years of experience in the field of nanocrystal synthesis.” Dec. on Inst. 13–14 (adopting Petitioner’s formulation, as supported by Dr. Owen’s testimony, because it is consistent with the ’051 patent and the asserted prior art.). Patent Owner does not dispute the level of ordinary skill in the art. *See Ex. 2001 ¶ 25*. Accordingly, having considered the arguments and evidence, we maintain our determination from the Institution Decision adopting Petitioner’s proposed level of ordinary skill in the art, as it is consistent with the problems and solutions in the ’051 patent and prior art of record.

*C. Principles of Law*

“Anticipation requires that every limitation of the claim in issue be disclosed, either expressly or under principles of inherency, in a single prior art reference,” *Corning Glass Works v. Sumitomo Elec. U.S.A., Inc.*, 868 F.2d 1251, 1255–56 (Fed. Cir. 1989), and that the claim limitations be “arranged or combined in the same way as recited in the claim,” *Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1371 (Fed. Cir. 2008). However, “the reference need not satisfy an *ipsissimis verbis* test.” *In re Gleave*, 560 F.3d 1331, 1334 (Fed. Cir. 2009).

A claim is unpatentable under 35 U.S.C. § 103 if “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 to a person having ordinary skill in the art to which said subject matter pertains.” *KSR Int’l Inc. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when available, evidence such as commercial success, long felt but unsolved needs, and failure of others. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966); *see KSR*, 550 U.S. at 407 (“While the sequence of these questions might be reordered in any particular case, the [Graham] factors continue to define the inquiry that controls.”).

The Supreme Court made clear that we apply “an expansive and flexible approach” to the question of obviousness. *KSR*, 550 U.S. at 415. Whether a patent claiming the combination of prior art elements would have

been obvious is determined by whether the improvement is more than the predictable use of prior art elements according to their established functions. *Id.* at 417. Reaching this conclusion, however, requires more than merely showing that the prior art includes separate references covering each separate limitation in a challenged claim. *Unigene Labs., Inc. v. Apotex, Inc.*, 655 F.3d 1352, 1360 (Fed. Cir. 2011). Rather, obviousness additionally requires that a person of ordinary skill at the time of the invention “would have selected and combined those prior art elements in the normal course of research and development to yield the claimed invention.” *Id.*

*D. Ground 1: Alleged Anticipation Based on Trentler*

Petitioner argues that claims 1–9, 11, 14, and 21 are anticipated by Trentler. Pet. 16–23.

*Trentler (Ex. 1005)*

Trentler is titled “Synthesis of TiO<sub>2</sub> Nanocrystals by Nonhydrolytic Solution-Based Reactions.” Ex. 1005, 1613. Trentler discloses a procedure for making nanocrystalline materials in which a titanium halide is mixed with distilled trioethylphosphine oxide (TOPO) in heptadecane and heated to 300 °C under dry nitrogen. *Id.* at 1613. Subsequently, a metal alkoxide is rapidly injected into the hot solution, with high reactant concentrations leading “to the formation of off-white precipitates which could be recovered as powders” while lower reactant concentrations provide clear, orange solutions. *Id.* Trentler describes isolating reaction precipitates via centrifugation and washing with acetone. *Id.* According to Trentler, the powders obtained were anatase TiO<sub>2</sub>, and X-ray diffraction line widths indicated crystalline domains under 10 nm in diameter. *Id.*

*Claim 1*

Petitioner contends that Trentler describes in detail the procedures, conditions, and reagents used in successfully synthesizing nanocrystals capable of forming a colloid in a solvent (Pet. 18 (citing Ex. 1003 ¶ 100)), and given the high level of skill in the art, a person of ordinary skill would have readily been able to repeat Trentler's procedures. *Id.* Petitioner further contends Trentler describes two products of its synthesis, i.e. “[p]owders having crystalline domains under 10 nm diameter” and “redispersed” nanocrystals. *Id.* at 17 (citing Ex. 1005, 1613). Petitioner contends that the powders under 10 nm diameter could have formed a colloid in a solvent, and that the “redispersed” nanocrystals were colloidal because they were dispersed in solution. *Id.* (citing Ex. 1003 ¶ 99).

*“cation-ligand complex”*

Claim 1 recites “combining a cation precursor, a ligand, and a non-coordinating solvent to form a cation-ligand complex.” Ex. 1001, 19:28–29. Petitioner contends that Trentler discloses a nanocrystal synthesis in which a titanium halide “‘was mixed with distilled trioctylphosphine oxide’ (TOPO) ‘in heptadecane.’” Pet. 16 (citing Ex. 1003 ¶¶ 91–92; Ex. 1005, 1613). Petitioner contends that a person of ordinary skill in the art would have understood that a titanium halide was a cation precursor, TOPO was a ligand, and heptadecane was a non-coordinating solvent, according to the ’051 patent (*id.* (citing Ex. 1003 ¶¶ 92–95); Pet. Reply 6–7), and further would have understood from Trentler's disclosure that titanium iodide and TOPO form a cation-ligand complex when heated to 300 °C, because the electron pairs of TOPO bind to titanium. *Id.* at 17 (citing Ex. 1003 ¶ 96; Ex. 1005, 1613); *see also* Pet. Reply 5–6; Ex. 1027 ¶ 24 (“titanium halides,

such as  $TiI_4$ , are powerful Lewis acids capable of binding with weakly coordinating ligands including ethers, water, and TOPO.”).

