UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NANOCO TECHNOLOGIES, LTD.,
Petitioner,

v.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2015-00532
Patent 6,501,091 B1

Before DONNA M. PRAISS, LYNNE E. PETTIGREW, and
JO-ANNE M. KOKOSKI, *Administrative Patent Judges.*

KOKOSKI, *Administrative Patent Judge.*

DECISION
Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

Nanoco Technologies Ltd. ("Petitioner") filed a Corrected Petition ("Pet.") to institute an *inter partes* review of claims 1–29 of U.S. Patent No. 6,501,091 B1 ("the '091 patent," Ex. 1001). Paper 5. Massachusetts Institute of Technology ("Patent Owner") filed a Preliminary Response ("Prelim. Resp."). Paper 7. We have jurisdiction under 35 U.S.C. § 314.

Upon consideration of the Petition and Preliminary Response and the evidence of record, we determine that Petitioner has established a reasonable likelihood of prevailing with respect to the unpatentability of claims 1–3, 8, 10–15, 17, 19–23, and 28 of the '091 patent. Accordingly, we institute an *inter partes* review of these claims.

A. Related Proceedings

Petitioner indicates that there are no related proceedings. Pet. 6.

B. The '091 Patent (Ex. 1001)

The '091 patent, titled "Quantum Dot White and Colored Light Emitting Diodes," is directed to an electronic device comprising quantum dots embedded in a host matrix, with a primary light source that causes the quantum dots to emit secondary light of a selected color, and to methods of making such a device. Ex. 1001, Abstract.

Figure 1 of the '091 patent is reproduced below:

FIG. 1

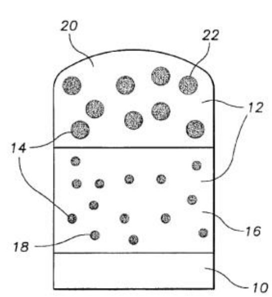

Figure 1 is a representation of one light emitting diode (“LED”) described in the ’091 patent. *Id.* at 4:43–44. Primary light source 10 can be an LED, a solid state laser, or a microfabricated UV source, “desirably chosen so that its energy spectrum includes light of higher energies than the desired LED color.” *Id.* at 4:58–63. Primary light source 10 is located so that it irradiates host matrix 12, which contains a population of quantum dots 14. *Id.* at 4:63–65. Primary light source 10, and the size distribution of quantum dots 14, are chosen such that the radiation emitted from the device is the desired color. *Id.* at 5:17–19.

The Specification describes an embodiment where a white LED is produced by combining different sizes of photoluminescent quantum dots with a standard blue LED. Ex. 1001, 5:53–56. Using Figure 1 above as a reference, blue LED 10 provides primary light that passes “through layer 16 of quantum dots 18 of a material and size adapted to emit green secondary light.” *Id.* at 5:61–64. Blue primary light not absorbed by layer 16, and the green secondary light, then pass through “second layer 20 of quantum dots 22 of a material and size adapted to emit red secondary light.” *Id.* at 5:64–67. After passing through second layer 20, the light is composed of a mix of unabsorbed blue primary light, green secondary light, and red secondary light, and will appear white to the observer. *Id.* at 5:67–6:4. According to the Specification, “[t]he relative amplitudes of the red, green, and blue components of the light can be controlled by varying the thickness and quantum dot concentrations of the red and green layers to produce an LED of a desired color.” *Id.* at 6:4–7. The described device can also be used to produce an LED of a color other than white, and can produce polychromatic and monochromatic light. *Id.* at 6:22–29.

The Specification also describes a quantum dot colloid, where quantum dots are disposed in a nonconductive host matrix. Ex. 1001, 3:28–30. The Specification states that "the phrase 'colloidally grown' quantum dots refers to dots which have been produced by precipitation and/or growth from a solution," and that "colloidally grown dots have a substantially uniform surface energy." *Id.* at 4:14–19. The host matrix can be any material that is somewhat transparent to the light emitted by the quantum dots, and in which the quantum dots can be dispersed. *Id.* at 6:64–67. The Specification describes an embodiment of a quantum dot colloid:

> In one embodiment, the dots comprise CdS, CdSe, CdTe, ZnS, or ZnSe, optionally overcoated with a material comprising ZnS, ZnSe, CdS, CdSe, CdTe, or MgSe. The nonconductive host matrix may be a polymer such as polystyrene, polyimide, or epoxy, a silica glass, or a silica gel. In one embodiment, the dots are coated with a monomer related to a polymer component of the host matrix. The dots may be selected to have a size distribution having an rms deviation in diameter of less than 10%; this embodiment will cause the dots to photoluminesce in a pure color.

Id. at 3:36–45.

C. Illustrative Claims

Petitioner challenges claims 1–29 of the '091 patent. Claims 1, 12, and 21 are independent claims. Claims 2–11 directly depend from claim 1, which is reproduced below:

> 1. An electronic device comprising:
>
> a solid-state device which serves as a primary light source; and
>
> a population of photoluminescent quantum dots dispersed in a host matrix, at least a portion of the quantum dots having a band gap energy smaller than the energy of at least a portion of the light produced by the source, and the matrix allowing light from the source to pass therethrough.

Ex. 1001, 9:65–10:6.

Claims 13–20 depend, directly or indirectly, from independent claim 12, which is reproduced below:

> 12. A quantum dot colloid, comprising a population of quantum dots dispersed in a nonconductive host matrix, each quantum dot having a substantially uniform surface energy, wherein the dots are of a size distribution, composition, or a combination thereof, selected to photoluminesce light of a spectral distribution of wavelengths characteristic of a selected color when the host matrix is irradiated with light from a primary source whose wavelength is shorter than the longest wavelength of said spectral distribution.

Id. at 10:33–42.

Claims 22–29 depend, directly or indirectly, from independent claim 21, which is reproduced below:

> 21. A method of producing light of a selected color, comprising:
>
> providing at least one population of photoluminescent quantum dots dispersed in a host matrix, each quantum dot having a characteristic band gap energy, and
>
> irradiating the host matrix with a solid-state primary light source, said source emitting light of an energy greater than the characteristic band gap energy of at least a portion of the dots;
>
> whereby the quantum dots photoluminesce light of the selected color when irradiated by the primary light source.

Id. at 11:1–12.

D. The Prior Art

Petitioner refers to the following prior art references:

Hakimi	U.S. 5,260,957	Nov. 9, 1993	Ex. 1010
Bhargava	U.S. 5,422,489	June 6, 1995	Ex. 1004
Vriens	U.S. 5,813,753	Sept. 29, 1998	Ex. 1012
Butterworth	U.S. 5,847,507	Dec. 8, 1998	Ex. 1002
Lawandy	U.S. 5,882,779	Mar. 16, 1999	Ex. 1008
Shimizu	U.S. 5,998,925	Dec. 7, 1999	Ex. 1009
Bawendi	U.S. 6,322,901 B1	Nov. 27, 2001	Ex. 1013
Baretz	U.S. 6,600,175 B1	July 29, 2003	Ex. 1011
Burt	WO 96/10282	April 4, 1996	Ex. 1007
Bhargava II	*Doped Nanocrystals of Semiconductors–A New Class of Luminescent Material*, 60 & 61 J. LUMIN. 275–280	1994	Ex. 1006
Hines	*Synthesis and Characterization of Strongly Luminescing ZnS-Capped CdSe Nanocrystals*, 100 J. PHYS. CHEM. 468–471	Jan. 11, 1996	Ex. 1014
Fogg	*Fabrication of Quantum Dot/Polymer Composites: Phosphine-Functionalized Block Copolymers as Passivating Hosts for Cadmium Selenide Nanoclusters*, 30 MACROMOLECULES 417–426	1997	Ex. 1015

Dabbousi	*(CdSe)ZnS Core-Shell Quantum Dots: Synthesis and Characterization of a Size Series of Highly Luminescent Nanocrystallites*, 101 J. PHYS. CHEM. 9463–9475	1997	Ex. 1016

