UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SATCO PRODUCTS, INC.,
Petitioner,

v.

SEOUL SEMICONDUCTOR CO., LTD.,
Patent Owner.

Case: IPR2020-00146
U.S. Patent No. 7,667,225

PETITIONER’S NOTICE OF APPEAL

Director of the United States Patent and Trademark Office
c/o Office of the General Counsel
Madison Building East, 10B20
600 Dulany Street
Alexandria, VA 22314

Notice is hereby given, pursuant to 35 U.S.C. §§ 141, 142, and 319, and 37 C.F.R. §§90.2-90.3, that Petitioner Satco Products, Inc. ("Satco") hereby appeals to the United States Court of Appeals for the Federal Circuit from the Final Written Decision entered on June 25, 2021, (Paper 44), and from all underlying findings, determinations, rulings, opinions, orders, and decisions regarding U.S. Patent No. 7,667,225. A copy of the Final Written Decision is attached.

In accordance with 37 C.F.R. §90.2(a)(3)(ii), Satco further indicates that the issues on appeal include, but are not limited to, the following: (1) the Board's determination that claims 1, 4-7, 10-11, and 16-19 of U.S. Patent No. 7,667,225 have not been shown to be unpatentable; (2) the Board's determination that Petitioner has not demonstrated by a preponderance of the evidence that claims 1, 4-7, 10-11, and 16-19 of the '225 patent are unpatentable under 35 U.S.C. §§ 102 and 103 in view of the grounds of unpatentability identified in the Petition and the Board's Final Written Decision; (3) the Board's application of the claim language and its failure to construe or faithfully apply the definition of "carrier trap portion" found in the '225 patent; (4) the Board's consideration of the expert testimony, prior art, and other evidence in the record; (5) the Board's factual findings, conclusions of law or other determinations supporting or related to those issues including the Board's application of the preponderance of the evidence burden of proof and its application of the law of anticipation; (6) the Board's conclusion that Petitioner's Reply exceeded the scope of a proper Reply under the Board's rules and/or the Administrative Procedure Act, as well as (7) all other issues decided adversely to Petitioner in any orders, decisions, rulings, and opinions.

Copies of the Notice of Appeal are being filed simultaneously with the Patent Trial and Appeal Board. In addition, three copies of this Notice of Appeal, along with the required docketing fees, are being filed with the Clerk's Office for the United States Court of Appeals for the Federal Circuit.

Dated: August 5, 2021

Respectfully submitted,

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CERTIFICATE OF FILING

I hereby certify that, in addition to being filed electronically through the Patent Trial and Appeal Board's PRPS system, the original version of the foregoing, PETITIONER'S NOTICE OF APPEAL, was filed by hand on this 5th day of August, 2021, with the Director of the United States Patent and Trademark Office, at the following address:

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I hereby certify that three (3) true and correct copies of the foregoing, PETITIONER'S NOTICE OF APPEAL and the docketing fee of $500 are being filed by CM/ECF and Pay.gov, and were served by hand on this 5th day of August, 2021 with the Clerk's Office of the United States of Appeals for the Federal Circuit, at the following address:

United States Court of Appeals for the Federal Circuit
c/o Clerk's Office
717 Madison Place, N.W., Suite 401
Washington, D.C. 20439

CERTIFICATE OF SERVICE

The undersigned hereby certifies that on the below date, I caused a true and correct copy of the foregoing, PETITIONER'S NOTICE OF APPEAL, to be served upon the following counsel of record via electronic mail:

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Dated: August 5, 2021

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Exhibit A

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Paper 44
Entered: June 25, 2021

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SATCO PRODUCTS, INC.,
Petitioner,

v.

SEOUL SEMICONDUCTOR CO, LTD.,
Patent Owner.

IPR2020-00146
Patent 7,667,225 B1

Before ERICA A. FRANKLIN, JEFFREY W. ABRAHAM, and ELIZABETH M. ROESEL, *Administrative Patent Judges.*

ABRAHAM, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining No Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

Satco Products, Inc. ("Petitioner"), filed a Corrected Petition (Paper 6, "Pet.") requesting *inter partes* review of claims 1, 4–7, 10, 11, and 16–19 of U.S. Patent No. 7,667,225 B1 (Ex. 1001, "the '225 patent"). Seoul Semiconductor Co., Ltd. ("Patent Owner"), filed a Preliminary Response to the Petition (Paper 8, "Prelim. Resp.").

On July 2, 2020, we instituted *inter partes* review of all of the challenged claims based on all of the grounds identified in the Petition. Paper 9 ("Inst. Dec."). Subsequently, Patent Owner filed a Response (Paper 18, "PO Resp."), Petitioner filed a Reply (Paper 27, "Reply"), and Patent Owner filed a Sur-reply (Paper 34, "Sur-reply"). We held an oral hearing on April 8, 2021, and a transcript of the hearing has been entered into the record. Paper 43 ("Tr.").

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a). For the reasons that follow, we determine that Petitioner has not shown by a preponderance of the evidence that claims 1, 4–7, 10, 11, and 16–19 of the '225 patent are unpatentable.

A. Related Proceedings

The parties identify *Seoul Semiconductor Co., Ltd. v. Satco Products, Inc.*, No. 2:19-cv-04951 (E.D.N.Y.), and *Seoul Semiconductor Co., Ltd. v. The Factory Depot Advantages, Inc.*, No. 2:19-cv-05065 (C.D. Cal.). Pet. 58–59; Paper 4, 1. Patent Owner additionally identifies *Seoul Semiconductor Co., Ltd. v. Vividgro, Inc.,* No. 6:19-cv-02263 (M.D. Fla.), and *Seoul Semiconductor Co., Ltd., v. Healthe, Inc.*, No. 6:19-cv-02264 (M.D. Fla.). Paper 4, 1.

B. The ’225 Patent

The ’225 patent, titled “Light Emitting Device,” issued on February 23, 2010. Ex. 1001, codes (45), (54). The ’225 patent is directed to a light emitting device configured to improve the crystal quality of a multi-quantum well structure and to “prevent a reduction in internal quantum efficiency which is caused by crystal defects such as dislocations in an active region.” Ex. 1001, 2:6–12. The devices of the ’225 patent can be used in light emitting diodes (LEDs) and laser diodes. Ex. 1001, 1:16–18.

The ’225 patent explains that LEDs generally include an n-type semiconductor layer, a p-type semiconductor layer, and an active region disposed between the semiconductor layers. Ex. 1001, 1:35–38. “The n-type and p-type semiconductor layers may be formed of Group-III nitride semiconductor layers, for example, (Al, In, Ga)N-based compound semiconductor layers . . . .” Ex. 1001, 1:38–41. According to the ’225 patent, when Group-III nitride semiconductor layers are grown on a heterogeneous substrate having a hexagonal structure, such as sapphire or silicon carbide, “the semiconductor layer undergoes cracking or warpage and dislocations due to differences in lattice constant and thermal expansion . . . coefficient between the semiconductor layer and the substrate.” Ex. 1001, 1:50–58. “Further, the crystal defects such as dislocations in the active region trap carriers introduced into the active region and do not emit light, thereby acting as a non-radiative center and significantly deteriorating internal quantum efficiency of the LED.” Ex. 1001, 1:65–2:2.

To prevent the deterioration of internal quantum efficiency, the ’225 patent includes at least one carrier trap portion in at least one layer of the active region. Ex. 1001, 4:11–14. The term carrier trap portion in the ’225 patent refers to

> a structure capable of using carriers which can be trapped and lost by the dislocations. Such a structure is not limited to a physical shape. In other words, according to embodiments of the invention, the carrier trap portion . . . may be a physical shape or a quantum-mechanical energy state capable of efficiently using the carriers which can be trapped and lost by the dislocations.

Ex. 1001, 4:40–47.

According to the ’225 patent, the carrier trap portions improve internal quantum efficiency by trapping carriers that otherwise would be trapped by dislocations in the multi-quantum well structure so that the carriers can be used for light emission. Ex. 1001, 6:8–15. “For this purpose, the carrier trap portion . . . is configured to have a band-gap energy that gradually decreases from a periphery of the carrier trap portion . . . to the center thereof . . . .” Ex. 1001, 4:16–19. The ’225 patent teaches that this can be accomplished “by controlling the temperature, pressure and flow rate of a source gas in a chamber during growth of the well layer.” Ex. 1001, 4:30–32. As one example, the ’225 patent discloses that for a well layer composed of InGaN, “when the indium content exceeds 5% and the growth temperature exceeds 600° C., indium is subjected to phase separation in the layer and exhibit[s] an intensive tendency to form the carrier trap portion . . . according to the embodiments of the invention.” Ex. 1001, 4:57–5:7. Additionally, applying a pressure of 300 torr or more can result in a carrier trap cluster formed by clustering of at least two carrier trap portions. Ex. 1001, 2:61–62, 5:59–62.

C. Illustrative Claim

Petitioner challenges claims 1, 4–7, 10, 11, and 16–19 of the ’225 patent. Independent claim 1, the only independent claim challenged, is illustrative and is reproduced below:

> 1. A light emitting device, comprising:
>
> a substrate;
>
> a first semiconductor layer on the substrate;
>
> a second semiconductor layer on the first semiconductor layer; and
>
> a multi-quantum well structure comprising at least one well layer and at least one barrier layer between the first and second semiconductor layers, at least one layer within the multi-quantum well structure comprising at least one carrier trap portion formed therein, the at least one carrier trap portion having a band-gap energy decreasing from a periphery of the carrier trap portion to a center of the carrier trap portion.

Ex. 1001, 6:42–55.

D. Reviewed Unpatentability Challenges

Claim(s) Challenged	**35 U.S.C. §[1]**	**Reference(s)/Basis**
1, 4–7, 10, 11, 17–19	102(b)	Lin[2]
4	103(a)	Lin, Schley[3]
16	103(a)	Lin, Lin II[4]
1, 5–7, 10, 11, 17–19	102(b)	Gerthsen[5]
16	103(a)	Gerthsen, Lin II

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, we construe claim terms according to the standard set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–17 (Fed. Cir. 2005) (en banc). *See* 37 C.F.R. § 42.100(b) (2019). Under *Phillips*,

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[1] The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. § 103, effective March 16, 2013. Because the application from which the '225 patent issued was filed before this date, the pre-AIA version of §§ 102 and 103 apply.

