

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

RAYVIO CORPORATION,
Petitioner,

v.

NITRIDE SEMICONDUCTORS CO., LTD.,
Patent Owner.

IPR2018-01141
Patent 6,861,270 B2

Before BARBARA A. BENOIT, FRANCES L. IPPOLITO, and
JOHN D. HAMANN, *Administrative Patent Judges*.

HAMANN, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining Some Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

This *inter partes* review, instituted pursuant to 35 U.S.C. § 314, challenges the patentability of claims 1–13 of U.S. Patent No. 6,861,270 B2 (Ex. 1001, “the ’270 patent”), owned by Nitride Semiconductors Company, Ltd. (“Patent Owner”). We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73 (July 2017).

For the reasons discussed herein, RayVio Corporation (“Petitioner”), by a preponderance of the evidence, (i) has shown that claims 5 and 12 of the ’270 patent are unpatentable, and (ii) has *not* shown that claims 1–4, 6–11, and 13 of the ’270 patent are unpatentable.

II. BACKGROUND

A. Procedural History

On May 22, 2018, Petitioner filed a Petition requesting *inter partes* review of the challenged claims of the ’270 patent. Paper 1 (“Pet.”). On September 10, 2018, Patent Owner filed a Preliminary Response. Paper 7. Petitioner, with our authorization, filed a Motion to Correct Petition and Maintain Filing Date, on September 28, 2018. Paper 10. In particular, Petitioner sought to correct clerical errors with respect to three exhibits it filed with the Petition. *Id.* at 2. Patent Owner filed an Opposition to Petitioner’s Motion. Paper 12. We granted this Motion, and authorized Petitioner to file corrected copies of the three exhibits at issue. Paper 13, 5–8.

We instituted *inter partes* review of all of the challenged claims of the ’270 patent on all of the asserted grounds. Paper 14 (“Inst. Dec.”), 30. Patent Owner filed a Response to the Petition. Paper 24 (“PO Resp.”).

Petitioner filed a Reply to Patent Owner's Response. Paper 27 ("Pet. Reply"). Patent Owner filed a Sur-Reply to Petitioner's Reply. Paper 34 ("PO Sur-Reply").

In addition, Petitioner, with our authorization, filed an unopposed Motion to File Supplemental Information. Paper 19. In particular, Petitioner sought to file two declarations and updated certificates of translations in support of the prior art status of submitted references. *Id.* at 1, 3. We granted this Motion, and authorized Petitioner to file its supplemental information. Paper 22.

In addition, Patent Owner, with our authorization, filed a Motion for Supplemental Information or Evidence. Paper 33. In particular, Patent Owner sought our authorization to file a foreign language reference and its English translation. *Id.* at 1. Petitioner filed an Opposition to Patent Owner's Motion. Paper 36. We denied this Motion. Paper 37, 7.

An oral hearing was held on September 5, 2019. A transcript of the oral hearing is included in the record. Paper 38 ("Tr.").

B. Related Matters

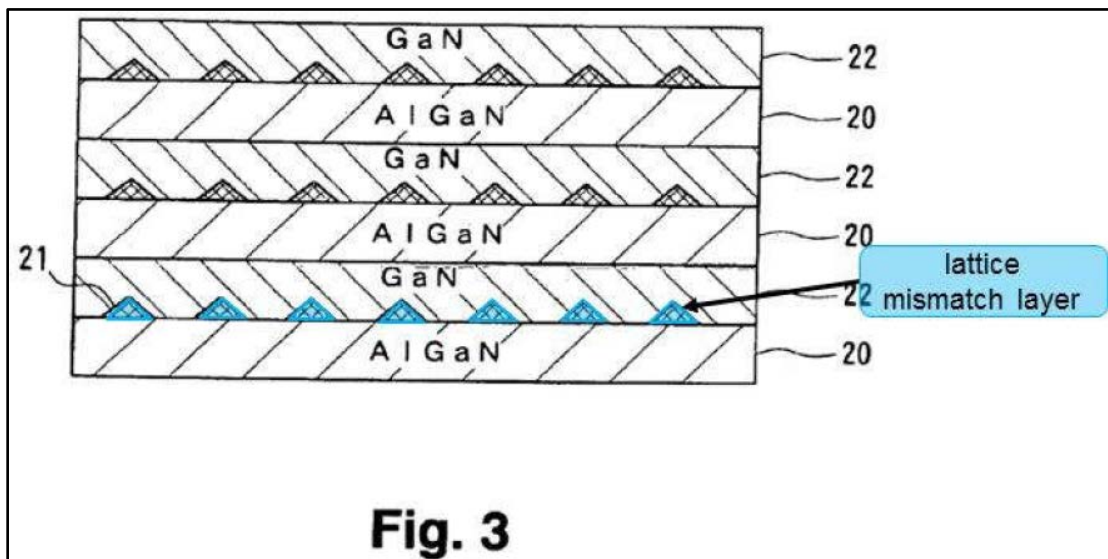
The parties identify the following matters that may affect or would be affected by a decision in this proceeding: (1) *Nitride Semiconductors Co. v. RayVio Corp.*, Case No. 5:17-cv-02952-CJD, in the U.S. District Court for the Northern District of California; and (2) *RayVio Corp. v. Nitride Semiconductors Co.*, IPR2018-01139, before the Patent Trial and Appeal Board. Pet. 1, Paper 6, 1.

C. The Challenged Patent

The '270 patent relates to manufacturing gallium nitride ("GaN") based semiconductors to improve their "light emitting efficiency, even when

dislocations [(i.e., defects)] are present in the semiconductor[s].” Ex. 1001, code(57), 1:42–45. To this end, the ’270 patent improves light emitting efficiency by increasing the locations in a semiconductor where electrons and holes recombine to emit light. *See id.* at 1:27–39, 4:63–5:5. These light emitting locations correspond to the narrower portions of a semiconductor’s band gap, when the band gap spatially fluctuates (i.e., widens and narrows). *See id.* at 1:26–30, 3:53–55. In other words, the ’270 patent discloses increasing the density of locations having a narrower band gap, so that more of the electrons and holes that recombine do so to produce light. *Id.*

The ’270 patent discloses three separate embodiments for increasing the density of the light emitting locations. *E.g., id.* at 3:9–20. The third of these embodiments is pertinent to our analysis below. This embodiment relies on lattice mismatch to increase the light emitting locations. *Id.* at 2:32–39, 4:45–47, 4: 4:62–5:1. Figure 3,¹ shown below, illustrates this third embodiment. *Id.* at 4:45–47.



¹ Shown as annotated by Petitioner. Pet. 6.

Figure 3 shows a GaN based semiconductor device manufactured in accordance with the third embodiment of the '270 patent. Ex. 1001, 4:45–47, Fig. 3. More specifically, Figure 3 shows a AlGa_N/GaN superlattice structure (i.e., a periodic structure of layers of two (e.g., AlGa_N and GaN) or more materials) manufactured according to the third embodiment. *Id.* at 4:47–49, Fig. 3.

The bottommost “AlGa_N layer 20 is formed on a substrate (not shown) and then a GaN layer 22 is formed. . . . The thickness of each layer can be set at 1~100 nm, for example, 5 nm.” *Id.* at 4:50–55. “When forming the GaN layer 22 on the AlGa_N layer 20, a discrete layer (lattice mismatch layer) 21 of a material having relatively high lattice mismatch . . . is formed, and the GaN layer 22 is formed on the AlGa_N layer 20 onto which this layer 21 is formed.” *Id.* at 4:54–59. As shown in Figure 3, lattice mismatch layer 21 is a “discrete” layer in that it is formed on less than the total area of AlGa_N layer 20’s surface. *Id.* at Fig. 3. In addition, the '270 patent discloses examples of materials “having relatively high lattice mismatch” relative to AlGa_N and GaN that can be used in forming the lattice mismatch layer, i.e., AlN, InN, AlInGa_N, Si, and MgN. *Id.* at 4:54–59.

Because layer 21 has high lattice mismatch, “minute unevenness is generated on the surface” of the AlGa_N layer 20. *Id.* at 4:61–63. In turn, this causes “the thickness of the GaN layer 22 in the portion of the unevenness [to] differ[] from that of the other portions, [and] the thickness of the [GaN] layer [22] becomes non-uniform.” *Id.* at 4:63–66. In other words, “[w]hen there is a lattice mismatch, the thickness of the gallium nitride based semiconductor layer at the region where the lattice mismatch is

present differs (namely, the thickness is narrower) from the thickness in the other regions.” *Id.* at 2:40–44.

“Due to this non-uniformity, the quantum level based on the quantum effect spatially varies and the band gap [of the GaN layer 22]” spatially fluctuates (i.e., widens and narrows). *Id.* at 4:66–5:1; *see also id.* at 2:44–45. Figure 4, shown below, “is an explanatory diagram illustrating spatial fluctuation in a band gap.” *Id.* at 3:21–22.

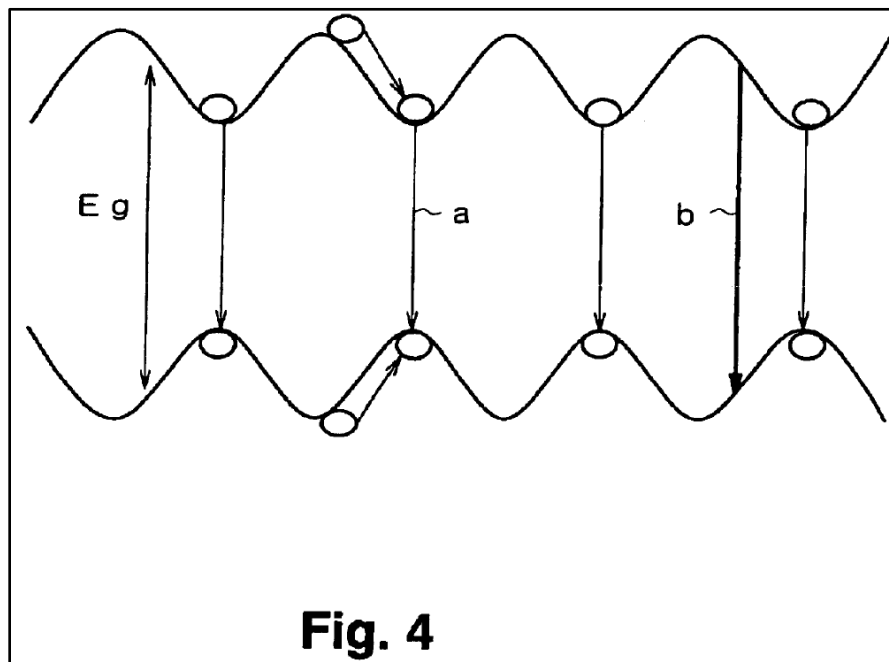


Figure 4 schematically shows a spatially fluctuating band gap (E_g) of a light emitting semiconductor. *Id.* at 1:26–27. The narrower gaps (labeled “a”) represent light emitting locations. *Id.* at 1:29–30. The wider gaps (labeled “b”) represent non-luminous recombination locations corresponding to dislocations. *Id.* at 1:36–38. The embodiments of the ’270 patent seek to increase the density of the light emitting locations (“a” gaps) relative to the density of the dislocations (“b” gaps) to improve light emitting efficiency. *Id.* at 1:31–39.

D. The Challenged Claims

Petitioner challenges claims 1–13 of the '270 patent, of which claims 1, 3, 5, 8, 10, and 12 are independent claims. For the reasons we provide below, our analysis of the challenged claims focuses on independent claim 5. Claim 5 is reproduced below:

5. A method for manufacturing a gallium nitride based semiconductor comprising the steps of:
- (a) forming, on a substrate, a base layer having a lattice mismatch layer formed on less than a total area of a surface of the base layer; and
 - (b) forming the gallium nitride based semiconductor on the base layer; wherein
- a spatial fluctuation is created in the band gap of the gallium nitride based semiconductor by the lattice mismatch, and the gallium nitride based semiconductor is a light emitting layer.

Ex. 1001, 6:1–11.

E. Asserted Grounds of Unpatentability

Petitioner asserts the following grounds of unpatentability:

Reference(s)	35 U.S.C. ²	Challenged Claims
Sakai ³	§ 102(a)	1–13
Ozaki ⁴	§ 102(b)	5, 12

² The Leahy-Smith America Invents Act (“AIA”) included revisions to 35 U.S.C. § 100 *et seq.* effective on March 16, 2013. Because the '270 patent issued from an application filed before March 16, 2013, we apply the pre-AIA versions of the statutory bases for unpatentability.

³ JP Pub. No. 2001-345478 (published Dec. 14, 2001) (Corrected Ex. 1005, hereinafter “Sakai” or “Ex. 1005”).

⁴ JP Pub. No. H10-215029 (published Aug. 11, 1998) (Corrected Ex. 1006, hereinafter “Ozaki” or “Ex. 1006”). Petitioner also filed a copy of Ozaki (as Exhibit 1032) when filing its Reply, which is inconsistent with our Rules. See 37 C.F.R. 42.63(c). Accordingly, our decision refers to Exhibit 1006.

Reference(s)	35 U.S.C. ²	Challenged Claims
Ozaki and Solymar ⁵	§ 103(a)	5, 12

Pet. 3, 15–55.

F. Submitted Declarations

Petitioner submits (i) the Declaration of Eugene Fitzgerald, Ph.D in Support of Petition for *Inter Partes* Review (Ex. 1002) and (ii) the Declaration of Eric Bretschneider, Ph.D in Support of Patent Owner’s Opening Claim Construction Brief (Ex. 1009), from the underlying District Court litigation, to support its arguments. Patent Owner submits the Declaration of Alan Doolittle Ph.D. in Support of Patent Owner’s Responses (Ex. 2053) to support its arguments.

III. LEVEL OF ORDINARY SKILL IN THE ART

In determining the level of ordinary skill in the art, various factors may be considered, including the “type of problems encountered in the art; prior art solutions to those problems; rapidity with which innovations are made; sophistication of the technology; and educational level of active workers in the field.” *In re GPAC, Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995) (citing *Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc.*, 807 F.2d 955, 962 (Fed. Cir. 1986)). “[O]ne or more factors may predominate.” *Id.*

Petitioner argues a person having ordinary skill in the art at the time of the invention of the ’270 patent would have had “a Bachelor’s degree in physics, electrical engineering, materials science, or the equivalent thereof,

⁵ Excerpts of L. SOLYMAR & D. WALSH, LECTURES ON THE ELECTRICAL PROPERTIES OF MATERIALS (5th ed. 1993) (Ex. 1011, “Solymar”).

and 3-5 years of professional experience working in the field of nitride semiconductors.” Pet. 6 (citing Ex. 1002 ¶ 17).