E. The Asserted Grounds of Unpatentability

Petitioner challenges the patentability of claims 1–29 of the ’091 patent based on the following grounds:

Reference(s)	**Basis**	**Claim(s) Challenged**
Bhargava	§ 102(b)	1, 2, 4, 6–8, 12, 13, 15–17, 18, 20–22, 24, 25, 27–29
Bhargava and Bhargava II	§ 103(a)	1, 2, 4, 6–8, 12, 13, 15–17, 18, 20–22, 24, 25, 27–29
Burt	§ 102(b)	1–3, 8, 10, 11
Lawandy	§ 102(e)	1–5, 10, 11
Lawandy, Butterworth, and Shimizu	§ 103(a)	1–5, 10, 11
Hakimi	§ 102(b)	1, 2, 4, 8–11
Butterworth, Shimizu, Baretz, Vriens, Burt, Lawandy, Hakimi, and Bhargava	§103(a)	1–11
Fogg	§102(a)	12–29
Fogg	§103(a)	12–29
Bawendi	§102(a)	12–14, 17, 19–23
Dabbousi	§102(a)	12–15, 19–23, 28

Reference(s)	**Basis**	**Claim(s) Challenged**
Hines	§102(b)	12–14, 19–23

II. ANALYSIS

A. Real Parties-In-Interest

Before addressing the merits of the grounds raised by Petitioner, we must first address whether the Petition names all real parties-in-interest ("RPIs"). 35 U.S.C. § 312(a)(2) ("A petition [for *inter partes* review] may be considered only if— . . . the petition identifies all real parties in interest."). The Board has held that determination of whether a Petition identifies all RPIs is a "threshold issue," on which Petitioner bears the burden of persuasion. *See Atlanta Gas Light Co. v. Bennett Regulator Guards, Inc.*, Case IPR2013-00453, slip op. at 7–8 (PTAB Jan. 6, 2015) (Paper 88).

Our Practice Guide explains that an RPI, as used in the AIA trial context, "is the party that desires review of the patent. Thus, the 'real party-in-interest' may be the petitioner itself, and/or it may be the party or parties at whose behest the petition has been filed." *Office Patent Trial Practice Guide*, 77 Fed. Reg. 48,756, 48,759 (Aug. 14, 2012). The determination of whether a party is an RPI is a "highly fact-dependent question" (*id.*), in which the focus is on the party's relationship to the *inter partes* review pending before the Board, and the degree of control the party can exert over the proceeding. *See Aruze Gaming Macau Ltd. v. MGT Gaming Inc.*, Case IPR2014-01288, slip op. at 11 (PTAB Feb. 20, 2015) (Paper 13). "[I]f a nonparty can influence a petitioner's actions in a proceeding before the

Board, to the degree that would be expected from a formal copetitioner, that nonparty should be considered an RPI to the proceeding." *Id.* at 12.

Patent Owner asserts that Petitioner fails to identify all RPIs. Prelim. Resp. 9–12. In particular, Patent Owner argues that Dow Chemical Company ("Dow") should have been identified in the Petition as a real party-in-interest. *Id.* at 10. Patent Owner argues that Dow and Petitioner have a global licensing agreement under which Dow Electronic Materials (a business unit of Dow) has exclusive world-wide rights to "the sale, marketing, and manufacture of Petitioner's cadmium-free quantum dots for use in electronic displays." *Id.* at 9–10. According to Patent Owner, this exclusive license "is directed to the same technology as that of the '091 patent," and therefore "it is likely that Dow and [Petitioner] will act in unison for all purposes regarding this *inter partes* review proceeding." *Id.* at 10. Patent Owner argues Dow "likely constitutes a real-party-interest" because it "likely has an opportunity to control this *inter partes* proceeding based on its relationship with Petitioner." *Id.*

Based on the record before us, we are not persuaded by Patent Owner's argument. There is no evidence in the record before us that Dow has the ability to control this proceeding to the extent that would be expected of a formal copetitioner. The mere existence of an exclusive license does not establish that Dow has control over the current proceeding such that it should have been named as an RPI. As such, we are not persuaded, on the current record, that Dow is an RPI to this proceeding. The fact that the Petition does not identify Dow does not prevent the Board from considering Petitioner's grounds of unpatentability.

B. The Declaration of Margaret A. Hines

Petitioner submitted the Declaration of Margaret A. Hines ("the Hines Declaration," Ex. 1003) in support of the Petition. Patent Owner contends Dr. Hines is not "a disinterested third party technical expert whose compensation is not dependent on the outcome of this proceeding." Prelim. Resp. 8. Patent Owner contends that Dr. Hines, an employee of Petitioner, will be benefitted directly if Petitioner is successful in invalidating the '091 patent, and "is assuredly biased to assist Petitioner in consideration for her continued employment at, and loyalty to, Petitioner." *Id.* Patent Owner contends that Dr. Hines's "inherently biased testimony" should be afforded "little—or at least diminished—weight." *Id.* at 9. Patent Owner also argues that Dr. Hines's testimony should be excluded, and trial should not be instituted on any grounds. *Id.*

On this record, we are not persuaded that the Hines Declaration should be excluded, and we give it weight in assessing Petitioner's contentions, as explained in further detail below.

C. Claim Interpretation

We interpret claims of an unexpired patent using the "broadest reasonable construction in light of the specification of the patent in which [the claims] appear[]." 37 C.F.R. § 42.100(b). The Board, however, may not "construe claims during IPR so broadly that its constructions are *unreasonable* under general claim construction principles. . . . [T]he protocol of giving claims their broadest reasonable interpretation . . . does not include giving claims a legally incorrect interpretation." *Microsoft Corp. v. Proxyconn, Inc.*, No. 2014-1542,-1543, slip. op. at 6 (Fed. Cir. June 16, 2015) (citation omitted). Rather, "claims should always be read in light of the specification and teachings in the underlying patent," and "[t]he PTO should also consult the patent's prosecution history in proceedings in which the patent has been brought back to the agency for a second review." *Id.* at 7 (citation omitted).

For purposes of this Decision, based on the record before us, we make explicit the interpretation of the claim terms "colloid" (claims 12–19), "substantially uniform surface energy" (claim 12), and "host matrix" (claims 1, 4–7, 12, 15–18, 21, 24, 25, 28, and 29).

1. "colloid"

Petitioner contends that the term "colloid" should be interpreted to mean "a mixture of substances, one substance being uniformly distributed in a finely divided state within the other substance," and "can be a solid, liquid, or gas." Pet. 7. Petitioner contends that this is the plain and ordinary meaning of colloid, as would be understood by a person having ordinary skill in the art. *Id.* In support of this interpretation, Petitioner relies on the Hines Declaration. *Id.* (citing Ex. 1003 ¶ 15). Dr. Hines cites *van Norstrand's Scientific Encyclopedia*, which sets forth, in relevant part, the following definition of "colloidal state":

> An intimate mixture of two substances, one of which, called the dispersed phase (or colloid) is uniformly distributed in a finely divided state through the second substance, called the dispersion medium (or dispersing medium). The dispersion medium may be a gas, liquid, or a solid, and the dispersed phase may also be any of these, with the exception that one does not speak of a colloidal system of one gas in another.

Ex. 1003, Appendix A, Ex. B.

Patent Owner argues that "colloid" should be interpreted to mean "a mixture produced by precipitation and/or growth from a solution." Prelim.

Resp. 3. In support of this interpretation, Patent Owner cites to the Specification's statements that "[t]he dots may be colloidally produced (i.e., by precipitation and/or growth from solution)" and that "the phrase 'colloidally grown' quantum dots refers to dots which have been produced by precipitation and/or growth from a solution." *Id.* at 4 (citing Ex. 1001, 3:6–7, 4:14–16).