Petitioner further contends that a person of ordinary skill in the art would have understood that Trentler discloses a cation-ligand complex in view of background prior art, Poleshchuk<sup>7</sup> (Ex. 1054). Pet. Reply, 6 (citing Ex. 1003 ¶ 96; Ex. 1027 ¶ 23–25; Ex. 1054, 5<sup>8</sup>). Petitioner relies on Dr. Owen’s testimony that a person of ordinary skill in the art would have understood that Poleshchuk shows  $TiCl_4$ , one of the titanium halides mentioned by Trentler, forms a ligand-cation complex with  $Ph_3PO$  in a non-coordinating solvent, carbon tetrachloride. *Id.* (citing Ex. 1027 ¶ 25). According to Dr. Owen, a person of ordinary skill would have expected TOPO would be more likely to form a cation-ligand complex than  $Ph_3PO$  because TOPO is a stronger binder. Ex. 1027 ¶ 25 (citing Ex. 1054, 16; Ex. 1061, 6).

Patent Owner contends that Trentler does not expressly disclose the formation of a cation-ligand complex.<sup>9</sup> PO Resp. 19–20. Patent Owner contends that Trentler instead describes TOPO “as a ‘passivating agent’ and ‘surface capping group’ that coordinates to the surface of a nanocrystal, not as an agent that forms a cation-ligand complex with titanium.” *Id.* at 20 (citing Ex. 1005, 7; Ex. 2001 ¶ 105). Patent Owner further contends that Trentler does not describe any indicia of the formation of a cation-ligand

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<sup>7</sup> Poleshchuk, O.Kh., *et al.*, “Electron Density Redistribution on Complexation in Non-transition Element Complexes,” *J. Mol. Structure*, 297, 295 (1993).

<sup>8</sup> We refer to the page numbers of Exhibit 1054 assigned by Petitioner.

<sup>9</sup> Petitioner does not contend that Trentler inherently discloses formation of a cation-ligand complex. Pet. Reply 6.

complex, such as solubilizing of the cation precursor, a color change, or a precipitate (PO Sur-reply 5 (citing Ex. 1005, 7; Ex. 1027 ¶¶ 23–25)), unlike the '051 patent and Poleshchuk, which demonstrate complex formation by an optically clear solution and precipitation, respectively. *Id.* at 5–6 (citing Ex. 1001, 16:22–18:26; Ex. 1053, 43:12–45:24, 48:5–49:14, 52:1–16; Ex. 2001, 126 (App. A), 131 (App. B); Ex. 1054, 5; Ex. 2041, 36:2–10). As to Poleshchuk, Patent Owner contends it provides no support for what a person of ordinary skill in the art would infer from Trentler, because it describes reactions different from those taught by Trentler and provides examples of mixing Lewis acids and bases that do not result in the formation of any complex. *Id.* at 9 (citing Ex. 1005, 7; Ex. 1054, 5, 7, 10; Ex. 2041, 18:22–28:7, 30:22–32:8, 33:4–35:24, 36:2–20, 39:23–40:7, 43:8–18, 47:19–50:3). Patent Owner also disputes that a person of ordinary skill would have expected TOPO to be more likely to form a cation-ligand complex than Poleshchuk's  $\text{Ph}_3\text{PO}$  because TOPO is a stronger binder; Patent Owner asserts that Tolman<sup>10</sup> (Ex. 1061) contradicts Dr. Owen's opinion that TOPO is a stronger binder. *Id.* at 10 (citing Ex. 1027 ¶ 25; Ex. 1061, 6, 13; Ex. 2041, 126:7–128:25; 135:17–137:20).

Patent Owner further contends that Dr. Owen's testimony that a person of ordinary skill in the art would have understood that Trentler discloses a cation-ligand complex is irreconcilable with how Trentler has been addressed in other literature in the art, which does not recognize Trentler's reaction as forming a cation-ligand complex. PO Sur-reply 7–8 (citing Ex. 2023, 17, 20; Ex. 2024, 10, 23, 24; Ex. 2025, 12, 25, 37, 60;

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<sup>10</sup> Tolman, C.A., "Steric Effects of Phosphorous Ligands in Organometallic Chemistry and Homogeneous Catalysis," *Chem. Rev.* 77: 313–348 (1977).

Ex. 2026, 14, 25, 34, 36, 41; Ex. 2028, 1, 2, 8). Also, Dr. Vela testifies that some literature in the art, unlike Trentler, explicitly reported formation of a cation-ligand complex. *See* PO Sur-reply 9 (citing Ex. 2001 ¶¶ 102–103; Ex. 1018, 9; Ex. 2007, 4).

Having considered the arguments and evidence of record, it is undisputed that Trentler does not expressly disclose the formation of a cation-ligand complex. As to whether a person of ordinary skill in the art would have understood Trentler to disclose the formation of a cation-ligand complex, we are not persuaded by Petitioner's argument that Poleshchuk would have led a person of ordinary skill to understand Trentler as disclosing a cation-ligand complex. Although Dr. Owen's testimony that a person of ordinary skill in the art would have expected Trentler's TOPO to form a cation-ligand complex with  $\text{TiCl}_4$  because Poleshchuk's  $\text{Ph}_3\text{PO}$  forms a cation-ligand complex with  $\text{TiCl}_4$  has a rational basis in its comparison of TOPO and  $\text{Ph}_3\text{PO}$ 's structures (*see* Ex. 1027 ¶ 25), Petitioner and Dr. Owen fail to consider the effects of other differences between Poleshchuk's and Trentler's reactions, such as thermal conditions and solvent differences. *E.g.*, Ex. 1005, 7; 1054, 5; Ex. 2041, 18:22-28:7, 43:8-18. Further, Petitioner and Dr. Owen do not address that Poleshchuk's reaction description includes formation of a precipitate, which indicates formation of a cation-ligand complex, whereas Trentler does not describe any indicia of formation of a complex. *See* Ex. 1027 ¶¶ 23–25. In view of the other literature referencing Trentler that Patent Owner identifies, as discussed below, Poleshchuk is not persuasive evidence that a person of ordinary skill would have understood Trentler to disclose formation of a cation-ligand complex.