Patent Owner argues that “[t]here is no material difference between Petitioner’s and Patent Owner’s definitions of a” person having ordinary skill in the art. PO Resp. 15. Patent Owner’s expert, Dr. Doolittle, opines that:

a person of ordinary skill in the art relevant to the ’270 patent at the time of the invention would have had an undergraduate degree in chemical engineering, material science, electrical engineering, applied physics, or an equivalent field of study, and at least three years of professional experience in the field of light-emitting diode device design and fabrication. Alternatively, a person of ordinary skill in the art would have had a graduate degree in chemical engineering, material science, electrical engineering, applied physics, or an equivalent field of study, and at least two years of professional experience in the field of light-emitting diode device design and fabrication.

Ex. 2053 ¶ 139.

Although there are slight differences between the parties’ definitions, we agree with Patent Owner that there is no meaningful distinction between them that would change the analysis as to patentability. PO Resp. 15. We also find that both definitions are consistent with the level of ordinary skill in the art reflected by the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001); *GPAC*, 57 F.3d at 1579; *In re Oelrich*, 579 F.2d 86, 91 (CCPA 1978).

In light of the above, we can choose either definition as there is no meaningful distinction between them. We select Petitioner’s articulation of the level of ordinary skill in the art, as we did in our Decision on Institution.

Inst. Dec. 8. Our analysis would not differ, however, if we selected Dr. Doolittle's definition.

IV. CLAIM CONSTRUCTION

For petitions filed before November 13, 2018, we interpret the claims of an unexpired patent that will not expire before issuance of a final written decision using the broadest reasonable interpretation in light of the specification. *See* 37 C.F.R. § 42.100(b) (2016); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under that standard, claim terms are presumed to be given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art, in the context of the entire disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007). Any special definition for a claim term must be set forth with reasonable clarity, deliberateness, and precision. *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

The parties collectively propose various claim terms for construction. Pet. 7–8; PO Resp. 11–13. As we address below, the only claim term having its construction in controversy is “a spatial fluctuation . . . in the band gap,” as recited in claim 5.

A. Spatial Fluctuation in the Band Gap

Independent claim 5 recites “a spatial fluctuation is created in the band gap,” and independent claim 12 recites “a spatial fluctuation in the band gap.”

In its Response, Patent Owner proposes that the district court's construction in the related litigation should be adopted. PO Resp. 11–13. Specifically, Patent Owner argues that we should construe the phrase “a spatial fluctuation . . . in the band gap” to mean “a ‘continuous widening and

narrowing of the band gap laterally within' the semiconductor.” *Id.* at 11 (quoting Ex. 1004, 27). To that end, Patent Owner argues that “[t]he plain meaning of a spatial fluctuation in the bandgap is a *continuous* widening and narrowing of that bandgap.” *Id.* at 12. “This plain meaning is consistent with the [S]pecification,” according to Patent Owner. *Id.* For example, Figure 4 of the ’270 patent “shows a ***continuous*** widening and narrowing of the band gap,” Patent Owner argues. *Id.* (citing Ex. 2053 ¶¶ 116–124). Put differently, Patent Owner argues that Figure 4 “shows a wavelike pattern, i.e., continuous widening and narrowing of the band gap E_g .” PO Sur-Reply 2–3 (citing Ex. 1001, 1:26–39, 3:21–22, Fig. 4). Moreover, “the ’270 patent expressly describes Figure 4 as ‘an explanatory diagram illustrating spatial fluctuation in a band gap,’” according to Patent Owner. *Id.* at 3 (quoting Ex. 1001, 3:21–22).

In addition, Patent Owner argues that Webster’s Dictionary defines “fluctuate” as meaning “to change continually; vary irregularly” or “[to] move in waves[;] . . . undulate.” PO Resp. 12 (quoting Ex. 2035, 310); *see also* PO Sur-Reply (quoting Ex. 1035, 3; Ex. 1036, 3) (arguing dictionaries cited by Petitioner also define “fluctuate” as including the meaning of “[t]o rise and fall in or as if in waves; undulate” and “[t]o rise and fall like waves”). Patent Owner also argues that Dr. Doolittle, Patent Owner’s expert, testifies that the Webster’s Dictionary definition “is the same in the art.” PO Resp. 12 (citing Ex. 2053 ¶¶ 110–115, 123–125).

Lastly, Patent Owner argues that Petitioner did not contest this construction in the District Court. *Id.* at 11 (citing Ex. 1004, 16). Nor did Petitioner “offer expert testimony to support its proposed construction,” according to Patent Owner. PO Sur-Reply at 3. In contrast, Patent Owner

argues that Dr. Doolittle’s testimony supports its proposed construction. PO Sur-Reply 3–4 (citing Ex. 2053 ¶¶ 116–127).

In its Reply, Petitioner responds that based on the Specification and extrinsic dictionary definitions, the broadest reasonable interpretation of the term should not include “continuous.” Pet. Reply 1 (Ex. 1001, 3:52–54; Ex. 1035; Ex. 1036). Petitioner further contends that, at the district court, “[g]iven the number of terms and limited briefing space, Petitioner focused its briefing on other terms and indefiniteness.” *Id.* at 2. Further, at the oral hearing, Petitioner indicated that it does not contest including “laterally” in the BRI construction, but that the Specification does not define the spatial fluctuation this way. Tr. 4:24–5:2 (“MR. TONKOVICH: Laterally is part of the District Court construction, and we don’t have a problem with laterally. Again, that’s not how the Patent Owner defined it, so I think there is a legitimate point in not having laterally in there either.”).

Based on the complete record, we understand the parties’ dispute to rest principally on whether the broadest reasonable interpretation of “spatial fluctuation . . . in the band gap” requires *continuous* widening and narrowing of the band gap. We determine that it does not.

Turning to the ’270 patent, we find that the Specification does not require that the spatial fluctuation in the band gap be continuous. *See generally* Ex. 1001. The ’270 patent expressly states that its invention “produces a spatial fluctuation in the band gap, *that is, widening and narrowing of the band gap.*” Ex. 1001, 3:51–54 (emphasis added). The ’270 patent teaches that, in some embodiments, a spatial fluctuation is created in the band gap by producing a change in compositional ratio in the

second gallium nitride based semiconductor by the composition material.

Ex. 1001, 1:56–58. For one embodiment, the '270 patent teaches that

[w]hen the composition material is present, the solid phase composition of the composition material is increased in a gallium nitride based semiconductor when it is formed on the composition material. Because of this, the compositional ratio in the region where the composition material is present differs from that in the region where the composition material is not present. Due to the difference in the compositional ratio, a spatial fluctuation is produced in the band gap. By forming the spatial fluctuation in the band gap, recombination of the carriers are facilitated at the region where the band gap is narrow, and, thus, the light emitting efficiency can be increased even when such dislocations are present.

Id. at 1:59–2:3. Referring to Figures 1A and 1B, reproduced below, the '270 patent teaches that in the regions where the Ga droplets are present, the solid phase composition of gallium within $\text{Al}_x\text{Ga}_{1-x}\text{N}$ layer 16 becomes high, and thus, a spatial fluctuation is formed in the band gap of $\text{Al}_x\text{Ga}_{1-x}\text{N}$ layer 16.

Id. at 3:44–48.

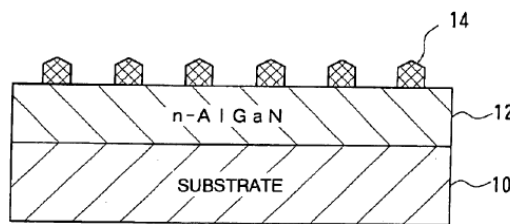


Fig. 1A

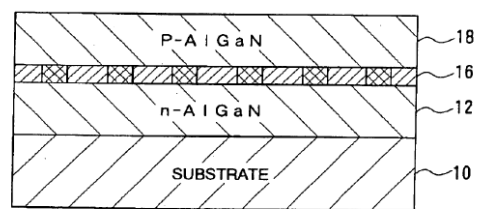


FIG. 1B

In describing a “second” embodiment, the '270 patent further teaches that “a spatial fluctuation in the band gap can easily be created with a density greater than or equal to the dislocation density, and, thus, the light emitting efficiency can be improved.” *Id.* at 4:40–44. Further, for another embodiment shown in Figure 3, the '270 patent teaches that “although FIG.

3 shows a lattice mismatch layer 21 formed on the AlGaN layer 20, it is also possible to form the lattice mismatch layer 21 on the GaN layer 22 and form a spatial fluctuation in the band gap of the AlGaN layer 20.” *Id.* at 5:18–21. The term “continuous” is not used to describe the spatial fluctuation present in any of these embodiments.

Additionally, the '270 patent provides Figure 4, reproduced below, to illustrate a spatial fluctuation in a band gap. Ex. 1001, 3:21–22.

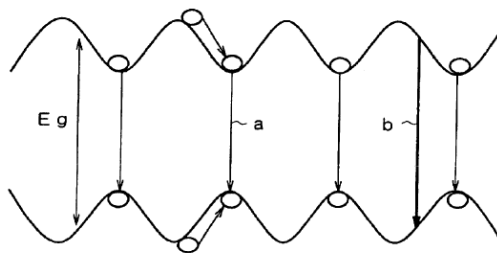


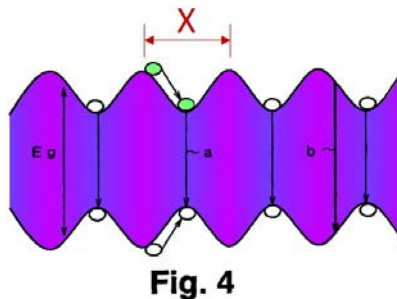
Fig. 4

Figure 4 schematically shows the band gap E_g of a material for a light emitting element. Ex. 1001, 1:26–27. Referring to Figure 4, the '270 patent teaches that

when there is a spatial fluctuation in the band gap of the light emitting element material, light emission occurs only at the locations where the band gap is narrow (gap “a” in the figure). Therefore, if the density of the light emitting points based on the spatial fluctuation of the band gap can be set to exceed the density of dislocations in the light emitting element materials, it is possible to obtain a percentage of the luminous recombination occurring at the points where the band gap is narrow which is higher than the percentage of the non-luminous recombination of an electron and a hole at the dislocations (gap “b” in the figure), and, therefore, degradation in the light emitting efficiency can be inhibited.

Id. at 1:26–39. Here, we observe that the '270 patent also does not expressly describe the spatial fluctuation as continuous. *Id.*

With regard to Figure 4, Patent Owner relies on the testimony of Dr. Doolittle, who testifies that “Figure 4 . . . is a generic depiction of the potential energy, and shows that the electron (colored green) and hole (uncolored) move to seek the lowest energy available.” Ex. 2053 ¶ 97. Dr. Doolittle’s annotated Figure 4 is reproduced below:



Annotated Figure 4 of the '270 patent from Dr. Doolittle’s Declaration shows the electron outside the low-bandgap region and moving down the conduction band edge toward the low bandgap region, according to Dr. Doolittle. Ex. 2053 ¶ 98. Referring to annotated Figure 4, Dr. Doolittle asserts that

Figure 4 shows the electron outside the low-bandgap region and moving down the conduction band edge toward the low bandgap region. *That the electron is outside the low bandgap area suggests no quantum confinement.* Additionally, no quantized states are shown in Figure 4. Instead, *the arrow (showing the movement of the electron and the hole) informs a POSA that there is a continuous movement in position (lateral directions in figure 4) and energy (vertical directions in Figure 4), and from that, a POSA would conclude that Figure 4 is showing a smoothly varying change in both position and energy.* Critically, electrons in a quantum state moving laterally do so without varying energy, i.e., they move straight across because the quantized energy is independent of position inside the quantum

dot. Electrons in a non-quantized state moving laterally fluctuate in energy as the band gap fluctuates, as shown above.

Ex. 2053 ¶ 98 (emphases added).

Additionally, Dr. Doolittle relies on extrinsic evidence to show that a PHOSITA would read Figure 4 to teach smooth continuous energy variations rather than the “abrupt changes in energy of quantum dots.” Ex. 2053 ¶ 99 (Figure 4 “stands in stark contrast to quantum dots, which involve abrupt changes in energy that a person of ordinary skill in the art would have easily recognized as discontinuous energy jumps and a constant energy, E_n , within the quantum dot.”) (citing Ex. 2038); *see also* ¶ 124 (citing Exhibits 2047–2048 as schematics showing continuous potential fluctuation).

Although we agree that Figure 4 provides, in Dr. Doolittle’s words, a “simplified approximation of potential energy fluctuation,” Dr. Doolittle’s testimony strays from the express disclosure in the ’270 patent. The Specification does not teach expressly that Figure 4 shows a *continuous* fluctuation. Further, the Specification states explicitly that the “compositional variation” shown in Figures 1A and 1B “*produces a spatial fluctuation in the band gap, that is, widening and narrowing of the band gap.*” Ex. 1001, 3:52–54 (emphasis added). Here, the intrinsic evidence supports Petitioner’s position that the construction of “spatial fluctuation . . . in the band gap” is reasonably broader than Patent Owner’s proposal.

Moreover, Patent Owner acknowledges that the ’270 patent describes Figure 4 as being “an *explanatory diagram* illustrating spatial fluctuation in a band gap.” Ex. 1001, 3:21–22 (emphasis added); PO Resp. 12 (quoting Ex. 1001, 3:21–22). As such, Figure 4 serves to explain the concept of spatial fluctuation, rather than to further limit spatial fluctuation, which we find the ’270 patent defines as “widening and narrowing of the band gap.”

