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Paper 18
Entered: June 27, 2016

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.*

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

Nanoco Technologies, Ltd. ("Petitioner") filed a Corrected Petition (Paper 5, "Pet.") to institute an *inter partes* review of claims 1–29 of U.S. Patent No. 6,501,091 B1 (Ex. 1001, "the '091 patent"). On July 27, 2015, we instituted an *inter partes* review of claims 1–3, 8, 10–15, 17, 19–23, and 28 on five grounds of unpatentability (Paper 8, "Dec. on Inst."). Massachusetts Institute of Technology ("Patent Owner") filed a Patent Owner Response (Paper 11, "PO Resp."). Petitioner filed a Reply (Paper 12, "Reply").

An oral hearing was held on April 20, 2016. A transcript of the hearing is included in the record (Paper 17, "Tr.").

We have jurisdiction under 35 U.S.C. § 6(b). This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. For the reasons that follow, we determine that Petitioner has shown by a preponderance of the evidence that claims 1–3, 8, 10–15, 17, 19–23, and 28 of the '091 patent are unpatentable.

A. The '091 Patent

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

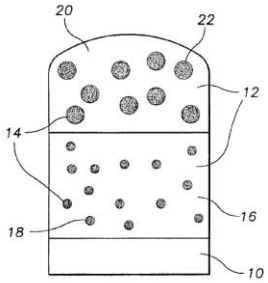

Figure 1 is a representation of one light emitting diode ("LED") described in the '091 patent. *Id.* at 4:43–44. Primary light source 10 can be an LED, a solid state laser, or a microfabricated UV source, "desirably chosen so that its energy spectrum includes light of higher energies than the desired 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 a 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 non-conductive 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 exhibiting 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.

Claims 1, 12, and 21 are independent claims. Claims 2, 3, 8, 10, and 11 depend, directly or indirectly, 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 13–15, 17, 19, and 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, 23, and 28 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.

B. Prior Art

The pending grounds of unpatentability in this *inter partes* review are based on the following prior art:

Reference	Title	Published	Exhibit
Bhargava	U.S. 5,422,489	June 6, 1995	Ex. 1004
Bawendi	U.S. 6,322,901 B1	Nov. 27, 2001	Ex. 1013
Burt	WO 96/10282	April 4, 1996	Ex. 1007
Hines	*Synthesis and Characterization of Strongly Luminescing ZnS-Capped CdSe Nanocrystals,* 100 J. PHYS. CHEM. 468–471	Jan. 11, 1996	Ex. 1014
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. 1015

C. Pending Grounds of Unpatentability

This *inter partes* review involves the following grounds of unpatentability:

Reference	Basis	Claim(s) Challenged
Bhargava	§ 102(b)	12, 13, 15, 20
Burt	§ 102(b)	1–3, 8, 10, 11
Dabbousi	§ 102(a)	12–15, 19–23, 28
Bawendi	§ 102(a)	12–14, 17, 19–23
Hines	§ 102(b)	12–14, 19, and 20

Dec. on Inst. 42.

II. ANALYSIS

A. 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); *see also Cuozzo Speed Techs., LLC v. Lee*, 579 U.S. __, 2016 WL 3369425 at *12 (June 20, 2016) ("We conclude that [37 C.F.R. § 42.100(b)] represents a reasonable exercise of the rulemaking authority that Congress delegated to the Patent Office."). 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.*, 789 F.3d 1292, 1298 (Fed. Cir. 2015) (citation omitted). "Rather, 'claims should always be read in light of the specification and teachings in the underlying patent'" and "[e]ven under the broadest reasonable interpretation, the Board's construction 'cannot be divorced from the specification and the record evidence.'" *Id.* (citations omitted). Only those terms in controversy need to be construed, and only to the extent necessary to resolve the controversy. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999).