We also credit Dr. Vela's testimony that Trentler describes TOPO as a "passivating agent" and a "surface capping group" that coordinates the surface of titanium atoms at the surface of the nanocrystal, not as an agent that forms a complex with the titanium cation precursor. Ex. 2001 ¶ 105. Trentler's description of its TiO<sub>2</sub> nanocrystals and their synthesis states:

These particles are highly dispersible in hydrocarbon solvents due to the coordination of surface titanium atoms to passivating agents employed during the reaction. The use of coordination chemistry to stabilize the nanocrystals allows for ready exchange of surface capping groups which should provide control over the surface and consequently over properties.

Ex. 1005, 1613. Trentler subsequently states that "[t]he amount of passivating agent (TOPO) present in the reactions also clearly influences the chemistry." *Id.* at 1614. Thus, Trentler itself supports Dr. Vela's testimony.

Further, Dr. Vela's opinion is consistent with literature in the art that does not recognize Trentler's reaction as forming a cation-ligand complex. Patent Owner points to numerous references (Exs. 2023, 2024, 2025, 2026, 2028) that summarize Trentler without mentioning formation of a cation-ligand complex, while expressly recognizing other reactions that formed cation-ligand complexes. Petitioner does not dispute the teachings of these references.

We do not find persuasive Petitioner's argument that Dr. Vela's testimony that a person of ordinary skill in the art "would have understood each example in the '051 patent described the formation of a 'cation-ligand complex' even though none of those examples explicitly mention such complexes" (Pet. Reply 5) undercuts his opinion as to Trentler's lack of disclosure of a cation-ligand complex. Dr. Vela's opinion is not merely

based on the absence of an express disclosure of “cation-ligand complex” in Trentler, but also on the absence of any indicia of the formation of a cation-ligand complex. Further, Petitioner mischaracterizes Dr. Vela’s testimony about complex formation; he did not testify “any POSA could have looked at a given reaction and known whether” a cation-ligand complex formed (*see* Pet. Reply 6), but rather opined that a person of ordinary skill in the art would have understood the ’051 patent’s examples describe formation of a cation-ligand complex in the context of the entire patent, including experimental indications such as a color change. Ex. 1053, 44–58.

At most, Dr. Owen’s testimony (Ex. 1003 ¶ 96; Ex. 1027 ¶¶ 24–25) demonstrates that a person of ordinary skill would have understood Trentler’s reaction as capable of forming a cation-ligand complex under certain conditions. Even if a person of ordinary skill in the art would have understood Trentler’s titanium halide to be capable of binding with a weakly coordinating ligand such as TOPO, however, that does not sufficiently demonstrate that Trentler discloses formation of a cation-ligand complex, for the purpose of finding anticipation.

Accordingly, we determine Petitioner has not carried its burden to demonstrate by a preponderance of the evidence that Trentler discloses formation of a cation-ligand complex, as required by claim 1.

*Claims 2–9, 11, 14, and 21*

Claims 2–9, 11, 14, and 21 each depend from claim 1. Petitioner’s arguments with respect to dependent claims 2–9, 11, 14, and 21 do not address the deficiency discussed above with respect to claim 1. *See* Pet. 16–23.

*Conclusion*

For the foregoing reasons, we conclude that Petitioner has not demonstrated by a preponderance of the evidence that claims 1–9, 11, 14, and 21 are anticipated by Trentler.

*E. Ground 2: Alleged Obviousness Based on Trentler and Aldrich Catalog*

Petitioner argues claim 10 would have been obvious over the combined teachings of Trentler and the Aldrich Catalog. Pet. 24–30. Petitioner’s obviousness arguments based on Trentler and the Aldrich Catalog do not address or remedy the deficiency discussed above with regard to formation of a cation-ligand complex. Thus, Petitioner has not demonstrated by a preponderance of the evidence that claim 10 would have been obvious over the combination of Trentler and Aldrich Catalog.

*F. Ground 3: Alleged Obviousness Based on Trentler and Murray 1993*

Petitioner argues claims 2, 3, and 15–18 would have been obvious over the combined teachings of Trentler and Murray 1993. Pet. 31–37. Petitioner’s obviousness arguments based on Trentler and Murray 1993 do not address or remedy the deficiency discussed above with regard to formation of a cation-ligand complex. Thus, Petitioner has not demonstrated by a preponderance of the evidence that claims 2, 3, and 15–18 would have been obvious over the combination of Trentler and Murray 1993.

*G. Ground 4: Alleged Obviousness Based on Trentler*

Petitioner argues dependent claim 13 would have been obvious over the combined teachings of Trentler. Pet. 37–41. Petitioner’s obviousness argument based on Trentler does not address or remedy the deficiency

discussed above with regard to formation of a cation-ligand complex. Thus, Petitioner has not demonstrated by a preponderance of the evidence that claim 13 would have been obvious over Trentler.