[2] Lin et al., *Effects of post-growth thermal annealing on the indium aggregated structures in InGaN/GaN quantum wells*, J. of Crystal Growth, Vol. 242, 35–40 (2002) (Ex. 1025).

[3] Schley et al., *Dielectric function and Van Hove singularities for In-rich $In_xGa_{1-x}N$ alloys: Comparison of N- and metal-face materials*, Physical Review B 75, 205204 (2007) (Ex. 1055).

[4] Lin et al., *Dependence of composition fluctuation on indium content in InGaN/GaN multiple quantum wells*, Appl. Phys. Lett., Vol. 77, No. 19, 2988–2990 (Nov. 6, 2000) (Ex. 1016).

[5] Gerthsen et al., *Indium distribution in epitaxially grown InGaN layers analyzed by transmission electron microscopy*, Phys. Stat. Sol (c), Vol. 0, No. 6, 1668–1683 (2003) (Ex. 1026).

claim terms are afforded "their ordinary and customary meaning." *Phillips*, 415 F.3d at 1312. "[T]he ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention . . . ." *Id.* at 1313. "Importantly, the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification." *Id.*

Petitioner proposes an express construction for the term "carrier trap portion[s]" and contends that the remaining terms of the '225 patent should be interpreted according to their ordinary and customary meaning.[6] Pet. 19–21. With regard to "carrier trap portion," Petitioner contends the '225 patent explicitly defines the term in the following passage:

> Herein, the carrier trap portion 27 refers to a structure capable of using carriers which can be trapped and lost by the dislocations. Such a structure is not limited to a physical shape. In other words, according to embodiments of the invention, a carrier trap portion 27 may be a physical shape or a quantum-mechanical energy state capable of efficiently using carriers which can be trapped and lost by the dislocations.

Ex. 1001, 4:40-47. Petitioner further contends that a person of ordinary skill in the art "would have understood that 'quantum-mechanical energy state[s] capable of efficiently using carriers which can be trapped and lost by the dislocations' are often called 'quantum dots' in the literature." Pet. 20.

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[6] Petitioner states that "[t]here are problems with the way that the 'multi-quantum well structure' is recited in claim 1," but does not propose an express construction for the term. Pet. 20–21.

Patent Owner does not dispute Petitioner's assertions regarding the meaning of "carrier trap portion." Patent Owner argues, however, that the preamble of claim 1, which recites a "light emitting device," is limiting and requires a semiconductor device that emits light when electric current passes through it. PO Resp. 11–19. Petitioner disagrees. Reply 3–7.

After reviewing the parties' arguments and evidence, we determine that we do not need to expressly construe any terms for purposes of this Decision, and we do not need to determine whether the preamble is limiting. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (citing *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy.")).

B. Level of Ordinary Skill in the Art

Petitioner contends that a person of ordinary skill in the art in the field of the '225 patent would have had "a Master's Degree in chemical engineering, materials engineering, or electrical engineering (with a focus on semiconductor materials), or similar advanced post-graduate education in this area, with roughly two years of experience in researching nitride-based light emitting devices." Pet. 18–19 (citing Ex. 1002 ¶ 27). Petitioner also contends that someone "with less education but more relevant practical experience, depending on the nature of that experience and degree of exposure to nitride-based light emitting semiconductor materials and their chemistry and physics, could also qualify as a person of ordinary skill in the art in the field of the '225 patent." Pet. 19.

Patent Owner contends that a person of ordinary skill in the art "would have had an undergraduate 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 fabricating Group-III nitride LEDs or laser diodes," or, alternatively, "a graduate degree in one of those fields and at least one year of professional experience." PO Resp. 21.

We discern only a slight difference between the parties' proposed definitions. Moreover, the parties agree that the level of skill in the art would not materially impact the outcome of this proceeding. PO Resp. 21 ("The challenged claims should be upheld under any of the proposed levels of ordinary skill in the art."); Tr. 54:2–13, 59:20–60:12 (counsel for Petitioner stating that "we have not briefed [the level of ordinary skill in the art] as materially impacting the outcome of this case").

In view of the foregoing, we adopt Petitioner's proposal regarding the level of one of ordinary skill in the art. The level of ordinary skill in the art is also reflected by the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). We, however, also agree with the parties that the level of skill in the art does not materially impact the outcome of this proceeding.

C. Overview of Asserted Art

1. Lin (Ex. 1025)

Lin studied the formation of quantum dots (QDs) in InGaN/GaN quantum well (QW) structures by post-growth thermal annealing. Ex. 1025, 36. Lin grew the quantum well sample used in its study with a low-pressure metal-organic chemical-vapor deposition reactor. Ex. 1025, 36. The

InGaN/GaN quantum well sample consisted of ten periods of InGaN wells, and the quantum well layers were positioned between a GaN buffer layer formed on a sapphire substrate and a GaN cap layer. Ex. 1025, 36. Lin subjected the samples to thermal annealing at different temperatures and used high-resolution transmission electron microscopy (HRTEM) and energy filter transmission electron microscopy (EFTEM) to characterize the material properties of test samples. Ex. 1025, 36.

Lin observed the formation of sphere-like, indium-rich quantum dots after annealing. Ex. 1025, 37. In particular, Lin observed quantum dots "with [a] size of 2–5 nm were regularly distributed within the designated InGaN QW layers after annealing treatment at 900° C." Ex. 1025, 37. Lin provided results from EFTEM observation of the samples annealed at 900° C in Figure 2, reproduced below.

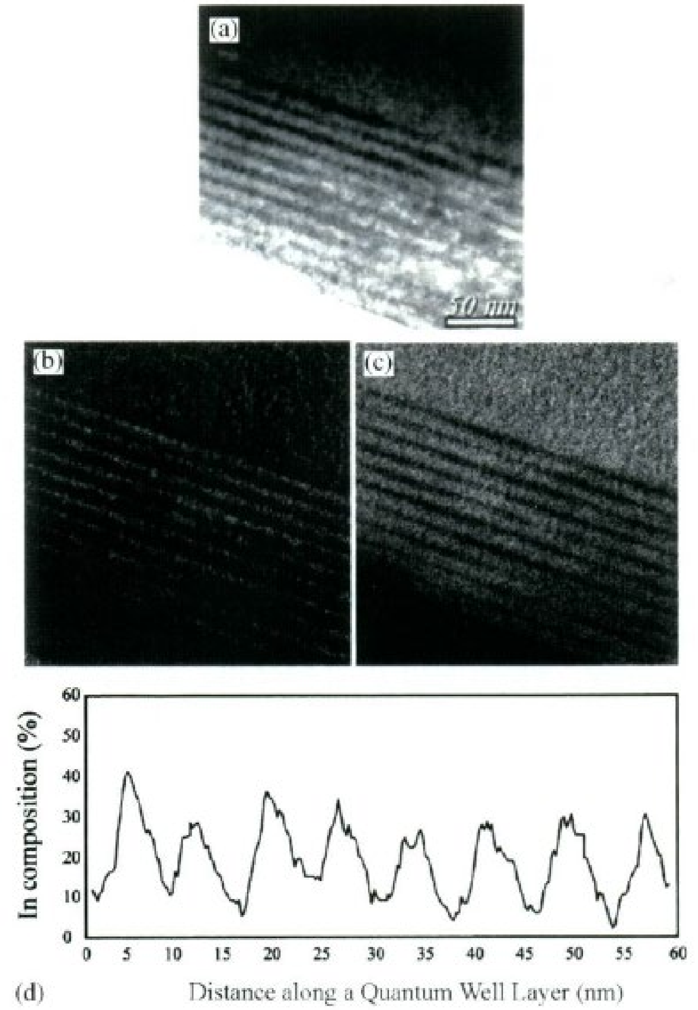


Fig. 2. EFTEM images of the 900°C annealing sample with (a) zero-loss map, (b) indium map, (c) gallium map, and (d) indium composition amplitude profile along a QW.

Figure 2 of Lin provides indium map and indium composition profiles along and across the quantum well layers of the sample after annealing at 900 degrees C. Ex. 1025, 37–38. Lin states that these figures show "[r]egularly arrayed QDs with nearly the same indium concentration at the cores of the QDs." Ex. 1025, 37.

2. *Gerthsen (Ex. 1026)*

Gerthsen describes an investigation of the structural properties and composition of InGaN quantum wells embedded in Ga(Al)N barriers. Ex. 1026, 1668. Gerthsen used HRTEM to investigate a variety of samples produced by molecular beam epitaxy and metal-organic vapor phase epitaxy. Ex. 1026, 1668. According to Gerthsen, "[t]he effect of the deposition temperature, growth rate, strain and high-temperature annealing treatments on the average In concentration and In distribution was studied to assess the influence of phase separation, In surface segregation, and In desorption." Ex. 1026, 1668.

Gerthsen shows the results of the analysis of an InGaN/GaN quantum well structure in Figure 4, reproduced below.

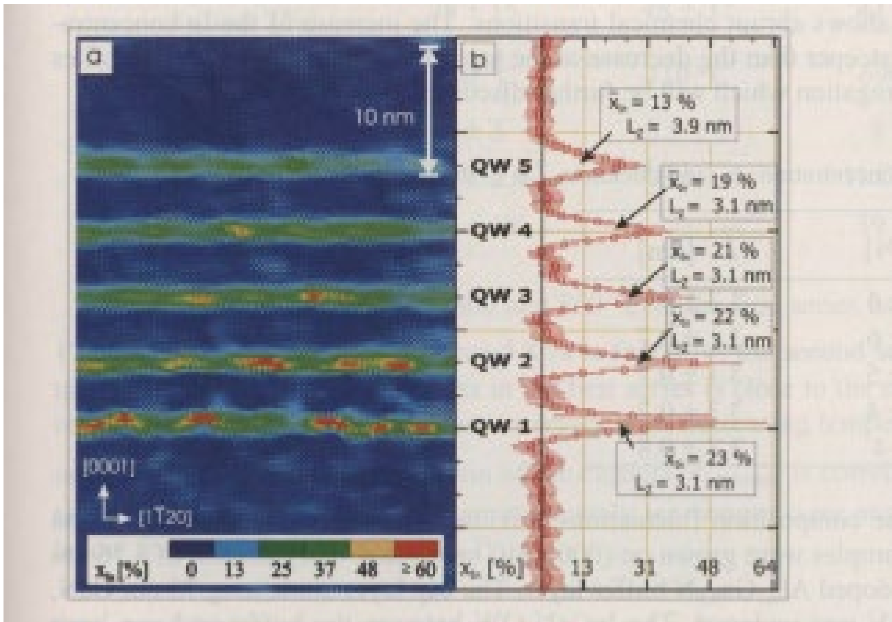


Fig. 4 a) Color-coded map of the In distribution of an InGaN/GaN multiple QW structure and b) averaged In concentration along the $[11\bar{2}0]$ direction plotted as a function of the (0002)-plane. number.