1. Claim Terms Interpreted in the Decision on Institution

In the Decision on Institution, we interpreted the following claim terms:

Term	Interpretation
"colloid"	"a mixture of substances, one substance being uniformly distributed in a finely divided state within the other substance"
"quantum dot having a substantially uniform surface energy"	"a colloidally grown quantum dot that has been produced by precipitation and/or growth from a solution"
"host matrix"	"any material at least partially transparent to visible light in which quantum dots can be dispersed"

Dec. on Inst. 11–15. The parties do not dispute these interpretations, and we see no reason to modify them in light of the record developed at trial.

2. "the matrix allowing light from the source to pass therethrough"

Claim 1 recites, in relevant part, that the host matrix allows "light from the source to pass therethrough." Although neither party proposed an interpretation of "the matrix allowing light from the source to pass therethrough" as set forth in claim 1, based on our review of the complete record, we address the interpretation of this claim term.

In its Patent Owner Response, Patent Owner argues that "Burt does not contemplate a 'matrix allowing light from the source to pass therethrough'" because "the fiber of Burt does not transmit the light from the pump at all." PO Resp. 8–9. Patent Owner also argued at the oral hearing that "therethrough means not into, but through" and "through means through, meaning it goes in and it comes out" because "through requires exiting." Tr. 16:22–25. According to Patent Owner, "it is inherent throughout the specification [that therethrough requires passing through to the other side] because every example and every description is about light

emitting devices that pass the primary light as well as the light emitted by the nanocrystals through the matrix." *Id.* at 18:17–20. Although Patent Owner does not address explicitly this interpretation of "therethrough" in its Patent Owner Response, Patent Owner implicitly applies this proposed interpretation in its assertions concerning the teachings of Burt.

We are not persuaded by Patent Owner's argument that "matrix allowing light from the source to pass therethrough" requires that the primary light enters and exits the host matrix. Contrary to Patent Owner's contention, the Specification states that light emitted from the device may be comprised of solely the secondary light emitted from the quantum dots, or a mixture of light emitted from the quantum dots and unabsorbed primary light from the source. *See* Ex. 1001, Abstract ("The light emitted from the device may be of either a pure (monochromatic) color, or a mixed (polychromatic) color, and may consist solely of light emitted from the dots themselves, or of a mixture of light emitted from the dots and light emitted from the primary source."); *id.* at 6:57–61 ("If a sufficiently large number of quantum dots is provided, the dots will absorb substantially all of the primary light, and only secondary light in the characteristic colors of the dots will be observed."). Specifically, the Specification states:

> The invention may be constructed with a large number of quantum dots, whereby substantially all light from the primary source is absorbed and the finally emitted radiation is produced only by photoluminescence of the quantum dots, or with a smaller number of quantum dots, whereby the light emerging from the device consists of a mixture of unabsorbed primary light and of secondary light produced by photoluminescence of the quantum dots. A very wide range of both pure and mixed colors can be produced by a device constructed according to the principles of the invention.

Id. at 5:20–30. Additionally, the Specification consistently states that the purpose of the primary light source is to cause the quantum dots to photoluminesce. *See, e.g., id.* at Abstract ("a primary light source which causes the [quantum] dots to emit secondary light of a selected color"); *id.* at 2:49–51 ("When the host matrix is irradiated by light from the source, that light causes the quantum dots to photoluminesce secondary light."); *id.* at 3:4–7 ("A solid-state light source is then provided to illuminate the dots, thereby causing them to photoluminesce light of a color characteristic of their size distribution."); *id.* at 3:31–35 ("When illuminated by a primary source of light of a higher energy than the band gap energy of the dots, the quantum dots photoluminesce in a color characteristic of their size distribution.").