*H. Ground 5: Alleged Obviousness Based on Trentler and Alivisatos*

Petitioner argues dependent claims 4, 19, and 20 would have been obvious over the combined teachings of Trentler and Alivisatos. Pet. 41–46. Petitioner’s obviousness arguments based on Trentler and Alivisatos do not address or remedy the deficiency discussed above with regard to formation of a cation-ligand complex. Thus, Petitioner has not demonstrated by a preponderance of the evidence that claims 4, 19, and 20 would have been obvious over the combination of Trentler and Alivisatos.

*I. Ground 6: Alleged Obviousness Based on Alivisatos and Trentler*

Petitioner argues that the combined teachings of Alivisatos and Trentler teach or suggest each limitation of claims 1–9, 11, 13, 14, and 19–21. Pet. 46–58.

*Overview of Alivisatos (Ex. 1008)*

Alivisatos, titled “Preparation of III-V Semiconductor Nanocrystals” discloses “reacting a group III metal source with a group V anion source in a liquid phase at elevated temperature in the presence of a crystallite growth terminator such as pyridine or quinolone.” Ex. 1008, codes (54), (57).

Alivisatos explains that a group III metal source can be “a GaIII salt, InIII salt, or AlIII salt, especially halide, or corresponding metal 1-6 carbon trialkyls” and “[r]epresentative metal sources include GaCl<sub>3</sub>, GaBr<sub>3</sub>, GaI<sub>3</sub>, InCl<sub>3</sub>, InBr<sub>3</sub>, AlCl<sub>3</sub>, Ga(Me)<sub>3</sub>, Ga(Et)<sub>3</sub>, Ga(Bu)<sub>3</sub>, or the like.” *Id.* at 4:16–24. Alivisatos states that “an arsenic, phosphorus, or antimony source” can serve

as a group V anion source “such as arsine, phosphine, or stibine; an alkyl arsine, phosphine or stibine; or an alkyl silyl arsine, phosphine or stibine in liquid phase at an elevated temperature.” *Id.* at 4:18–22.

Alivisatos states that when preparing III–V compounds by reacting a group III metal source with a group V nonmetal source, “the reaction medium employed plays a big part in the III–V crystallite form ultimately obtained” and “if a crystal growth terminator such as a nitrogen- or phosphorus-containing polar organic solvent is present in place of the pure nonpolar hydrocarbon of the art, one can obtain III-V crystallites which are sized in the range 30-50 Å and which are relatively monodisperse and redissolvable.” *Id.* at 2:3–12. Alivisatos further states that “[a] distinguishing feature of the preparation process is that it is carried out in a liquid reaction phase which includes at least one of these crystallite growth terminators.” *Id.* at 3:31–33. According to Alivisatos, “[c]rystallite growth terminators can include compounds which include a phosphorus or nitrogen having an unshared pair of electrons” that “can complex with the metal and bind to it, thereby presenting a surface which will prevent further crystal growth.” *Id.* at 3:33–38.

Alivisatos includes six examples of preparation of III–V nanocrystals, varying in the selection of the metal and nonmetal sources, reaction media, and crystallite growth terminators. Alivisatos’s Example 6 combines gallium and arsenide precursors in 15%/85% tributyl phosphine and a high-boiling petroleum distillate, followed by heating the solution and allowing the reaction to proceed at 300 °C for 20 hours to obtain a powder consisting of GaAs particles which are redissolvable in pyridine or quinolone. Ex. 1008, 5:27–35, 6:30–35, 6:42–46.

*Combination of Alivisatos and Trentler*

Petitioner contends that a person of ordinary skill in the art would have understood that in Alivisatos's Example 6, GaCl<sub>3</sub> was the cation precursor, tributylphosphine was the ligand, and high-boiling petroleum distillate fraction was the non-coordinating solvent. Pet. 47 (citing Ex. 1003 ¶ 211). Petitioner further contends a person of ordinary skill in the art would have understood that the GaCl<sub>3</sub> and tributylphosphine form a cation-ligand complex because the electron pairs of tributylphosphine bound to Ga. *Id.*

Petitioner also contends that Alivisatos's Example 6 discloses tris(trimethylsilyl)arsine as an anion precursor combined with petroleum distillate fraction, that was mixed with the GaCl<sub>3</sub>-tributylphosphine cation ligand complex and heated at 300 °C for 20 hours to obtain a "red powder [that] was isolated by removal of the solvent, and the powder consisted of [semiconducting] particles which are redissolvable in pyridine or quinolone." Pet. 47–48 (citing Ex. 1008, 5:27–36, 6:31–35, 6:42–46; Ex. 1003 ¶ 213). Petitioner further contends a person of ordinary skill in the art would have understood that the red powder consisted of nanocrystals capable of forming a colloid in a solvent because they were redissolvable in pyridine or quinolone and because Alivisatos further discloses "[f]lame annealing of the powder under vacuum at 450 °C improved the crystallinity of the particles." *Id.* at 48 (citing Ex. 1008, 5:33–38; Ex. 1003 ¶ 213).

Petitioner contends that to the extent Alivisatos does not disclose admixing "at a temperature sufficient to form nanocrystals," it would have been obvious to modify Alivisatos to incorporate Trentler's hot-injection method, for several reasons. Pet. 48 (citing Ex. 1003 ¶ 214). Petitioner contends that Trentler describes hot injection as a method of nanocrystal

synthesis involving injection of the solution containing the anion precursor into a pre-heated solution containing the cation-ligand complex. Ex. 1003 ¶ 214 (citing Ex. 1005, 1613).