Based on the record before us, we are persuaded that Petitioner's proposed interpretation is the broadest reasonable interpretation in light of the Specification. Petitioner's proposed interpretation is consistent with the Specification, which states that "the invention comprises a quantum dot colloid, in which quantum dots are disposed in a nonconductive host matrix." Ex. 1001, 3:28–30. The portion of the Specification that Patent Owner relies upon does not require that we limit "colloid" to the method used to produce quantum dots, because the Specification does not express a clear intent to limit "colloid" in that way. Additionally, the claims do not include the phrases "colloidally grown" or "colloidally produced," but, instead, broadly refer to a "colloid." *Id.* at 10:33–64 (Claims 12–19).

Therefore, for purposes of this Decision, and in accordance with the broadest reasonable interpretation in light of the Specification, we interpret "colloid" to mean "a mixture of substances, one substance being uniformly distributed in a finely divided state within the other substance."

2. "quantum dot having a substantially uniform surface energy"

Petitioner argues that the term "substantially uniform surface energy" should be interpreted to mean "quantum dots that are precipitated from solution." Pet. 7–8. In support of its proposed interpretation, Petitioner cites the following passage from the Specification:

> As used herein, the phrase "colloidally grown" quantum dots refers to dots which have been produced by precipitation and/or growth from a solution. A distinction between these dots and quantum dots epitaxially grown on a substrate is that colloidally grown dots have a substantially uniform surface energy, while epitaxially grown dots usually have different surface energies on the face in contact with the substrate and on the remainder of the dot surface.

Ex. 1001, 4:14-21. According to Petitioner, a person having ordinary skill in the art would understand, therefore, that "a substantially uniform surface energy" refers to quantum dots precipitated from solution.

Patent Owner responds that "a substantially uniform surface energy" should be interpreted "according to its plain and ordinary meaning, and should be given its 'broadest reasonable interpretation in light of the specification.'" Prelim. Resp. 5. Patent Owner relies on the same disclosure in the Specification as does Petitioner in support of its contention, and argues that "the claimed 'a substantially uniform surface energy' limitation further clarifies that the quantum dots, as claimed, are not epitaxially grown, but rather colloidally grown." *Id.*

Based on the record before us, and for purposes of this Decision, we construe "quantum dot having a substantially uniform surface energy" to mean "a colloidally grown quantum dot that has been produced by precipitation and/or growth from a solution." The Specification explicitly defines "colloidally grown" quantum dots as "dots which have been produced by precipitation and/or growth from a solution." Ex. 1001, 4:14–16. The Specification goes on to state that such colloidally grown quantum dots "have a substantially uniform surface energy." *Id.* at 4:18–19. These disclosures in the Specification express a clear intent to define "quantum dot having a substantially uniform surface energy" as quantum dots that are colloidally grown.

3. "host matrix"

Petitioner argues that the term "host matrix" should be interpreted to mean "any material—solid, liquid, or gas—in which the [quantum dots] can be suspended." Pet. 8. As support for this interpretation, Petitioner cites the Specification's disclosure that "[t]he host matrix may be any material in which quantum dots may be dispersed in a configuration in which they may be illuminated by the primary light source." *Id.* (citing Ex. 1001, 3:11-13). Patent Owner contends that "host matrix" should be interpreted to mean "any material at least partially transparent to visible light in which quantum dots can be dispersed." Prelim. Resp. 6. To support this proposed interpretation, Patent Owner points to the Specification's statement that the host matrix "may be any material at least partially transparent to visible light in which quantum dots can be disposed." *Id.* at 7 (citing Ex. 1001, 4:65–67).

Based on the record before us, we are persuaded that Patent Owner's proposed interpretation is the broadest reasonable interpretation in light of the Specification. Patent Owner's proposed interpretation is consistent with the Specification, which states that "[t]he host matrix will typically be a polymer, a silica glass or a silica gel, but any material which is at least somewhat transparent to the light emitted by the quantum dots and in which quantum dots can be dispersed may serve as the host matrix." Ex. 1001, 6:64–7:1. Petitioner's proposed interpretation does not take into account the Specification's disclosures regarding the transparency of the material that comprises the host matrix.

Therefore, for purposes of this Decision and in accordance with the broadest reasonable interpretation in light of the Specification, we interpret "host matrix" to mean "any material at least partially transparent to visible light in which quantum dots can be dispersed."

D. Grounds Based on Bhargava

Petitioner contends that claims 1, 2, 4, 6–8, 12, 13, 15–17, 18, 20–22, 24, 25, and 27–29 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Bhargava, or, in the alternative, would have been obvious under 35 U.S.C. § 103 alone or in combination with Bhargava II. Pet. 11–14, 21–22, 25–60. In support of these contentions, Petitioner relies on the Hines Declaration.

1. Overview of Bhargava

Bhargava is directed to a radiation-responsive light-emitting device that "efficiently converts a relatively wide range of wavelengths of incident radiation to radiation over a narrower range of wavelengths." Ex. 1004, 1:4–8. Bhargava describes a light-emitting device "comprising a substrate, for example of glass or acrylic plastic, referred to herein from time to time as 'glowing glass' obtained by coating a given colored or filtered substrate with a nanocrystal layer that emits the same colored light under excitation by wavelengths of higher energy." *Id.* at 2:48–54.

Bhargava Figures 2 and 3 are reproduced below:

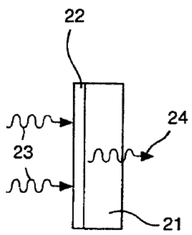

Fig. 2

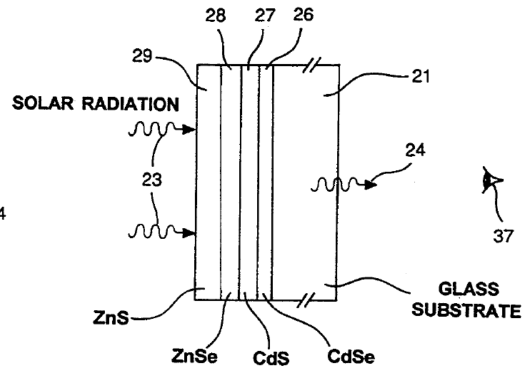

Fig. 3

Figures 2 and 3 are schematic diagrams illustrating forms of the device described in Bhargava. *Id.* at 2:32–35. In Figure 2, yellow-colored glass substrate 21 supports Mn-doped ZnS layer 22. *Id.* at 3:61–62. Solar radiation 23 passes through Mn-doped ZnS layer 22, and radiation in the spectral region of 250–350 nanometers is absorbed by the ZnS "and excites the Mn activator to emit radiation in the range of 560–600 nm." *Id.* at 3:66–4:2. Output 24 comprises the "emitted characteristic of the Mn activator in the yellow spectral region, and that portion of the yellow spectral region from the incident solar radiation which is too long in wavelength to be absorbed by the doped nanocrystalline materials." *Id.* at 4:5–10.

Figure 3 depicts a light emitting device comprised of multiple layers of doped nanocrystalline materials with different hosts, where glass substrate 21 supports first light-emitting nanocrystal layer 26 (CdSe activated by Mn), second light-emitting nanocrystal layer 27 (CdS activated by Mn), third light-emitting nanocrystal layer 28 (ZnSe activated by Mn), and fourth light-emitting nanocrystal layer 29 (ZnS activated by Mn). *Id.* at 4:11–21. When solar radiation 23 passes through the coated side of substrate 21, the output generated is yellow light 24. *Id.* at 4:22–24.

Bhargava states that radiative transitions in other colors can be achieved by changing the activator in the same or different hosts. *Id.* at 5:3–5. Bhargava further states that "instead of multiple discrete thin layers of different host active materials as described in connection with FIG. 3, it is possible to make up a single thicker layer containing a mixture of a plurality of doped nanoparticle hosts, usually with the same activator . . . ." *Id.* at 6:3–8.