Id. at 3:51–54. Further, to the extent that Figure 4 depicts spatial fluctuation that is continuous, such a depiction is a specific example of “widening and narrowing of the band gap,” rather than serving to limit the claims to that example, when viewed in light of the entire disclosure of the ’270 patent. E.g., Ex. 1001, 1:26–39, 3:21–22, 3:51–54, Fig. 4; *see also Phillips v. AWH Corp.*, 415 F.3d 1303, 1321 (Fed. Cir. 2005) (“Properly viewed, the ‘ordinary meaning’ of a claim term is its meaning to the ordinary artisan after reading the entire patent.”); *MBO Labs., Inc. v. Becton, Dickinson & Co.*, 474 F.3d 1323, 1333–34 (Fed. Cir. 2007) (citing *Gart v. Logitech, Inc.*, 254 F.3d 1334, 1342 (Fed. Cir. 2001)) (“[P]atent coverage is not necessarily limited to inventions that look like the ones in the figures.”). Rather, the express language of the ’270 patent is broader and states that a spatial fluctuation in the band gap is “widening and narrowing of the band gap.” Ex. 1001, 3:51–54.

Additionally, we are not persuaded that the ’270 patent considered as a whole excludes irregular or discontinuous fluctuations that may characterize energy variations on the quantum level. *See* Ex. 2053 ¶¶ 99, 123. Referring to Figure 3, the ’270 patent expressly teaches that

[b]ecause the thickness of the GaN layer 22 in the portion of the unevenness differs from that of the other portions, the thickness of the layer becomes non-uniform. Due to this non-uniformity, the *quantum level based on the quantum effect spatially varies and the band gap is spatially fluctuated*.

Ex. 1001, 4:63–5:1 (emphasis added). At a minimum, the ’270 patent contemplates that quantum level effects, including spatial variation, which undercuts Dr. Doolittle’s testimony that the ’270 patent excludes any discontinuous spatial fluctuations on the quantum level.

Also, at the very least, Dr. Doolittle's testimony does not address "continuous" with respect to the third embodiment's teaching that "the quantum level . . . spatially varies and the band gap is spatially fluctuated." Nor does Dr. Doolittle address how continuous relates to transitions between spatially varying quantum levels and lateral position, for this third embodiment. We also find Dr. Doolittle's testimony that "[t]he '270 discusses a range of sizes (i.e., up to a micron distance between narrow band gap regions) that cannot result in a quantized state" unavailing. *Id.* ¶ 97 (citing Ex. 1001, 2:5–8). This testimony does not change that the '270 patent also teaches an embodiment having a quantum well and that the quantum level spatially varies. Ex. 1001, 4:63–5:1. Thus, we find insufficient justification for a construction that would exclude the '270 patent's third embodiment. *Starhome GmbH v. AT & T Mobility LLC*, 743 F.3d 849, 857 (Fed. Cir. 2014) (quoting *Vitronics Corp.*, 90 F.3d at 1583) ("[A] construction that excludes a preferred embodiment 'is rarely, if ever, correct and would require highly persuasive evidentiary support.'"). Thus, to the extent that we would have considered Dr. Doolittle's testimony for this construction, we would have given it little weight in light of the express teachings in the Specification that contradict his testimony.

We further note that because we construe spatial fluctuation in the band gap in light of the intrinsic evidence in the record, we need not resort to extrinsic evidence, such as the dictionary definitions offered by the parties. *See Power Integrations, Inc. v. Fairchild Semiconductor Int'l., Inc.*, 711 F.3d 1348, 1360 (Fed. Cir. 2013); *Vitronics Corp.*, 90 F.3d at 1583 ("In most situations, an analysis of the intrinsic evidence alone will resolve any ambiguity in a disputed claim term. In such circumstances, it is improper to

rely on extrinsic evidence.”). Nonetheless, we determine also that the parties’ reliance on dictionary definitions is consistent with our construction. Dr. Doolittle asserts that, based on dictionary definitions, the plain and ordinary meaning of “fluctuate” or “fluctuation” is: “1. To change continually; vary irregularly; shift back and forth or up and down 2. To move in waves; undulate,” (Ex. 2035, 310), and “1. constant change; vacillation; instability. 2. undulation,” (Ex. 2046, 627). Ex. 2053 ¶ 123. Petitioner submits a similar definition from the American Heritage Dictionary: “1. To vary irregularly. . . 2. To rise or fall in or as if in waves; undulate. . . .” Ex. 1005, 310. We find that these definitions support our determination that the plain and ordinary meaning of “fluctuate” may include a broad range of variation that is not limited to Patent Owner’s narrower proposal of *continuous* fluctuation.

Further, we are not persuaded that Petitioner has conceded the construction of this term in this proceeding because “Petitioner did not contest this construction in District Court.” PO Resp. 11. Petitioner has explained that it did not agree with Patent Owner’s proposal in the related litigation for the full phrase “a spatial fluctuation is created in the band gap by variation in the compositional ratio in the second gallium nitride based semiconductor created by the composition material, and the second gallium nitride based semiconductor is a light emitting layer,” recited in claim 1, but opted to focus its district court briefing on other claim terms and issues. Pet. Reply 1–2.

The district court’s claim construction order indicates that it adopted Patent Owner’s construction without having considered any of Petitioner’s arguments that have been presented in this proceeding. Ex. 1004, 16

(“Nitride proposes that ‘spatial fluctuation . . . in the band gap’ should be construed as ‘continuous widening and narrowing of the band gap laterally within the second gallium nitride based semiconductor.’ RayVio does not appear to disagree with this proposed construction. Responsive Br. 11. Accordingly, the Court adopts Nitride’s proposed construction of this phrase.”). Thus, we determine that the record here is different from that in the related litigation, and when our complete record is considered, Petitioner’s arguments are better supported by and consistent with the Specification.

For the reasons discussed above, we determine that the broadest reasonable interpretation of “spatial fluctuation . . . in the band gap” is “widening and narrowing of the band gap.”

B. Remaining Claim Terms Proposed for Construction

Petitioner proposes that we adopt certain of the district court’s claim constructions from the underlying district court litigation. Pet. 7–8. More specifically, Petitioner proposes that we adopt the district court’s claim constructions for: (i) “forming on”/“formed on,” (ii) “a light emitting layer,” (iii) “a base layer,” (iv) “lattice mismatch layer,” and (v) “the lattice mismatch”/“a lattice mismatch.” *Id.* (citing Ex. 1004 (“Claim Construction Order”), 11:20–21, 14:14–16, 23:22–23, 25:3–10, 27:2–10). Patent Owner argues that “[i]n this proceeding, [it] focuses on explaining why Petitioner failed to carry its burden to show unpatentability even assuming Petitioner’s constructions.” PO Resp. 10.

Accordingly, we determine that express constructions for these other terms are not needed because “we need only construe terms ‘that are in

controversy, and only to the extent necessary to resolve the controversy.’”
Nidec, 868 F.3d at 1017.

V. SAKAI IS NOT PRIOR ART

Under § 102(a), prior art constitutes what “was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, *before the invention thereof by the applicant* for patent.” 35 U.S.C. § 102(a) (emphases added). In other words, “one’s own work is not prior art under § 102(a) even though it has been disclosed to the public in a manner or form which otherwise would fall under § 102(a).” *In re Katz*, 687 F.2d 450, 454 (CCPA 1982); *see also Trebro Mfg., Inc. v. Firefly Equip., LLC*, 748 F.3d 1159, 1169 (Fed. Cir. 2014) (finding a patent with the same inventive entity as a challenged patent does not qualify as prior art under 35 U.S.C. § 102(a) or § 102(e)).

The parties correctly agree that Sakai and the ’270 patent have the same inventive entity, i.e., Mr. Shiro Sakai. Pet. 8; PO Resp. 15; *see also* Ex. 1001, code(75); Ex. 1005, code(72). Because of having the same inventive entity, Sakai cannot be § 102(a) prior art (or § 102(e) prior art) to the ’270 patent. *E.g., Katz*, 687 F.2d at 454. We also note that Sakai was published on December 14, 2001, which is less than one year before the application for the ’270 patent was filed (March 6, 2002). Thus, Sakai does not qualify as prior art under § 102(b) against the ’270 patent. *See* 35 U.S.C. § 102(b) (stating that prior art includes where “the invention was patented or

described in a printed publication in this or a foreign country . . . , more than one year prior to the date of the application for patent in the United States”).

Moreover, during the oral hearing, Petitioner agreed, for the purposes of this proceeding, that Sakai is not prior art to the ’270 patent, and that it is “not going forward with Sakai as . . . prior art.” Tr. 25:2–14.

Accordingly, we determine that Sakai is not prior art to the ’270 patent. We, therefore, also determine that Petitioner has not shown, by a preponderance of the evidence, that claims 1–13 are unpatentable in view of Sakai.

VI. OBVIOUSNESS OVER OZAKI AND SOLYMAR

For the reasons that follow, we determine that the combination of Ozaki and Solymer would have rendered obvious the subject matter of claims 5 and 12 of the ’270 patent.

A. *Law for Demonstrating Obviousness*

To prevail in challenging Patent Owner’s claims, Petitioner must demonstrate by a preponderance of the evidence that the claims are unpatentable. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d). “In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.” *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify “with particularity . . . the evidence that supports the grounds for the challenge to each claim”)). This burden of persuasion never shifts to Patent Owner. See *Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (citing *Tech. Licensing Corp. v. Videotek, Inc.*, 545 F.3d

1316, 1326–27 (Fed. Cir. 2008)) (discussing the burden of proof in *inter partes* review).

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time of the invention to a person having ordinary skill in the art. *KSR Int’l Co. v. Teleflex, Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) objective evidence of non-obviousness, if present.⁶ *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966). When evaluating a claim for obviousness, we also must “determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue.” *KSR*, 550 U.S. at 418 (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)).

B. Summary of Ozaki

Ozaki discloses manufacturing nitride semiconductor devices that have significantly improved light emitting performance. *E.g.*, Ex. 1006 ¶¶ 1, 7, 16, 19. More specifically, Ozaki describes a laminated semiconductor structure that includes a nitride semiconductor layer between a substrate and an active layer. Ex. 1006 ¶ 13. Examples of this structure are shown in Figures 2 and 3, which are reproduced below.

⁶ Patent Owner does not present arguments or evidence of such objective evidence of non-obviousness in its Response. *See generally* PO Resp. 16–41.

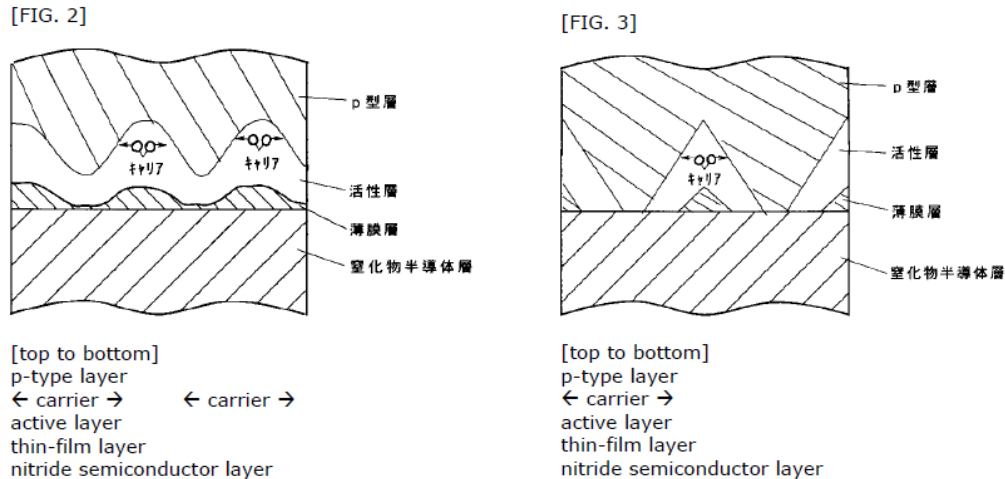


Figure 2 (above, left) and Figure 3 (above, right) are cross-sectional views of laminated structures with a n-type nitride semiconductor layer, a thin-film layer with a lattice constant irregularity difference of $\pm 3\%$ or more, an active layer, and a p-type layer on top. Ex. 1006 ¶ 15.

Ozaki teaches that when a thin-film layer is very thin, there are spots in the film where metal atoms are present and spots in the film where metal atoms are absent from a microscopic viewpoint. Ex. 1006 ¶ 16. The presence or absence of these atoms in the film cause the film thickness to be uneven. *Id.* According to Ozaki, when the thickness of the thin-film layer is uneven, the properties of the crystals will be different. *Id.* Ozaki further teaches:

The crystal component constituting the thin-film layer is selected depending on the atoms or compound present in the crystals constituting the nitride semiconductor layer in contact with the thin-film layer so that the lattice constant irregularity difference of the thin-film layer is $\pm 3\%$ or more relative to that of the nitride semiconductor layer. There are no particular restrictions on this in the present invention. When the thin-film layer in the present invention is a nitride semiconductor, there are no particular restrictions on the metal atoms contained in the nitride

semiconductor. However, at least one type of atom from Group 2 or Group 3 of the periodic table is preferred, and Mg, Zn, Cd, Ga, or In is especially preferred . . . The thin-film layer may be a layer with only metal atoms (sometimes referred to below as a metallic layer).

Ex. 1006 ¶ 11.

Further, Ozaki teaches that when an active layer is grown on top of the thin-film layer, the active layer selectively forms quantum boxes or quantum dots and the output improves significantly. *Id.*

Ozaki additionally discloses an InGaN active layer grown very thin to form a quantum structure in which strain energy causes the indium (“In”) content to be entirely uneven with indium-rich regions with a larger amount of In and indium-poor regions with a smaller amount of In. Ex. 1006 ¶ 16. Ozaki observes that when a nitride semiconductor containing In is grown with an uneven thickness in the in-plane direction, In compositional separation tends to occur. *Id.* “Quantum dots formed due to the In compositional separation and dots formed due to the uneven thickness of the well layer in the in-plane direction both act to form quantum dots, quantum disks, or quantum boxes.” *Id.* “In other words, the indium-rich regions constitute quantum dots or quantum boxes. By forming a thin-film layer, the InGaN active layer readily forms quantum dots or quantum boxes, and this is believed to significantly improve the output.” Ex. 1006 ¶ 17.