*Motivation to Combine*

Petitioner contends that a person of ordinary skill in the art would have been motivated to use Trentler's hot-injection method to modify Alivisatos's heat-up method because hot injection was a "versatile maneuver easily adaptable into known methods of synthesizing nanocrystals, and capable of yielding higher quality nanocrystals" as compared to Alivisatos, and therefore would improve it. Pet. 48–49 (citing Ex. 1022, 8715; Ex. 1003 ¶ 215; Ex. 1005, 1613). Petitioner further contends a person of ordinary skill in the art would have known that modifying Alivisatos by incorporating Trentler's hot-injection method would improve the quality of nanocrystals (*id.* at 49–50 (citing Ex. 1003 ¶¶ 215–216; Ex. 1010, 4109; Ex. 1022, 8715)) and would have appreciated the interchangeability of Alivisatos's and Trentler's heating methods because "both references reported synthesizing nanocrystals despite varying the temperature." *Id.* at 50 (citing Ex. 1003 ¶¶ 215–216; Ex. 1005, 1613; Ex. 1008, 6:31–35, 44–46; Ex. 1022, 8715).

Patent Owner argues several reasons for why a person of ordinary skill in the art would not have been motivated to modify Alivisatos with Trentler as Petitioner proposes. PO Resp. 54–58. According to Patent Owner, Alivisatos was published in an early stage in the nanocrystal industry (1991), and over the next decade, other publications reported better results and diminished its significance. *Id.* at 55 (citing Ex. 2001 ¶ 239; Ex. 1018, 8–9; Ex. 1016, 10–11). Patent Owner contends a person of ordinary skill in the art would have known the difficulties of synthesizing Group III-

V semiconductor nanocrystals as described in Alivisatos and would not have been motivated to pursue the benefit of Trentler's hot-injection method, as Petitioner contends. *Id.* at 55–56 (citing Ex. 2001 ¶¶ 240–242; Ex. 1012, 8; Ex. 1016, 10; Ex. 1018, 8).

Patent Owner further contends that even if a person of ordinary skill in the art would have sought to modify Alivisatos to incorporate the hot-injection method, there would have been no reason to select Example 6 over other examples in Alivisatos. PO Resp. 56–57 (citing Ex. 2001 ¶¶ 214, 242–243; Ex.1022, 4; Ex. 1012, 8 n. 22). Patent Owner contends a person of ordinary skill in the art would instead have been guided toward the use of a coordinating solvent system, as in the four examples of Alivisatos that use quinolone or pyridine, because it was known that a coordinating solvent system helped to avoid difficulties in synthesizing Group III-V nanocrystals. *Id.*; PO Sur-reply 19–20.

Petitioner responds that difficulties in synthesizing Group III-V nanocrystals, such as agglomeration and polydispersity, are irrelevant because the challenged claims do not require uniformly sized or monodisperse nanocrystals. Pet. Reply 14–16. Petitioner further responds that one of the '051 patent's inventors in fact reported successful production of a Group III-V semiconductor using the hot-injection method in 1998. *Id.* at 16 (citing Ex. 1012, 9). Petitioner further contends that Patent Owner misconstrues Alivisatos because it does not point to a coordinating solvent as preferred, but rather points a person of ordinary skill to use a non-coordinating solvent to synthesize InP and InAs (Group III-V) nanocrystals. *Id.* at 16–17 (citing Ex. 1008, 4:2–5, 4:16–20, 6:37–46).

We agree with Patent Owner that Petitioner has not demonstrated sufficiently that a person of ordinary skill in the art would have modified Alivisatos's Example 6 with Trentler's hot-injection method. In view of the art Patent Owner points to that reported difficulties in preparing Group III-V nanocrystals in non-coordinating solvents at high temperatures, Petitioner does not adequately explain why a person of ordinary skill in the art would have used Alivisatos's Example 6, which used a non-coordinating solvent, as a starting point, for trying to improve the quality of Alivisatos's Group III-V nanocrystals. Instead, Petitioner argues that the difficulties are irrelevant because of the challenged claims' scope. We disagree. For purposes of an obviousness challenge, demonstrating a reason to combine teachings in the prior art requires showing that a modification would have been desirable, not merely feasible. *Winner Intern. Royalty Corp. v. Wang*, 202 F.3d 1340, 1349 (Fed. Cir. 2000); *see also 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.”). Although the reported difficulties may not be relevant to the question of whether the proposed combination was altogether feasible, we consider them to be relevant to the question of whether a person of ordinary skill in the art would have had a reason to pursue such a combination.

Petitioner's other arguments also are not persuasive in light of the art of record as a whole. The publication describing use of a hot-injection method with Group III-V semiconductors (*see* Pet. Reply 16) used a coordinating solvent, trioctylphosphine. Ex. 1012, 8. Prior art submitted by Patent Owner, as summarized above, on the whole suggests coordinating

solvents were crucial to any improvement. Further, Alivisatos does not state there is any advantage in Example 6 versus its four examples prepared in coordinating solvents. Thus, we are persuaded by Patent Owner's argument that even if a person of ordinary skill in the art had been motivated to improve the quality of Alivisatos's nanocrystals, the skilled artisan would not try do so with Trentler's hot-injection method. Rather, according to the art of record at the time of the invention as a whole, the artisan would have used coordinating solvents to try and improve Group III-V nanocrystals, rather than modifying Alivisatos's Example 6.