2. Overview of Bhargava II

Bhargava II reports "on the unique luminescent properties of nanocrystals of Mn-doped ZnS with varying sizes" prepared at room temperature. Ex. 1006, Abstract. Bhargava II describes doping ZnS by reacting manganese chloride with ethylmagnesium chloride to form diethylmanganese in a tetrahydrofuran solvent. *Id.* at 2. According to Bhargava II, "[t]he separation of the particles is maintained by coating with the surfactant methacrylic acid." *Id.*

3. Claims 1, 2, 4, and 6–8

Independent claim 1 recites an electronic device that includes, among other elements, "a solid-state device which serves as a primary light source." Petitioner contends that Bhargava includes solar radiation 23 as a light source, "and is not specific to the type of light source used." Pet. 27. Petitioner further contends that Bhargava teaches that the described nanocrystal films can be used in applications wherever colored glass is used, and that Bhargava states that there are known devices that respond to shorter wavelength incident radiation to emit radiation of a longer wavelength. *Id.* (citing Ex. 1001, 1:10–13, 23–27). Petitioner also notes that Bhargava discloses that a black light can be included in the structure of the device to enhance the glow. *Id.* (citing Ex. 1001, 5:27–31).

We are not persuaded that Petitioner has established that Bhargava teaches the "solid-state device which serves as a primary light source" limitation recited in claim 1. A reference cannot be said to anticipate a claimed invention unless that reference "discloses within the four corners of the document not only all of the limitations claimed, but also all of the limitations 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). Bhargava describes a glowing device that responds to incident radiation (Ex. 1004, 1:30–33), but does not describe that the glowing device itself comprises a solid-state device as a primary light source. The examples in Bhargava show the light source as being external to Bhargava's glowing device. *See, e.g.*, *id.* at 3:66–67 (Figure 2 described with "solar radiation 23 incident on the coated side of the substrate); 4:22–23 ("solar radiation 23" in Figure 3). Moreover, Bhargava's independent claims describe the glowing device as "being positioned such that the active layer faces in the direction of and can receive incident radiation." *Id.* at 6:21–33; 6:60–7:6; 7:30–50; 8:40–55 (Claims 1(c), 7(d), 14(e), 24(c)).

Petitioner does not provide any support for its contention that because Bhargava is not specific as to the source of the incident radiation, Bhargava discloses "a solid-state device which serves as a primary light source" as recited in claim 1. *See* Pet. 27. Petitioner similarly fails to provide any objective evidence or explanation as to how Bhargava's statement that the described glowing devices can be used in applications wherever colored glass is used meets the "solid-state device" limitation. *See id.*

Consequently, we conclude that Petitioner has not demonstrated a reasonable likelihood that independent claim 1, and claims 2, 4, and 6–8 that depend therefrom, are anticipated by Bhargava.

Petitioner further contends that, "[t]o the extent this limitation is not met by Bhargava, it would be obvious to use a solid-state light source" because "Bhargava states that the films can be used wherever colored glass is used." Pet. 27. Challenging claims under an obviousness alternative to anticipation does not relieve Petitioner of the burden of articulating "reasoning with rational underpinning" to show obviousness. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007) (quoting *In re Kahn*, 551 F.3d 977, 988 (Fed. Cir. 2006)). On this record, Petitioner has not demonstrated a reasonable likelihood that it would prevail on the ground that Bhargava renders claims 1, 2, 4, and 6–8 obvious.

4. Claims 12, 13, 15–18, and 20

Petitioner contends that Bhargava discloses all of the elements of independent claim 12, and provides arguments setting forth where each of the limitations may be found. Pet. 40–45. For example, Petitioner contends that Bhargava discloses "[a] quantum dot colloid" (suspension of quantum dots in a polymer matrix), "a population of quantum dots dispersed in a nonconductive host matrix" (polymer matrices in which quantum dots are suspended include polymers resulting from curing of methacrylate surfactant coated on the surface of the quantum dots), and "each quantum dot having a substantially uniform surface energy" (quantum dots are produced by precipitation, resulting in substantially uniform surface energy). *Id.* at 40–42. We are persuaded, on this record, that Petitioner's discussion of particular structures in Bhargava, and the explanations in the Petition, are sufficient to establish a reasonable likelihood that claim 12 is unpatentable as anticipated by Bhargava.

Claim 13 depends from claim 12, and further requires "the quantum dots comprise at least one material selected from the group consisting of CdS, CdSe, CdTe, ZnS, and ZnSe." Claim 15 depends from claim 12 and additionally requires "the host matrix comprises at least one material selected from the group consisting of a polymer, a silica glass, and a silica gel." Claim 20 depends from claim 12 and further recites that "the spectral distribution is determined by the size and distribution of the quantum dots." We have considered the arguments and evidence, and are persuaded on the present record that Petitioner has demonstrated a reasonable likelihood that it would prevail in showing that claims 13, 15, and 20 are unpatentable as anticipated by Bhargava.

Claim 16 depends from claim 12, and additionally recites that "the host matrix comprises a polymer selected from the group consisting of polystyrene, polyimides, and epoxies." Petitioner contends that Bhargava teaches quantum dots dispersed in a polymer host matrix, and a person having ordinary skill in the art "would be motivated to exchange the polymers in Bhargava for epoxy polymers, as taught in *Baretz (9:24–29)* or *Vriens (3:43–4:62),* because those references teach that epoxy polymers are known to be suitable for dispersing phosphors in luminescent devices." Pet. 47. Petitioner contends that this is nothing more than the selection of a known material based on its suitability for its intended purpose, and therefore claim 16 is obvious over Bhargava. *Id.*

To support a showing of obviousness, there has to be an articulated reasoning with rational underpinning to support a motivation to combine prior art teachings. *KSR*, 550 U.S. at 418. As explained in *KSR*, that reasoning "should be made explicit." *Id.* Petitioner appears to be contending[1] that a person having ordinary skill in the art would be motivated to modify Bhargava with the disclosures in Baretz or Vriens. Pet. 47. Petitioner does not articulate, however, any reasoning why a person having ordinary skill in the art would combine elements of Bhargava with some elements of Baretz or Vriens, or why one of ordinary skill in the art would modify the teachings of Bhargava in view of Baretz's or Vriens's teachings to arrive at the claimed invention.

Petitioner's contention that exchanging the epoxy polymers taught in Baretz or Vriens for the polymers in Bhargava is simply the selection of a known material based on its suitability for its intended purpose is conclusory, and is nothing more than a restatement of one of the basic tests identified by the Supreme Court for determining whether an invention would have been obvious. *See KSR*, 550 U.S. at 417 ("whether the improvement is more than the predictable use of prior elements according to their established functions"). General principles on what may constitute a supporting rationale cannot substitute for specific application of those principles to the facts. For these reasons, Petitioner has not demonstrated a reasonable likelihood that it would prevail in demonstrating the claim 16 would have been obvious over the combination of Bhargava and Baretz or Vriens.

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[1] Petitioner has not asserted that claim 16 would have been obvious over the combination of Bhargava, Baretz, and Vriens. *See* Pet. 9–11 ("Identification of Challenge"). Petitioner's argument, however, relies on disclosures in Baretz and Vriens, and, therefore, we consider those references in analyzing Petitioner's contentions with respect to claim 16.

Claim 17 depends from claim 12 and further recites "the quantum dots are coated with a coating material having an affinity for the host matrix." Claim 18 depends from claim 17 and additionally requires that "the host matrix comprises a polymer and the coating material comprises a related monomer." Petitioner contends that Bhargava describes quantum dots that are coated with methacrylic acid surfactant, "which a person having ordinary skill in the art would recognize is a polymerizable monomer." Pet. 35. Petitioner further contends that "Bhargava II teaches polymerizing the surfactant that is coated onto the" quantum dots, and "[t]he surface-bound methacrylic acid becomes incorporated into the poly(methacrylic acid) polymer matrix that results from polymerization of the surfactant and becomes part of the host matrix." *Id.*

We are not persuaded by Petitioner's arguments. Petitioner does not explain how the methacrylic acid-coated quantum dots described in Bhargava have "an affinity for the host matrix," as required by claim 17. Petitioner relies on the Hines Declaration in support of its contentions, but Dr. Hines's testimony does not provide any evidence or explanation as to why a person having ordinary skill in the art would understand that Bhargava's methacrylic acid-coated quantum dots have an affinity for the host matrix. *See* Ex. 1003 ¶ 19 ("A [person having ordinary skill in the art] would also understand from Bhargava II that the [quantum dots] of Bhargava/Bhargava II are surface-coated with methacrylic acid that is then polymerized to form a polymer matrix incorporating the [quantum dots] via the surface-bound monomers."). Consequently, we are not persuaded that Petitioner has demonstrated that Bhargava, either alone or in combination with Bhargava II, discloses the "quantum dots are coated with a coating material having an affinity for the host matrix" limitation recited in claim 17.