These disclosures in the Specification indicate that, while at least some portion of unabsorbed primary light may exit the host matrix when there are a relatively small number of quantum dots, it is also the case that all of the primary light may be absorbed by the quantum dots, so that the emitted light is produced only by the photoluminescence of the quantum dots. In that instance, the primary light would only pass through the host matrix to the point where it is absorbed by a quantum dot. Although there is an embodiment described in the Specification that shows a device that emits light composed of a mixture of unabsorbed primary light and secondary light produced by the quantum dots (*id.* at 5:53–6:4), we are not inclined to import a requirement into claim 1 that the light that exits the host matrix must be composed of unabsorbed primary light and secondary light produced by the quantum dots. *See Arlington Indus. Inc. v. Bridgeport*

Fitness, Inc., 345 F.3d 1318, 1327 (Fed. Cir. 2003) (stating that it is improper to read a limitation from the specification into the claims).

The prosecution history of the '091 patent supports this result. As originally submitted with the application, claim 1 recited "the matrix being disposed so as to allow light from the source to pass therethrough, thereby causing the quantum dots to photoluminesce light of a color characteristic of their sizes." Ex. 1005, 38. In response to a rejection under 35 U.S.C. § 112, ¶ 2 (*id.* at 90), the Applicants amended this clause to "the matrix allowing light from the source to pass therethrough." *Id.* at 101. The Applicants explained:

> Claim 1 (from which claims 2–9 depend), has been amended to recite that the matrix allows light from the source to pass therethrough. That is, the light source is placed in such a way that light may travel from the light source to the matrix, and the matrix is sufficiently transparent that at least a portion of the light passes through the matrix, as described in the Detailed Description at page 7, lines 2–7 and in the Examples at page 14, lines 12–15. Applicants submit that this is the meaning that would be given to this phrase by one of ordinary skill in the art in light of the specification, and that the language is clear and definite.

Id. at 104. Claim 1 subsequently was allowed without further comment from the Examiner or the Applicants. *Id.* at 116, 118. The Applicants' representation—that "the matrix allowing light from the source to pass therethrough" means that at least a portion of the light from the primary source passes through the matrix—does not support Patent Owner's position that this claim term requires that the light from the primary source must enter and exit the host matrix.

Accordingly, we interpret "the matrix allowing light from the source to pass therethrough" to encompass primary light that travels through the

host matrix and is absorbed by the quantum dots. The claim language also encompasses, but is not limited to, unabsorbed primary light that passes through the host matrix and is emitted from the host matrix in combination with the secondary light emitted from the quantum dots.

B. Anticipation of Claims 1–3, 8, 10, and 11 by Burt

To prevail on its patentability challenge, Petitioner must establish facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d). Petitioner asserts that claims 1–3, 8, 10, and 11 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Burt, and relies on the Declaration of Margaret A. Hines (Ex. 1003, "the Hines Declaration"). Pet. 14, 26–33, 36–39. Patent Owner disagrees with Petitioner's assertions. PO Resp. 6–9.

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:

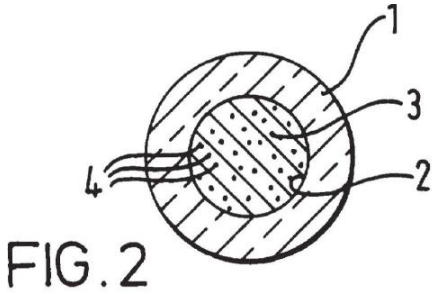

FIG. 2

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:

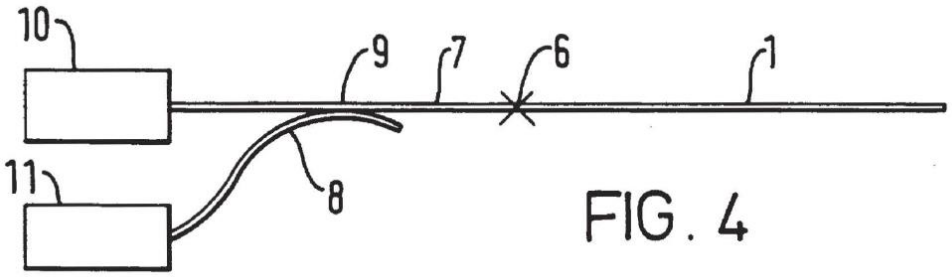

Figure 4 depicts the Burt fiber used in an optical amplifier. *Id.* at 3:3. Fiber 1 is spliced at region 6 to conventional silica optical fiber 7. *Id.* at 5:5–6. Silica optical fiber 7 is fused to fiber 8 in coupling region 9. *Id.* at 5:6–7. Optical signals from source 10 are directed into fiber 1, 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

The parties focus their arguments on "the matrix allowing light from the source to pass therethrough" element of claim 1. As to the other

elements of claim 1, we have reviewed the evidence and arguments presented in the Petition and find that Petitioner has shown sufficiently that those elements are disclosed. Pet. 26–32.

Petitioner contends that Burt discloses a system that "includes a semiconductor laser which is a solid-state device" that "is used to excite the quantum dots contained in the colloidal material within the optical fiber." Pet. 27 (citing Ex. 1007, 8:8–11). Petitioner contends that Burt discloses "the matrix allowing light from the source to pass therethrough" because "Burt states that incident light is propagated along the length of the core through the matrix" and "must therefore allow light from the source to pass through." *Id.* at 31–32 (citing Ex. 1007, 8:14–19).

Patent Owner argues that "Burt describes [a] device (a tubular sheath) that requires a 'light source' (laser, element 11 in Burt) that is designed to 'pump' the quantum dots to 'amplify a light signal from the source 10'," but "does not describe a structure in which 'the matrix allowing light from the source to pass therethrough' as in claim 1." PO Resp. 8–9. According to Patent Owner, "the fiber of Burt does not transmit the light from the pump at all," and, therefore, "the semiconductor laser in Burt is not a 'primary light source' because light emitted from it is not allowed to pass through the matrix due to the fact that the device in Burt is designed for improved amplification or wavelength conversion." *Id.*

Patent Owner's argument is unpersuasive because it relies upon Patent Owner's contention that the "matrix allowing light from the source to pass therethrough" limitation of claim 1 requires that light from the primary light source enters, travels through, and exits the host matrix as emitted light. PO Resp. 8–9; Tr. 16:22–25, 18:17–20. We do not agree that the claim term

should be interpreted in that manner, for the reasons explained above. *See supra,* Section II.A.2.

We agree with Petitioner that Burt teaches "the matrix allowing light from the source to pass therethrough" as recited in claim 1. In particular, Burt describes a semiconductor laser that pumps an optical fiber, which contains a core of a colloid of quantum dots that are selected to produce photoluminescence, "in order to promote an electron from one of the low energy states (normally occupied in the absence of the pump or signal beams) in the quantum dot into one of the high energy states (normally unoccupied in the absence of the pump or signal beams)." Ex. 1007, 5:8–12. As Petitioner notes, "[t]o impinge upon quantum dots, the light **must** pass through the matrix because the quantum dots are contained within that matrix." Reply 5 (citing Ex. 1003 ¶ 21); *see also* Ex. 1007, 3:18–19 ("[L]ight transmitted along the fibre is incident on the quantum dots 4 held in the support medium 3."); Ex. 1003 ¶ 10 (describing what happens when a quantum dot absorbs light).

We also are persuaded that Burt's semiconductor laser is "a solid state device which serves as a primary light source." As set forth above, the '091 patent specification consistently describes the purpose of the primary light source is to cause the quantum dots to photoluminesce. *See supra,* Section II.A.2. In addition, the '091 patent specification identifies "a solid-state laser" as an example of a primary light source. Ex. 1001, 4:58–60. Because the semiconductor laser described in Burt is used to excite the quantum dots, causing them to photoluminesce, it is "a solid-state device which serves as a primary light source" as required by claim 1. *See* Ex. 1007, 3:21 ("The quantum dots 4 are selected to produce photoluminescence."), 5:8–12.