Figure 4 shows a color-coded map of the indium distribution in the InGaN/GaN multiple quantum well structure and the average indium concentration along the horizontal direction of the wells. Ex. 1026, 1673. Gerthsen observed a "strongly inhomogeneous In distribution in all QWs," including "small In-rich clusters with lateral extensions below 4 nm, which are present at an extremely high density." Ex. 1026, 1673–1674.

3. *Schley (Ex. 1055)*

Schley describes a study of the optical properties of InGaN alloy films using spectroscopic ellipsometry. Ex. 1055, 205204-1. As part of its study, Schley provides the following equation that allows for the calculation of bandgap energy (E_{CP}) as a function of composition:

$$E_{CP} = xE_{CP,InN} + (1-x)E_{CP,GaN} - bx(1-x)$$

Ex. 1055, 205204-5. In this equation, b is a bowing parameter, $E_{CP,InN}$ is the bandgap energy for pure InN, $E_{CP,GaN}$ is the bandgap energy for pure GaN, and x is the indium concentration from the expression $In_xGa_{1-x}N$. Ex. 1055, 205204-5.

4. *Lin II (Ex. 1016)*

Lin II notes that "[i]n many articles, it was proposed that nanoscale indium composition fluctuations, due to indium aggregation of phase separation, acted as quantum dots (QDs) in optical characteristics." Ex. 1016, 2988. Lin II explains that "[i]n the QDs, carriers are deeply localized and their migration toward nonradiative defects (dislocations) is hindered. Therefore, high-luminescence efficiency is expected if the density of QDs is much higher than that of dislocations." Ex. 1016, 2988. In view of this, Lin II describes a study of the effects of nominal indium content on the composition fluctuation/QD formation and structural defects in InGaN/GaN multiple quantum wells. Ex. 1016, 2988.

D. Claims 1, 4–7, 10, 11, and 17–19 — Alleged Anticipation by Lin

Petitioner contends Lin anticipates claims 1, 4–7, 10, 11, and 17–19. Pet. 26–41. Petitioner relies on declarations from Dr. Dupuis (Ex. 1002 (“First Declaration”) and Ex. 1071 (“Second Declaration”)) and Dr. Ponce (Ex. 1066) to support its arguments.

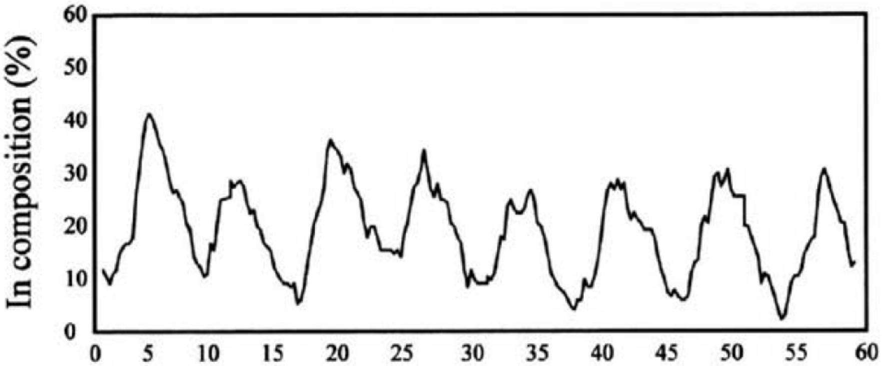
1. Claim 1

Independent claim 1 of the ’225 patent recites a light emitting device comprising a substrate, a first semiconductor layer on the substrate, a second semiconductor layer on the first semiconductor layer, and multi-quantum well structure comprising at least one well layer and one barrier layer between the first and second semiconductor layers. For these limitations, Petitioner directs us to Lin’s disclosure of an “InGaN/GaN QW sample consist[ing] of ten periods of InGaN wells,” wherein the quantum well layers “were sandwiched between a 1.5 μm GaN buffer layer on a (0 0 0 1) sapphire substrate and a 50 nm GaN cap layer.” Ex. 1025, 36; Pet. 27–28. According to Petitioner, the “(0 0 0 1) sapphire substrate” in Lin corresponds to the claimed substrate, the “1.5 μm GaN buffer layer” corresponds to the claimed first semiconductor layer, the “50 nm GaN cap layer” corresponds to the second semiconductor layer, and the InGaN/GaN quantum wells sandwiched between the layers correspond to the claimed multi-quantum well structure. Pet. 27–28.

Claim 1 of the ’225 patent further requires “at least one layer within the multi-quantum well structure comprising at least one carrier trap portion formed therein.” Ex. 1001, 6:50–52. Petitioner contends that Lin’s InGaN well layers include indium-rich quantum clusters that become sphere-like shaped after annealing. Pet. 28–29 (citing Ex. 1025, 36–37). Petitioner directs us to Lin's HRTEM images of its samples, and Lin's statement that "one can observe that fine indium-rich QDs with size 2–5 nm were regularly distributed within the designated InGaN QW layers." Pet. 28–29 (quoting Ex. 1025, 37). According to Petitioner, "[t]his regular distribution of quantum dots within the InGaN well layer describes a number of 'carrier trap portions' within the layer." Pet. 29 (citing Ex. 1002 ¶¶ 89–90).

Patent Owner does not dispute that Lin's quantum dots correspond to the carrier trap portions recited in claim 1. *See, e.g.*, PO Resp. 24, 31–33. The parties' positions are consistent with Lin's introductory disclosure that "[i]ndium-rich clusters near InGaN quantum well (QW) layers in an InGaN/GaN QW structure are closely related to the photon emission efficiency of such a compound. . . . The localized energy states formed at these clusters can trap carriers for photon emission and reduce non-radiative recombination rate." Ex. 1025, 35 (citation omitted).

Claim 1 next recites "the at least one carrier trap portion having a band-gap energy decreasing from a periphery of the carrier trap portion to a center of the carrier trap portion." Ex. 1001, 6:52–55 (referred to herein as the "bandgap energy profile" limitation). Petitioner asserts that "Lin's quantum dots" satisfy this limitation and relies on the known inverse relationship between indium concentration and bandgap energy, namely a higher indium content means lower bandgap energy. Pet. 30–31. Petitioner also directs us to Figure 2(d) of Lin, reproduced below. Pet. 30.



(d)

Figure 2d shows the indium composition amplitude profile along a quantum well layer in Lin's sample. Ex. 1025, 38.

Petitioner argues

> The distribution of indium within the indium-rich quantum dots for the sample annealed at 900°C is shown in [Lin Figure 2(d)]. . . . As can be seen from this graph, the indium concentration increases from one minima to a maxima and then returns to an adjacent minima periodically. A POSA reviewing this graph would have understood that the center of each of the quantum dots is defined by the point with a maximum indium composition. Ex. 1002, ¶ 92. On either side of each maxima, the concentration of indium decreases until it hits a local minima. *Id.*, ¶ 91. Therefore, regardless of where the precise bounds of carrier trap portion are defined—something that the '225 patent says need not have "a physical shape," Ex. 1001, 4:42-47—a POSA would have recognized that the indium concentration *increases* from the outer periphery of the carrier trap portion to the maxima for each quantum dot. Ex. 1002, ¶ 92; Ex. 1025, p.38 (Fig. 2(d)).

Pet. 30–31.

Petitioner thus concludes that, "because Lin teaches that the indium concentration increases within the carrier trap portion, Lin teaches that the bandgap energy decreases from the periphery of the carrier trap portion to its center." Pet. 31–32 (citing Ex. 1002 ¶¶ 91–93).

Patent Owner contends that Lin does not disclose how indium concentration changes within any individual alleged carrier trap portion. PO Resp. 21–22. Patent Owner argues Figure 2(d) of Lin, which forms the basis of Petitioner's anticipation argument, is derived from TEM measurements. PO Resp. 27. According to Patent Owner, it is undisputed that TEM images "are based on the average of what electrons experience as they travel through the sample thickness." PO Resp. 27, 31 (emphasis omitted) (citing Ex. 2014, 124:18–125:16, deposition testimony from Dr. Dupuis acknowledging that Lin's measurements in Figure 2(d) are "clearly . . . an average of the scan"). Patent Owner asserts that Lin describes its QDs as regularly distributed within the quantum well layers, and having a size between 2–5 nm. PO Resp. 28 (citing Ex. 1025, 37). Patent Owner contends that because Lin discloses nothing about the thickness of the sample used to generate the data in Lin Figure 2(d), it is "it is impossible to know how many 'QDs with size 2-5 nm' electrons encountered as they traveled through the sample thickness." PO Resp. 32 (quoting Ex. 1025, 37; citing Ex. 2016 ¶132; Ex. 2014, 127:11–17); *see also* PO Resp. 31–32 (arguing it is "impossible to know how many QDs (or portions thereof) were encountered by the electrons that traveled through the sample to yield Figure 2(d)"); PO Resp. 24–25 (emphasis omitted) (contending that Lin discloses "indium distributions averaged through the sample thickness, which includes an unknown number of indium-rich QDs (or portions thereof) and relatively indium-poor regions around them").

Patent Owner thus argues that the averaged TEM measurements reported in Lin Figure 2(d) "cannot be attributed to any particular QD." PO

Resp. 27.[7] In this regard, Patent Owner directs us to testimony from Petitioner's declarant, Dr. Dupuis, indicating that the regions inside Lin's quantum dots are "not directly imageable." PO Resp. 31 (quoting Ex. 2014, 126:10–21). Accordingly, Patent Owner argues that "[t]here is simply no way to determine how indium is distributed within any QDs from Lin's Figure 2(d)." PO Resp. 32.