Accordingly, we conclude that Petitioner has not demonstrated a reasonable likelihood that claims 17 and 18 are anticipated by Bhargava, or would have been obvious over the combination of Bhargava and Bhargava II.

5. Claims 21, 22, 24, 25, 27, and 29

Independent claim 21 recites a method of producing light of a selected color comprising "irradiating the host matrix with a solid-state primary light source." As set forth above with respect to claim 1, we are not persuaded that Bhargava discloses a solid-state primary light source. Petitioner argues that "[t]he source of the light as opposed to the light itself is not significant, because it is the energy of the light that causes the photoluminescence." Pet. 52. Petitioner's argument reads the "solid-state primary light source" limitation out of claim 21, without explanation as to why that element is insignificant. To the extent that Petitioner is arguing that Bhargava inherently discloses a solid-state primary light source, that argument is unavailing. Inherency requires that the claim limitation in question is necessarily present in the reference. *See, e.g.*, *Schering Corp. v. Geneva Pharms., Inc.*, 339 F.3d 1373, 1377 (Fed. Cir. 2003) ("[A] prior art reference may anticipate without disclosing a feature of the claimed invention if that missing characteristic is necessarily present, or inherent, in the single anticipating reference."). Petitioner does not provide evidence or explanation that Bhargava necessarily discloses "irradiating the host matrix with a solid-state primary light source."

Accordingly, we conclude that Petitioner has not demonstrated a reasonable likelihood that independent claim 21, and claims 22, 24, 25, 27, and 29 that depend therefrom, are anticipated by Bhargava.

E. Anticipation by Burt

Petitioner contends that claims 1–3, 8, 10, and 11 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Burt. Pet. 14, 26–33, 36–39. In support of these contentions, Petitioner relies on the Hines Declaration.

1. Overview of Burt

Burt is directed to an optical fiber comprising tubular glass cladding that is filled with a colloidal solution of quantum dots. Ex. 1007, Abstract. The quantum dots "may be caused to produce luminescence in response to input optical radiation." *Id.* Figure 2 of Burt is reproduced below:

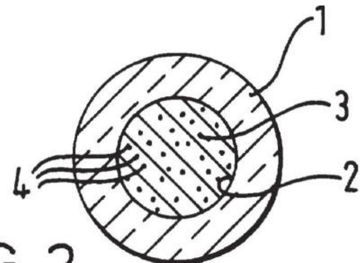

FIG. 2

Figure 2 is a transverse cross section of an optical fiber described by Burt. *Id.* at 3:1. Tubular glass sheath 1 has elongated central opening 2 running the length thereof. *Id.* at 3:6–7. Central opening 2 is filled with a colloid of quantum dots comprising support medium 3 containing quantum dots 4, which are selected to produce photoluminescence. *Id.* at 3:9–11, 21.

Figure 4 of Burt is reproduced below:

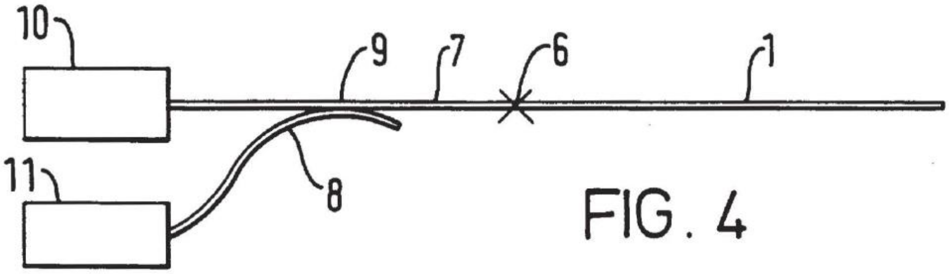

Figure 4 depicts the Burt fiber used in an optical amplifier. *Id.* at 3:3. Fiber 1 is spliced at region 6 to conventional silica optical fiber 7. *Id.* at 5:5–6. Silica optical fiber 7 is fused to fiber 8 in coupling region 9. *Id.* at 5:6–7. Optical signals from source 10 are directed into fiber 1, and fiber 1 is pumped by semiconductor laser 11 "in order to promote an electron from one of the low energy states (normally occupied in the absence of the pump of signal beams) in the quantum dot into one of the high energy states (normally unoccupied in the absence of the pump of signal beams)." *Id.* at 5:7–12. The electron amplifies a light signal from source 10 by transitioning back from one of the high energy states to one of the low energy states and emitting a photon. *Id.* at 5:12–14.

Burt states that wavelength conversion can be achieved by the appropriate choice of quantum dots, where "sources 10 and 11 may be selected to stimulate different wavelength transitions associated with the quantum dots." *Id.* at 6:1–5.

2. Analysis

Petitioner contends that Burt discloses all of the elements of independent claim 1, and provides arguments setting forth where each of the limitations may be found. Pet. 26–32. For example, Petitioner contends that Burt discloses "a solid-state device which serves as a primary light source" (semiconductor laser 11), "a population of photoluminescent quantum dots dispersed in a host matrix" (colloid of quantum dots comprising support medium 3 containing quantum dots 4), and "the matrix allowing light from the source to pass therethrough" (incident light propagated along length of the core through the matrix). *Id.* at 27, 29, 32. We are persuaded, on this record, that Petitioner's discussion of particular structures in Burt, and the explanations in the Petition, are sufficient to establish a reasonable likelihood that independent claim 1 is unpatentable as anticipated by Burt. We have also considered the arguments and evidence with respect to dependent claims 2, 3, 8, 10, and 11, and likewise are persuaded, based on the current record, that Petitioner has demonstrated a reasonable likelihood that it would prevail as to those claims as well.

F. Ground Based on Dabbousi

Petitioner contends that claims 12–15, 19–23, and 28 are unpatentable under 35 U.S.C. § 102(a) as anticipated Dabbousi. Pet. 24, 40–46, 48–55, 59–60. Petitioner relies on the Hines Declaration in support of these contentions.

1. Overview of Dabbousi

Dabbousi is directed to the "synthesis of highly luminescent (CdSe)ZnS composite quantum dots." Ex. 1016, 1. Dabbousi states that electroluminescent devices incorporating the described (CdSe)ZnS quantum dots may show greater stability. *Id.* Dabbousi describes six different samples of ZnS-overcoated CdSe quantum dots dispersed in dilute hexane solutions which, when irradiated with 365 nm ultraviolet light from a UV lamp, luminesce at different colors depending on the size of the CdSe core of the quantum dots. *Id.* at 4. According to Dabbousi, the described synthetic procedure produces “quantum dots whose emission spans most of the visible spectrum.” *Id.* at 13.

2. Analysis

Petitioner argues that Dabbousi discloses all of the limitations of independent claim 12, and provides arguments setting forth where each of the limitations may be found. Pet. 40–44. For example, Petitioner argues that Dabbousi discloses “a population of quantum dots in a nonconductive host matrix” (dispersions of (CdSe)ZnS quantum dots in hexane are illustrated in Figure 3) and “each quantum dot having a substantially uniform surface energy” (quantum dots are synthesized by high-temperature colloidal growth). *Id.* at 41–42. We are persuaded, on this record, that Petitioner’s discussion of particular structures in Dabbousi, and the explanations in the Petition, are sufficient to establish a reasonable likelihood that independent claim 12 is unpatentable as anticipated by Dabbousi. We have also considered the arguments and evidence with respect to dependent claims 13–15, 19, and 20 and likewise are persuaded, based on the current record, that Petitioner has demonstrated a reasonable likelihood that it would prevail as to those claims as well.