Patent Owner does not make any further arguments directed to dependent claims 2, 3, 8, 10, and 11. These claims recite additional features related to the composition of the quantum dots (claims 2 and 10), the coating on the quantum dots (claim 3), the identity of the primary light source (claim 8), and the photoluminescent characteristics of the quantum dots (claim 11). We have reviewed the evidence and arguments presented in the Petition with respect to dependent claims 2, 3, 8, 10, and 11 and find that Petitioner has shown sufficiently that those elements are disclosed by Burt. Pet. 32–33, 36, 38–39.

Accordingly, after considering Petitioner's and Patent Owner's positions, as well as the evidence of record, we determine that Petitioner has shown, by a preponderance of the evidence, that claim 1, and claims 2, 3, 8, 10, and 11 that depend, directly or indirectly, therefrom, are unpatentable under 35 U.S.C. § 102(b) as anticipated by Burt.

C. Claims 12–15, 17, 19–23, and 28

In the Petition, Petitioner challenges the patentability of claims 1–29 of the '091 patent under 35 U.S.C. §§ 102 and 103. Pet. 9–60. After considering the arguments and evidence presented in the Petition and Preliminary Response, we instituted trial against claims 1–3, 8, 10–15, 17, 19–23, and 28, determining that Petitioner was likely to prevail in showing the unpatentability of each of these seventeen claims. Dec. on Inst. 42.

Once trial was instituted, and after a specified period of discovery, Patent Owner was afforded the opportunity to file a Patent Owner Response to address "any ground for unpatentability not already denied" by our Decision on Institution. 37 C.F.R. § 42.120. In its Patent Owner Response, Patent Owner only addresses the ground instituted against claims 1–3, 8, 10,

and 11, as described in the previous section, and is silent on the grounds instituted against claims 12–15, 17, 19–23, and 28. PO Resp. 1.

Our Scheduling Order in this case cautioned Patent Owner "that any arguments for patentability not raised in the [Patent Owner Response] will be deemed waived." Paper 9, 3. The Board's Trial Practice Guide also states that the Patent Owner Response "should identify all the involved claims that are believed to be patentable and state the basis for that belief." Office Patent Trial Practice Guide, 77 Fed. Reg. 48,756, 48,766 (Aug. 14, 2012). Furthermore, as the Board has stated, our governing statute and Rules "clearly place some onus on the patent owner, once trial is instituted, to address the material facts raised by the petition as jeopardizing patentability of the challenged claims." *Johnson Health Tech Co. Ltd. v. ICON Health & Fitness, Inc.*, Case IPR2013-00463, slip op. at 12 (PTAB Jan. 29, 2015) (Paper 41).

Here, Patent Owner does not articulate in the Patent Owner Response any reasons supporting the patentability of claims 12–15, 17, 19–23, and 28 over any of the grounds on which we instituted trial. *See* PO Resp. 1. In the absence of any response addressing the patentability of claims 12–15, 17, 19–23, and 28, Patent Owner effectively precluded Petitioner from replying any further to the merits of those eleven claims. *See* 37 C.F.R. § 42.23(b) ("A reply may only respond to arguments raised in the corresponding opposition or patent owner response."). Petitioner relied on Patent Owner's silence with respect to the unaddressed claims, and in its Reply only addresses "the issues Patent Owner raised in its Response." Reply 1; *see also* Tr. 5:14–18 (Petitioner argues that "Patent Owner has failed to introduce any argument or evidence as to the unpatentability of claims 12

through 15, 17, 19 through 23, and 28" and "has waived argument as to those claims."). At the oral hearing, however, Patent Owner stated that it was not conceding the unpatentability of the claims that were not addressed in the Patent Owner Response, and instead is "resting on the record." Tr. 21:13–20.