After considering both parties' arguments and evidence, we determine that Petitioner has not met its burden of proof to show that Lin discloses the bandgap energy profile limitation of claim 1. We recognize that the '225 patent indicates that the claimed carrier trap portion is "not limited to a physical shape." Ex. 1001, 4:40–43. Petitioner, however, argues Lin's quantum dots correspond to the claimed carrier trap portions. Pet. 28–29. Accordingly, the relevant inquiry for purposes of anticipation is whether Petitioner has shown that Lin's quantum dots have the bandgap energy profile recited in claim 1.

We are persuaded by Patent Owner's arguments that the TEM data presented in Lin Figure 2(d) cannot be attributed to any particular quantum dot in Lin, and, therefore, does not constitute evidence sufficient to support

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[7] Patent Owner also presents illustrations and hypothetical examples to explain why TEM measurements do not necessarily reveal granular information about local regions within a sample, and, therefore, it is improper to interpret TEM measurements as showing the indium concentration inside a single quantum dot. PO Resp. 25–27, 34–38. Petitioner contends that Patent Owner relies on these hypotheticals to "attack" Lin's conclusions. Reply 17. We disagree. Patent Owner relies on these hypotheticals to show the limitations of TEM measurements and the reasons why Petitioner's attempt to draw a conclusion regarding the composition profile within Lin's quantum dots from TEM's averaged measurements is flawed.

Petitioner's contention that "Lin's quantum dots" (Pet. 30) satisfy the bandgap energy profile limitation in claim 1. Declarants from both parties agree that TEM measurements report an average indium composition over the thickness of the sample. Ex. 2016 (Doolittle Decl.) ¶ 132; Ex. 2014 (Dupuis Deposition Tr.), 17:7–13; 124:18–125:22, 126:10–21; Ex. 2019 (Ponce Deposition Tr.), 41:3–14. Lin states its quantum dots range in size between 2–5 nm, and, it is undisputed that Lin does not disclose the thickness of its sample. Ex. 1025, 37; Ex. 2014: 127:11–17; Ex. 2016 ¶ 132. We thus agree with Patent Owner that "it is impossible to know how many 'QDs with size 2-5 nm' electrons encountered as they traveled through the sample thickness." PO Resp. 32.

In view of Dr. Dupuis' deposition testimony (*e.g.*, Ex. 2014, 124:18–125:22, referring to "an average of the scan"), we do not credit his declaration testimony that Lin Figure 2(d) shows the "distribution of indium *within the indium-rich quantum dots*," wherein "the center of *each of the quantum dots* is defined by the point with a maximum indium composition." Ex. 1002 ¶¶ 91–92 (emphasis added). Because we do not find this testimony from Dr. Dupuis' declaration to be credible, there is insufficient basis for Petitioner's argument that Lin discloses "at least one carrier trap portion having a band-gap energy decreasing from a periphery of the carrier trap portion to a center of the carrier trap portion." Pet. 30–31.

In its Reply, Petitioner maintains that it has provided evidence that Lin's "quantum dots" have the bandgap energy profile recited in claim 1. Reply 16–23. Petitioner, however, appears to shift from its original position in the Petition that Figure 2(d) shows the "distribution of indium *within the indium-rich quantum dots*." Pet. 30 (emphasis added). Instead, Petitioner acknowledges in the Reply that Figure 2(d) "shows variations in indium content *within an InGaN well layer*." Reply 20 (emphasis added); *see also* Reply 1 (Petitioner noting that Lin "describes *well layers* with periodically varying indium content" (emphasis added)). Petitioner also states that "Lin's . . . conclusions do not rest solely on TEM" (Reply 19) and Lin's analysis, "including the TEM images" provides a "reliable indication[ ] of changes in indium composition within QDs" (Reply 23). Petitioner's Reply includes arguments based on the natural behavior of indium clusters, the assertion that "InGaN exhibits complex growth processes," and evidence purporting to establish that InGaN quantum wells naturally have a variation in indium composition. Reply 17–22 (citing Ex. 1071 ¶¶ 12–15; Ex. 1066 ¶¶ 27, 58, 61); Tr. 19:14–20:4 (referring to "how indium behaves").

Patent Owner argues Petitioner raises new arguments in its Reply that we should not consider, citing the Federal Circuit's holding in *Wasica Fin. GmbH v. Cont'l Auto. Sys. Inc.*, 853 F.3d 1272, 1286 (Fed. Cir. 2017), that a petitioner cannot "cure the petition's deficiencies in its subsequent briefing." Sur-reply 4. We find this argument persuasive.

As discussed above, in the Petition, Petitioner argued Figure 2(d) shows Lin's quantum dots have an indium composition that varies from its periphery to its core. Pet. 30–31. In its Patent Owner Response, Patent Owner presented undisputed evidence that TEM measurements provide an average value over the thickness of a sample, demonstrating a flaw in Petitioner's argument. PO Resp. 24–39. Rather than explaining why its original argument in the Petition was correct, e.g., that Patent Owner's criticism of TEM was wrong and/or that the TEM data presented in Lin Figure 2(d) can be attributed to a particular quantum dot in Lin, Petitioner shifted its argument and improperly relied on new evidence that was absent from the Petition.

For example, in the Reply, in addition to Figure 2(d), Petitioner relies on Lin's x-ray diffraction (XRD) experiments (Reply 21–22) and contends that InGaN's "complex growth processes" (Reply 17) as well as "the understanding that indium-rich clusters allowed InGaN LEDs to be highly luminescent despite their high levels of dislocations" (Reply 19) support its conclusion that a person of ordinary skill in the art "would have understood that Lin['s] . . . indium composition measurements represent changes in bandgap energy that meet the claims" (Reply 18–19). We discern no reference to or meaningful discussion of XRD in the Petition or Dr. Dupuis' First Declaration (Ex. 1002). Nor do these documents contain any meaningful discussion of the behavior of indium or the InGaN growth process. Instead, these topics appear for the first time in Dr. Dupuis' Second Declaration and Dr. Ponce's Declaration, both filed in support of Petitioner's Reply. *See, e.g.*, Ex. 1071 ¶ 12 (referring to "the way that the InGaN alloys were understood to behave"); ¶¶ 14–15 (discussing Lin's XRD measurements); Ex. 1066 ¶ 61 (referring to "the physics of the InGaN lattice structure and its formation"). Petitioner thus did not rely on this evidence to support anticipation in the Petition. *See Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.,* 821 F.3d 1359, 1369 (Fed. Cir. 2016) ("*Illumina*").

In *Wasica*, the Federal Circuit stated that "[i]t is of the utmost importance that petitioners in the IPR proceedings adhere to the requirement that the initial petition identify with particularity the evidence that supports the grounds for the challenge to each claim." *Wasica*, 853 F. 3d at 1286 (quoting *Illumina,* 821 F.3d at 1369). Similar to the petitioner in *Wasica*, instead of relying on the evidence and arguments presented in the Petition, namely that Figure 2(d) shows Lin's quantum dots have the required bandgap properties, Petitioner directs us, in the Reply, to a different portion of Lin (e.g., Figure 4 and the corresponding discussion of Lin's XRD data) along with other new evidence regarding the natural behavior of InGaN alloys during the growth of InGaN (e.g., Ex. 1071 ¶¶ 12–15; Ex. 1066 ¶ 61), and shifts its position to argue that it's evidence "including the TEM images" in Lin Figure 2(d) demonstrates a person of ordinary skill in the art would have understood Lin discloses carrier trap portions having the required bandgap energy profile. Reply 16–22; *Wasica*, 853 F.3d at 1286. As the Federal Circuit found in *Wasica*, Petitioner's actions reveal an attempt to cure the deficiencies in the Petition, and are "foreclosed by statute, [Federal Circuit] precedent, and Board guidelines." *Wasica*, 853 F.3d at 1286–87 (citing *Illumina*, 821 F.3d at 1369–70, 35 U.S.C. § 312(a)(3), and the Board's *Trial Practice Guide,* 77 Fed. Reg. 48,756, 48,767 (Aug. 14, 2012)[8]).

Under these circumstances the Federal Circuit has indicated that we may decline to consider Petitioner's new arguments and evidence. *Id.* at 1287. Doing so here results in weighing Petitioner's reliance on Lin Figure 2(d) as the basis for its argument that Lin discloses a carrier trap portion having the required bandgap energy profile against Patent Owner's largely undisputed evidence that the TEM data presented in Lin Figure 2(d) cannot be attributed to any particular quantum dot in Lin. For the reasons

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[8] Our Consolidated Trial Practice Guide ("CTPG," *available at* https://www.uspto.gov/TrialPracticeGuideConsolidated), issued November 2019, contains similar guidelines. CTPG, 73.

discussed above, namely the inability to attribute the indium composition variation in Figure 2(d) to a particular quantum dot in Lin, the evidence Petitioner presents in the Petition is not sufficient to support Petitioner's contention that "Lin's quantum dots" satisfy the bandgap energy profile limitation in claim 1.

Nor are we persuaded by Petitioner's argument in the Reply that Patent Owner's declarant, Dr. Doolittle, admitted that the bandgap energy in InGaN quantum dots or carrier traps is not constant. Reply 16–17. To arrive at this purported admission, Petitioner pieces together answers from different questions during the deposition of Dr. Doolittle. Reply 16–17. Notably, Petitioner relies upon Dr. Doolittle's testimony that there are "other materials . . . that have substantially flatter quantum wells than perhaps in the indium gallium nitride case." Reply 17 (quoting Ex. 1064, 93:10–22). During the deposition, however, counsel for Petitioner noted that Dr. Doolittle's answer referred to quantum wells, not carrier traps. Ex. 1064, 93:23–25. After clarifying that point, counsel for Petitioner asked the same question again, and Dr. Doolittle provided a different answer. Ex. 1064, 93:23–94:20. Furthermore, as Patent Owner points out, Dr. Doolittle testified that "it is possible to grow . . . quantum well structures that are abrupt and have a flat region inside what would be then a portion of the material that could capture carriers." Ex. 1064, 96:16–21; Sur-reply 6.