C. Summary of Solymar

Solymar is a book titled “Lectures on the Electrical Properties of Materials.” Ex. 1011, 1. The excerpts of Solymar submitted by Petitioner discuss, *inter alia*, properties of quantum wells in a semiconductor. *Id.* at 5–

6.⁷ For example, Solymar discloses the following formula which describes the relationship of the band gap of a quantum well with its thickness:

$E = \hbar^2 k^2 / 2m^* = \hbar^2 n^2 / 8m^* L^2$, where $\hbar$ is Planck's constant, n is a positive integer, L is the quantum well thickness, and m^* is the effective mass of an electron. *Id.*

D. Challenged Claim 5

Petitioner argues that the combination of Ozaki and Solymar teaches claim 5 of the '270 patent. Pet. 49–53. For many of claim 5's limitations, Petitioner incorporates into this obviousness challenge its arguments that Ozaki anticipates claim 5. *Id.* at 51–52. Similarly, Patent Owner relies on certain of its arguments disputing that Ozaki anticipates claim 5 into this obviousness challenge. PO Resp. 40. Because Petitioner relies on arguments from “Ground 2” that Ozaki anticipates challenged claims 5 and 12 (found on pages 37–49 of the Petition) into its obviousness challenge, we address those arguments and evidence below. Pet. 31.

1. A method for manufacturing a gallium nitride based semiconductor

Petitioner argues that to the extent that the preamble is limiting, Ozaki teaches “[a] method for manufacturing a gallium nitride based semiconductor,” as recited in claim 5. Pet. 37–38, 51. More specifically, Petitioner relies on Ozaki's teaching that “[t]he method for manufacturing a nitride semiconductor element of the present invention is a method for forming a nitride semiconductor using metalorganic vapor phase epitaxy in

⁷ Petitioner sometimes cites to the exhibit page number of Exhibit 1011, and other times cites to the book's page number. We use the exhibit page number throughout to cite the relevant material.

which a nitride semiconductor layer is grown on a substrate.” *Id.* (quoting Ex. 1006 ¶ 19). Petitioner further argues that “Ozaki teaches ‘an element made of a nitride semiconductor ($\text{In}_x\text{Al}_y\text{Ga}_{1-x-y}\text{N}$, where $0 \leq X$, $0 \leq Y$, and $X + Y \leq 1$) used in a light-emitting element.” *Id.* at 37 (quoting Ex. 1006 ¶ 1). In addition, Petitioner argues that the “examples and embodiments in Ozaki teach methods for manufacturing a gallium nitride based semiconductor.” *Id.* at 38 (citing Ex. 1006 ¶¶ 22–36, 41–52); *see also id.* (citing Ex. 1002 ¶¶ 126–127) (opining that Ozaki teaches the preamble).

Based on a plain reading of the disclosures from Ozaki identified above, we find that Ozaki teaches a method for manufacturing a gallium nitride based semiconductor. Ex. 1006 ¶¶ 1, 19; *see also id.* ¶¶ 22–36, 41–52. Our finding is further supported by Dr. Fitzgerald’s declaration testimony that Ozaki teaches, in the paragraphs identified above, “a method for manufacturing a gallium nitride based semiconductor.” Ex. 1002 ¶ 127 (quoting Ex. 1006 ¶¶ 1, 19). We also credit Dr. Fitzgerald’s declaration testimony that specific examples and embodiments in Ozaki teach methods for manufacturing a gallium nitride based semiconductor because his testimony relies on citations to Ozaki, which are consistent with and, therefore, support his testimony. Ex. 1002 ¶ 127 (citing Ex. 1006 ¶¶ 22–36, 41–52) (opining that “the examples and embodiments in Ozaki teach methods for manufacturing a gallium nitride based semiconductor”); *see Pet.* 38 (citing Ex. 1006 ¶¶ 22–36, 41–52).

As we find that Ozaki teaches the preamble, we need not determine whether the preamble is limiting.

2. *forming, on a substrate, a base layer having a lattice mismatch layer formed on less than a total area of a surface of the base layer*

Independent claim 1 recites “forming, on a substrate, a base layer having a lattice mismatch layer formed on less than a total area of a surface of the base layer.” Petitioner relies on the teaching of Ozaki for this limitation. Pet. 38.

First, Petitioner argues that Ozaki’s claim 5 and paragraph 19 disclose forming a layer (i.e., a nitride semiconductor layer) directly on a substrate. *Id.* at 38–39 (citing Ex. 1006, Claim 1, ¶ 19). Second, Petitioner argues that “Ozaki further teaches that any buffer layer can be ‘omitted’ such that the nitride semiconductor (i.e., base layer) is in contact with and above the substrate.” Pet. 39 (citing Ex. 1002 ¶ 129); Pet. Reply 3 (citing Ex. 1002 ¶¶ 128–129). Third, Petitioner argues that Ozaki’s nitride semiconductor layer is a “base layer” because it “serves as a base for forming other layers above it.” Pet. 39–44. Petitioner then maps Ozaki’s thin-film layer in contact with the nitride semiconductor layer to the recited “lattice mismatch layer.” Pet. 44 (citing Ex. 1006, claim 1, ¶¶ 9, 11, Fig. 3). Petitioner argues that, “because the thin-film layer undergoes island-like growth as shown in Fig[ure] 3, the thin-film layer (‘lattice mismatch layer’) is ‘on less than a total area of a surface of the base layer.’” Pet. 41 (citing Ex. 1006, Fig. 3; Ex. 1002 ¶ 132).

a. Patent Owner’s Arguments

Patent Owner disputes that Ozaki discloses forming a base layer on a substrate. PO. Resp. 17–22. Patent Owner argues that Ozaki instead discloses having a buffer layer (i.e., a layer between the substrate and the

base layer), which prevents the base layer from being directly formed on (i.e., in contact with) the substrate. *Id.*

More specifically, Patent Owner argues that “Ozaki does not expressly or inherently disclose *any* semiconductor device *without* a buffer layer,” and to the contrary, “[e]very embodiment in Ozaki (beyond the above-discussed high-level, abstract statements in claim 1 and ¶19) that involves a ‘nitride semiconductor’ and a ‘substrate’ includes a ‘buffer layer’ between them.” *Id.* at 17 (citing Ex. 2053 ¶¶ 181–195). To that end, Patent Owner argues that in Ozaki: (1) the prior art Figure 1 includes a GaN buffer layer between the sapphire substrate and the n-GaN; (2) the laser element of Figure 4 and LED element of Figure 5 each include a buffer layer between the substrate and n-type contact layer; and (3) Examples 1–14 each include a buffer layer. PO Resp. 17–18 (citing Ex. 1006 ¶¶ 3, 22–23, 42–43, 72, 81, Figs. 1, 4–5; Ex. 2053 ¶¶ 182–191).

Patent Owner adds that “[c]laim 1 of Ozaki specifically recites layers ‘formed in contact’ with one another and, by contrast, uses the broader phrase ‘provided on’ in referring to ‘the nitride semiconductor layer provided on the substrate.’” *Id.* at 18–19 (citing Ex. 1006, claim 1). According to Patent Owner, “[t]he broader phrase ‘provided on’ encompasses the possibility of having a buffer layer in between the nitride semiconductor layer and the substrate or omitting it.” *Id.* at 19 (citing Ex. 2053 ¶ 204). “Such use of broad language which allows for the *possibility* of omitting a buffer layer is not a *disclosure* (much less an enabling one) of actually omitting a buffer layer,” Patent Owner argues. *Id.*

Similarly, Patent Owner argues that Ozaki’s paragraph 19 uses “grown on,” which is a broad phrase, “in stating ‘a nitride semiconductor

layer is grown on a substrate,’ in contrast to more specific ‘forming . . . in contact’ language used to describe direct contact between other layers.” *Id.* (citing Ex. 1006 ¶ 19; Ex. 2053 ¶ 205). Furthermore, “Ozaki uses the phrase ‘grown on’ to describe a structure where a buffer layer exists in between the substrate and the layer ‘grown on’ it,” according to Patent Owner. *Id.*; see also *id.* at 19–20 (citing Ex. 2036) (arguing that Ozaki uses “grown on” when referring to an embodiment in JP H07-312445, which, in fact, has a buffer layer). In addition, Patent Owner relies on Dr. Doolittle’s testimony that “‘in contact with’ means direct contact with no layer in between, a nitride semiconductor layer ‘provided on’/‘grown on’ a substrate encompasses having a buffer layer in between them.” PO Sur-Reply 5–6 (citing Ex. 2053 ¶¶ 204–205).

Lastly, Patent Owner argues that Ozaki “states that a buffer layer ‘*can be omitted depending on the nitride semiconductor growing method and type of substrate 1,*’ and never specifies the particular combinations of growing method(s) and substrate(s) that permit omitting a buffer layer.” PO Sur-Reply 8. (citing Ex. 1006 ¶ 25). Patent Owner further argues that:

[o]nly Dr. Doolittle has addressed the issue with reference to specific substrates and growth methods (HVPE and MOCVD) for nitrides. He explained that suitable GaN substrates were not available at the relevant time and that, even when such substrates became available, it was a standard practice to use buffer layers with these substrates.

Id. at 9 (citing Ex. 2053 ¶¶ 198–203). On the other hand, “Dr. Fitzgerald identified neither a growing method nor a substrate for growing a semiconductor structure without a buffer layer,” according to Patent Owner. *Id.* at 8. Patent Owner argues that “Dr. Fitzgerald admits (1) there were ‘many’ methods of growing nitride semiconductors as of 1998, when Ozaki

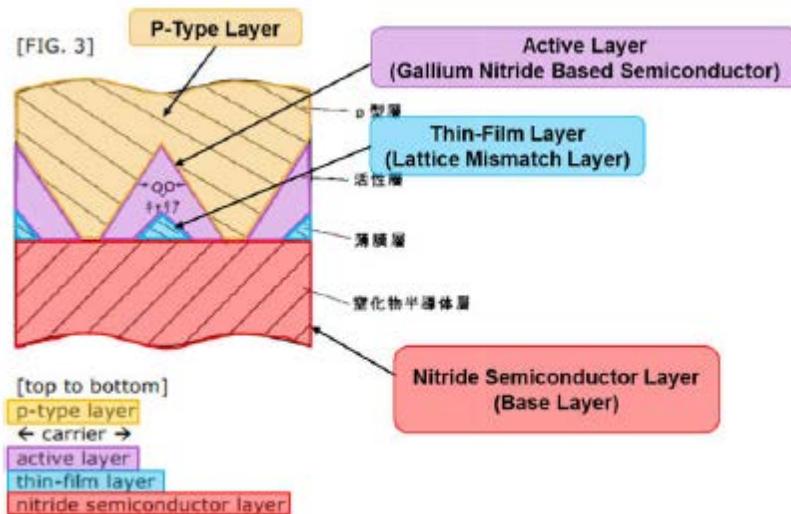
was published; (2) there was ‘a lot of flux at this time between how you do things’; and (3) ‘people are always trying to figure out how to skip’ buffer layers.” *Id.* at 8–9 (quoting Ex. 2037, 57:20–58:18, 60:15–61:22).

b. Our Analysis

Based on the complete record, we find that the cited portions of Ozaki and other evidence of record discussed below support Petitioner’s contentions that Ozaki teaches or suggests “forming, on a substrate, a base layer having a lattice mismatch layer formed on less than a total area of a surface of the base layer,” as recited in claim 5.

In particular, we agree with Petitioner that Ozaki’s nitride semiconductor layer grown on a substrate teaches or suggests a base layer formed on a substrate as required in claim 5. *See* Pet. 38–43 (citing Ex. 1006 ¶¶ 8, 11, 14–16, 19, 25, Fig. 3, Claim 1). Ozaki describes a “method for forming a nitride semiconductor using metalorganic vapor phase epitaxy in which a nitride semiconductor layer is grown on a substrate.” Ex. 1006, ¶ 19. The plain text indicates that “a nitride semiconductor layer is grown on a substrate.”

We also agree with Petitioner that Ozaki’s thin-film layer teaches or suggests “a lattice mismatch layer formed on less than a total area of a surface of the base layer.” Pet. 40 (citing Ex. 1006 ¶¶ 8, 11, 14–16, Fig. 3). Petitioner’s annotation of Ozaki’s Figure 3 shown below, illustrates “the structure near the active layer in a nitride semiconductor” device, in accordance with Ozaki’s invention.



Pet. 21; Ex. 1006 ¶ 15. Figure 3 illustrates a “nitride semiconductor layer, a thin-film layer . . . , [and] an active layer” of a nitride semiconductor device. Ex. 1006 ¶ 15. The “thin-film layer is grown on top of . . . [the] nitride semiconductor layer.” Ex. 1006 ¶ 18.

Based on this express teaching of Ozaki, we agree with Petitioner that Ozaki describes that “the thin-film layer (‘lattice mismatch layer’) is in contact with and above the nitride semiconductor layer (‘base layer’)” and so teaches “a lattice mismatch layer formed on . . . a surface of the base layer,” as required in claim 5. Pet. 41 (citing Ex. 1006, ¶¶ 9, 11, Fig. 3, Claim 1). We also agree with Petitioner that, “because the thin-film layer undergoes island-like growth as shown in Fig[ure] 3, the thin-film layer (‘lattice mismatch layer’) is ‘on less than a total area of a surface of the base layer’” as required by claim 5. Pet. 41 (citing Ex. 1006, Fig. 3; Ex. 1002 ¶ 132); see Ex. 1006 ¶ 14 (describing the active layer has being shown in the shape of islands). Petitioner’s annotation of Ozaki’s Figure 3 shows the thin-film layer in blue and the active layer in purple. Because the triangular shape of the thin-film layer is like the triangular shape of the active layer, one of

ordinary skill in the art would understand Ozaki's thin-film layer also to be in the shape of islands and to be on less than a total area of surface of the base layer. See Ex. 1002 ¶ 132.