By instituting trial, we determined that Petitioner presented credible evidence pointing towards the unpatentability of claims 12–15, 17, 19–23, and 28. Dec. on Inst. 19–20, 26–31. Rather than address the evidence applied against those challenged claims, Patent Owner chose to forego the opportunity, provided by statute, to present rebuttal evidence or argument on the issue of the patentability of those claims. Absent any rebuttal, we will not scour the record to locate evidence supporting patentability. Thus, we are left to consider only the evidence of record as presented in the Petition. *See* Pet. 22–25, 40–56, 59–60. As discussed below, after considering Petitioner's evidence with respect to claims 12–15, 17, 19–23, and 28, we find that Petitioner has shown, by a preponderance of the evidence, that these claims are unpatentable.

1. Anticipation of Claims 12, 13, 15, and 20 by Bhargava

Petitioner asserts that claims 12, 13, 15, and 20 are unpatentable under 35 U.S.C. § 102(b) as anticipated by Bhargava, and relies on the Hines Declaration. Pet. 40–46, 49–50.

a. 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:

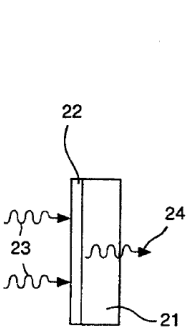

Fig. 2

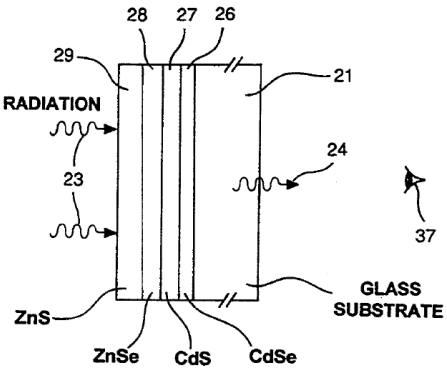

Fig. 3

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 radiation 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 a 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.

b. Analysis

Petitioner has presented sufficient evidence showing that Bhargava discloses every limitation of claims 12, 13, 15, and 20. Pet. 40–44, 46, 49. For example, with respect to claim 12, Petitioner asserts, with supporting testimony from Dr. Hines, that Bhargava discloses (1) "[a] quantum dot colloid" (suspension of quantum dots in a polymer matrix); (2) "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 (3) "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; Ex. 1003 ¶¶ 16–17. Petitioner further argues that Bhargava necessarily discloses the "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" element of claim 12 because this limitation is a description of how quantum dots emit light. Pet. 43 (citing Ex. 1003 ¶¶ 10–14). We also have reviewed Petitioner's arguments and evidence for claims 13, 15, and 20, and are persuaded that Petitioner has met its burden of demonstrating anticipation by a preponderance of the evidence as to those claims as well. Based on all of the evidence of record, we determine that Petitioner has shown, by a preponderance of the evidence, that claims 12, 13, 15, and 20 are anticipated by Bhargava under 35 U.S.C. § 102(b).

2. Anticipation of Claims 12–15, 19–23, and 28 by 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. *Id.*

a. 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.

b. Claims 12–15, 19, and 20

Petitioner has presented sufficient evidence showing that Dabbousi discloses every limitation of claims 12–15, 19, and 20. Pet. 40–46, 48–49. For example, with respect to claim 12, Petitioner asserts, with supporting testimony from Dr. Hines, that Dabbousi discloses (1) "[a] quantum dot colloid" (dispersions of ZnS-overcoated CdSe quantum dots); (2) "a population of quantum dots dispersed in a nonconductive host matrix" ((CdSe)ZnS quantum dots in host matrix hexane); and (3) "each quantum dot having a substantially uniform surface energy" (quantum dots are colloidally grown). *Id.* at 40–42; Ex. 1003 ¶ 16. Petitioner further argues that Dabbousi discloses the "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" element of claim 12 because the dispersions shown in Dabbousi Figure 3 are irradiated with light having a wavelength of 365 nm, and the emission wavelengths of the quantum dots are between 470 and 620 nm. Pet. 44. We also have reviewed Petitioner's arguments and evidence for claims 13–15, 19, and 20, and are persuaded that Petitioner has met its burden of demonstrating anticipation by a preponderance of the evidence as to those claims as well. Based on all of the evidence of record, we determine that Petitioner has shown, by a preponderance of the evidence,

that claims 12–15, 19, and 20 are anticipated by Dabbousi under 35 U.S.C. § 102(a).