Nevertheless, even if Dr. Doolittle's testimony does amount to an admission that the bandgap energy in InGaN quantum dots or carrier trap portions is not constant, such an admission does not demonstrate that InGaN quantum dots have the specific bandgap energy profile required in claim 1. The burden of proving Lin discloses a quantum dot having a bandgap energy that decreases from its periphery to its center remains with Petitioner, and an admission that the bandgap energy in InGaN quantum dots is not constant does not satisfy that burden.

For all of the foregoing reasons, we find Petitioner has failed to demonstrate sufficiently that Lin discloses all limitations in claim 1, and, therefore, has not demonstrated by a preponderance of evidence that Lin anticipates claim 1.

While we decline to consider Petitioner's new evidence and arguments that go beyond Lin Figure 2(b) because Petitioner presented them for the first time in the Reply, we further note that the outcome here would not change even if we were to consider the merits of the new arguments and evidence. For example, Petitioner directs us to several portions of Lin in support of its Reply arguments. Reply 19–20. We agree with Petitioner that Lin teaches that indium-rich clusters "can trap carriers for photon emission and reduce non-radiative recombination rate." Ex. 1025, 35; Reply 19. Lin also teaches that post-growth annealing "led to better confinement of indium-rich clusters," "[t]he QDs become sphere-like shaped and their average size becomes smaller after annealing treatment," and "[t]he originally shaped cluster boundaries became sharpened after post-growth thermal annealing." Ex. 1025, 37; Reply 19. Lin also states that it performed EFTEM measurements "[t]o further understand the composition variation" in the InGaN QW structure, and "[i]ndium map and indium composition profiles along and across QW layers of the sample after 900°C annealing are shown in Figure 2." Ex. 1025, 37; Reply 19–20. Lin reports that, based on the EFTEM measurements, it observed "[r]egularly arrayed

QDs with nearly the same indium concentration at the cores of the QDs." Ex. 1025, 37.

None of these statements in Lin, however, demonstrate sufficiently that Lin discloses quantum dots having the bandgap energy profile recited in the claims. At best, these statements demonstrate that Lin understood quantum dots can trap carriers, and that Lin was able to grow an InGaN quantum well structure having quantum dots that are sphere-like in shape, have nearly the same indium content at their cores, and form sharper boundaries after annealing. Ex. 1025, 37. These statements also demonstrate Lin used TEM to map indium composition across and along quantum well layers and provided an indium composition amplitude profile along a QW in Figure 2(d). Ex. 1025, 37–38.

Referring to Figure 2(d), Petitioner argues that "Patent Owner cannot credibly deny that Lin shows ***local variations*** of indium through the cross-section of the sample." Reply 20 (emphasis added). According to Petitioner, "Patent Owner's expert agrees that ***on average*** the region shown at 5 nm in Lin's Figure 2(d) and the region shown at 10 nm have a different indium composition." *Id.* (emphasis added; citing Ex. 1064, 88:8–89:9). As discussed above, however, averages across an unknown sample thickness are not sufficient to show a variation within the 2–5 nm sphere-like quantum dots Petitioner identifies as the carrier traps in Lin. We are persuaded by Patent Owner's argument that the nature of TEM measurement, namely averaging indium concentration through the sample thickness, means the data from Figure 2(d) cannot be attributed to any particular quantum dot. *E.g.*, PO Resp. 39.

Petitioner's argument that the indium is not uniformly distributed through the sample because InGaN creates "clusters which act to confine the carriers and prevent non-radiative recombination," as opposed to "neat quantum wires," is unavailing. Reply 20 (citing Ex. 1071 ¶¶ 12–13). Petitioner admits that it is not asserting an inherency argument – so the fact that InGaN forms clusters that confine carriers, i.e., carrier trap portions, does not constitute evidence sufficient to demonstrate that Lin's carrier trap portions have the required bandgap energy profile for purposes of anticipation. *See* Tr. 27:1–10; 42:16–17. The relevant inquiry here is not whether Lin discloses clusters that confine carriers, but whether Petitioner has shown, by a preponderance of evidence, that Lin's carrier trap portions (i.e., its quantum dots) have the specific bandgap energy profile recited in claim 1. *See* Pet. 30 (Petitioner arguing "Lin's quantum dots have a band-gap energy that decreases from a periphery of the quantum dot (where the concentration of indium is lower) to the center of the quantum dot (where the concentration of indium is higher)"). A "periodic arrangement of indium rich regions" in an InGaN well layer (Reply 20) is not sufficient to meet the bandgap energy profile limitation, which requires Petitioner to show a bandgap energy gradient within the carrier trap portions (i.e., Lin's quantum dots).

Petitioner next directs us to Lin's XRD experiments. Reply 21. Referring to Figure 4b of Lin, Petitioner contends Lin's XRD data shows pronounced peaks for InN and GaN, and "subtle peaks . . . in the angular range for InGaN." Reply 21. Petitioner presents an annotated version of Lin Figure 4(b) with red arrows indicating the purported InGaN peaks.

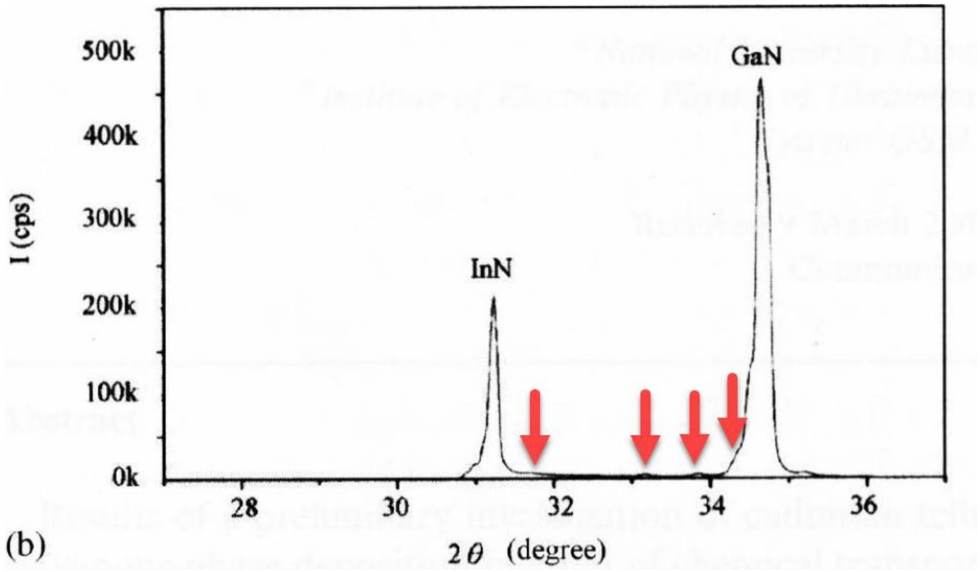

Figure 4(b) of Lin shows XRD spectra of Lin's sample annealed at 900°C. Ex. 1025, 39.

Dr. Dupuis states that Lin's XRD measurements "show that there is a gradual change in the indium composition within the InGaN QWs." Ex. 1071 ¶ 14. Dr. Dupuis' opinion is based on a comparison between Figure 4 in Lin and "similar XRD scans of other InGaN/GaN MQW samples" from Lin II (Ex. 1016), a 2000 article written by Lin. Ex. 1071 ¶ 14. Dr. Dupuis testifies that Lin Figures 4(a) and (b) show peaks for InN and GaN, along with "some shoulders and lower-intensity XRD signals." Ex. 1071 ¶ 14. Dr. Dupuis states that the XRD scans in Lin II show peaks for GaN and InN, as well as a distinct peak that "indicates the existence of a distinct local 'region' of InGaN ternary alloy material" corresponding to $In_{0.09}Ga_{0.91}N$ material, which is not the intended $In_{0.20}Ga_{0.80}N$ alloy composition. Ex. 1071 ¶ 14. Again referring to Lin II's XRD scans, Dr. Dupuis identifies "a shoulder" due to a region having a graded $In_xGa_{1-x}N$ alloy composition. Ex. 1071 ¶ 14.

From the XRD data in Lin II (Ex. 1016), Dr. Dupuis concludes that "there has been spinodal decomposition taking place in the InGaN layers during the growth of this MQW region and the $In_xGa_{1-x}N$ QWs, intended to be pure $In_{0.20}Ga_{0.80}N$, have decomposed during MOCVD growth into InN regions, $In_{0.09}Ga_{0.91}N$ regions, and $In_xGa_{1-x}N$ regions having a graded In alloy composition." Ex. 1071 ¶ 14. Dr. Dupuis then testifies that, similar to the decomposition observed in the samples in Lin II, Lin's XRD spectra in Figure 4(b) shows "very subtle ripples" that suggest a

> high degree of decomposition has occurred during MQW growth such that instead of QWs having a constant $In_xGa_{1-x}N$ alloy composition, there are regions of InN—that would have a relatively smaller energy gap—and $In_xGa_{1-x}N$ regions having relatively larger energy gap, and a gradual variation in the alloy composition of $In_xGa_{1-x}N$ between the GaN material in the barrier and the localized InN regions in the QWs.

Ex. 1071 ¶ 15. According to Dr. Dupuis, a structure with this type of gradual variation in indium composition "would, necessarily, have quantum states in the MQW region defined by the smaller-bandgap InN regions and the larger-bandgap graded-composition $In_xGa_{1-x}N$ regions that surround these InN regions." Ex. 1071 ¶ 15.

Based on Dr. Dupuis' testimony, Petitioner argues that

> In comparison to [Lin II], the absence of defined peaks of InGaN shows that there are few defined regions of a specific indium composition within the InGaN. Ex. 1071, ¶ 15. Instead, the XRD simulation is consistent with a curved bandgap profile for the QDs as they approach an InN phase region.

Reply 21–22. Petitioner also contends that the XRD data confirms Lin's "conclu[sion] that by annealing, indium diffused in an 'uphill manner,' i.e., 'diffusion in the opposite direction of the *composition gradient*,' thus producing a 'stronger InN peak and sharper interfaces between InN and surrounding matrix.'" Reply 22 (quoting Ex. 1025, 38 and citing Ex. 1071 ¶ 15).