We also agree with Petitioner that Ozaki's thin-film layer teaches or suggests a "lattice mismatch layer" because (1) Ozaki's thin-film layer has a different lattice constant (i.e., difference of $\pm 3\%$) than the nitride semiconductor layer and (2) Ozaki's thin-film layer is composed of a different type of material than the nitride semiconductor layer (i.e., base layer) and the active layer (i.e., gallium nitride based semiconductor). Ex. 1006, Fig. 3, Claim 1 ("A nitride semiconductor element comprising a thin-film layer having a thickness of 50 Å or less and a lattice constant irregularity difference of $\pm 3\%$ or more relative to that of a nitride semiconductor layer formed in contact with the nitride semiconductor layer provided on the substrate in a nitride semiconductor element, and an active layer made of a nitride semiconductor containing at least indium formed in contact with the thin-film layer,"), ¶¶ 8 (disclosing the nitride semiconductor layer is preferably "GaN, InGaN, AlGaN, InN, or AlN"), 9, 11, 12 (disclosing examples of the materials (e.g., MgS, MgSe, and InP) for the thin-film layer), 14 (disclosing the active layer is a nitride semiconductor containing at least indium, and preferably a layer formed from InGaN); Ex. 1002 ¶ 133); Pet. 41 (citing Ex. 1006, Fig. 3, Claim 1, ¶¶ 8, 9, 11, 12, 14; Ex. 1002 ¶ 133). This finding is further supported by Dr. Fitzgerald's declaration testimony that is well-reasoned and relies on detailed citations to Ozaki that are consistent with his testimony. Ex. 1002 ¶¶ 134–135 (citing Ex. 1006 ¶¶ 12, 14, 46–47, 62–73).

For these reasons, we agree with Petitioner and we find that Ozaki discloses a base layer (nitride semiconductor layer) having a lattice mismatch layer (thin-film layer having a lattice constant difference of $\pm 3\%$ and comprised of a different material) formed on less than a total area (e.g., islands and holes) of a surface of the base layer. Ex. 1006, Claim 1, ¶¶ 8, 9, 11, 12, 14, Fig. 3; Ex. 1002 ¶¶ 131–135).

With respect to this limitation, the parties dispute whether Ozaki teaches omitting a buffer layer between the claimed substrate and base layer. Pet. 38–43; PO Resp. 17–22. We find that Ozaki expressly teaches or suggests the omission of a buffer layer. See Ex. 1041 ¶ 25. In paragraph 25, Ozaki teaches that

[t]he buffer layer 2 is, for example, AlN, GaN, or AlGaIn formed to a thickness from tens of angstroms to hundreds of angstroms at a temperature of 900°C or less. *The buffer layer 2 is formed to relax the lattice constant mismatch between the substrate 1 and the nitride semiconductor. This can be omitted depending on the nitride semiconductor growing method and type of substrate 1.*

Ex. 1041 ¶ 25 (emphasis added). We note that the parties dispute whether the express statements in paragraph 25 apply generally to all or, more specifically, to some embodiments disclosed in Figure 3, Figure 5, Examples 1–14, claim 1, or paragraph 19 in Ozaki. Patent Owner takes the position that Ozaki only teaches the possibility that the buffer layer can be removed, but does not ascribe the omission of the buffer layer to any disclosed embodiment. See Tr. 10:23–12:4; PO Resp. 19 (“Such use of broad language which allows for the possibility of omitting a buffer layer is not a disclosure of actually omitting a buffer layer, and therefore cannot anticipate even if ‘a skilled artisan would immediately envision’ the possibility of omitting the buffer layer.”).

While we agree that Ozaki uses broad language (e.g., “grown on” and “provided on”) to describe how the nitride semiconductor layer is positioned relative to the substrate, such language at least allows for one of ordinary skill in the art to omit a buffer layer in these embodiments. *E.g., id.* ¶¶ 19, 25, claim 1. With this, Patent Owner’s expert, Dr. Doolittle, agrees. Ex. 2053 ¶ 204 (testifying that “provided on” encompasses omitting the buffer layer). Moreover, this broad language also should be read in light of Ozaki’s express teaching that a buffer layer “can be omitted.” Ex. 1006 ¶ 25; *see also EWP Corp. v. Reliance Universal Inc.*, 755 F.2d 898, 907 (Fed. Cir. 1985) (“A reference must be considered for everything it *teaches* by way of technology and is not limited to the particular *invention* it is describing and attempting to protect.”).

We are not persuaded by Patent Owner’s arguments that Ozaki does not disclose any semiconductor device without a buffer layer and, according to Patent Owner, so does not teach omitting a buffer layer. PO Resp. 17–18. First, we disagree because Ozaki’s teaching that a buffer layer can be omitted relates to a specific embodiment. Ex. 1006 ¶¶ 23–25 (discussing Figure 5’s nitride semiconductor element used as an LED). Teaching that buffer layer 2 can be omitted is an actual disclosure of an embodiment without a buffer layer. *Id.* Second, in the context of obviousness, Patent Owner’s arguments are misplaced. Even assuming that the statements in paragraph 25 of Ozaki are not tied to specific embodiments (e.g., Figure 3, paragraph 19, or claim 1), obviousness relates to combined teachings and, in circumstances similar to this case, can be based on the combination of multiple embodiments disclosed in a single reference. *See, e.g., Boston Scientific Scimed, Inc. v. Cordis Corp.*, 554 F.3d 982, 991 (Fed. Cir. 2009)

(“Combining two embodiments disclosed adjacent to each other in a prior art patent does not require a leap of inventiveness.”); *see also* *KSR*, 550 U.S. at 417 (“If a person of ordinary skill can implement a predictable variation, § 103 likely bars its patentability.”); *EWP*, 755 F.2d at 907. Moreover, Ozaki’s express teaching of omitting the buffer layer provides the motivation to do so. Ex. 1006 ¶ 25.

We also credit the testimony of Dr. Fitzgerald (*see* Pet. 39 (citing Ex. 1002 ¶ 129)), who explains that “Ozaki . . . teaches that any buffer layer can be ‘omitted’ such that the nitride semiconductor (i.e., base layer) is in contact with and above the substrate.” Ex. 1002 ¶ 129. In this regard, Dr. Fitzgerald’s testimony is more consistent than Dr. Doolittle’s with respect to Ozaki’s express statement that a buffer layer can be omitted depending on the growing method and substrate type employed. Ex. 1006 ¶ 25. Dr. Fitzgerald’s testimony is consistent with and supported by the express statements in Ozaki that teach (1) different substrates may be used (e.g., SiC, ZnS, ZnO, GaAs, and GaN); and (2) the buffer layer may be omitted depending on the substrate used and technique employed. Ex. 1006 ¶¶ 24–25.

Further, in considering and weighing the testimony of the experts on this issue, we determine that Dr. Doolittle’s testimony is entitled to less weight than Dr. Fitzgerald’s because Dr. Doolittle’s testimony contradicts Ozaki’s express disclosure. For example, Dr. Doolittle testifies that one of ordinary skill in the art would not have understood Ozaki to disclose any semiconductor device having a nitride semiconductor layer formed directly on a substrate (i.e., without a buffer layer) because Ozaki’s figures, examples, and claims all include a buffer layer. *See* Ex. 2053 ¶¶ 181–195.

As we discuss above, however, Ozaki's teachings are not as narrow as Dr. Doolittle testifies. Rather, Ozaki expressly contemplates embodiments that omit a buffer layer depending on the growing method and substrate. Ex. 1006 ¶ 25; *see also* Ex. 1002 ¶ 129.

Furthermore, we are not persuaded by Patent Owner's arguments which fault Dr. Fitzgerald for not identifying specific growing methods nor substrates for growing a semiconductor structure without a buffer layer. PO Sur-Reply 8. We find Patent Owner's arguments to be akin to an enablement argument that one of ordinary skill in the art would have been unable to grow a suitable semiconductor structure without a buffer layer based on Ozaki's teachings. *Id.* at 8–9. This argument is unpersuasive because even “[a] non-enabling reference may qualify as prior art for the purpose of determining obviousness, . . . and even an inoperative device . . . is prior art for all that it teaches.” *ABT Sys., LLC v. Emerson Elec. Co.*, 797 F.3d 1350, 1360 n.2 (Fed. Cir. 2015) (quoting *Beckman Instruments, Inc. v. LKB Produkter AB*, 892 F.2d 1547, 1551 (Fed. Cir. 1989) and *Symbol Tech., Inc. v. Opticon, Inc.*, 935 F.2d 1569, 1578 (Fed. Cir. 1991)).

We also note that contrary to Dr. Doolittle's testimony (Ex. 2053 ¶ 195) that “Dr. Fitzgerald did not explain *when* the buffer layer can be omitted,” Dr. Fitzgerald explains “there's . . . just a lot of ways that people were growing materials, so it makes sense that Ozaki doesn't want to specify that because there's people saying that . . . high-temperature layers don't require buffer layers, but . . . lower temperature may.” Ex. 2037, 58:10–15.

We also are not persuaded by Dr. Doolittle's testimony that, even if a suitable GaN substrate were available, “it is often desirable to grow a buffer layer on GaN . . . to bury any contamination or damage to the substrate.”

Ex. 2053 ¶ 202 (citing Ex. 2023); *see id.* ¶ 203 (“So even if a ‘GaN substrate’ could have been used, a person of ordinary skill in the art would have still known to grow an additional buffer layer of GaN for the purpose of cleaning up the surface of the substrate from damage and/or contaminants.”). Even assuming there were advantages in using a buffer layer, as Dr. Doolittle testifies, these advantages would not alter our findings because “our case law does not require that a particular combination must be the preferred, or the most desirable, combination described in the prior art in order to provide motivation for the current invention.” *Novartis Pharm. Corp. v. W.-Ward Pharm. Int’l Ltd.*, 923 F.3d 1051, 1059 (Fed. Cir. 2019) (citing *In re Fulton*, 391 F.3d 1195, 1200 (Fed. Cir. 2004)). The existence of better alternatives in the prior art does not mean that an inferior combination is inapt for obviousness purposes. *In re Mouttet*, 686 F.3d 1322, 1333 (Fed. Cir. 2012) (citing *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994)).

Lastly, we agree with Petitioner that Ozaki’s nitride semiconductor layer is a “base layer” that serves as a base for forming other layers above it. Pet. 39–44. In particular, we find that Ozaki teaches forming a thin-film layer and an active layer in contact with and above the nitride semiconductor layer. Ex. 1006, Claim 1, ¶¶ 8–9, 11, 14–16, Fig. 3; Ex. 1002 ¶¶ 131–132, 138.

In summary, we find that Ozaki teaches omitting a buffer layer, and that Ozaki’s nitride semiconductor layer is a base layer. In other words, we find that one of ordinary skill in the art would have understood that Ozaki teaches “forming, on a substrate, a base layer.”

Accordingly, for these reasons, we find that one of ordinary skill in the art would understand Ozaki to teach or suggest “forming, on a substrate, a base layer having a lattice mismatch layer formed on less than a total area of a surface of the base layer,” as recited in claim 5.

3. *forming the gallium nitride based semiconductor on the base layer*

Petitioner argues that Ozaki teaches “forming the gallium nitride based semiconductor on the base layer,” as recited in claim 5. Pet. 43–44, 51–52. More specifically, Petitioner argues that Ozaki discloses an active layer which is formed on (i.e., in contact with) the nitride semiconductor layer (i.e., “base layer”). *Id.* at 43–44 (citing Ex. 1006 ¶¶ 14–16, Fig. 3; Ex. 1002 ¶ 138). In addition, Petitioner argues Ozaki discloses that the active layer is made of a nitride semiconductor containing at least indium, and preferably formed from InGaN (i.e., a gallium nitride based semiconductor⁸). *Id.* at 43 (citing Ex. 1006 ¶ 14; Ex. 1002 ¶ 137). Petitioner argues Ozaki thus discloses this limitation. *Id.*

We agree with Petitioner and, based on the plain teaching of Ozaki identified above, we find that Ozaki teaches forming the gallium nitride based semiconductor (i.e., the InGaN active layer) on the base layer (i.e., nitride semiconductor layer). Ex. 1006 ¶¶ 14–16, Fig. 3. We also credit Dr. Fitzgerald’s testimony as it is consistent with Ozaki’s teachings. Ex. 1002 ¶¶ 137–138.

⁸ “[A]lthough gallium nitride is a specific compound that is a semiconductor, the phrase ‘gallium nitride semiconductor’ is commonly used to refer to a gallium nitride based semiconductor that may be AlGaN, InGaN or even AlInGaN.” Ex. 1009 ¶ 46; see also *id.* ¶ 94.

4. *Spatial Fluctuation is Created in the Band Gap of the Gallium Nitride Based Semiconductor By the Lattice Mismatch*

a. *Petitioner's Arguments*

Petitioner argues that the combination of Ozaki and Solymar teaches “wherein a spatial fluctuation is created in the band gap of the gallium nitride based semiconductor by the lattice mismatch,” as recited in claim 5. Pet. 44–47, 51–53. To that end, Petitioner argues that Ozaki’s express and inherent teachings disclose this limitation, or, alternatively, the combined express teachings of Ozaki and Solymar disclose this limitation. Pet. 44–47. Pet. Reply 8–22.

More specifically, Petitioner argues that (1) Ozaki discloses changes in thickness in the active layer (i.e., the gallium nitride based semiconductor) caused by the lattice mismatch of the thin-film layer (i.e., lattice mismatch layer), and (2) Ozaki inherently⁹ discloses spatial fluctuations in the band gap of the active layer due to the changes in thickness, or Solymar teaches that the changes in thickness cause corresponding spatial fluctuations in the band gap of the active layer. Pet. 44–47. Pet. Reply 22–25.

i. *Ozaki's Teachings*

First, Petitioner argues “that [in Ozaki] the lattice mismatch caused by the thin-film layer (*‘lattice mismatch layer’*) results in the thin-film layer and the active layer (*‘gallium nitride based semiconductor’*) being uneven in

⁹ Patent Owner argues that Petitioner’s Reply improperly recasts Petitioner’s arguments for Ozaki for this limitation as an express disclosure in addition to an inherency disclosure. PO Sur-Reply 9–10 (citing Pet. Reply 10–11). As we find that Ozaki at least inherently discloses this limitation, we need not, and thus do not, reach this dispute.

thickness.” Pet. 44 (citing Ex. 1002 ¶ 139). More specifically, Petitioner argues that Ozaki teaches:

[B]y providing a thin-film layer with a lattice constant irregularity difference of $\pm 3\%$ or more [relative to a nitride semiconductor layer,] and forming an active layer in contact with this thin-film layer[,] . . . the lattice mismatch of the thin-film layer formed in contact with the nitride layer causes the film thickness to become uneven, and that forming an active layer in contact with an uneven thin-film layer causes uneven growth of the active layer. *Id.* (emphases omitted).