c. Claims 21–23 and 28

Petitioner has presented sufficient evidence showing that Dabbousi discloses every limitation of claims 21–23 and 28. Pet. 50–56, 59–60. For example, with respect to claim 21, Petitioner asserts, with supporting testimony from Dr. Hines, that Dabbousi discloses (1) "[a] method of producing light of a selected color" (dispersions of quantum dots emit light of a selected color when irradiated); (2) "providing at least one population of photoluminescent quantum dots dispersed in a host matrix" (quantum dots are dispersed in solvents and in polymers); and (3) "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" (band gap energy is determined by the size of the quantum dot, the quantum dots emit light of selected color when irradiated, and the energy of the irradiating light is greater than the band gap energy). *Id.* at 50–54; Ex. 1003 ¶¶ 10–14, 26. Petitioner further argues that Dabbousi discloses the "whereby the quantum dots photoluminesce light of the selected color when irradiated by the primary light source" element of claim 21 because the dispersions shown in Dabbousi Figure 3 show that quantum dots emit light of a selected color when irradiated. Pet. 54. We also have reviewed Petitioner's arguments and evidence for claims 22, 23, and 28, and are persuaded that Petitioner has met its burden of demonstrating anticipation by a preponderance of the evidence as to those claims as well. Based on all of the evidence of record, we determine that Petitioner has shown, by a

preponderance of the evidence, that claims 21–23 and 28 are anticipated by Dabbousi under 35 U.S.C. § 102(a).

3. Anticipation of Claims 12–14, 17, and 19–23 by 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. *Id.*

a. 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 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 of 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.

b. Claims 12–14, 17, 19, and 20

Petitioner has presented sufficient evidence showing that Bawendi discloses every limitation of claims 12–14, 17, 19, and 20. Pet. 40–45, 47–49. For example, with respect to claim 12, Petitioner asserts, with supporting testimony from Dr. Hines, that Dabbousi discloses (1) "[a] quantum dot colloid" (highly monodisperse colloidal suspensions of quantum dots); (2) "a population of quantum dots dispersed in a nonconductive host matrix" (ZnS-overcoated quantum dots dispersed in dilute hexane and other solvents); and (3) "each quantum dot having a substantially uniform surface energy" (quantum dot cores are prepared by a high-temperature solution growth process). *Id.* at 40–42; Ex. 1003 ¶¶ 15–16. Petitioner further argues that Bawendi discloses the "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" element of claim 12 because Bawendi describes selecting specific quantum dot size distributions to provide specific colors. Pet. 43–44. We also have reviewed Petitioner's arguments and evidence with respect to claims 13, 14, 17, 19, and 20, and are persuaded that Petitioner has met its burden of demonstrating anticipation by a preponderance of the evidence as to those claims as well. Based on all of the evidence of record, we determine that Petitioner has shown, by a

preponderance of the evidence, that claims 12–14, 17, 19, and 20 are anticipated by Bawendi under 35 U.S.C. § 102(a).