Petitioner contends that Dabbousi discloses all of the limitations of independent claim 21, and provides arguments setting forth where each of the limitations may be found. Pet. 50–54. For example, Petitioner contends that Dabbousi discloses “irradiating the host matrix with a solid-state primary light source, said source emitting a light of an energy greater than the characteristic band gap energy of at least a portion of the dots” because Figure 3 shows quantum dots that emit light of a selected color when irradiated, and the band gap energy of each quantum dot is determined by the size of the quantum dot. *Id.* at 53. Based on the current record, we are persuaded that Petitioner's discussion of Dabbousi in the Petition is sufficient to establish a reasonable likelihood that independent claim 21 is unpatentable as anticipated by Dabbousi. We have also considered the arguments and evidence with respect to dependent claims 22, 23, and 28 and likewise are persuaded, on the current record, that Petitioner has demonstrated a reasonable likelihood that it would prevail as to those claims as well.

G. Grounds Based on Bawendi

Petitioner contends that claims 12–14, 17, and 19–23 are unpatentable under 35 U.S.C. § 102(a) as anticipated by Bawendi. Pet. 22–24, 40–44, 47–55. Petitioner relies on the Hines Declaration in support of these contentions.

1. Overview of Bawendi

Bawendi is directed to luminescent nanocrystalline materials that emit visible light over a narrow range of wavelengths. Ex. 1013, 1:18–20. Bawendi describes ZnS-overcoated CdSe quantum dots with "narrow band edge luminescence spanning most of the visible spectrum from 470 nm to 625 nm." *Id.* at 4:9–16. The cores of the quantum dots are substantially monodisperse, and "deviate less than 10% in rms diameter in the core, and preferably less than 5% in the core." *Id.* at 4:16–22. Bawendi describes a method of preparing CdSe dots using a high-temperature colloidal growth process. *Id.* at 4:58–60.

Bawendi states that when the quantum dots are illuminated with a primary light source, "a secondary emission of light occurs at a frequency that corresponds to the band gap of the semiconductor material used in the quantum dot," and that the band gap is a function of the size of the nanocrystallite. *Id.* at 4:23–28. Bawendi describes six different samples of ZnS-overcoated CdSe quantum dots dispersed in dilute hexane solutions that were irradiated with 356 nm ultraviolet light from a UV lamp. *Id.* at 7:65–8:3. According to Bawendi, "[a]s the size of the CdSe core increased, the color of the luminescence shows a continuous progression from the blue through the green, yellow, orange to red." *Id.* at 8:3–6.

2. Analysis

Petitioner contends that Bawendi discloses all of the elements of independent claim 12, and provides arguments setting forth where each of the elements may be found. Pet. 22–24, 40–44. For example, Petitioner contends that Bawendi discloses "a population of quantum dots dispersed in a nonconductive host matrix" (ZnS-overcoated CdSe quantum dots dispersed in dilute hexane), and "each quantum dot having a substantially uniform surface energy" (quantum dot cores are produced by a high temperature solution growth process). *Id.* at 41–42. We are persuaded, on this record, that Petitioner's discussion of particular structures in Bawendi, and the explanations in the Petition, are sufficient to establish a reasonable likelihood that independent claim 12 is unpatentable as anticipated by Bawendi. We have also considered the arguments and evidence with respect to dependent claims 13, 14, 17, 19, and 20 and likewise are persuaded, based on the current record, that Petitioner has demonstrated a reasonable likelihood that it would prevail as to those claims as well.

Petitioner also contends that Bawendi discloses all of the limitations of independent claim 21, and provides arguments setting forth where each of the limitations may be found. Pet. 50–54. For example, Petitioner contends that Bawendi discloses "each quantum dot having a characteristic band gap energy, and irradiating the host matrix with a solid-state primary light source, said source emitting light of an energy greater than the characteristic band gap energy of at least a portion of the dots" because Bawendi describes samples of ZnS-overcoated CdSe quantum dots that emit different colored light when irradiated. *Id.* at 52–53. Based on this record, we are persuaded that Petitioner's discussion of Bawendi in the Petition is sufficient to establish a reasonable likelihood that independent claim 21 is unpatentable as anticipated by Bawendi. We have also considered the arguments and evidence with respect to dependent claims 22 and 23 and likewise are persuaded, on the current record, that Petitioner has demonstrated a reasonable likelihood that it would prevail as to those claims as well.

H. Grounds Based on Hines

Petitioner contends that claims 12–14 and 19–23 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Hines. Pet. 24–25, 40–46, 48–56. Petitioner relies on the Hines Declaration in support of its contentions.

1. Overview of Hines

Hines is directed to the synthesis of ZnS-overcoated CdSe semiconductor nanocrystals that "exhibit strong and stable band-edge luminescence with a 50% quantum yield at room temperature." Ex. 1014, Abstract. Hines describes experiments that were performed on nanocrystals dispersed in anhydrous chloroform in order to acquire luminescence spectra. *Id.* at 4. Hines states that the described nanocrystals contain cores "of nearly monodisperse CdSe of 27–30 Å diameter with a ZnS capping 6 ± 3 Å thick." *Id.* at Abstract.

2. Analysis

Petitioner argues that Hines discloses all of the limitations of independent claim 12, and provides arguments setting forth where each of the limitations may be found. Pet. 40–44. For example, Petitioner argues that Hines discloses "a population of quantum dots in a nonconductive host matrix" (Zn-S overcoated CdSe quantum dots dispersed in chloroform) and "each quantum dot having a substantially uniform surface energy" (quantum dots are prepared by reaction and precipitation from a solvent). *Id.* at 41–42. We are persuaded, on this record, that Petitioner's discussion of particular structures in Hines, and the explanations in the Petition, are sufficient to establish a reasonable likelihood that independent claim 12 is unpatentable as anticipated by Hines. We have also considered the arguments and evidence with respect to dependent claims 13, 14, 19, and 20 and likewise are persuaded, based on the current record, that Petitioner has demonstrated a reasonable likelihood that it would prevail as to those claims as well.

Independent claim 21 recites a method of producing light of a selected color comprising, among other elements, "irradiating the host matrix with a solid-state primary light source." Petitioner contends that Figure 3 of Hines shows "the excitation wavelength (i.e., the light of the primary light source) (470 nm) is shorter that the wavelength of the light emitted by the" quantum dots. Pet. 54. Petitioner further contends that it is not significant whether the primary light source is solid-state "because it is the energy of the primary light that causes the photoluminescence." *Id.* Petitioner's argument effectively reads the "solid-state primary light source" limitation out of claim 21, without explanation as to why that element is insignificant. To the extent that Petitioner is arguing that Hines inherently discloses a solid-state primary light source, that argument is unavailing. Petitioner does not provide evidence or explanation that Hines necessarily discloses "irradiating the host matrix with a solid-state primary light source."

Accordingly, we conclude that Petitioner has not demonstrated a reasonable likelihood that independent claim 21, and claims 22 and 23 that depend therefrom, are anticipated by Hines.

I. Grounds Based on Fogg

Petitioner contends that claims 12–29 are unpatentable under 35 U.S.C. § 102(b) as anticipated Fogg, or, in the alternative, are obvious under 35 U.S.C. § 103 over Fogg. Pet. 21, 40–60. Petitioner relies on the Hines Declaration in support of these contentions.

1. Overview of Fogg

Fogg is directed to the fabrication of CdSe quantum dots, "in which prefabricated clusters are incorporated within a polymer containing phosphine donors attached to the polymer backbone." Ex. 1015, 1. According to Fogg, "excellent retention of the narrow size distribution of the clusters is found," and "[f]lourescence is enhanced." *Id.* at 2.