Patent Owner argues this evidence does not support a conclusion that Lin's quantum dots have the claimed bandgap energy profile because it "reveals nothing about how, if at all, the indium distribution changes *within* any QD." Sur-reply 8. We agree with Patent Owner.

First, Dr. Dupuis' conclusions regarding the distribution of indium in the sample in Lin Figure 4 are based largely on XRD data in Lin II, which was generated from different samples in a different study conducted by Lin. Ex. 1071 ¶¶ 14–15 (discussing XRD data in Lin and Lin II), ¶ 16 (stating that the decomposition that occurs in the sample in Lin Figure 4 is "similar to the InGaN decomposition Lin describes in his earlier paper, Ex. 1016"). The XRD scans in Lin II (Ex. 1016), however, are noticeably different than those in Lin Figure 4. For example, as Dr. Dupuis discusses, Figure 1(b) in Lin II contains a distinct peak that "indicates the existence of a distinct local 'region' of InGaN ternary alloy material of a specific alloy composition." Ex. 1071 ¶ 14 (referring to the peak labeled (C) in Figure 1 of Ex. 1016). No such distinct peak for an InGaN ternary alloy material appears in Lin Figure 4. Ex. 1025, 39. Additionally, the InN peak in Lin II (designated (A) in Figure 1(b)) is significantly smaller than the InN peak in Lin Figure 4. *Compare* Ex. 1025, 38 (Figure 4(b)) *with* Ex. 1016, 2989 (Figure 1(b)). Nevertheless, Petitioner and Dr. Dupuis assert that the sample in Lin Figure 4 would decompose during growth just as the samples in Lin II Figure 1(b) did, to also produce InN regions and $In_xGa_{1-x}N$ regions having a graded In alloy composition. Ex. 1071 ¶¶ 15–16; Reply 21–22. The differences in the XRD scans between the samples in Lin Figure 4 and Lin II

(Ex. 1016), and the failure of Petitioner and Dr. Dupuis to account for these differences, diminishes the weight we are willing to assign to Dr. Dupuis' opinion. *See* 37 C.F.R. § 42.65 (a).

Setting the aforementioned deficiency aside, and assuming that Petitioner and Dr. Dupuis are correct that the XRD data shows the sample in Lin Figure 4(b) has a "graded $In_xGa_{1-x}N$ alloy composition," we remain unpersuaded by Petitioner's argument. Dr. Dupuis and Dr. Ponce acknowledge that the XRD data in Lin provides no information about where in the sample certain material is located. Ex. 2019, 95:14–16; Ex. 2020, 146:17–20; Sur-reply 9 n.4. Thus, it is impossible to tell from the XRD data exactly where in the sample the purported graded alloy composition is present, and likewise impossible to conclude that the sample "would, *necessarily*, have quantum states in the MQW region defined by the smaller-bandgap InN regions and the larger-bandgap graded-composition $In_xGa_{1-x}N$ regions *that surround these InN regions*." Ex. 1071 ¶ 15 (emphasis added). Indeed, Dr. Dupuis testified "the features of InGaN aren't revealed in [Lin's Figure 4 XRD] data." Ex. 2014, 117:6–7. Thus, we are not persuaded that Lin's XRD data, even when considered with the average indium distribution shown Figure 2(d), provides sufficient evidence regarding the indium distribution within Lin's quantum dots.

Nor are we persuaded by Petitioner's reliance on Lin's disclosure that "[p]ost growth thermal annealing facilitates indium-rich phase to grow gradually . . . via the 'uphill' diffusion mechanism, i.e., diffusion in the opposite direction to the composition gradient." Ex. 1025, 38; Reply 22. Lin's statement that indium moves from areas of low indium concentration to areas of high indium concentration during growth does not provide sufficient information about where there areas of low indium concentration exist within the sample in relation to Lin's quantum dots. As a result, we are not persuaded Lin's description of the general movement of indium provides information about how, if at all, the indium composition varies *within* any quantum dot.

Petitioner also relies on Dr. Ponce's testimony that Lin's results "clearly indicate that compositional inhomogeneities exist in as-grown InGaN QWs." Ex. 1066 ¶ 60; Reply 22. According to Dr. Ponce, Lin attributes the formation of QDs to "clustering of indium atoms along the [0001] direction and anti-clustering of indium atoms in the (0001) plane . . . due to dipole interaction energy." Ex. 1066 ¶ 60. Referring to "the physics of the InGaN lattice structure and its formation," Dr. Ponce states that "[t]he only reasonable conclusion from the data shown in Lin's Fig. 2 is that the bandgap" of Lin's carrier trap portions "is not constant, and that it shows indium-rich clusters in the quantum wells that due the 'anti-clustering of indium atoms in the (0001) plane' have bandgap energies that decrease from a periphery of the indium cluster towards the center of the cluster." Ex. 1066 ¶ 61.

Dr. Ponce, however, does not explain sufficiently what "anti-clustering of indium atoms in the (0001) plane" means or how it allows a person of ordinary skill in the art to conclude that the bandgap energy of Lin's carrier trap portions decrease from a periphery of the indium cluster to the center of the cluster.[9] Further, even if Dr. Ponce is correct that the

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[9] Additionally, Lin states that the formation of sphere-like quantum dots may arise from a second mechanism—"a disk-like island with a small height/width ratio is practically non-relaxed." Ex. 1025, 37. Dr. Ponce does

physics of the InGaN lattice structure and its formation lead to "compositional variations" in InGaN quantum wells, the existence of such variations alone is not sufficient to demonstrate that Lin's quantum dots have the bandgap energy profile required in claim 1. For example, Dr. Ponce does not provide information about the location of any compositional variation in Lin's quantum wells such that a person of ordinary skill in the art would be able to determine the indium distribution *within* Lin's quantum dots. As Patent Owner points out, Dr. Ponce acknowledges that "Lin is not claiming to provide a distribution of indium within the indium-rich clusters." Sur-reply 4 (emphasis omitted); Ex. 2019, 112:8–21. Accordingly, we are not persuaded that Dr. Ponce has adequately supported his opinion that "[t]he only reasonable conclusion from the data shown in Lin's Fig. 2" is that Lin's carrier trap portions "have bandgap energies that decrease from a periphery of the indium cluster towards the center of the cluster." Ex. 1066 ¶ 61.

Although Petitioner maps Lin's quantum dots to the carrier trap portion recited in claim 1 in its Petition, in its Reply Petitioner attempts to rely on the purported composition gradient in the matrix surrounding Lin's quantum dots as evidence that Lin's quantum dots have the bandgap energy profile recited in claim 1. Pet. 30–31; Reply 16–22. As Patent Owner points out, the evidence of a composition gradient in the matrix is not evidence of indium composition within the quantum dot itself. Sur-reply 4. For example, Petitioner's evidence regarding the presence of a composition

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not address this mechanism or explain how it may impact his conclusions that appear to be based only on the first mechanism Lin describes, which involves the anti-clustering effect Dr. Ponce discusses.

gradient in Lin's quantum wells is based on XRD data that does not provide information regarding the location of the components within a sample. Ex. 2019, 95:14–17; Ex. 2020, 146:17–20. Petitioner's evidence regarding the natural behavior of indium during growth suffers from the same deficiency. Thus, the evidence does not demonstrate the presence of a composition gradient in a location sufficient to identify a carrier trap portion having the bandgap energy profile requirement in claim 1.

For all of the foregoing reasons, we find Petitioner has failed to demonstrate, by a preponderance of evidence, that Lin discloses a carrier trap portion having the bandgap energy profile claim 1 requires, and therefore, anticipates claim 1.

2. *Claims 4–7, 10, 11, and 17–19*

Claims 4–7, 10, 11, and 17–19 depend directly or indirectly from claim 1, and therefore contain all the limitations of claim 1. In its analysis of these dependent claims, Petitioner does not present any additional information regarding Lin's disclosure of carrier trap portions having the bandgap energy profile recited in claim 1. Pet. 32–41. Thus, for the same reasons discussed above in connection with claim 1, we determine Petitioner has failed to establish sufficiently that Lin teaches each limitation of claims 4–7, 10, 11, and 17–19. In view of this, we determine Petitioner has failed to demonstrate, by a preponderance of evidence, that Lin anticipates claims 4–7, 10, 11, and 17–19 of the '225 patent.

E. Obviousness Challenges Based on Lin

Petitioner argues dependent claim 4 is unpatentable as obvious in view of the combined teachings of Lin and Schley (Pet. 42–44) and dependent claim 16 is unpatentable as obvious in view of the combined teachings of Lin and Lin II (Pet. 44–45). Claims 4 and 16 depend from claim 1, and therefore contain all of the limitations in claim 1. Petitioner does not rely on Schley or Lin II to cure the deficiencies discussed above regarding Petitioner's assertion that Lin discloses all of the limitations in claim 1. Pet. 42–45. As a result, for the same reasons discussed above, we determine Petitioner has failed to demonstrate, by a preponderance of evidence, that claim 4 is unpatentable as obvious in view of Lin and Schley, or that claim 16 is unpatentable as obvious in view of Lin and Lin II.

F. Claims 1, 5–7, 10, 11, 15, and 17–19 — Alleged Anticipation by Gerthsen

Petitioner contends Gerthsen anticipates claims 1, 5–7, 10, 11, 15, and 17–19. Pet. 46–56. Petitioner directs us to portions of Gerthsen that purportedly disclose all the limitations of the challenged claims, and also relies on declarations from Dr. Dupuis and Dr. Ponce to support its arguments.

1. Claim 1

Independent claim 1 of the '225 patent recites a light emitting device comprising a substrate, a first semiconductor layer on the substrate, a second semiconductor layer on the first semiconductor layer, and a multi-quantum well structure comprising at least one well layer and one barrier layer between the first and second semiconductor layers. For these limitations, Petitioner directs us to Gerthsen's disclosure of an "InGaN/GaN QW structure, which contains 5 InGaN layers separated by 5 nm GaN spacers . . . grown on a SiC(0001) substrate on Si-doped 380 nm AlGaN and 75 nm GaN buffer layers," and "capped by 75 nm GaN and 240 nm AlGaN doped with Mg." Ex. 1026, 1673; Pet. 46–47. According to Petitioner, the

"SiC(0001) substrate" in Gerthsen corresponds to the claimed substrate, the "Si-doped 380 nm AlGaN" corresponds to the claimed first semiconductor layer, the "240 nm AlGaN doped with Mg" corresponds to the second semiconductor layer, and the InGaN/GaN quantum well structure corresponds to the claimed multi-quantum well structure. Pet. 46–47 (emphasis omitted).