Id. at 44–45 (quoting Ex. 1006 ¶ 7). In addition, Ozaki also teaches that “the active layer assumes a quantum well structure . . . [or] quantum dot” structure, according to Petitioner. *Id.* at 44–45 (quoting Ex. 1006 ¶ 7) (emphasis omitted); see also *id.* at 45 (quoting Ex. 1006 ¶ 18; citing *id.* ¶ 16) (same). Petitioner argues that “[t]his uneven thickness of the active layer (“gallium nitride based semiconductor”) is shown . . . in Figure 3.” *Id.* at 45.

Figure 3, shown below, has been annotated by Petitioner to illustrate its argument of uneven thickness of the active layer. Pet. 46.

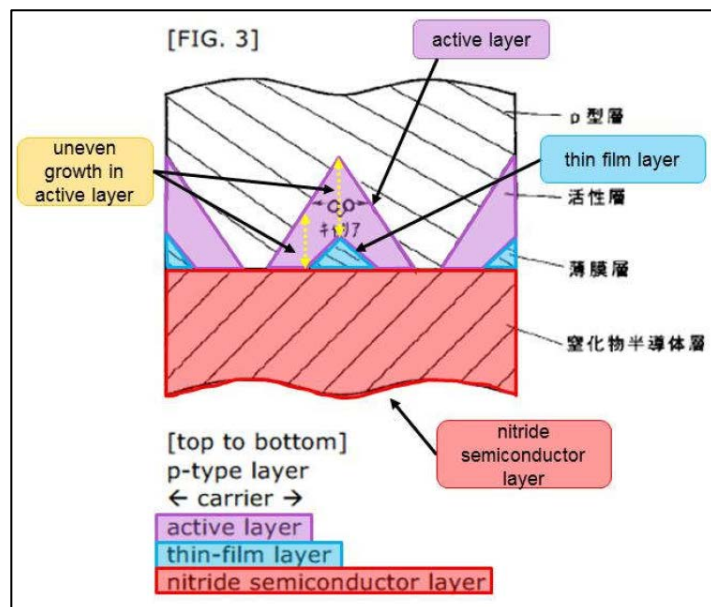


Figure 3 illustrates “the structure near the active layer in a nitride semiconductor” device, in accordance with Ozaki’s invention. *Id.* at 21. In particular, as annotated by Petitioner, Figure 3 illustrates a nitride semiconductor layer (shown in red), a thin-film layer (shown in blue), and an active layer (shown in purple) of a nitride semiconductor device. *Id.* ¶ 15; Pet 46. Petitioner also illustrates what it argues is the uneven growth in the active layer (shown as two different arrowed, yellow lines of different length, spanning different positions in the active layer vertically). Pet. 46 (annotating Ex. 1006, Fig. 3). In addition, Petitioner argues that Ozaki teaches that these layers are subject to quantum effects, forming “a quantum structure, such as a quantum well or quantum dots.” *Id.* (citing Ex. 1006 ¶¶ 7, 9–11, 14–16).

Second, Petitioner, relying on the equation taught in Solymar, argues that for Ozaki’s quantum structure, “the band gap is inherently inversely proportional to the thickness of the well layer as shown . . . in the mathematical relationship between thickness (L) and the energy band gap E_n ” (i.e., $E_n = h^2 n^2 / 8m^* L^2$, where “h is Planck’s constant, n is a positive integer, L is the ‘quantum well’ thickness, and m^* is the effective mass of the electron”). *Id.* (citing Ex. 1011, 5–6; Ex. 1002 ¶¶ 62–64, 141). Put differently, Petitioner argues that where “the active layer is thicker, the band gap will be narrower than in places where the active layer is thinner thereby creating a spatial fluctuation in the band gap by widening and narrowing the band gap laterally through the active layer as the thickness of the active layer changes.” *Id.* at 46–47 (citing Ex. 1002 ¶¶ 62–64, 142¹⁰; Ex. 1011, 5–6).

¹⁰ Petitioner quotes from paragraph 142 of Dr. Fitzgerald’s Declaration, but cites to paragraph 141.

Moreover, Petitioner argues that “Ozaki states that [its] invention applies equally to quantum wells and quantum dots, which is the case because the same mathematical relationship exists in quantum wells and quantum dots.” Pet. Reply 23–24 (citing Ex. 1006 ¶¶ 7, 9, 10, 11). In addition, Petitioner argues that “[f]or a quantum structure, such as a quantum well or quantum dots as disclosed in Ozaki . . ., one of ordinary skill in the art would have understood that uneven thickness of the active layer is synonymous with a spatial fluctuation in the band gap.” Pet. Reply 10–11 (citing Ex. 1006 ¶¶ 7, 9–11, 14–16; Ex. 1011, 5–6; Ex. 1002 ¶¶ 62–64, 141).

ii. Solymar’s Teachings

Alternatively, Petitioner argues Solymar teaches “that the variations in thickness of a semiconductor layer creates ‘spatial fluctuations in the band gap.’” Pet. 49 (citing Ex. 1011, 414–15; Ex. 1002 ¶¶ 152–159). Specifically, Petitioner argues “Solymar discloses the fact that, in a quantum structure, a variation in the thickness of the quantum structure (*i.e.*, quantum well or quantum dot) results in a spatial fluctuation in the band gap because the band gap energy is inversely proportional to the square of the thickness of the quantum structure.” *Id.* at 50–53 (citing Ex. 1011, 5–6; Ex. 1002 ¶¶ 62–63, 144); *see also id.* at 50–51 (arguing that Solymar “show[s] the mathematical relationship between [quantum well] thickness (L) and the energy band gap E_n : $E_n = h^2 n^2 / 8m * L^2$ ”). Moreover, Petitioner argues that “Solymar shows the mathematical relationship between thickness and band gap for quantum structure, which applies equally to wells and dots.” Pet. Reply 22 (citing Ex. 1011, 5–6; Ex. 1002 ¶¶ 62–64, 141).

Petitioner argues that one of ordinary skill in the art “would have been motivated to combine Ozaki with Solymar.” Pet. 50 (citing Ex. 1002 ¶ 152).

Petitioner argues that Ozaki “describes using quantum structures, such as quantum dots and quantum wells, for light emission.” *Id.* (citing Ex. 1006, Fig. 3, ¶¶ 7, 14, 16–18). In addition, Petitioner argues that “Ozaki uses a thin film layer with a lattice mismatch greater than 3% to cause unevenness in the InGaN active layer in the context of a quantum structure.” *Id.* (citing Ex. 1006 ¶¶ 7, 9, 14–16).

“Solymer is a typical textbook used for undergraduate and graduate students and represents the knowledge of one of ordinary skill in the art,” according to Petitioner. *Id.* (citing Ex. 1002 ¶¶ 80, 152). Petitioner argues that “Solymer discloses the fact that, in a quantum structure, a variation in the thickness of the quantum structure (*i.e.*, quantum well or quantum dot) results in a spatial fluctuation in the band gap because the band gap energy is inversely proportional to the square of the thickness of the quantum structure.” *Id.* (citing Ex. 1011, 5–6; Ex. 1002 ¶ 144).

To that end, “Solymer provides the following equation showing the mathematical relationship between thickness (L) and the energy band gap E_n : $E_n = h^2 n^2 / 8m * L^2$,” according to Petitioner. *Id.* (citing Ex. 1011, 5–6; Ex. 1002 ¶¶ 62–63). Petitioner argues that one of ordinary skill in the art

would have been aware of the mathematical relationship between energy band gap and thickness in a quantum structure and would have applied this knowledge when reading Ozaki to maximize the thickness fluctuations in the InGaN layer as taught in Ozaki to increase the spatial fluctuation in the band gap and improve light emission.

Id. at 51 (citing Ex. 1002 ¶¶ 80–82); *see also id.* at 52–53 (citing Ex. 1002 ¶¶ 158–159) (same).

b. Patent Owner's Arguments

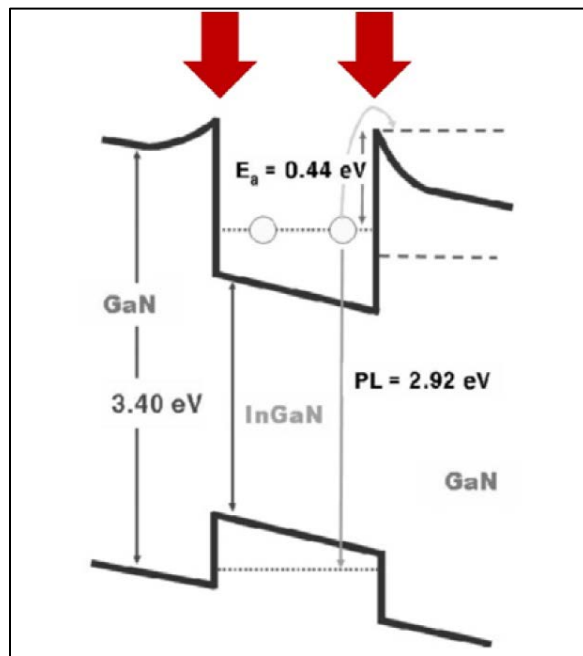
Patent Owner argues that (1) Petitioner fails to show that Ozaki teaches this limitation, and (2) one of ordinary skill in the art “would not have applied Solymar’s quantum-well equation in the context of Ozaki’s quantum *dots*.” PO Resp. 22–41; PO Sur-Reply 9–20.

i. Ozaki's Teachings

First, Patent Owner argues that “Petitioner has failed to establish that spatial fluctuation is an *inherent* characteristic of Ozaki’s . . . active layer.” PO Resp. 26 (emphasis added). In particular, Patent Owner argues that “[i]nherency requires the missing descriptive matter necessarily be present in what the reference describes and may not be established by probabilities or possibilities.” *Id.* at 26–27 (citations omitted). Patent Owner argues that, however, “Petitioner’s expert has conceded that Petitioner’s argument is based on the mere probability that fluctuation in the band gap would be present.” *Id.* at 27. More specifically, Patent Owner argues that “Dr. Fitzgerald testified that the quantum dots lead to fluctuation in the band gap ‘*in most cases*,’ which falls short of the exacting standard for inherency, which requires ‘that the missing descriptive matter is necessarily present.’” *Id.* at 27–28 (citing Ex. 2037, 74:6–75:2) (other citation omitted); PO Sur-Reply 13–14 (citing Ex. 2037, 70:23–75:2); *see also* PO Resp. 28–29 (citations omitted) (discussing cases finding no inherent anticipation).

Second, Patent Owner argues that Petitioner relies on “Ozaki[’s] . . . form[ing] of indium-rich *quantum dots* within the active layer.” *Id.* at 30–31 (citing Ex. 1006 ¶¶ 14, 16–18; Ex. 2037, 35:5–8; Ex. 2053 ¶¶ 254–260, 414–417) (emphasis added). According to Patent Owner, “[q]uantum dots[, however,] have a discrete, well-defined band structure that is quite

different from the irregular variations, or ‘widening and narrowing of the band gap’ required to have the claimed ‘spatial fluctuation . . . in the band gap.’” *Id.* at 31. Specifically, “quantum dots are characterized by [] sharp, discrete transitions in the band gap that create discontinuities in potential energy,” according to Patent Owner. *Id.* (citing Ex. 2053 ¶¶ 260–267; Ex. 2037, 46:22–47:1); *see also* PO Sur-Reply 12 (arguing that “Petitioner offers **no evidence** to rebut . . . that the energy levels of quantum structures are (unsurprisingly) quantized with discrete transitions—and are not (continuously) widening and narrowing or otherwise irregularly varying”). To illustrate this argument, Patent Owner provides as an example Figure 6 from Kim.¹¹ *Id.* at 31–32 (citing Ex. 2038, Fig. 6). Figure 6 (cropped of its labeling sentences) is shown below, as annotated by Patent Owner.



¹¹ Jin Soak Kim et al., *Study on the Energy-Band Structure of Indium-Rich InGaN/GaN Quantum Dot System*, 51 JOURNAL OF THE KOREAN PHYSICAL SOCIETY 1195 (Sept. 2007) (Ex. 2038, “Kim”).

Figure 6 illustrates the “[e]nergy band diagram of the InGaN/GaN [quantum dot] system.” Ex. 2038, Fig. 6. In addition, Patent Owner annotated this figure with two red arrows indicating the transitions between GaN and InGaN. PO Resp. 32. Patent Owner argues that “[t]he discrete transition resulting from the In-rich quantum dots in the InGaN active layer is evident in the middle of the diagram . . . , at the positions indicated by the red arrows.” *Id.* (citing Ex. 2038, Fig. 6).

Patent Owner also argues that Figure 6 illustrates that “quantum dots have a well-defined floor, or ground state, for their energy levels.” *Id.* (citing Ex. 2038, Fig. 6; quoting Ex. 2038, 1198 (“[T]he ground states of InGaN [quantum dots] are located at 0.44 [electron volt (“eV”) from the top of the barrier.”); citing Ex. 2053 ¶¶260–270). Patent Owner also argued during the oral hearing that a quantum dot, such as in Ozaki, has only one quantum energy level. Tr. 38:1–9 (arguing that a quantum dot is confined in all three dimensions, and has “just one quantized energy level”), 42:3–5 (“It’s one quantization level in all dimensions.”).

Patent Owner argues that “[a]s the energy band diagram [of Figure 6] illustrates, quantum dots do **not** have irregular variations in, or widening and narrowing of, the band gap (and much less ‘continuous’ ones).” PO Resp. 32. Patent Owner argues that there is a “substantial difference in the band gap structure[]” of Figure 6’s “sharp, discrete transitions in the band gap for In-rich quantum dots . . . to the spatial fluctuation in the band gap illustrated [in] the ’270 patent[’s]” Figure 4. *Id.* at 32–33 (comparing Ex. 2038, Fig. 6, with Ex. 1001, Fig. 4). “Petitioner does not explain how the abrupt transitions to discrete energy levels that characterize [quantum dots] constitute ‘spatial fluctuation’ even under Petitioner’s proposed construction

that requires ‘widening and narrowing,’ according to Patent Owner. PO Sur-Reply 15.