2. Claims 12–20

Petitioner contends that Fogg discloses the "each quantum dot having a substantially uniform surface energy" limitation of claim 12 because it describes quantum dots prepared by pyrolysis of dimethylcadmium and selenium trictylphosphine. Pet. 42. Petitioner argues that a person having ordinary skill in the art would "understand that this method is a colloidal synthesis" that results in quantum dots having substantially uniform surface energy, relying on the Hines Declaration in support thereof. *Id.* (citing Ex. 1003 ¶ 16). The cited testimony, however, does not provide any evidence or explanation as to why a person having ordinary skill in the art would understand that pyrolysis of dimethylcadmium and selenium trictylphosphine is a colloidal synthesis. *See* Ex. 1003 ¶ 16 (describing the broadest reasonable construction of "substantially uniform surface energy" as used in the claims of the '091 patent). Consequently, we are not persuaded that Petitioner has demonstrated that the limitation "quantum dot having a substantially uniform surface energy" is disclosed by Fogg.

We determine, therefore, that the record before us does not establish a reasonable likelihood that Petitioner would prevail in showing that claim 12, and claims 13–20 that depend therefrom, are unpatentable as anticipated by Fogg.

3. Claims 21–29

Independent claim 21 recites a method of producing light of a selected color comprising, among other elements, "irradiating the host matrix with a solid-state primary light source, said source emitting light of an energy greater than the characteristic band gap energy of at least a portion of the dots." Petitioner contends that Figures 2 and 3 of Fogg "illustrate the photoluminescence of [quantum dots] dispersed in block copolymers." Pet. 51. Petitioner further contends that "[w]hether the primary light source is solid-state is not significant; it is the energy of the primary light that causes the photoluminescence." *Id.* at 52. Petitioner's argument effectively reads the "solid-state primary light source" limitation out of claim 21, without explanation as to why that element is insignificant. To the extent that Petitioner is arguing that Fogg inherently discloses a solid-state primary light source, that argument is unavailing. Petitioner does not provide evidence or explanation that Fogg necessarily discloses "irradiating the host matrix with a solid-state primary light source."

Accordingly, we conclude that Petitioner has not demonstrated a reasonable likelihood that independent claim 21, and claims 22–29 that depend therefrom, are anticipated by Fogg.

J. Grounds Based on Hakimi

Petitioner contends that claims 1, 2, 4, and 8–11 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Hakimi. Pet. 16–17, 26–34, 36–40. Petitioner relies on the Hines Declaration in support of its contentions.

1. Overview of Hakimi

Hakimi is directed to quantum dot lasers that can be implemented in bulk optic or channel wave-guided lasers. Ex. 1010, 1:5–9. Hakimi describes a quantum dot laser comprising a plurality of quantum dots disposed in a host material. *Id.* at 1:60–62. The host material can be a polymer, such as polymethylmethacrylate, "or any other suitable low-loss striaefree, optically clear material." *Id.* at 3:31–34. Hakimi states that "[t]he quantum dots may be cadmium, selenide, zinc, telluride, cadmium telluride or zinc selenide." *Id.* at 2:7–9. Hakimi also states that the fluorescence of the quantum dots occurs at a wavelength determined by the size of the dot, as well as material that comprises the dot. *Id.* at 2:64–3:1. The quantum dot lasers described by Hakimi also include "a pumping source for exciting and inducing a population inversion in the quantum dots to produce the lasing action." *Id.* at 2:16–18.

Figure 1 of Hakimi is reproduced below:

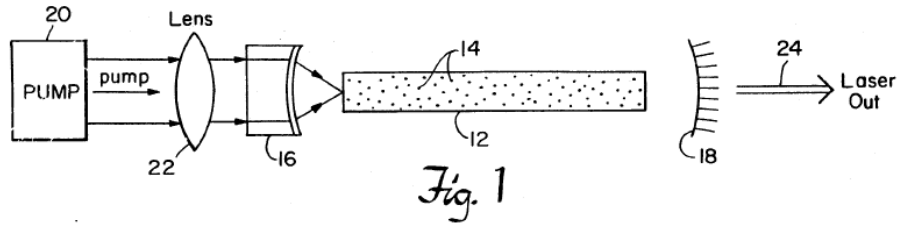

Figure 1 is a schematic side elevation view of an end-pumped quantum dot laser as described in Hakimi. Ex. 1010, 2:26–28. The bulk laser shown in Figure 1 includes laser host material 12 with quantum dots 14 dispersed therein. *Id.* at 3:31–35. Mirrored element 16 and partially silvered mirror 18 are disposed at opposite ends of host material 12. *Id.* at 3:36–39. Pumping source 20 provides pumping energy through lens 22 and mirror 16 to energize quantum dots 14 in host material 12. *Id.* at 3:39–42. Laser output beam 24 exits partially silvered mirror 18. *Id.* at 3:43–44.

2. Analysis

Independent claim 1 recites an electronic device that includes, among other elements, "a solid-state device which serves as a primary light source." Petitioner contends that Hakimi discloses that "[p]umping source 20 is a primary light source laser," and that "Hakimi is general as to the type of laser." Pet. 28. According to Petitioner, a solid-state laser, "such as the semiconductor laser described in Burt," is an example of a laser as set forth in Hakimi. *Id.*

We are not persuaded that Petitioner has established that Hakimi teaches the "solid-state device which serves as a primary light source" limitation recited in claim 1. Hakimi describes that the quantum dots "are energized by a light source so that common fluorescence is induced," but does not specify that the light source is a solid-state device. Ex. 1010, 2:49–

50. The only specific example of a pumping source set forth in Hakimi is an argon ion laser. *Id.* at 3:39–40. Petitioner does not provide any support for its contention that because Hakimi is not specific as to the type of laser that can be used as a pumping source, Hakimi discloses "a solid-state device which serves as a primary light source" as recited in claim 1. *See* Pet. 28. Consequently, we conclude that Petitioner has not demonstrated a reasonable likelihood that independent claim 1, and claims 2, 4, and 8–11 that depend therefrom, are anticipated by Hakimi.

K. Grounds Based on Lawandy

Petitioner contends that claims 1–5, 10, and 11 are unpatentable under 35 U.S.C. § 102(e) as anticipated by Lawandy, or, in the alternative, would have been obvious under 35 U.S.C. § 103 over the combination of Lawandy, Butterworth, and/or Shimizu. Pet. 14–20, 26–35, 38–39. Petitioner relies on the Hines Declaration in support of these contentions.

1. Overview of Lawandy

Lawandy is directed to high efficiency materials comprised of nanocrystals that may contain a luminescent center, or may be doped with a luminescent center. Ex. 1008, Abstract. The described materials are "suitable for emitting electromagnetic radiation with visible wavelength when suitably excited." *Id.* at 1:9–11. Lawandy describes nanocrystals containing crystalline semiconductors such as ZnSe, CdTe, and ZnS, which may be doped with Mn^{2+} or a transition metal. *Id.* at 2:17–26.

Lawandy Figure 2 is reproduced below:

FIG. 2

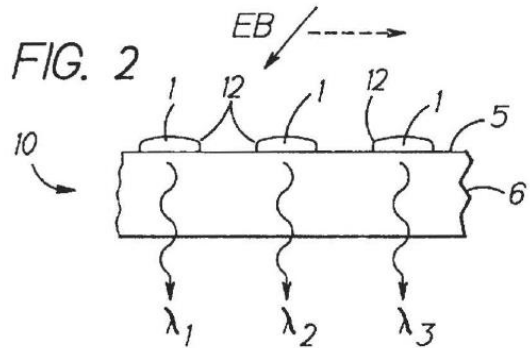

Figure 2 is a cross-sectional view of a display screen that includes the Lawandy nanocrystals. Ex. 1008, 2:51–53. Nanocrystals 1, localized within regions or pixels 12, are contacted on surface 5 of substrate 6 to form display screen 10. *Id.* at 4:51–53, 60–61. Substrate 6 is preferably transparent to the wavelengths emitted by nanocrystals 1, and may be comprised of glass, quartz, or a suitable polymer. *Id.* at 4:53–57. Lawandy states that "the excitation source may be a conventional electron beam (EB) that is scanned across the nanocrystal in a raster fashion." *Id.* at 4:58–60. According to Lawandy, "[c]onventional phosphor-type deposition methods can be employed for contacting" nanocrystals 1 onto surface 5. *Id.* at 4:61–63. Lawandy also states that nanocrystals 1 can be contacted in a substantially uniform layer or coating upon surface 5. *Id.* at 4: 63–66.