Claim 1 of the '225 patent further requires "at least one layer within the multi-quantum well structure comprising at least one carrier trap portion formed therein, the at least one carrier trap portion having a band-gap energy decreasing from a periphery of the carrier trap portion to a center of the carrier trap portion." Ex. 1001, 6:48–55.

Petitioner directs us to Gerthsen's statement that "composition fluctuations are always present in InGaN. In particular, In-rich agglomerates with sizes of only a few nm are a characteristic feature, which are often suggested to act optically as quantum dots." Pet. 47–48; Ex. 1026, 1669. According to Petitioner, a person of ordinary skill in the art "would have recognized that indium-rich quantum dots are carrier traps because an increase in indium reduces the bandgap energy to create localized states." Pet. 48 (citing Ex. 1002 ¶¶ 33, 40, 46, 103; Ex. 1016, 2988).

Petitioner further argues that Gerthsen's carrier trap portions have a band-gap energy decreasing from a periphery of the carrier trap portion to a center of the carrier trap portion based on the information presented in Figure 4(a) of Gerthsen, reproduced below. Pet. 49.

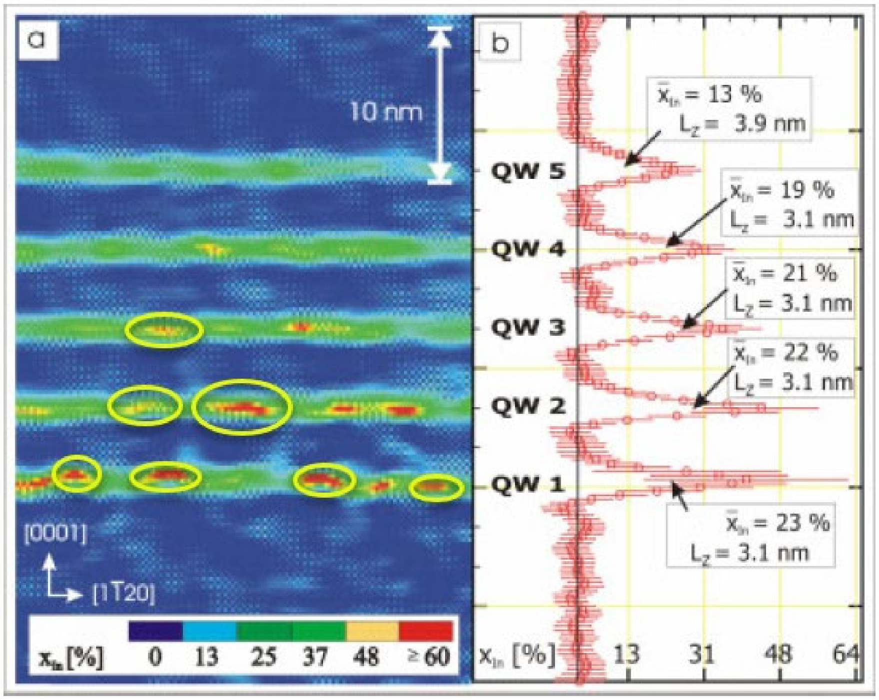

Fig. 4 a) Color-coded map of the In distribution of an InGaN/GaN multiple QW structure and b) averaged In concentration along the $[11\bar{2}0]$ direction plotted as a function of the (0002)-plane. number.

Figure 4(a) shows a color coded map of the indium distribution of an InGaN multiple-quantum well structure. Ex. 1026, 1673. Petitioner argues that a person of ordinary skill in the art would recognize that the indium concentration increases from the outer periphery of the carrier trap portion to the maxima for each indium-rich quantum dot because "the indium concentration (X_{In}[%]) in, for example, the bottom most well-layer of the MQW structure is nominally at 37% and increases in regions of the quantum dots from 48% to a concentration of greater than 60%." Pet. 49–50 (citing Ex. 1002 ¶ 104). In view of this, and the well-known inverse relationship between indium concentration and bandgap energy, Petitioner argues that Gerthsen teaches the bandgap energy of the carrier trap portion decreases from the outer periphery of the carrier trap portion to the center, as claim 1 requires. Pet. 50 (citing Ex. 1002 ¶ 106).

Similar to the arguments presented regarding Lin, Patent Owner argues that Petitioner failed to demonstrate that Gerthsen discloses a carrier trap portion having a band-gap energy decreasing from its periphery to its center because Gerthsen obtained Figure 4(a) using HRTEM. PO Resp. 28–29. Patent Owner contends that Gerthsen Figure 4(a) shows "average indium distribution through the sample thickness, which includes an unknown number of purported indium-rich QDs (and portions thereof) and relatively indium-poor regions around them." PO Resp. 29 (citing Ex. 2016 ¶¶ 126–136; Ex. 2014, 17:7–13). Patent Owner argues that Gerthsen's Figure 4(a) shows average indium concentration through the sample thickness, not actual concentration at any particular location. PO Resp. 29 (citing Ex. 1026, 1674). Patent Owner relies on Gerthsen's statements that Figure 4(a) shows "an apparent In concentration," and "[t]he measured In concentrations are an ***averaged value*** determined by the composition of the cluster and the embedding matrix along the electron-beam direction for HRTEM sample thicknesses." PO Resp. 29–30 (quoting Ex. 1026, 1674 (emphasis added by Patent Owner)). Patent Owner notes that Gerthsen does not disclose the thickness of the sample analyzed in Figure 4, stating only that it "typically range[s] between 5 and 20 nm." PO Resp. 31 (quoting Ex. 1026, 1674). Patent Owner also argues that Gerthsen fails to disclose enough information about the quantum dots to know their size, noting that Gerthsen states that the quantum dots have "lateral extensions below 4 nm," but does not describe their depth. PO Resp. 31; Ex. 1026 at 1673–74. In view of this, Patent Owner argues "[i]t is impossible to determine how indium is distributed within any particular QD from an average indium distribution obtained using TEM." PO Resp. 30.

In its Reply, Petitioner contends "Gerthsen describes samples that can be as little as a QD thick," and that "Gerthsen studied the effect of sample thickness and concluded its variations (from 5 nm to 20 nm) had 'negligible influence.'" Reply 22 (citing Ex. 1026, 1673). Based on this, Petitioner argues that Gerthsen itself does not support a finding that "averaging through the sample played a potential dramatic effect on Gerthsen's conclusions." Reply 22 (citing Ex. 1071 ¶¶ 18–21).

Patent Owner disputes this assertion, arguing that Gerthsen's statement regarding the "negligible influence of the sample thickness variation" refers to "Gerthsen's simulation modeling use of local lattice parameter (LLP)." Sur-reply 10–11. Patent Owner argues Gerthsen does not present information sufficient to evaluate whether samples of different thicknesses yield similar TEM images. Sur-reply 11 (citing Ex. 2020 (Dupuis Second Deposition Tr.), 180:10–13).

We are not persuaded by Petitioner's arguments that Gerthsen discloses a carrier trap portion having the bandgap energy profile recited in claim 1. Gerthsen expressly states that Figure 4 reflects averaging over the sample thickness. Ex. 1026, 1674. Petitioner's declarants, Dr. Dupuis and Dr. Ponce, do not dispute this fact. Ex. 2014, 94:13–22; Ex. 2019, 184:14–18. Gerthsen also states that Figure 4(a) shows "an apparent In concentration" of the clusters. Ex. 1026, 1674; Sur-reply 10.

With regard to sample size, although Petitioner contends "Gerthsen describes samples that can be as little as a QD thick," Petitioner does not provide support for that statement. Reply 22. Even if Petitioner had provided support for this statement, its relevance is limited because it demonstrates only the size the sample *could have been*, not the size of the samples actually used. Similarly, Gerthsen states only that samples "typically range between 5 and 20 nm." Ex. 1026, 1674.

As to the size of Gerthsen's clusters, Gerthsen states that "In-rich agglomerates with sizes of only a few nm are a characteristic feature," but Gerthsen does not provide a specific value. Ex. 1026, 1669; Ex. 1071 ¶ 17. As Patent Owner points out, Gerthsen states that its In-rich quantum dots have "lateral extensions below 4 nm," but does not describe their depth. PO Resp. 31; Ex. 1026, 1673–74. Accordingly, we agree with Patent Owner that Gerthsen fails to disclose enough information about the quantum dots to know their size. PO Resp. 31; Ex. 2014, 98:17–99:15 (Dr. Dupuis testifying that "the details are not revealed" regarding Gerthsen Figure 4); 97:15–98:3 (Dr. Dupuis acknowledging that the "number of indium-rich clusters that an electron would encounter in going through the sample to form the image that's shown in Figure 4 would vary, or at least could vary, depending on the thickness of the sample").

Furthermore, Dr. Dupuis confirmed during his deposition that Gerthsen's statement regarding the "negligible influence" of sample thickness variation referred to the influence of sample thickness on the local lattice parameters that are calculated from the model being used in a simulation. Ex. 2020, 184:10–13. Neither Petitioner nor Dr. Dupuis explain adequately how Gerthsen's conclusion, derived from its calculations of LLP from a model being used in a simulation, affects actual TEM measurements. For example, we note that Figure 3(e), which Petitioner and Dr. Dupuis rely on to support its assertions, plots normalized (0002) distances vs. distance in the [0001] direction, whereas Figure 4 plots "averaged In concentration along the [1120] direction . . . as a function of the (0002)-plane, number." Ex. 1026, 1672–1673; Ex. 1071 ¶¶ 18–21. In view of the foregoing, we agree with Patent Owner that neither Gerthsen nor Petitioner present sufficient evidence to support a conclusion that samples of different thicknesses yield similar TEM images. Sur-reply 10–11.