*Reasonable Expectation of Success*

Petitioner contends a person of ordinary skill in the art would have had a reasonable expectation of success in modifying Alivisatos with Trentler's hot-injection method because Trentler explicitly disclosed successfully synthesizing nanocrystals using the hot-injection method, and Alivisatos disclosed nanocrystal synthesis reactions similar to Trentler's reactions. Pet. 51–52 (citing Ex. 1003 ¶ 216; Ex. 1005, 1613; Ex. 1008, 4:54–65). Patent Owner contends there would have been no reasonable expectation of success in modifying Alivisatos's Example 6 to incorporate Trentler's hot-injection method. PO Resp. 58–59.

The parties' evidence and arguments on this issue overlap substantially with their evidence and arguments directed to motivation to combine. Because we have determined Petitioner has not shown a motivation to combine, it is not necessary to further address reasonable expectation of success.

*Conclusion*

For the reasons discussed above, we determine that Petitioner has not demonstrated by a preponderance of the evidence that a person of ordinary skill in the art would have had a reason to combine the teachings of Alivisatos and Trentler. Therefore, Petitioner has not shown by a preponderance of the evidence that the combination of Alivisatos and Trentler renders claims 1–9, 11, 13, 14, and 19–21 obvious.

*J. Ground 7: Alleged Anticipation Based on Gao*

Petitioner argues that Gao anticipates claims 22 and 23. Pet. 58–61.

*Gao (Ex. 1009)*

Gao, titled “Study on the factors affecting the particles size of GaP nanocrystalline materials,” describes synthesizing GaP by reacting GaCl<sub>3</sub>–Et<sub>2</sub>O and GaCl<sub>3</sub>–benzene with Na<sub>3</sub>P, respectively, at high temperature, high pressure benzene-thermal conditions. Ex. 1009, 89. According to Gao, when GaCl<sub>3</sub>–Et<sub>2</sub>O is used as a starting material, the empty p orbital of Ga atoms coordinates with O atoms of Et<sub>2</sub>O to form “a rather strong Ga ← O bond” that is difficult to break down during the reaction process, which causes the Ga atoms in solution to be small and the particle size of GaP crystals to be small with a narrow distribution. *Id.* at 91–92. Gao further states that using GaCl<sub>3</sub>–Et<sub>2</sub>O as a starting material results in more perfect crystal grains and a better particle size distribution than a sample prepared from GaCl<sub>3</sub>–benzene as the starting material. *Id.* at 91.

*Claim 22*

*a first temperature sufficient to induce reaction between the cation-ligand complex and the anion precursor*

Petitioner contends that Gao discloses procedures for synthesizing nanocrystals in which ether was used to extract GaCl<sub>3</sub> and benzene was added to the extracted GaCl<sub>3</sub>. Pet. 58 (citing Ex. 1009, 90; Ex. 1003 ¶¶ 267–268). Petitioner contends that a person of ordinary skill in the art would have understood that in Gao’s procedure, GaCl<sub>3</sub> was a cation precursor, ether was a ligand, and benzene was a non-coordinating solvent, and that the GaCl<sub>3</sub> and ether (Et<sub>2</sub>O) form a cation-ligand complex. *Id.* (citing Ex. 1009, 90; Ex. 1003 ¶ 269). Petitioner further contends that Gao discloses transferring the resulting solution containing GaCl<sub>3</sub>, ether, and benzene into an autoclave, adding benzene and Na<sub>3</sub>P, which a person of ordinary skill would recognize as an anion precursor, then sealing the autoclave. *Id.* at 59 (citing Ex. 1009, 90; Ex. 1003 ¶¶ 271–272). Petitioner contends Gao discloses “admixing . . . at a first temperature sufficient to induce reaction between the cation-ligand complex and the anion precursor” because a person of ordinary skill in the art would have understood that “the strong coordinating ability between GaCl<sub>3</sub> and Na<sub>3</sub>P would cause the formation of a Lewis acid-base adduct, even at room temperature.” *Id.* at 59–60 (citing Ex. 1003 ¶ 272). Petitioner and Dr. Owen rely on two publications, Wells 1989<sup>11</sup> (Ex. 1029) and Wells 1997<sup>12</sup> (Ex. 1020), as supporting Dr. Owen’s

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<sup>11</sup> Wells, R.L., *et al.*, “Use of Tris(trimethylsilyl)arsine To Prepare Gallium Arsenide and Indium Arsenide,” *Chemistry of Materials*, 1 (1989).

<sup>12</sup> Wells, R.L., *et al.*, “Pathways to Nanocrystalline II-V (13-15) Compound Semiconductors,” *Journal of Cluster Science*, 8, 2 (1997).

opinion that  $\text{GaCl}_3$  and  $\text{Na}_3\text{P}$  would react at room temperature. Ex. 1003 ¶ 272 (citing Ex. 1029, 4–5; Ex. 1020, 223).

Patent Owner contends Gao does not disclose admixing a cation-ligand complex and anion precursor at room temperature to induce a reaction between them. PO Resp. 60–61. Specifically, Patent Owner contends that Gao describes

very extreme conditions for the reaction to occur, including heating the reactants in an autoclave to 350–380 °C, well above the boiling point of the solvent (benzene), resulting in a high-pressure system . . . . That Gao employed these extreme conditions indicates that no reaction occurred at room temperature.