2. Analysis

Independent claim 1 recites an electronic device that includes, among other elements, "a population of photoluminescent quantum dots dispersed in a host matrix." Petitioner contends that Lawandy describes quantum dot phosphors applied to the surface of a substrate using "conventional phosphor-type deposition methods." Pet. 29 (citing Ex. 1008, 4:61–63). Petitioner further contends that a person having ordinary skill in the art would recognize that such conventional methods "include methods whereby phosphors are suspended in a matrix and applied to a substrate, as illustrated in Shimizu Fig. 2." *Id.* (citing Ex. 1003 ¶ 24).

The information presented in the Petition does not show sufficiently that Lawandy discloses the "population of photoluminescent quantum dots dispersed in a host matrix" limitation recited in claim 1. Lawandy describes photoluminescent nanocrystals (Ex. 1008, 2:17–26), but does not describe the nanocrystals dispersed in a material that is at least partially transparent to visible light. Lawandy discloses nanocrystals that are contacted on the surface of the substrate, are applied in a substantially uniform layer or coating on the surface of the substrate, and are entrapped in a region of the substrate adjacent to the surface. *See, e.g., id.* at 4:51–53, 63–66; 5:3–10. Although Lawandy states that the substrate "is preferably transparent to the wavelengths emitted by the nanocrystals," there is no disclosure in Lawandy that indicates that the nanocrystals are dispersed in the substrate.

We are not persuaded by Petitioner's contention that a person having ordinary skill in the art would have understood that Lawandy's disclosure that nanocrystals can be applied to a substrate using "conventional phosphor-type deposition methods" includes "methods whereby a conventional phosphor is dispersed in a matrix and applied to a substrate." Pet. 15. In support of its contention, Petitioner cites to the following testimony in the Hines Declaration:

> I have reviewed the reference referred to in the Petition as Shimizu. Shimizu is directed to LEDs coated with a phosphor-containing resin. Exemplary phosphors are YAG fluorescent materials chosen to emit light of particular wavelengths. Shimizu is an example of the type of "conventional phosphor-type deposition" reference that a [person having ordinary skill

> in the art] would turn to for information about how to deposit [quantum dot] phosphors on a surface, based on the guidance of Lawandy.

Ex. 1003 ¶ 24 (internal citations omitted). Neither Petitioner nor Dr. Hines provides any objective evidence or explanation as to how or why a person having ordinary skill in the art would understand the "conventional phosphor-type deposition methods" disclosure in Lawandy to include dispersing nanocrystals in a host matrix as required by claim 1. Dr. Hines's statements that Shimizu exemplifies "conventional phosphor-type deposition methods," and that a person having ordinary skill in the art would look to Shimizu "based on the guidance of Lawandy," are similarly conclusive and unsupported.

For these reasons, we conclude that Petitioner has not demonstrated a reasonable likelihood that independent claim 1, and claims 2–5, 10, and 11 that depend therefrom, are anticipated by Lawandy.

To the extent that Petitioner is arguing that claim 1–5, 10, and 11 would have been obvious over the combination of Lawandy and Shimizu, that argument is unpersuasive. Challenging claims under an obviousness alternative to anticipation does not relieve Petitioner of the burden of articulating "reasoning with rational underpinning" to show obviousness. *KSR*, 550 U.S. at 418. Petitioner has not provided any such reasoning with respect to the combination of Lawandy and Shimizu. On this record, Petitioner has not demonstrated a reasonable likelihood that it would prevail on the ground that the combination of Lawandy and Shimizu renders claims 1–5, 10, and 11 obvious.

Petitioner also contends that claims 1–5, 10, and 11 would have been obvious over the combination of Lawandy and Butterworth. Pet. 28.

Petitioner does not rely on Butterworth, however, as teaching the "population of photoluminescent quantum dots dispersed in a host matrix" limitation of claim 1. Accordingly, we determine that the record before us does not establish a reasonable likelihood that Petitioner would prevail in establishing that claims 1–5, 10, and 11 would have been obvious over the combination of Lawandy and Butterworth.

L. Other Grounds

Petitioner contends that claims 1–11 are unpatentable as obvious over the combination of any of Butterworth, Shimizu, Baretz, and Vriens (collectively, "the Conventional Phosphor References") with Burt, Lawandy, Hakimi, or Bhargava. Pet. 17–20, 26–40. Petitioner argues that the Conventional Phosphor References "are substantially identical in geometry and operation to the devices illustrated in the '091 Patent," except that they "utilize conventional inorganic and/or organic phosphors, rather than [quantum dots], to down-convert light of an LED." *Id.* at 19. Petitioner argues that "Burt, Lawandy, and Hakimi illustrate examples of replacing conventional phosphors with [quantum dots] in optical applications." *Id.* Petitioner further argues that it would have been obvious to a person having ordinary skill in the art to substitute quantum dots for the conventional phosphors described in the Conventional Phosphor References by combining any of the Conventional Phosphor References with any of Burt, Lawandy, and Hakimi. *Id.* at 20. According to Petitioner, a person having ordinary skill in the art would have been motivated to substitute quantum dots for phosphors because "it was well known that [quantum dots] possess properties that make them useful in optical applications" and "the color that a [quantum dot] phosphor emits can be tuned for various applications by simply adjusting the [quantum dot's] size." *Id*.

"Obviousness requires more than a mere showing that the prior art includes separate references covering each separate limitation in a claim under examination." *Unigene Labs., Inc. v. Apotex, Inc.*, 655 F.3d 1352, 1360 (Fed. Cir. 2011). Petitioner does not articulate sufficient reasoning as to why a person having ordinary skill in the art would combine elements of any one of the Conventional Phosphor References with any one of Burt, Lawandy, Hakimi, and Bhargava, or why one of ordinary skill in the art would modify the teachings of Burt, Lawandy, Hakimi, or Bhargava in view of the teachings of the Conventional Phosphor References to arrive at the claimed invention. Petitioner's unsupported, conclusory contention that a person having ordinary skill in the art would be motivated to substitute quantum dots for conventional phosphors because the color emitted by the quantum dots can be adjusted by changing the size of the quantum dots is not articulated reasoning with rational underpinnings sufficient to support a motivation to combine prior art teachings. *KSR*, 550 U.S. at 418.

For these reasons, Petitioner has not demonstrated a reasonable likelihood that it would prevail in demonstrating that claims 1–11 would have been obvious over the combination of any of the Conventional Phosphor References and Burt, Lawandy, Hakimi, or Bhargava.

III. CONCLUSION

Based on the arguments in the Petition and Preliminary Response, and the evidence of record, we determine that Petitioner has demonstrated a reasonable likelihood that it would prevail on its challenge to claims 1–3, 8, 10–15, 17, 19–23, and 28 of the ’091 patent.

The Board has not made a final determination as to the patentability of any challenged claim.

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that *inter partes* review is *granted* as to claims 1–3, 8, 10–15, 17, 19–23, and 28 of the ’091 patent with respect to the following grounds:

Whether claims 12, 13, 15, and 20 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Bhargava;

Whether claims 1–3, 8, 10, and 11 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Burt;

Whether claims 12–15, 19–23, and 28 are unpatentable under 35 U.S.C. § 102(a) as anticipated by Dabbousi;

Whether claims 12–14, 17, and 19–23 are unpatentable under 35 U.S.C. § 102(a) as anticipated by Bawendi; and

Whether claims 12–14, 19, and 20 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Hines;

FURTHER ORDERED that, pursuant to 35 U.S.C. § 314(a), *inter partes* review of the ’091 patent is hereby instituted commencing on the entry date of this Order, and, pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial; and

FURTHER ORDERED that no ground other than those specifically granted above is authorized for *inter partes* review as to the claims of the ’091 patent.

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