Because Gerthsen reports average values over the entire sample and does not specify sample size or the size of the quantum dots within the samples, it is impossible to know how many quantum dots the electrons encountered as they traveled through Gerthsen's sample during the TEM analysis that generated Figure 4. Accordingly, we agree with Patent Owner that the TEM data presented in Gerthsen Figure 4(a) cannot be attributed to any particular quantum dot in Gerthsen. This data undermines Petitioner's argument that "[t]he distribution of indium within the indium-rich quantum dots for a MQW sample disclosed by Gerthsen is shown" in Figure 4. Pet. 49.

Similar to its challenge based on Lin, Petitioner, in its Reply, appears to shift its arguments and present improper new evidence in attempt to establish that Gerthsen discloses carrier trap portions having the bandgap energy profile required in claim 1.[10] For example, in the Reply Petitioner states that "Gerthsen's conclusions do not rest solely on TEM" and "Gerthsen's analysis should be interpreted in light of the understanding that

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[10] To the extent Petitioner presents proper arguments in the Reply responding to Patent Owner's assertions regarding the limitations of Gerthsen's TEM measurements, these properly responsive arguments have been considered and addressed above.

indium-rich clusters allowed InGaN LEDs to be highly luminescent despite their high levels of dislocations, consistent with the known literature." Reply 19. Once again, Petitioner's Reply includes arguments based on the natural behavior of indium clusters, the assertion that "InGaN exhibits complex growth processes," and evidence purporting to establish that InGaN quantum wells naturally have a variation in indium composition. Reply 17–23 (citing Ex. 1071 ¶¶ 12–21; Ex. 1066 ¶¶ 27, 58, 61); Tr. 19:14–20:4 (referring to "how indium behaves").

For the same reasons discussed above, we decline to consider Petitioner's new arguments and evidence. *Wasica,* 853 F.3d at 1287. Doing so here results in weighing Petitioner's reliance on Gerthsen Figure 4 as the basis for its argument that Gerthsen discloses a carrier trap portion having the bandgap energy profile claim 1 requires against Patent Owner's evidence that the TEM data presented in Gerthsen Figure 4 cannot be attributed to any particular indium-rich quantum dot in Gerthsen. For the reasons discussed above, the evidence Petitioner has presented does not demonstrate, by a preponderance of evidence, that Gerthsen Figure 4 shows quantum dots that satisfy the bandgap limitation in claim 1. Additionally, Petitioner's arguments regarding Dr. Doolittle's purported admission are no more persuasive here than they were when we considered them in connection with Lin's disclosures, and they do not cure the deficiencies in Petitioner's evidence.

Even if we did consider Petitioner's evidence and arguments presented for the first time in the Reply, the outcome here would not change. For example, in its Reply, Petitioner states "Gerthsen describes a 'high accuracy' analytical technique that is used to show composition fluctuations which are '***always present*** in InGaN' and the presence of 'In-rich agglomerates' which 'act optically as quantum dots.'" Reply 22 (quoting Ex. 1026, 1669 (emphasis added by Petitioner)). Petitioner also contends that Gerthsen provides plots that "demonstrate that the indium composition varies from one position within the sample to the next." Reply 22 (citing Ex. 1026, 1673).

Because Petitioner acknowledges it is not presenting an inherency argument, the fact that Gerthsen discloses indium-rich clusters that act as quantum dots does not demonstrate that Gerthsen's indium-rich quantum dots have the specific bandgap energy profile required in claim 1. Furthermore, based on the limitations of TEM discussed above, we are not persuaded that the presence of composition fluctuations throughout an InGaN layer—detected using TEM—demonstrates a variation of indium composition within a carrier trap portion, as argued by Petitioner.

Petitioner also argues that "Gerthsen's discussion of the formation of the QDs is consistent with a variation in bandgap energy in the manner claimed because indium exhibits temperature-dependent phase separation during growth." Reply 23 (citing Ex. 1026, 1679–1681; Ex. 1066 ¶ 58). Petitioner cites to paragraph 58 in Dr. Ponce's declaration in support of this assertion. Reply 23. Dr. Ponce, however, does not discuss temperature-dependent phase separation during growth in this paragraph. Ex. 1066 ¶ 58. Instead, he refers to the Stransky-Krastanov ("SK") growth mode in support of his opinion that "[t]he only reasonable conclusion from the data shown in [Gerthsen's] Fig. 4 is that there are regions of higher indium content in the quantum wells that have bandgap energies that decrease from a periphery of the indium cluster towards the center of the cluster." Ex. 1066 ¶ 58. As

Patent Owner points out, however, Gerthsen states that SK growth does not explain the indium-rich clusters observed it its samples. Ex. 1026, 1679 ("It is, however, quite obvious, that an SK transition cannot be responsible for the In-rich clusters . . . ."); *see also* Ex. 1026, 1680 (Gerthsen stating that "we observe small and large-scale fluctuations [which] are also incompatible with the theory of spinodal decomposition," whereas Dr. Dupuis (Ex. 1071 ¶¶ 12–13) and Petitioner (Reply 17) rely on spinodal decomposition to explain InGaN's "complex growth processes").

Petitioner also relies on paragraph 21 in Dr. Dupuis' Second Declaration, wherein Dr. Dupuis states that "Gerthsen's study is consistent with the depictions in the '225 patent," and compares Figures 3 and 4 of the '225 patent with Figures 4(a) and 4(b), respectively, of Gerthsen. Reply 22–23. Dr. Dupuis' comparison, however, is flawed. First, what Dr. Dupuis identifies as Figure 3 in Exhibit 1071 is different from Figure 3 in Exhibit 1001, which is the copy of the '225 patent submitted by Petitioner. *Compare* Ex. 1071 ¶ 21 *with* Ex. 1001, Fig. 3. Instead of Figure 3, it appears Dr. Dupuis has reproduced a version of Figure 7 from the '225 patent in paragraph 21 of his Second Declaration. *See* Ex. 1001, Fig. 7. The '225 patent describes Figure 7 as "a diagram illustrating compressive stress generated in a carrier trap portion and tensile stress generated in a barrier layer to offset the compressive stress." Ex. 1001, 3:22–24. We fail to see, and Dr. Dupuis does not explain, how this figure can properly be compared with Gerthsen Figure 4(a) which shows a "[c]olor-coded map of the In distribution of an InGaN/GaN multiple QW structure." Ex. 1026, 1673.

Additionally, Dr. Dupuis attempts to compare Figure 4 of the '225 patent, which is an "energy band diagram" with Gerthsen Figure 4(b) which shows "averaged In concentration along the [1120] direction plotted as a function of the (0002)-plane number." Ex. 1001, 3:12–15; Ex. 1026, 1673. Dr. Dupuis does not address the differences between the figures or otherwise explain why Gerthsen's study is consistent with the depictions in the '225 patent.

Although Petitioner maps Gerthsen's quantum dots to the carrier trap portion recited in claim 1 in its Petition, in its Reply it attempts to rely on the purported composition gradient in the matrix *surrounding* Gerthsen's quantum dots as evidence that the quantum dots themselves have the bandgap energy profile recited in claim 1. Pet. 48–49; Reply 16–23. But we are not persuaded that Petitioner's evidence regarding the natural behavior of indium during growth to form a composition gradient somewhere in a quantum well shows a specific variation of indium composition within one of Gerthsen's indium-rich quantum dots itself. Sur-reply 4. This is especially true considering the only indium composition measurements in Gerthsen are based on TEM, which undisputedly provides average values across a sample of unspecified thickness. Ex. 1026, 1674 (stating that samples "typically range between 5 and 20 nm"). Thus, the evidence does not demonstrate the presence of a composition gradient in a location sufficient to identify a carrier trap portion having the bandgap energy requirements in claim 1.

For all of the foregoing reasons, we find Petitioner has failed to demonstrate, by a preponderance of evidence, that Gerthsen discloses a carrier trap portion having the bandgap energy profile claim 1 requires, and therefore, that Gerthsen anticipates claim 1.

2. *Claims 5–7, 10, 11, and 17–19*

Claims 5–7, 10, 11, and 17–19 depend directly or indirectly from claim 1, and therefore contain all the limitations of claim 1. In its analysis of these dependent claims, Petitioner does not present any additional information regarding Gerthsen's disclosure of carrier trap portions having the bandgap energy profile recited in claim 1. Pet. 50–56. Thus, for the reasons discussed above in connection with claim 1, we determine Petitioner has failed to establish sufficiently that Gerthsen teaches each limitation of claims 5–7, 10, 11, and 17–19. In view of this, we determine Petitioner has failed to demonstrate, by a preponderance of evidence, that Gerthsen anticipates claims 5–7, 10, 11, and 17–19 of the '225 patent.

G. Claim 16 — Obvious in view of Gerthsen and Lin II

Petitioner argues dependent claim 16 is unpatentable as obvious in view of the combined teachings of Gerthsen and Lin II (Pet. 57–58). Claim 16 depends from claim 1, and therefore contains all of the limitations in claim 1. Petitioner does not rely on Lin II to cure the deficiencies discussed above regarding Petitioner's assertion that Gerthsen discloses all of the limitations in claim 1. Pet. 57–58. As a result, for the reasons discussed above, we determine Petitioner has failed to demonstrate, by a preponderance of evidence, that claim 16 is unpatentable as obvious in view of Gerthsen and Lin II.

III. CONCLUSION

For the foregoing reasons, Petitioner has not demonstrated, by a preponderance of the evidence, that claims 1, 4–7, 10, 11, and 16–19 of the '225 patent are unpatentable over the prior art of record.

In summary:

Claim(s) Challenged	35 U.S.C. §	Reference(s)	Claims Shown Unpatentable	Claim(s) Not Shown Unpatentable
1, 4–7, 10, 11, 17–19	102(b)	Lin		1, 4–7, 10, 11, 17–19
4	103(a)	Lin, Schley		4
16	103(a)	Lin, Lin II		16
1, 5–7, 10, 11, 17–19	102(b)	Gerthsen		1, 5–7, 10, 11, 17–19
16	103(a)	Gerthsen, Lin II		16
Overall Outcome				1, 4–7, 10, 11, 16–19

IV. ORDER

It is hereby

ORDERED that, Petitioner has not shown, by a preponderance of the evidence, that claims 1, 4–7, 10, 11, and 16–19 of the ’225 patent are unpatentable; and

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

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