c. Claims 21–23

Petitioner has presented sufficient evidence showing that Bawendi discloses every limitation of claims 21–23. Pet. 50–55. For example, with respect to claim 21, Petitioner asserts, with supporting testimony from Dr. Hines, that Bawendi discloses (1) "[a] method of producing light of a selected color" (various colors of light produced by irradiating suspensions of quantum dots); (2) "providing at least one population of photoluminescent quantum dots dispersed in a host matrix" (quantum dots are dispersed in solvents, including dilute hexane); and (3) "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" (Figure 3 shows different samples of ZnS-overcoated quantum dots dispersed in dilute hexane emitting various light colors). *Id.* at 50–53; Ex. 1003 ¶¶ 10–14, 26. Petitioner further argues that Bawendi discloses the "whereby the quantum dots photoluminesce light of the selected color when irradiated by the primary light source" element of claim 21 because it was known that the characteristic band gap energy and color of photoluminescent quantum dots are determined by the size of the quantum dot. Pet. 54 (citing Ex. 1003 ¶¶ 10–14). We also have reviewed Petitioner's arguments and evidence with respect to claims 22 and 23, and are persuaded that Petitioner has met its burden of demonstrating anticipation by a preponderance of the evidence as to those claims as well. Based on all of the evidence of record,

we determine that Petitioner has shown, by a preponderance of the evidence, that claims 21–23 are anticipated by Bawendi under 35 U.S.C. § 102(a).

4. Anticipation of Claims 12–14, 19, and 20 by Hines

Petitioner contends that claims 12–14, 19, and 20 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. *Id.*

a. 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.

b. Analysis

Petitioner has presented sufficient evidence showing that Hines discloses every limitation of claims 12–14, 19, and 20. Pet. 24–25, 40–46, 48–56. For example, with respect to claim 12, Petitioner asserts, with supporting testimony from Dr. Hines, that Hines discloses (1) "[a] quantum dot colloid" (colloidal synthesis of ZnS-overcoated CdSe quantum dots); (2) "a population of quantum dots dispersed in a nonconductive host matrix" (quantum dots dispersed in solvents including TOP, chloroform, and pyridine); and (3) "each quantum dot having a substantially uniform surface energy" (quantum dots prepared by reaction and precipitation from a

solvent). *Id.* at 40–42; Ex. 1003 ¶¶ 16, 32. Petitioner further argues that Hines discloses the "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" element of claim 12 because Hines Figure 3 shows that the excitation wavelength (light from the primary light source) is shorter than the wavelength of the light emitted from the quantum dots. Pet. 44. We also have reviewed Petitioner's arguments and evidence with respect to claims 13, 14, 19, and 20, and are persuaded that Petitioner has met its burden of demonstrating anticipation by a preponderance of the evidence as to those claims as well. Based on all of the evidence of record, we determine that Petitioner has shown, by a preponderance of the evidence, that claims 12–14, 19, and 20 are anticipated by Hines under 35 U.S.C. § 102(b).

III. CONCLUSION

Petitioner has shown, by a preponderance of the evidence, that claims 1–3, 8, 10, and 11 of the '091 patent are unpatentable under 35 U.S.C. § 102(b) as anticipated by Burt.

Petitioner has shown, by a preponderance of the evidence, that claims 12, 13, 15, and 20 of the '091 patent are unpatentable under 35 U.S.C. § 102(b) as anticipated by Bhargava.

Petitioner has shown, by a preponderance of the evidence, that claims 12–15, 19–23, and 28 of the '091 patent are unpatentable under 35 U.S.C. § 102(a) as anticipated Dabbousi.

Petitioner has shown, by a preponderance of the evidence, that claims 12–14, 17, and 19–23 of the ’091 patent are unpatentable under 35 U.S.C. § 102(a) as anticipated by Bawendi.

Petitioner has shown, by a preponderance of the evidence, that claims 12–14, 19, and 20 of the ’091 patent are unpatentable under 35 U.S.C. § 102(b) as anticipated by Hines.

IV. ORDER

In consideration of the foregoing, it is

ORDERED that claims 1–3, 8, 10–15, 17, 19–23, and 28 of the ’091 patent are determined to be *unpatentable*; and

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

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