In addition, Patent Owner argues that “[q]uantum dots must be very small to provide their quantum confinement effects.” PO Resp. 33 (citing Ex. 2053 ¶¶ 73–78, 268). “By contrast, the spatial fluctuation in the band gap claimed in the ’270 patent exists on a length scale that is several orders of magnitude larger,” according to Patent Owner. *Id.* at 33–34 (citing Ex. 1001, 2:6–9; Ex. 2053 ¶ 97). Nor does the ’270 patent mention quantum dots because “Dr. Sakai[, the named inventor of the ’270 patent,] was seeking to solve the problem of improving light emission ‘in the ultraviolet band,’ . . . [and h]e was not able to exploit the formation of indium-rich quantum dots in seeking to solve this problem,” according to Patent Owner. *Id.* at 34–35 (citations omitted). In particular, Patent Owner argues that “AlGaIn[, which is taught in the ’270 patent,] will not form quantum dots as Ozaki describes with InGaIn.” *Id.* at 36. “Accordingly, Professor Sakai had to invent a new approach[] to improve emission of ultraviolet light from AlGaIn,” Patent Owner argues. *Id.*

ii. Solymar’s Teachings

Patent Owner argues that Petitioner “points[s] to Solymar only for the same equation it relied on for its inherent[cy] argument.” PO Resp. 40 (citing Pet. 46–47, 50–53). “As such, Solymar adds nothing of substance,” according to Patent Owner. *Id.* (citing Ex. 2053 ¶¶ 172, 418–419).

In addition, Patent Owner argues that one of ordinary skill in the art “would not have applied Solymar’s quantum-well equation in the context of Ozaki’s quantum dots.” *Id.* at 41 (citing Ex. 1011, 5–6 (arguing Solymar “expressly discuss[es] quantum wells”); Ex. 2037, 89–91; Ex. 1002 ¶¶ 156–

157; Ex. 2053 ¶ 418). Put differently, Patent Owner argues that “Solymar’s equation applies only to quantum *wells*.” *Id.*; *see also* PO Sur-Reply 10–11 (citing Ex. 1011, 6; Ex. 2053 ¶ 418) (arguing that “this equation merely provides an unremarkable equation relating bandgap and the thickness of a quantum *well* and does not address the fact that Ozaki forms quantum *dots* with its well layer”). Patent Owner argues “Solymar specifically notes the limitations for use of the equation to quantum confinement in a single direction, explaining:”

Note that the electron is confined in only one direction, it is free to move in the other two. Hence the density of states is not a set of discrete states but rather a set of sub-bands. The momentum is quantized in the direction perpendicular to the walls but not in the other two.

Id. (quoting Ex. 1011, 6). In addition, Patent Owner argues that Dr. Fitzgerald “concede[s] that ‘L’ in the equation . . . refers to ‘**quantum well**’ thickness.” PO Sur-Reply 17 (citing Ex. 1002 ¶ 141). Moreover, “Solymar expressly states that ‘L is the **width of the well**,’” “the equation appears in a section entitled ‘Quantum wells,’ is introduced with a sentence that refers to ‘the energy levels of a well,’ and the results of the equation are illustrated using a figure that refers to ‘30 nm thick quantum well material.’” *Id.* (citing Ex. 1011, 5–6).

Patent Owner argues, however, that “Ozaki’s Figure 3—the embodiment upon which Petitioner relies—has quantum *dots*.” *Id.* (citation omitted). “In contrast, quantum dots by definition confine an electron in all three directions, so quantization exists in all three dimensions and a set of discrete states is produced,” according to Patent Owner. *Id.* (citing Ex. 2053 ¶ 418). “Petitioner has failed to account for this difference,” according to Patent Owner. PO Sur-Reply 11. Patent Owner argues that even when

“‘spatial fluctuation . . . in the band gap[]’ is interpreted to require only widening and narrowing of the band gap . . . (as Petitioner proposes) . . . , Ozaki’s quantum dots with their discrete, abrupt energy transitions cannot meet the ‘spatial fluctuation . . . in the band gap’ requirement.” PO Sur-Reply 19.

c. Our Analysis

Based on the complete record, we find that Petitioner has explained sufficiently how Ozaki, and alternatively, the combination of Ozaki and Solymar, teaches “wherein a spatial fluctuation is created in the band gap of the gallium nitride based semiconductor by the lattice mismatch,” as recited in claim 5.

First, we find that Ozaki teaches that the lattice mismatch caused by the thin-film layer (lattice mismatch layer) results in the active layer (gallium nitride based semiconductor) being uneven in thickness. *E.g.*, Ex. 1006 ¶¶ 7, 9–10, 16. For example, we find Ozaki teaches:

[B]y providing a thin-film layer with a lattice constant irregularity difference of $\pm 3\%$ or more [relative to a nitride semiconductor layer,] and forming an active layer in contact with this thin-film layer[,] . . . the lattice mismatch of the thin-film layer formed in contact with the nitride layer causes the film thickness to become uneven, and that forming an active layer in contact with an uneven thin-film layer causes uneven growth of the active layer.

Id. ¶ 7. We find that Ozaki’s Figure 3 illustrates this uneven thickness of the active layer (gallium nitride based semiconductor), as annotated by Petitioner as two arrowed, yellow lines of different length and at different lateral positions, spanning the active layer vertically. Pet. 46 (annotating Ex. 1006, Fig. 3).

Second, we turn to whether Ozaki's teaching of this uneven thickness in the active layer inherently discloses that the corresponding band gap spatially fluctuates. To begin, we note that "inherency may supply a missing claim limitation in an obviousness analysis." *Par Pharm., Inc. v. TWi Pharm., Inc.*, 773 F.3d 1186, 1194–95 (Fed. Cir. 2014) (citations omitted). "[T]he use of inherency, [however] . . . , must be carefully circumscribed in the context of obviousness." *Id.* at 1195 (citations omitted). "[I]n order to rely on inherency to establish the existence of a claim limitation in the prior art in an obviousness analysis[,] . . . the limitation at issue necessarily must be present, or the natural result of the combination of elements explicitly disclosed by the prior art." *Id.* at 1195–96 (citation omitted).

With the foregoing in mind, we turn to Ozaki's teachings. We find that Ozaki teaches that "the active layer [also] assumes[, *inter alia*,] a quantum well structure . . . or quantum dot structure." Ex. 1006 ¶ 7; *see also id.* ¶¶ 9, 10 ("[A]n active layer is formed in contact with the thin-film layer and the grown active layer assumes the shape of[, *inter alia*,] a quantum well structure . . . or a quantum dot structure."), 11, 14–15. Additionally, paragraph 16 teaches that:

[i]n the present invention, when a thin-film layer is grown that is very thin, there are spots in the film where metal atoms are present and spots in the film where metal atoms are absent from a microscopic viewpoint, and the presence or absence of these atoms in the film cause the film thickness to be uneven. When the thickness of the thin-film layer is uneven, that is, when the thin-film layer is thick in places and thin in other places, the properties of the crystals will be different. When an active layer is grown on top of this thin-film layer, the active layer grows selectively. *When the active layer grows selectively, the active layer itself forms quantum boxes or quantum dots, and the output improves significantly.*

Ex. 1006 ¶ 16 (emphasis added).

For quantum structures, the band gap is inversely proportional to the thickness of the layer as shown in the mathematical relationship between thickness (L) and the energy band gap E_n (i.e., $E_n = h^2 n^2 / 8m^* L^2$, where “ h is Planck’s constant, n is a positive integer, L is the ‘quantum well’ thickness, and m^* is the effective mass of the electron”). Ex. 1011 (Solymar), 5–6; Ex. 1002 ¶¶ 62–64, 141; *see also Continental Can Co. USA v. Monsanto Co.*, 948 F.2d 1264, 1268 (Fed. Cir. 1991) (finding that recourse to extrinsic evidence can be appropriate to show that a reference inherently discloses a feature). This mathematical relationship establishes that the corresponding band gap spatially fluctuates (i.e., widens and narrows by changing values of E_n / changing quantum levels) based on the thickness. *Id.* In other words, due to the uneven thickness, “the quantum level based on the quantum effect spatially varies and the band gap is spatially fluctuated.” Ex. 1001, 4:63–5:1. We also credit Dr. Fitzgerald’s testimony that where “the active layer is thicker, the band gap will be narrower than in places where the active layer is thinner thereby creating a spatial fluctuation in the band gap by widening and narrowing the band gap laterally through the active layer as the thickness of the active layer changes.” Ex. 1002 ¶¶ 62–64, 142; Ex. 1011, 5–6. This testimony is consistent with the mathematical relationship. *Id.*

Moreover, this mathematical relationship evidences that the changing values of E_n (i.e., widening and narrowing of the band gap) of the active layer for Ozaki’s quantum structure is the natural result of, and necessarily present due to, the active layer’s uneven thickness. Ex. 1011, 5–6; *see also* Ex. 1002 ¶¶ 62–64, 141–142. Accordingly, we find that Ozaki’s teaching of

uneven thickness in the active layer inherently discloses that the corresponding band gap spatially fluctuates. *Par*, 773 F.3d at 1195–96.

Alternatively, we find that the combination of Solymar and Ozaki teaches the disputed limitation. In other words, instead of analyzing Solymar as extrinsic evidence for what Ozaki inherently teaches, we analyze Solymar’s express teaching as combined with Ozaki. As we discuss above, Ozaki teaches that the lattice mismatch caused by the thin-film layer (lattice mismatch layer) results in the active layer (gallium nitride based semiconductor) being uneven in thickness. *E.g.*, Ex. 1006 ¶¶ 7, 9–10, 16. As to Solymar, as we discuss above, Solymar teaches that the band gap of Ozaki’s quantum structure is inversely proportional to the thickness of the layer as shown in the mathematical relationship between thickness (L) and the energy band gap E_n (i.e., $E_n = h^2 n^2 / 8m^* L^2$). Ex. 1011, 5–6; Ex. 1002 ¶¶ 62–64, 141.

In addition, based on the entirety of the record, we find Petitioner has shown sufficiently articulated reasoning with rational underpinning to support the legal conclusion of obviousness. *Kahn*, 441 F.3d at 988 (citations omitted), *cited with approval in KSR*, 550 U.S. at 418. Petitioner provides detailed analysis of the prior art and explains why, based on the teachings of the references, a person of ordinary skill in the art would have combined the references. *See* Pet. 50–53.

Petitioner’s reasoning, which we find persuasive, includes that one of ordinary skill in the art would have applied Solymar’s mathematical relationship between energy band gap and thickness in a quantum structure to Ozaki’s teachings “to maximize the thickness fluctuations in the InGaN layer as taught in Ozaki to increase the spatial fluctuation in the band gap

and improve light emission.” *Id.* at 51 (citing Ex. 1002 ¶¶ 80–82); *see also id.* at 52–53 (citing Ex. 1002 ¶¶ 158–159) (same). As Dr. Fitzgerald explains, “[t]he Solymar text is a standard textbook that would be used by undergraduate or graduate students to understand fundamental electronic and optoelectronic properties of semiconductors and other materials.” Ex. 1003 ¶ 1003 (citing Ex. 1011). We credit this testimony that is supported by the indicia of the reference itself: the title of the book—“Lectures on the Electrical Properties of Materials”; the publisher of the book—“Oxford University Press, Inc.”; the citations used—“For a review see D. A. Miller *et al.* *IEEE Journal of Quantum Electronics*, QE-22, pp. 1816–1830, 1986.” Ex. 1011, 1, 2, 4. The technical level of the material in the reference also supports our finding. For example, with regard to quantum wells, Solymar states:

When discussing semiconductor lasers I have already emphasized the advantages of hetero-junctions. A GaAlAs-GaAs-GaAlAs junction had the advantage that the field was confined on account of the higher dielectric constant of GaAs and the carriers were confined on account of the barrier represented by the higher energy gap of GaAlAs.

Thus, because Dr. Fitzgerald’s declaration testimony is well-reasoned and supported by detailed citations to Solymar, we also agree with Dr. Fitzgerald’s declaration testimony that “a PHOSITA would understand the basic physics of quantum wells and quantum confinement as explained [in the reference]” and also “would understand that the band gap of a quantum well is inherently inversely proportional to the thickness of the quantum well as provided for in the well-known equation $E_n = h^2 n^2 / 8m^* L^2$ disclosed and explained in Solymar. Ex. 1002 ¶ 81–83.

We also credit Dr. Fitzgerald's testimony that one of ordinary skill in the art would understand that Solymar's mathematical relationship between energy band gap and thickness in a quantum structure teaches that "changes in well thickness result in fluctuations in the band gap, which are well known to be a desirable feature in light emitting devices." Ex. 1002 ¶ 159 (citing Ex. 1011 ¶¶ [5–6]). We credit this testimony because it accurately reflects what is disclosed in Solymar. *See, e.g.*, (Ex. 1011, 6 (Fig. 13.22 showing "Absorbption as a function of excess photo energy for bulk material . . . and 30 nm thick quantum well material").

Thus, we agree that one of ordinary skill in the art would have applied Solymar's mathematical relationship between energy band gap and thickness in a quantum structure to Ozaki's teachings "to maximize the thickness fluctuations in the InGaN layer as taught in Ozaki to increase the spatial fluctuation in the band gap and improve light emission." to Ozaki's teachings "to maximize the thickness fluctuations in the InGaN layer as taught in Ozaki to increase the spatial fluctuation in the band gap and improve light emission." Pet. 51.

We also find that one of ordinary skill in the art would have a reasonable expectation of such in applying Solymar's equation to create a spatial fluctuation in the band gap in Ozaki's active layer to achieve spatial fluctuation (widening and narrowing) in the band gap of the active layer because this combination applies a known technique (Solymar's equation) to do so. Pet. 53 ("Combining Ozaki and Solymar would be nothing more than applying a known technique (Solymar's equation) to create a spatial fluctuation in the band gap in Ozaki's active layer ('second gallium nitride based semiconductor') to achieve a spatial fluctuation (widening and

narrowing) in the band gap of the active layer (‘second gallium nitride based semiconductor’). Ex. 1002, ¶159.”). We credit Dr. Fitzgerald’s testimony that Petitioner’s combination of Ozaki and Solymar applies “a known technique (Solymar’s equation for electrons and holes) to calculate the band gap in Ozaki’s active layer / well layer . . . to show there is a spatial fluctuation (widening and narrowing) in the band gap.” Ex. 1002 ¶ 159; Pet. 51 (citing Ex. 1002 ¶ 159). Dr. Fitzgerald’s testimony is well-reasoned and reflects Solymar’s disclosures.

Accordingly, for these reasons, we determine one of ordinary skill in the art would have found it obvious to combine Ozaki’s and Solymar’s relevant teachings and would have had a reasonable likelihood of success in doing so.