*Id.* (citing Ex. 1009, 90<sup>13</sup>; Ex. 2001 ¶ 257). Patent Owner further contends that Gao teaches it was difficult to initiate reaction between  $\text{GaCl}_3\text{-Et}_2\text{O}$  and  $\text{Na}_3\text{P}$  for several reasons: (1) Gao’s characterization of the Ga-O bond as “rather strong;” (2) the equilibrium constant of the reaction; (3) the understanding of a person of ordinary skill that reaction at room temperature would have been deterred by the stability of the Ga-O bond and the low solubility of the  $\text{Na}_3\text{P}$  precursor in benzene. *Id.* at 61 (citing Ex. 1009, 92; Ex. 2001 ¶¶ 255–257).

Patent Owner also contends that the Wells publications do not suggest that a reaction would occur at room temperature. *Id.* at 61–62 (citing Ex. 1003 ¶ 272; Ex. 2001 ¶¶ 259–261). Specifically, Patent Owner contends that neither of the Wells publications describes a reaction involving  $\text{GaCl}_3\text{-Et}_2\text{O}$  and  $\text{Na}_3\text{P}$ . *Id.*

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<sup>13</sup> We refer to the page numbering on Ex. 1009 that Petitioner referenced in the Petition.

Petitioner replies by disputing that  $\text{Na}_3\text{P}$  is “relatively unreactive” and that the  $\text{GaCl}_3\text{-Et}_2\text{O}$  complex must be broken for complexing with  $\text{Na}_3\text{P}$  to occur. Pet. Reply 22 (citing Ex. 1027 ¶¶ 39–42). Petitioner and Dr. Owen rely on two publications, Bock<sup>14</sup> (Ex. 1059) and Boardman<sup>15</sup> (Ex. 1060) as supporting Dr. Owen’s opinion that the  $\text{GaCl}_3\text{-Et}_2\text{O}$  complex need not be broken, because  $\text{GaCl}_3\text{-Et}_2\text{O}$  “binds fifth ligands.” Ex. 1027 ¶¶ 41–42 (citing Ex. 1059, 3; Ex. 1060, 1). Petitioner also contends that a person of ordinary skill in the art would have understood that  $\text{GaCl}_3\text{-Et}_2\text{O}$  “would have reacted with the extraordinarily reactive  $\text{Na}_3\text{P}$  before the reaction mixture was heated to 350–380 °C” in Gao’s process (Pet. Reply 22 (citing Ex. 1027 ¶ 42)).

Petitioner’s reply arguments do not persuasively explain why a person of ordinary skill in the art would have understood that the cation-ligand complex,  $\text{GaCl}_3\text{-Et}_2\text{O}$ , and anion precursor,  $\text{Na}_3\text{P}$ , in Gao’s procedure react at room temperature. As to the anion precursor  $\text{Na}_3\text{P}$ , Dr. Owen’s assertion that it is “extraordinarily reactive” appears to be based on a data sheet that addresses its reactivity in water, not benzene, which is the solvent in Gao’s procedure. See Ex. 1027 ¶ 39 (citing Ex. 1056). Further, Dr. Owen does not dispute that  $\text{Na}_3\text{P}$  is largely insoluble in benzene. See Ex. 2041, 139:2–4. As to the  $\text{GaCl}_3\text{-Et}_2\text{O}$  cation ligand complex, Dr. Owen’s reliance on Bock does not support Petitioner’s argument that the complex binds fifth ligands because Bock states that the complex is tetraordinated. Ex. 1059, 3.

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<sup>14</sup> Bock, S., *et al.*, “Solutions of Gallium Trichloride in Ethers,” *Z. Naturforsch.* 45b:979–984 (1990).

<sup>15</sup> Boardman, A., *et al.*, “A Gallium(III) Halide Complex Containing 5-Coordinate Gallium  $\text{GaCl}_3\text{-1,4-dioxane}$ ,” *Inorganica Chimica Acta*, 87 (1984).

Boardman also does not support Petitioner's argument because it does not expressly address Et<sub>2</sub>O as a ligand, and further explains that whether GaCl<sub>3</sub> pentacoordinates depends on the ligand. Ex. 1060; Ex. 2041, 149:13–19.

Accordingly, we are not persuaded that Petitioner presents sufficient evidence that Gao discloses mixing its cation-ligand complex with an anion precursor at a first temperature (which Petitioner contends is room temperature) sufficient to induce reaction between them. Gao does not expressly disclose inducing a reaction at room temperature, and Petitioner's contention rests on its showing that a person of ordinary skill in the art would have understood that “the strong coordinating ability between GaCl<sub>3</sub> and Na<sub>3</sub>P would cause the formation of a Lewis acid-base adduct, even at room temperature.” Pet. 59–60 (citing Ex. 1003 ¶ 272). The Wells publications (Exs. 1020, 1029) on which Petitioner relies, however, describe different reactants, solvents, and conditions than Gao, and Petitioner does not explain in light of those differences how a person of ordinary skill in the art would have applied any teaching from the Wells publications to Gao.

Therefore, we determine Petitioner has not carried its burden to demonstrate by a preponderance of the evidence that Gao discloses all of the limitations required by claim 22.

### *Claim 23*

Claim 23 depends from claim 22. Petitioner's arguments with respect to dependent claim 23 do not address the deficiency discussed above with respect to claim 22. *See* Pet. 61.

*Conclusion*

For the foregoing reasons, we conclude that Petitioner has not demonstrated by a preponderance of the evidence that claims 22 and 23 are anticipated by Gao.

*K. Ground 8: Alleged Anticipation Based on Alivisatos*

Petitioner contends that claims 22 and 23 are anticipated by Alivisatos. Pet. 61–64.