In addition, Dr. Fitzgerald’s deposition testimony also supports our findings. Specifically, Dr. Fitzgerald testifies that:

[i]f you have changing thickness within the realm that we’re talking about, the quantum realm, right, then in most cases, you’re going to have a fluctuation in the band gap. Because of the relationship between quantum confinement, it’s inversely proportional. So the smaller you make the confinement, the higher the energy goes. So you change the band gap.

Ex. 2037, 74:14–20. Patent Owner argues that Dr. Fitzgerald’s testimony is insufficient to show Ozaki teaches a band gap fluctuation because it is not enough that “in most cases, you’re going to have a fluctuation in the band gap.” PO Resp. 27 (quoting Ex. 2037, 74:14–17) (emphasis omitted). In its Reply, Petitioner explains that Dr. Fitzgerald accidentally and incorrectly included “in most cases” in his response. Pet. Reply 14. Petitioner argues “[a]s stated in his original declaration, when using quantum confinement as in Ozaki, changes in thickness always change the band gap because,

mathematically, band gap and thickness are always inversely proportional in quantum structures like quantum dots.” *Id.* (citing Ex. 1002 ¶¶ 62–64, 141–142). We agree with Petitioner that the complete record supports its reading of Dr. Fitzgerald’s testimony. *E.g.*, Ex. 1002 ¶¶ 62–64, 141–142.

Moreover, Dr. Doolittle’s testimony is consistent with the concept that thickness affects band gap energy. Dr. Doolittle testifies that Solymar provides an “unremarkable equation relating band gap and the thickness of a quantum well.” Ex. 2053 ¶ 172. Dr. Doolittle further includes, and does not dispute, a portion of Dr. Fitzgerald’s testimony that explains the mathematical relationship expressed by the equation $E_n = h^2 n^2 / 8m^* L^2$. *Id.* In this context, we understand Dr. Doolittle to agree that the thickness of a “quantum well” affects the band gap. *Id.*

Additionally, we are not persuaded by Patent Owner’s argument that Solymar’s equation applies only to quantum wells and not quantum dots. PO Resp. 41. Rather, we agree with Petitioner and find that Solymar’s equation is a “well-known and commonly accepted mathematical relationship between the thickness of a quantum structure (*e.g.*, a quantum well) and the band gap.” Pet. 15 (citing Ex. 1011, 5–6); *see also* Ex. 1002 ¶ 64 (testifying one of ordinary skill in the art would have been aware of Solymar’s equation “that show[s] the mathematical relationship between energy band gap and thickness in a quantum structure”); Ex. 1033 ¶¶ 3–4.

To be clear, a “quantum structure” is a broad term encompassing, *inter alia*, a quantum well and a quantum dot. *E.g.*, Ex. 1002 ¶ 155; Ex. 1006 ¶ 7. “[Q]uantum wells confine electrons/holes in only one dimension, while quantum dots confine them in all three dimensions.” *E.g.*,

PO Resp. 24 n.7 (citing Ex. 2053 ¶ 74–77; Ex. 2010 (Bimberg¹²), 11–13). Solymar provides one instance of the $E_n = h^2 n^2 / 8m * L^2$ equation as a quantum well confines in one dimension with one thickness. Ex. 1011, 5–6; Ex. 2053 ¶ 74–77. However, a quantum dot confines in three dimensions, and “[i]n general, each added dimension of quantization results in additional energy discretization and increasing quantized energies compared to the energy bandgap.” Ex. 2053 ¶ 77. Dr. Doolittle testifies that the mathematical equation for the quantized energies of a quantum dot is $E_n = [h^2 n_x^2 / (8m * L_x^2)] + [h^2 n_y^2 / (8m * L_y^2)] + [h^2 n_z^2 / (8m * L_z^2)]$, where “ L_x , L_y and L_z are the quantum dot dimensions.” *Id.* at 36–37 n.7. In other words, Solymar’s equation relating energy band gap and thickness applies for each dimension of quantum confinement. *Id.*; see also Tr., 40:9–14 (Patent Owner agreeing that Dr. Doolittle’s equation has three terms, each of which is Solymar’s equation), 41:5–11 (Patent Owner agreeing that there are three instances of Solymar’s equation for a quantum dot’s three dimensions). Notably, the quantum dot’s band gap energy, as expressed by Dr. Doolittle’s equation, has an inverse relationship to the thickness of the confinement barrier for each of the three dimensions. *Id.* at 36–37 n.7. Dr. Fitzgerald’s testimony is consistent with this equation for quantum dots: “Because the band gap energy is inversely proportional to the thickness of the well squared, a quantum well *or other quantized structure with varying thickness* will necessarily have a strong spatial fluctuation in the band gap.” Ex. 1002 ¶ 83 (emphasis added).

¹² Excerpts of D. BIMBERG ET AL., QUANTUM DOT HETEROSTRUCTURES (1999) (Ex. 2010, “Bimberg”).

Regardless, Petitioner also clearly relies on Ozaki's teachings that its quantum structure can be a quantum well. *E.g.*, Pet. 44–45 (quoting Ex. 1006 ¶ 7), 46 (citing Ex. 1006 ¶¶ 7, 9–11, 14–16). There is no dispute that Solymar's equation applies to quantum wells. PO Sur-Reply 10–11 (citing Ex. 1011, 6; Ex. 2053 ¶ 418). Thus, Patent Owner's argument that Solymar's equation only applies to quantum wells is unavailing.

We also are not persuaded by Patent Owner's argument that quantum dots do not have a “widening and narrowing of the band gap” because quantum dots have “sharp, discrete transitions in the band gap that create *discontinuities* in potential energy.” PO Resp. 31 (emphasis added). Patent Owner illustrates these discontinuities in Kim's Figure 6 with two red arrows. *Id.* at 32 (annotating Ex. 2038, Fig. 6) (arguing that the two red arrows indicate transitions between GaN and InGaN). Simply put, our construction of “spatial fluctuation . . . in the band gap” does not include “continuous” (*see supra* Section IV(A)), and thus, Patent Owner's arguments concerning *discontinuities* are unavailing.

We also are not persuaded by Patent Owner's argument that a quantum dot, such as in Ozaki, has only one quantum energy level, and thus, cannot have a widening and narrowing within the quantum dot. Tr. 38:1–9, 42:3–5. This argument is contrary to the balance of the record evidence. For example, Dr. Doolittle testifies that “[b]ecause carriers may only exist within the quantum dot at specified discrete energies, carriers can move laterally without any energy fluctuations at all *or alternatively have to ‘jump’ between discrete bandgap energies both within the quantum dot itself and to escape the quantum dot.*” Ex. 2053 ¶ 270 (emphases added). Thus, we understand Dr. Doolittle's testimony acknowledges multiple discrete

quantum energy levels within a quantum dot. Likewise, Bimberg's Figure 1.2, which illustrates the nature of electronic states in bulk material, quantum wells, and quantum dots, shows more than one quantized electronic state for a quantum dot. Ex. 2010, 12.

We also are not persuaded by Patent Owner's arguments that (i) the '270 patent does not mention quantum dots, (ii) quantum dots must be very small, while the '270 patent's spatial fluctuation exists on a length scale that is several orders of magnitude larger, (iii) Dr. Sakai was seeking to solve a different problem involving the ultraviolet band, and (iv) AlGaIn will not form quantum dots like InGaIn. PO Resp. 33–37. The focus of our obviousness analysis is on the claims, rather than the '270 patent's Specification or purported facts untethered to the claims. *In re Hiniker Co.*, 150 F.3d 1362, 1369 (Fed. Cir. 1998) (finding “the name of the game is the claim”). Simply put, these arguments are not directed to limitations in claim 5, and are thus unavailing. *In re Self*, 671 F.2d 1344, 1348 (CCPA 1982) (stating limitations not appearing in the claims cannot be relied upon for patentability). For example, claim 5 does not expressly recite any size/scale requirements or exclude quantum structures. Additionally, claim 5 does not require AlGaIn. Rather, claim 5 recites the step of “forming the gallium based semiconductor on the base layer.” Ozaki teaches that the use of several gallium nitride materials, including the use of an InGaIn, i.e., a gallium nitride, as the active layer material. See Ex. 1006 ¶ 14.

Lastly, Patent Owner argues that Dr. Fitzgerald is inconsistent in identifying Ozaki's quantum dots, which casts doubt on the credibility of his opinions. PO Resp. 39–40. Patent Owner also argues that “Dr. Fitzgerald lacks particular expertise with gallium-nitride based semiconductors.” *Id.*

(citing Ex. 2042, 4-43–4-45; Ex. 2037, 144:22–147:23). Petitioner responds that Dr. Fitzgerald has extensive experience and “the Federal Circuit found Dr. Fitzgerald . . . credible and relied on his testimony in finding the patent in that case invalid.” Pet. Reply 21–22 (citing *Tr. of Boston Univ. v. Everlight Elec. Co., Ltd.*, 896 F.3d 1357, 1362 (Fed. Cir. 2018)). We find at least the testimony of Dr. Fitzgerald that we rely upon in this Decision credible and we give it appropriate weight.

Accordingly, for the reasons discussed above, we are persuaded that Petitioner has sufficiently shown that Ozaki alone, or alternatively, in combination with Solymar, teaches “wherein a spatial fluctuation is created in the band gap of the gallium nitride based semiconductor by the lattice mismatch.”

5. gallium nitride based semiconductor is a light emitting layer

Petitioner argues that Ozaki teaches that “the gallium nitride based semiconductor is a light emitting layer,” as recited in claim 5. Pet. 47, 52–53. Ozaki discloses that “[t]he active layer emits light due to the quantum effect of the quantum well structure.” *Id.* at 47 (citing Ex. 1006 ¶ 14). Based on this express teaching, we find that Ozaki teaches that the gallium nitride based semiconductor (active layer) is a light emitting layer. Ex. 1006 ¶ 14, Fig. 3.

6. Summary

We find that Petitioner has demonstrated by a preponderance of the evidence that the combination of Ozaki and Solymar teaches all of the limitations recited in claim 5, and that one of ordinary skill in the art would have found it obvious to combine Ozaki’s and Solymar’s relevant teachings

would have had a reasonable likelihood of success in doing so, discussed above.

E. Challenged Claim 12

Claim 12 is an independent claim. Ex. 1001, 6:52–61. Petitioner relies on the same combination of Ozaki and Solymar discussed above and incorporates its arguments for claim 5 into its challenge of claim 12. Pet. 53–55. Patent Owner likewise incorporates its arguments in response from claim 5 into the challenge of claim 12. PO Resp. 17 n.5, 40–41.

We find that claim 12 is of commensurate scope to claim 5. *Compare* Ex. 1001, 6:1–11, *with id.* at 6:52–61. Claim 5 recites “the gallium nitride based semiconductor is a light emitting layer,” whereas claim 12 recites “[a] light emitting element using a gallium nitride based semiconductor.” Claim 5 recites “forming, on a substrate, a base layer having a lattice mismatch layer formed on less than a total area of a surface of the base layer,” whereas claim 12 recites “a substrate; [and] a base layer formed on the substrate and having a lattice mismatch formed on less than a total area of a surface of the base layer.” Claim 5 recites “forming the gallium nitride based semiconductor on the base layer,” wherein claim 12 recites “a gallium nitride based semiconductor layer formed on the base layer.” Claim 5 recites “a spatial fluctuation is created in the band gap of the gallium nitride based semiconductor by the lattice mismatch, and the gallium nitride based semiconductor is a light emitting layer,” whereas claim 12 recites “having a spatial fluctuation in the band gap, and the gallium nitride based semiconductor is a light emitting layer.”

For the same reasons as we discuss above with respect to claim 5, we find that Petitioner has demonstrated by a preponderance of the evidence

that the combination of Ozaki and Solymar teaches all of the limitations recited in claim 12, and that one of ordinary skill in the art would have found it obvious to combine Ozaki's and Solymar's relevant teachings, for the reasons discussed above.

VII. ALLEGED ANTICIPATION BY OZAKI

Having found that challenged claims 5 and 12 are unpatentable for obviousness, we decline to address Petitioner's other challenge that claims 5 and 12 are unpatentable for anticipation. Specifically, we decline to address the parties arguments directed to Ozaki anticipating claims 5 and 12 of the '270 patent. *See SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348, 1359 (2018) (holding that a petitioner "is entitled to a final written decision addressing all of the claims it has challenged"); *see also Beloit Corp. v. Valmet Oy*, 742 F.2d 1421, 1423 (Fed. Cir. 1984) (holding that once a dispositive issue is decided, there is no need to decide other potentially dispositive issues); *see also SZ DJI Tech. Co., LTD. v. Drone-Control, LLC*, Case IPR2018-00207, slip op. at 30–33 (Paper 44) (PTAB June 11, 2019) (discussing basis for declining consideration of other grounds when all challenged claims are shown to be unpatentable); *cf. In re Gleave*, 560 F.3d 1331, 1338 (Fed. Cir. 2009) (not reaching other grounds of unpatentability after affirming anticipation ground).

VIII. CONCLUSION¹³

Based on the full record before us, we determine that Petitioner has demonstrated by a preponderance of the evidence that claims 5 and 12 of the

¹³ Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 Notice

'270 patent are unpatentable under 35 U.S.C. § 103(a) as directed to subject matter that would have been obvious over Ozaki and Solymar to a person of ordinary skill in the art. We also determine that Petitioner has not demonstrated by a preponderance of the evidence that claims 1–4, 6–11, and 13 of the '270 patent are unpatentable under 35 U.S.C. § 102(a) over Sakai.

Claims	35 U.S.C §	Reference(s)	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1–13	102(a)	Sakai		1–13
5, 12	102(b) ¹⁴	Ozaki		
5, 12	103(a)	Ozaki and Solymar	5, 12	
Overall Outcome			5, 12	1–4, 6–11, 13

IX. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that, pursuant to 35 U.S.C. § 314(a), Petitioner has shown by a preponderance of the evidence that claims 5 and 12 of the '270 patent are unpatentable;

FURTHER ORDERED that Petitioner has not shown by a preponderance of the evidence that claims 1–4, 6–11, and 13 of the '270 patent are unpatentable; and

Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding. See 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. See 37 C.F.R. § 42.8(a)(3), (b)(2).

¹⁴ As explained above, we do not reach this ground as we find claims 5 and 12 obvious.

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

IPR2018-01141
Patent 6,861,270 B2

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