*Claim 22*

*a first temperature sufficient to induce reaction between the cation-ligand complex and the anion precursor*

As discussed in Ground 6 *supra*, Petitioner contends that a person of ordinary skill in the art would have understood that in Alivisatos’s Example 6, GaCl<sub>3</sub> was a cation precursor, tributylphosphine was a ligand, and high-boiling petroleum distillate fraction was a non-coordinating solvent, and that the GaCl<sub>3</sub> and tributylphosphine form a cation-ligand complex because the electron pairs of tributylphosphine bound to Ga. Pet. 62 (citing Ex. 1003 ¶ 285). Petitioner further contends that Alivisatos discloses tris(trimethylsilyl)arsine as an anion precursor that is mixed with the GaCl<sub>3</sub>-tributylphosphine cation ligand complex to induce a reaction at room temperature. *Id.* (citing Ex. 1003 ¶¶ 287–288). Petitioner contends a person of ordinary skill in the art would have understood “that the combination of GaCl<sub>3</sub> (a Lewis acid) and tris(trimethylsilyl)arsine (a Lewis base) would induce a reaction . . . because the strong coordinating ability between GaCl<sub>3</sub> and tris(trimethylsilyl)arsine would cause the formation of a Lewis acid-base adduct, even at room temperature.” *Id.* (citing Ex. 1003 ¶ 288).

Patent Owner contends Alivisatos does not disclose that the anion precursor and cation ligand complex were mixed “at a first temperature sufficient to induce reaction” because Alivisatos does not state the temperature at which the reagents were combined, and fails to state any sign that a reaction was induced prior to heating. PO Resp. 63 (citing Ex. 1008, 5:29–33; Ex. 2001 ¶ 269). Patent Owner further contends, similarly as discussed *supra* in Ground 7, that the Wells publications (Exs. 1020 and 1029) do not support Dr. Owen’s opinion that a reaction would occur at room temperature, because they report different precursors and reaction media from Alivisatos. *Id.* at 63–64 (citing Ex. 1003 ¶ 272; Ex. 2001 ¶¶ 259–261).

Petitioner replies by arguing that Patent Owner points to “trivial differences such as Wells 1997 using  $\text{InCl}_3$  and Alivisatos using  $\text{GaCl}_3$ , ignoring that In and Ga are both Group 13 elements.” Pet. Reply 23.

We are not persuaded that Petitioner presents sufficient evidence that Alivisatos discloses mixing its cation-ligand complex with an anion precursor at a first temperature (which Petitioner contends is room temperature) sufficient to induce reaction between them. Alivisatos does not expressly disclose inducing a reaction at room temperature. Further, Alivisatos does not describe any indicia that a reaction occurred prior to heating to 300 °C, such as a color change or formation of a precipitate. Ex. 1008, 5:19–33, 6:30–35, 44–46. In the absence of such evidence, Petitioner’s contention rests on its showing that a person of ordinary skill in the art would have understood that “the strong coordinating ability between  $\text{GaCl}_3$  and tris(trimethylsilyl)arsine would cause the formation of a Lewis acid-base adduct, even at room temperature.” Pet. 62 (citing Ex. 1003

¶ 288). The Wells publications on which Dr. Owen relies, however, describe different reactants, reaction media, and conditions than Alivisatos. Ex. 1020, 9; Ex. 1029, 6. Petitioner’s argument that these differences are “trivial” because In and Ga are both Group 13 elements is not persuasive, because it does not address additional differences between the reactions, such as temperature and reaction media. Dr. Owen acknowledged that such differences are impactful. *See* Ex. 2041, 135:17–137:3 (discussing disassociation of ligands in Tolman). In light of those differences, Petitioner does not sufficiently explain how a person of ordinary skill in the art would have applied teachings from the Wells publications to Alivisatos’s Example 6.

Therefore, we determine Petitioner has not carried its burden to demonstrate by a preponderance of the evidence that Alivisatos discloses all of the limitations required by claim 22.

#### *Claim 23*

Claim 23 depends from claim 22. Petitioner’s arguments with respect to dependent claim 23 do not address the deficiency discussed above with respect to claim 22. *See* Pet. 64.

#### *Conclusion*

For the foregoing reasons, we conclude that Petitioner has not demonstrated by a preponderance of the evidence that claims 22 and 23 are anticipated by Alivisatos.

#### IV. CONCLUSION

Based on the arguments and evidence presented by the parties during this entire proceeding, we determine that Petitioner has failed to establish, by

a preponderance of the evidence, that claims 1–11 and 13–23 of the '051 patent are unpatentable.

V. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner has not shown by a preponderance of the evidence that claims 1–11 and 13–23 of the '051 Patent are unpatentable.

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.

In summary:

<b>Claims</b>	<b>35 U.S.C. §</b>	<b>Reference(s)/Basis</b>	<b>Claims Shown Unpatentable</b>	<b>Claims Not shown Unpatentable</b>
1-9, 11, 14, 21	102(b)	Trentler		1-9, 11, 14, 21
10	103	Trentler, Aldrich Catalog		10
2, 3, 15-18	103	Trentler, Murray 1993		2, 3, 15-18
13	103	Trentler		13
4, 19, 20	103	Trentler, Alivisatos		4, 19, 20
1-9, 11, 13, 14, 19- 21	103	Alivisatos, Trentler		1-9, 11, 13, 14, 19-21
22, 23	102(b)	Gao		22, 23
22, 23	102(b)	Alivisatos		22, 23
<b>Overall Outcome</b>				1-11, 13-23

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